Agriculture and Allied Science

Restructured and Revised Syllabi of Post-graduate Programmes

Volume 7 - Basic Sciences

- Agricultural Chemicals
- Biochemistry
- Microbiology

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Compiled By

Dean & Director of Instruction Co-Ordination Committee of SAU's 2022-23

Restructured and Revised Syllabi of Post Graduate Programmes

M. Sc. and Ph. D. (Agriculture)

In

Agricultural Chemicals

Compiled
by

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Preamble

Agricultural chemicals, generally referred to as pesticides, play a vital role in sustaining agriculture productivity by controlling insect pests and diseases that damage field crops and food commodities during cultivation, transport and storage. In addition, they stimulate plant growth, enhance agri-input (water and fertilizer-N use) efficiency to increase farm productivity, and control pests of veterinary and public health importance. The Discipline of Agricultural Chemicals is multidisciplinary as it is linked to various agricultural and basic science disciplines like Entomology, Plant Pathology, Nematology, Toxicology, Weed Science, Environmental Science, Chemistry, Biochemistry, Microbiology, and Soil Sciences & Agricultural Chemistry. Due to the excessive use/ misuse of inherently toxic pesticides, environmental scientists and ecologists from time to time raise concerns about their harmful effects on humans, domestic animals and the environment. However, since benefits outweigh risks, agricultural chemicals will continue to play a leading role in crop protection.

The world is witnessing huge scientific, technological, digital and socio-economical transformation necessitating nations to launch new initiatives for their development and growth. With emphasis on the holistic education, the new National Education Policy (NEP) declared by the Government of India is aimed at bringing about sea changes in higher education. It will not only transform India into a global knowledge superpower, but will also help it achieve United Nations Sustainable Development Goal-4 aimed at ensuring inclusive and equitable quality education and promoting lifelong learning opportunities forall.

Global warming and climate change has posed significant challenges to food security. Changes in crop-pest and host-pathogen complexions have resulted in minor pests becoming major, and have increased the instances of pest resurgence and resistance development in insect pests and pathogens. In last ten years significant advances have been made globally in the field of crop protection and agricultural chemicals in particular. New molecules with novel chemistries and modes of actions are being developed and registered globally. With change in focus from pest kill to pest control, old generation highly toxic and persistent pesticides are being replaced with new generation reduced risk pesticides with novel chemistries and modes of action. These developments have necessitated restructuring of the course curriculum of the Discipline of Agricultural Chemicals at the Master's and Doctoral level to enable students undertake research in the emerging areas of agrochemical R & D, formulation technology, as well as food and environment safety through chemical, biochemical, biotechnological and nano-technological interventions. The in-depth understanding of the subject will empower students, researchers, farmers and other stakeholders to take informed decisions about safe use of pesticides in crop and environment protection.

In the discipline of Agricultural Chemicals, 20 post-graduate courses have been comprehensively restructured after modification of the existing courses. Of these, 12 are M.Sc. and 8 are Ph.D. courses. Course numbered AC-503,AC-504, AC-505, AC-506, and AC-510 (15 credits) will be compulsory for the M. Sc. students, and the courses numbered AC-601 and AC-602 (7 credits) will be compulsory for the Ph.D. students. The course numbered AC-501 and AC-502 have been designed for students from outside the discipline, and courses AC-503, AC-504, AC-505 and AC-602 may be joint interdisciplinary courses. The doctoral degree level courses (AC-601 to AC-605) are advanced and research oriented.

Basic Chemistry (AC-503) course has been consolidated after clubbing Basic Chemistry I and II courses and modifying/ updating the entire course content. Natural Product Chemistry (AC-504) course has been designed as a new course with more emphasis on metabolomics,
health-benefitting nutraceuticals, phytoceuticals, natural antioxidants and food colorants, polymers, enzymes and other natural products for industrial and other applications. The course on Agrochemical Regulation, Quality Control and Management (AC-505) and Pesticide Residue Chemistry (AC-510) have been completely revamped by incorporating provisions
of Food Safety and Standards Act 2006 and Rules 2011, Pesticide Management Bill (2017), ecological and consumer risk assessment, and MRL fixation as per the national/ international guidelines. In view of the recent advancements, new topics on acaricides, termiticides, management of resistance in insects, fungi and weeds, NABL accreditation of *laboratories,* and national/international guidelines on good agricultural practices (GAP), and good laboratory practices (GLP) have been added in the revised syllabus. New crop protection
concepts like development and use of entomo-pathogenic nematodes, entomo-pathogenic fungi, plant inhabited fungal endophytes, nanotechnology, biotechnology and plant incorporated protectants have also been introduced in the revised syllabus,

Practical content in the designed courses requires modern equipment for extraction, separations, chemical characterization, structure determination, synthesis, and analysis of pesticide residues in food commodities and in soil and aquatic environment. For better research and teaching capabilities, obsolete equipment(s) need to be replaced with new ones like GLC, HPLC, GC-MS-MS, LC-MS-MS, particle size analyzers etc. Additional funds
may be required for purchasing such equipment and their spare parts and supplies. Thus, a one-time grant of Rs. 5 crores with a recurring contingency of Rs. 20 lacs per annum will be needed to effectively run Master's and Doctoral programmes in ICAR-IARI/SAUs wherethe courses of Agricultural Chemicals are taught.

State level Committee for revision in Course and Syllabus of Masters and Doctoral Degree in Agricultural Chemicals

Sr. No.	Name	Designation	Office Address
1	Dr, Sanjay Bhoyar	Discipline Coordinator & Professor and Head	Department of Soil Science and Agricultural Chemistry, DR. PDKV, Akola

Organization of Course Contents &Credit Requirements

Minimum Residential Requirement:

M.Sc.: 4 Semesters
Ph.D.: 6 Semesters

Name of the Departments / Divisions

- Soil Science

Nomenclature of Degree Programme

(a) M.Sc. Programmes

i) M.Sc. (Agriculture) in Agricultural Chemicals

(b) Ph.D. Programmes

i) Ph.D. (Agriculture) in Agricultural Chemicals

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also been given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Eligibility for Admission

Master's Degree Programme

B.Sc.(Agri.) / **B. Sc. (Hons.) Agriculture,** B. Sc. (Hort.) / B.Sc. (Hons.) Horticulture / B. Sc. (Forestry) / B.Sc. (Hons.) under 10+2+4 system with minimum of 5.50/10 or equivalent percentage of marks or equivalent degree with four years duration of agriculture related Universities and having the Common Entrance Test in Agriculture conducted by competent authority.

Doctoral Degree Programme

Master's degree in concerned discipline with minimum of 6.50/10 or equivalent percentage of marks and based on CET score CET conducted by MAUEB or AIEEA – ICAR, Agricultural Universities (AUs) which have expressed their willingness to utilize NTA scores for their PG admissions. If required the scores will be provided by NTA.

(i) Master Degree in the concerned Department /Discipline of Agricultural Chemicals and having appearing the Common Entrance Test of Agricultural Chemicals subject conducted by competent authority.

Sr. No	Name of Department	Specialization in Ph. D.	Eligibility criteria
1.	Soil Science / Agricultural Chemicals	Ph. D (Agriculture) Agricultural Chemicals	M.Sc. (Agriculture) Agricultural Chemicals have appearing common Entrance Test in Relevant to Degree Program

Course and Credit Requirements

Course Details	Master's Degree	Doctoral Degree
Major Courses	20	15
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

Course Title with Credit Load of M.Sc. (Ag) in Agricultural Chemicals

Course Code	Course Title	Hours
AC 501	Introduction to Agrochemicals	2+0
AC 502	Chemical Laboratory Techniques	1+2
AC 503*	Basic Chemistry	3+1
AC 504*	Natural Product Chemistry	2+1
AC 505*	Agrochemical Regulation, Quality Control and Management	2+0
AC 506*	Agrochemicals for Insect Mite and Termite Management	2+1
AC 507	Agrochemicals for Disease Management	2+1
AC 508	Agrochemicals for Weed and Crop Management	2+1
AC 509	Chromatographic and Spectroscopic Techniques	2+1
AC 510*	Pesticide Residue Chemistry	2+1
AC 591	Master's Seminar	1+0
AC 599	Master's Research	30

*Core courses

Minor and Supporting Courses/ Disciplines

Minor Disciplines:

1. Agronomy
2. Soil Science
3. Plant Pathology
4. Microbiology
5. Agriculture Entomology
6. Organic Farming
7. Natural Resource Management

Suggestive Minor Courses:

Course Code	**Semester**	**Course Title**	**Credit Hrs.**
SOIL 502	I	Soil fertility and fertilizer use	2+1
SOIL 503	II	Soil Chemistry	2+1
ENT 506	II	Toxicology of Insecticides	2+1
ENT 515	I	Techniques in Plant Protection	0+1
PL PATH 511		Chemicals & Botanicals in Plant Disease Management	2+1
AGRON 513	II	Principal and practices of organic farming	2+1
NEM 514/ ENT 520		Plant Quarantine, Biosafety and Biosecurity	2+0
Any other course	Relevant to student research topic		

	I	2+1

Supporting/Optional Courses:

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Soil Science
3. Biochemistry
4. Plant Patjhology
5. Organic Farming
6. Computer Science and Information Technology

Some of the suggested courses are

Course Code	**Semester**	**Course Title**	**Credit Hrs.**
BIOCHEM 501	I	Basic Biochemistry	3+1=4
STAT 502	I	Statistical Methods for Applied Sciences	3+1=4
OF 504	II	Plant Health Management	2+1=3
BIOCHEM 505	II	Techniques in Biochemistry	2+2 =4
Any other course	Any relevant subject to student research topic		

Common Non Credit Compulsory PGS Courses:

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	0+1=1
PGS 504	I	Basic Concepts in Laboratory Techniques	0+1=1
PGS 502	I	Technical Writing and Communications Skills	0+1=1
PGS 503	II	Intellectual Property and its management in Agriculture	1+0=1
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0=1

Compulsory Non Credit Deficiency Courses (those who are non Agricultural Graduates)
Students from Non Agriculture stream will be required to completed Non credit deficiency courses (6-10 credits) from the courses related to the discipline in which admitted and as decided by the Student Advisory committee.

Sr. No.	Semester	Course No.	Credits	Course Title
1	I	SSAC 111	3(2+1)	Fundamentals of Soil Science
2	II	SSAC 242	2(1+1)	Problematic Soils and their Management
3	I	SSAC 353	3(2+1)	Manures, Fertilizers and Soil Fertility Management
4	II	ELE SSAC 364	3(2+1)	Agrochemicals

Course Contents and Syllabus

Course Title : Introduction to Agrochemicals

Course Code : AC 501

Credit Hours : 2+0

Why this Course?

Pesticides and allied agrochemicals are required for the management of pests of agriculture, veterinary and public health importance. Since pesticides are inherently toxic, their excessive use has led to the residues detrimental to human health and the environment. This interdisciplinary course provides introductory knowledge to students about the use of crop protection chemicals in pest control.

Aim of the Course

To provide basic information about crop protection chemicals, their production/ consumption and trade statistics, and adverse impact of these chemicals on human health and the environment.

The course is organized as follows:

No.	Blocks	Units
1.	Agrochemical use and Trade Statistics	1. Agrochemicals and Pest Management 2. Pesticide Production, Consumption and Trade Statistics
2.	Different Group Pesticides	1. Botanical and Biopesticides 2. Synthetic Pesticides
3.	Pesticides Formulation	1. Solid and Liquid Formulations 2. Role of Adjuvants in Pesticide Formulations
4.	Pesticide Residues, their Adverse and the Effects and Safe Disposal	1. Pesticide Residues in Food Environment 2. Adverse Effect of Pesticides on Non-target Organisms 3. Safe Disposal of Pesticides

Theory

Block 1: Agrochemicals and Trade Statistics

Unit 1: Agrochemicals and Pest Management

Definition of pests and pesticides, Synthetic and natural plant protection chemicals – history and classification, House-hold pesticides, Non-pesticidal agrochemicals like nitrification inhibitors, chemical hybridizing agents, hydrogels, soil conditioners, and plant growth stimulants, Pesticide toxicity (LD_{50}, LD_{90}, LC_{50}, EC_{50}, I_{50}),Pesticide antidotes. Safety precautions in pesticide application, Introduction to integrated pest management (IPM).

Unit 2: Pesticide Production, Consumption and Trade Statistics

Pesticide production and consumption in India and other countries, Pesticide exportand import

Block 2: Pesticide Groups

Unit 1: Botanical and Biopesticides

History of botanical and biopesticide use, Structure, properties, and use of conventional botanical insecticides - nicotine, pyrethrins, rotenones and neem limonoids. Plant allelochemicals, Biopesticides and bioagents.

Unit 2: Synthetic Pesticides

History of synthetic pesticide use, Structure, properties, and uses of insecticides-organochlorines, organophosphates, carbamates, synthetic pyrethroids, fungicides (inorganic and organic), nematicides, rodenticides, herbicides, and plant growth regulators (PGR)

Block 3: Pesticide Formulation

Unit 1: Solid and Liquid Formulations

Formulation of pesticides- objective and classification, Conventional solid and liquid formulations such as EC, WP, Dust, Granule etc. Physico-chemical properties of formulations

Unit 2: Role of Adjuvants in Pesticide Formulations

Pesticide adjuvants like synergists, stabilizers and surfactants, Pesticide carriers and diluents General methods of preparation of solid and liquid formulations

Block 4: Pesticide Residues, Their Adverse Effects And Safe Disposal

Unit 1: Pesticide Residues in Food and the Environment

Pesticide residue - definition and significance, Pesticide residues in food commoditiesand in water, air and in soil environment

Unit 2: Adverse Effect of Pesticides on Non-target Organisms

Adverse effect of pesticides on human health, soil health, and on non-target organisms

Unit 3: Safe Disposal of Pesticides

Various techniques for disposal of unused, obsolete, and expired pesticides andtheir solid and liquid formulations, Disposal of pesticide containers

Teaching methods/activities

- Lectures assignments
- Review of research documents and its presentation
- Periodical quizzes
- Mid-term and final examination

Learning outcome

After successful completion of the course, student will acquire basic knowledge about agrochemicals, their formulations and safe use in crop protection.

Student will also know about the adverse effects of pesticides and ways to dispose obsolete, expired and unused pesticides and pesticide containers/packaging

Suggested Learning

- DC Buchel KH. (Ed.). 1992. *Chemistry of Pesticides*. John Wiley & Sons.
- Marrs TC & Bryan BT. (Eds.). 2004. *Pesticide Toxicology and International Regulation*. John Wiley & Sons.
- Parmar BS and Tomar SS. 2004. *Pesticide Formulation Theory and Practice*, CBS Publishers& Distributors-New Delhi, ISBN: 9788123911243, 8123911246
- Tomar SS and Parmar BS. 1992. *Dictionary of Agricultural Chemicals*. Academic India Publ.
- Handa SK 2004. *Principles of Pesticide Chemistry*. Publisher Agrobios (India), Jodhpur (ISBN 10: 8177542168 ISBN 13: 9788177542165)
- Pimentel D. *Encyclopedia of Pest Management* (1st Edition), CRC Press, 931 pp. ISBN 9780824706326.
- Pimentel and Lehman H (Eds.). 1993. The Pesticide Question, Environment, Economics and Ethics, pp442.DOI 10.1007/b102353, Springer US.
- Hassall KA. 2013. *The Chemistry of pesticides, their metabolism, mode of action and uses in Crop Protection* (ISBN: 9789386237118, 9386237113) Scientific Publishers India, pp 372.
- FICCI-TSMG (2016). *Next Generation Indian Agriculture: Role of Crop Protection Solution, A report on Indian Agrochemical Industry*. pp 45.

Course Title : Chemical Laboratory Techniques

Course Code : AC 502

Credit Hours : 1+2

Why this Course?

Students desirous of pursuing research in agrochemicals and crop protection are expected to know about the safe handling of laboratory chemicals and instruments. They need to be well versed with extraction, purification and separation techniques commonly employed in a chemical laboratory.

Aim of the Course

To acquaint students with laboratory hygiene, upkeep and maintenance of laboratory, handling of chemicals/solvents/glassware, as well as distillation and chromatographic techniques:

No.	Blocks	Units
1.	Laboratory Hygiene and Safe Chemicals Laboratory Practices Laboratory	1. Safe Storage and Handling of 2. Safety Practices in Chemical
2.	Distillation, Extraction and Drying of Solvents	1. Theory and Practice of Distillation and Separation Techniques 2. Theory and Practice of Extraction and Other Techniques 3. Theory and Practice of Chromatographic Techniques

Theory

Block 1: Laboratory Hygiene and Safe Laboratory Practices Unit 1: Safe Storage and Handling of Chemicals

Laboratory hygiene and safety, Handling and storage of hazardous (flammable, volatile, and corrosive) chemicals, Accurate weighing of chemicals, Maintenance of lab-wares, Maintenance of lab notebooks and records of laboratory chemicals/solvents

Unit 2: Safety Practices in Chemical Laboratory

Precautions while carrying out lab experiments, Use of safety gadgets, Safe disposal of reaction wastes and used solvents, Laboratory accidents and their management

Block 2: Distillation, Extraction and Separation Techniques

Unit 1: Theory and Practice of Distillation and Drying of Solvents Solvent distillation, Fractional distillation, Steam distillation, Hydro-distillation, Drying of solvents,

Unit 2: Theory and Practice of Extraction and Other Techniques

Different extraction techniques, Cold extraction, Soxhlet extraction, liquid-liquid partitioning, Crystallization and sublimation, Determination of melting point, boilingpoint, and density of organic compounds

Unit 3: Theory and Practice of Chromatographic Techniques

Chromatography - principle and practice, Partition and adsorption chromatography (TLC, Preparative TLC, HPTLC, Paper chromatography, Column chromatography), Chromatography solvents and chromogenic reagents.

Practicals

- Simple distillation, vacuum distillation, and fractional distillation of solvents/volatile materials (e.g. essential oils)
- Determination of melting point, boiling point, density, etc.
- Purification and drying of organic solvents
- Crystallization and sublimation techniques.
- Solvent extraction techniques (cold extraction, Soxhlet extraction, percolation,accelerated solvent extraction), and refluxing a reaction
- Chromatographic separation of organic compounds by paper chromatography and thin layer chromatography (TLC)
- Separation of compounds by preparative TLC, HP-TLC and column chromatography

Teaching methods/activities

- Lectures assignments
- Review of research documents
- Presentation of review
- Periodical quizzes
- Mid-term and final examination

Learning outcome

After successful completion of the course, student will acquire knowledge aboutsafe handling of chemicals, lab safety and basic laboratory techniques

Suggested Reading

- Fessenden RJ, Fessenden JS, Feist P. 2001. *Organic Laboratory Techniques* 3rd Edition,Publisher: Cengage Learning, 256 pages
- Feist P. 2002. *Handbook for Organic Chemistry Lab*. 6th Ed. Brooks/Cole
- Vogel AI. 1996. *Vogel's Textbook of Practical Organic Chemistry*. 5th Ed. Prentice Hall.
- Pavia DL, Kriz GS, Engel UJF. 2006. *Organic Chemistry: A Lab Manual*, Thomson andBrooks/Cole 972 pages.
- Brown SL. 2012. *Laboratory Techniques for General Chemistry*, Hayden McNeil; 208 pages
- ICAR Institute/SAU, *Practical Manual on Chemical Laboratory Techniques*

Course Title : Basic Chemistry
Course Code : AC 503*
Credit Hours : 3+1

Why this Course?
Basic knowledge of physical, inorganic and organic chemistry is fundamental for understanding various aspects of pesticides and allied agrochemicals, pesticide residue analysis, and dynamics in the environment. This course empower the students with important aspects of chemistry.

Aim of the Course
To acquaint the students about the basics of inorganic, physical and organic chemistry
The course is organized as follows:

No.	Blocks	Units
1.	Basics of Inorganic Chemistry	1. Properties of Atoms, Molecules And Basic Elements 2. Chemical Bonding and Electronic Effects
2.	Basics of Physical Chemistry	1. Chemical Kinetics 2. Chemical Thermodynamics 3. Surface Chemistry 4. Solution and Electrochemistry
3.	Basics of Organic Chemistry	1. Reactive Intermediates in Chemical Reactions 2. Introduction to Stereochemistry 3. Chemistry of Aliphatic and AromaticCompounds 4. Chemistry of Heterocyclic Compounds

Theory
Block 1: Basics of Inorganic Chemistry
Unit 1: Properties of Atoms, Molecules and Basic Elements

Modern periodic law and periodic table, Properties of atoms, molecules and basic elements like C, H, O, S, and N, Atmospheric pollutants (oxides of C, N, and S), Atomic and ionic radii, Oxidation states and chemical reactivity, Acid-base chemistry, Introduction to organometallic and coordinated compounds

Unit 2: Chemical Bonding and Electronic effects

Nature of chemical bonding, hydrogen bonding, Van der Waals forces, Inductive effect, electromeric effect, Resonance effect, Hyper conjugation, Electronegativity and Dipole moment

Block 2: Basics of Physical Chemistry
Unit 1: Chemical Kinetics

Kinetic theory of gases, Collision theory, Maxwell - Boltzmann distribution law, Order and molecularity of reactions, First order and second order reactions, Effect of concentration, temperature, pressure and catalyst on rate of reaction, Arrhenius equation, Enzyme kinetics, Catalysis.

Unit 2: Chemical Thermodynamics

First law of thermodynamics, concept of work, internal energy and enthalpy, Second law of thermodynamics, entropy and free energy, Third law of thermodynamics

Unit 3: Surface Chemistry

Introduction to surface chemistry, Adsorption, physi-sorption, and chemisorption, Factors affecting adsorption of gases on solids- Freundlich and Langmuir adsorption isotherm

Unit 4: Solution and Electrochemistry

Colligative properties of solutions, law of mass action, Ionic equilibria in solutions, Phase rule and its application to one- and two- component systems, Hydrolysis, Solubility product, pH and buffer solutions, True solutions, colloid and suspensions, Electrochemistry, Redox reactions, Potentiometric analyses, Conductance in electrolytic solutions, Laws of electrolysis, Nernst equation, Metal corrosion

Block 3: Basics of Organic Chemistry

Unit 1: Reactive Intermediates in Chemical Reactions

Carbenes, carbanions, carbonium ion, free radicals and their role in organic reactions

Unit 2: Introduction to Stereochemistry

Chirality and optical isomerism, Geometric isomerism, Designation of configuration (D-L and R-S system), Conformations of acyclic and cyclic systems

Unit 3: Chemistry of Aliphatic and Aromatic Compounds

Preparation, properties and uses of some important aliphatic, alicyclic and aromatic compounds (halogenated, nitro, amino-compounds, diazonium salts, aromatic sulphonic acids, phenols, quinones and aromatic acids, naphthalene and naphthaquinone).

Unit 4: Chemistry of Heterocyclic Compounds

Preparation, properties and uses of some important heterocyclic compounds (furan, thiophene, pyrrole, pyrazole, imidazole, oxazole, thiazole, pyridine, piperidine, quinnoline, isoquinnoline etc.)

Practicals

- Micro-weighing of compounds and preparation of different concentration of solutions Preparation of different pH solutions and buffer solutions
- Detection of elements (C, H, O, N, S Halogens) in organic compounds
- Detection of functional groups
- Experiments to demonstrate adsorption of a chemical on solid substrate
- Separation and identification of organic compounds in binary mixtures.
- Rate kinetics and Colligative properties.
- Teaching methods/activities
- Lectures assignments
- Review of research documents
- Presentation of review
- Periodical quizzes

Learning outcome

After successful completion of the course, student will acquire knowledge about the fundamental aspects and concepts of basic chemistry

Suggested Reading

- Eliel EL and Wilen SH. 1994. Stereochemistry of Organic Compounds. Wiley-Interscience.
- Finar IL. 1989. Organic Chemistry. Vols. I, II. Longmans.
- Hendrickson JB, Cram DJ and Hammond GS. 1970. Organic Chemistry. McGraw-Hill.
- Morrison RT and Boyd RN. 1992. Organic Chemistry. 6th Ed. Prentice Hall.
- Vogel AI, Tatchell AR, Furnis BS and Hannaford AJ. 1996. Vogel Textbook of Practical Organic Chemistry. Forestmill books,UK.
- Negi AS and Anand SC. 2003. A Text Book of Physical Chemistry. Wiley Eastern.
- Moore WJ. 1987. Basic Physical Chemistry. Prentice Hall of India
- Alberty RA and Silbey RJ. 1996. Physical Chemistry. 2nd Ed. John Wiley & Sons.
- Moore WJ. 1987. Basic Physical Chemistry. Prentice Hall of India
- ICAR Institute/SAU Practical Manual on Basic Chemistry

Course Title : Natural Product Chemistry

Course code : AC 504*

Credit Hours : 2+1

Why this Course?

Natural Product Chemistry course is useful to multidisciplinary students of chemistry, agricultural chemicals, entomology, pathology, and biochemistry. The course is designed to improve the student's understanding of bioactive natural products and their role in human welfare.

Aim of the Course

To apprise the students about the extraction, purification, and characterization of bioactive natural products and their use in human health, medicines and agriculture The course is organized as follows:

No.	Blocks	Units
1.	Natural Products: Chemistry and Uses	1. Chemistry and Uses of Fats, Lipids, Terpenoids, and Carotenoids 2. Chemistry and Uses of Alkaloids, Flavonoids, Steroids, and Triterpenoids 3. Chemistry and Uses of Carbohydrates, Amino Acids, Proteins, and Nucleic Acids 4. Introduction to Metabolomics
2.	Natural Antioxidants and Food Colorants from Food Non-Food Sources	1. Natural Antioxidants and Food Colorants and from Food Crops 2. Nutraceuticals and Phytoceuticals from Non-Food Sources
3.	Natural Polymers And Enzymes	1. Natural Polymers and their Application 2. Enzymes and Their Industrial Applications

Theory

Block 1: Natural Products: Chemistry and Uses

Unit 1: Chemistry of Fats, Lipids, Terpenoids, and Carotenoid

Introduction to natural products, Structure, chemistry, properties and function of fats, lipids, terpenoids, and carotenoid group of natural products

Unit 2: Chemistry of Alkaloids, Flavonoids, Steroids, and Triterpenoids

Structure, chemistry, properties and function alkaloids (berberine, morphine, caffeine, atropine), flavonoids (Luteolin, quercetin, catechin, naringin, anthocyanins, theaflavins) and phenolic acids (benzoic acid and cinnamic acid derivatives), steroids (cholesterol, cortisone, testosterone, progesterone), and saponin (steroidal, triterpenic and steroid-alkaloidal) group of natural products.

Unit 3: Chemistry of Carbohydrates, Amino Acids, Proteins, and Nucleic Acids

Structure, chemistry, properties and function of carbohydrates, amino acids, proteins, and nucleic acids

Unit 4: Introduction to Metabolomics

Definition, Plant and microbial metabolomics, Metabolome analysis (profiling

of secondary metabolites) by GC-MS, LC-MS and NMR spectrometery, Application of metabolomics in different fields

Block 2: Natural Antioxidants and Food Colorants From Food and Non- food Sources

Unit 1: Natural Antioxidants and Food Colorants from Food Crops

Natural oxidants and their mode of action, Different types of natural oxidants from vegetable, fruit and cereal crops (Examples: carotene, lycopene, betanaine, capsanthins, capsicinoids, anthocyanins, curcuminoids etc.)

Unit 2: Nutraceuticals and Phytoceuticals from Non-Food Sources

Nutraceuticals and phytoceuticals from microalgae (e.g. phycocyanins), seabuckthorn (phenolics and flavonoids), medicinal plants (boswellic acid, artemisinin, andrographinolides, withanolides, taxol, forskolinetc.) and marine products

Block 3: Natural Polymers and Enzymes

Unit 1: Natural Polymers and their Application

Different types of natural polymers, Chemistry of natural polymers (Starch, cellulose, Agar, inulin, chitosan, alginate, dextran, guar gum, gum Arabic, gum tragacanthin, xanthan gum, pectin, psyllium etc.). Application of polymers in agrochemical, food and other industries

Unit 2: Enzymes and their Industrial Application

Major classes of enzymes, Enzymes in food industry, industrial enzymes and their application in pharma, leather, textile, detergent and other industries

Practicals

- Extraction of essential oil from mint leaves, lemon and orange peel etc.
- Extraction and purification of bioactive natural products like lycopene, from tomatoor watermelon
- Extraction and purification of curcuminoids from turmeric rhizome
- Extraction and purification of anthocyanins from black carrot, purple cabbage, grapesor jamun etc
- Extraction and purification of bioactive natural products namely capsanthin and capsaicinoids from chili/paprika.
- Identification and characterization of the phytochemicals by GC-MS/LC-MS

Suggested Reading

- Thomson RH (Ed). 1993. *The Chemistry of Natural Products*, DOI 10.1007/978-94-011-2144- 6, Springer Netherlands, 453 pages
- Sujata V. Bhat, B.A. Nagasampagi, Meenakshi Sivakumar. 2005. *Chemistry of NaturalProducts* Springer Science & Business Media, 840 pages
- Rensheng Xu, Yang Ye, Weimin Zhao. 2011. *Introduction to Natural Products Chemistry*, CRC Press, 381 Pages
- Bernd Schaefer. 2014. *Natural Products in the Chemical Industry*, Springer-Verlag Berlin Heidelberg, 831 pages.
- Talapatra SK and Talapatra B. 2015. Chemistry of Plant Natural Products, Springer-VerlagBerlin Heidelberg, 1180 pages
- ICAR Institute/SAU. *Practical Manual on Natural Product Chemistry*

Course Title : Agrochemical Regulation, Quality Control and Management
Course Code : AC 505*
Credit Hours : 2+0

Why this course?
Agricultural chemicals being inherently toxic need to be handled with caution during their production, transport, storage, usage and disposal. The national and international regulations and guidelines ensure their safe distribution and use. Students need to be aware of such regulations and guidelines

Aim of the course
To acquaint students about the provisions of Insecticide Act 1968, Food Safety and Standard Act 2006, pesticide registration process, and guidelines for their safe use. The course is organized as follows:

No.	Blocks	Units
1.	Pesticide Regulation and Food Safety	1. The Insecticides Act (1968) and Rules (1971) 2. Food Safety and Standard Act (2006) & Rules(2011) 3. Pesticide Registration in India
2.	National/ International Guidelines and Goodfor Safe Use of Pesticides	1. Good Agricultural Practices (GAP) Laboratory Practices (GLP) 2. International Guidelines for Safe Use ofPesticides
3.	Quality Control, Quality Assurance and Accreditation	1. Quality Assurance and Quality Control in Pesticide Analysis 2. Accreditation of Laboratories

Theory
Block 1: Pesticide Registration in India
Unit 1: The Insecticides Act (1968) and Rules (1971)
Provisions of the Insecticides Act 1968 and Insecticides Rules 1971, Schedule of the Insecticide Act. Directorate of Plant Protection, Quarantine & Storage (DPPQ&S), Central Insecticide Board and Registration Committee (CIB&RC),Guidelines for production and use of pesticides
Unit 2: Food Safety and Standard Act (2006) & Rules (2011)
Provisions of the Food Safety and Standard Act (2006) & rules (2011), Acts relating to protection of air, water and the general environment
Unit 3: Pesticide Registration in India
Requirement of data (Chemistry, Bioefficacy, Residue, Toxicology, Packaging etc) for pesticide registration in the country, Guidelines for pesticide export and import, Current status of registered, restricted, and banned pesticides in India

Block 2: National/ International Guidelines for Safe Use of Pesticides
Unit 1: Good Agricultural Practices (GAP) and Good Laboratory Practices (GLP)
Definition of GAP and GLP, National and international guidelines for GAP, and GLP.
Unit-2: International Guidelines for Safe Use of Pesticides

WHO/FAO Joint Meeting on Pesticide Residues (JMPR), Codex Alimentarius Commission (CAC) EU and EPA guidelines for food safety, Sanitary and phytosanitary (SPS) measures and food safety

Block 3: Quality Control, Quality Assurance and Accreditation

Unit 1: Quality Assurance and Quality Control in Pesticide Analysis

Spurious/ fake pesticides and pesticide formulations, Quality Assurance (QA) and Quality Control (QC) Quality control procedures for pesticide residue analysis, Problems related to pesticide residue analysis in a regulatory laboratory.

Unit 2: Accreditation of Laboratories

Accreditation and its importance, General criteria for accreditation of chemical and food laboratories, Introduction to ISO/IEC 17025. NABL and GLP compliance of laboratories, Role of International Laboratory Accreditation Cooperation (ILAC) and Asia Pacific Laboratory Accreditation Cooperation (APLAC) in promoting accreditation recognition arrangements (MRAs) and practices

Suggested Reading

- EU.http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=pesticide. residue. Current MRL & language=EN & pest Residue ID=69.
- Pest Management Regulatory Agency Canada. 21 May 2014. ISSN: 1925-0843 (PDF version), Catalogue number: H113-24/2014-25E-PDF. Cucurbit vegetables (Crop group 9). http:// www.hc-sc.gc.ca/cps-spc/pest/part/consultations/_pmrl2014-25/pmrl2014-25-eng.php.
- OECD (Organization for Economic Co-operation and Development), 2011. OECD MRL calculator: spreadsheet for single data set and spreadsheet for multiple data set, 2 March 2011. In: Pesticide Publications/Publications on Pesticide Residues. http://www.oecd.org.
- SANTE. 2017. Guidance document on analytical quality control and validation procedures for pesticide residues analysis in food and feed. European Commission Health and Consumer
- Protection Directorate–General. SANTE/11813/2017 Supersedes SANCO/11945/2015.
- USEPA (2016). https://www.epa.gov/sites/production/files/2016-03/documents/ flubendiamide_ noic_published_03-04-16.pdf. (accessed 18 May 2016).
- USEPA 2016 United States Environmental Protection Agency https://www.epa.gov/sites / production/files/2016-03/documents/flubendiamide_noic_published_03-04-16.pdf.
- Gnther Voss, Gerardo Ramos &GüNther Voss. 2003. Chemistry of Crop Protection: Progress and Prospects in Science and Regulation. Wiley-vch Verlag Gmbh.

Course Title : Agrochemicals for Insect, Mite and Termite Management
Course Code : AC 506*
Credit Hours : 2+1

Why this course?
Insect pests, mites and termites are the major destroyer of the agricultural crops, food commodities as well as buildings and wooden structures. Since synthetic insecticides are used to control such pests, students must learn about the chemistry, mode of action and safe use of such pest control chemicals

Aim of the course
To understand chemistry, synthesis, mode of action, and use of insecticides, acaricides and termiticides in agriculture and protection of buildings and wooden structures. The course is organized as follows:

No.	Blocks	Units
1.	Organochlorine, Carbamate and Organophosphorus Group Insecticides	1. Chemistry and Use of organochlorine Insecticides 2. Chemistry and Use of Carbamate Insecticides 3.. Chemistry and Use of Organophosphorus Insecticides
2.	Synthetic Pyrethroid and Neonicotinoid Group Insecticides	1. Chemistry and Use of Synthetic Pyrethroid Insecticides 2. Chemistry and Use of Neonicotinoid Insecticides
3.	Acaricides, Termiticides, Insect Regulators and Newly Discovered Insecticidal Molecules	1. Chemistry and Use of Acaricides Growth 2. Chemistry and Use of Termiticides 3. Chemistry and Use of IGRs and Newly Discovered Insecticidal Molecules
4.	Insecticide resistance	1. Insecticide Resistance and its Management

Theory
Block 1: Organochlorine, Carbamate and Organophosphorus Insecticides
Unit 1: Chemistry and Use Of Organochlorine Insecticides
Introduction and classification of synthetic insecticides, Chemistry, use and mode of action of some important conventional organochlorine and cyclodiene insecticides, Present status of organochlorine pesticides
Unit 2: Chemistry and Use of Carbamate Insecticides
Chemistry, use, and mode of action of carbamate insecticides, Present status of carbamate pesticides
Unit 3: Chemistry and Use of Organophosphorus Insecticides
Chemistry, use and mode of action of some important organophosphorus insecticides. Important reactions namely Michaelis- Arbuzov reaction, Perkow reaction, Thiono- thiolo rearrangement. Present status of OP pesticides

Block 2: Synthetic Pyrethroid and Neonicotenoid Insecticides

Unit 1: Chemistry and Use of Synthetic Pyrethroid Insecticides

History and evolution of synthetic pyrethroid insecticides, Synthesis, properties, structure activity relationships, and mode of action of some important ester and non-ester synthetic pyrethroids. Current status of synthetic pyrethroids insecticides

Unit 2: Chemistry and Use of Neonicotinoid Insecticides

Neonicotinoids: Chemistry, classification, mode of action and uses, Preparation, properties anduses of some important neonicotinoids, Current status of neonicotinid insecticides

Block 3: Acaricides, Termiticides, Insect Growth Regulatorsand Newly Discovered Insecticidal Molecules

Unit 1: Chemistry and Use of Acaricides

Chemistry, classification, mode of action of some important acaricidal molecules.

Unit 2: Chemistry and Use of Termiticides

Termites of different types infesting crops and building materials, Chemistry, mode of action and uses of some important termiticides

Unit 3: Chemistry and Use of Igrs and Newly Discovered Insecticidal Molecules

Chemistry of insect growth regulators: Juvenile hormone mimics, anti-JH, Chitin synthesis inhibitors. Chemosterilants, Mode of action of IGRs, Endocrine disruptor compounds, Chemistry of newly discovered insecticidal molecules

Block 4: Insecticde Resistance

Unit 1: Insecticide Resistance and its Management

Definition, types and mechanism of insecticide resistance, Insecticide Resistance Action Committee (IRAC) guidelines for resistance management, Status of resistance to neo-nicotinoid, synthetic pyrethroids, and other group insecticides

Practicals

- Preparation and characterization of organochlorine insecticides and their intermediates, metabolites and degradation products
- Preparation of representative organochlorine insecticide like dicofol
- Preparation of representative organophosphorus insecticide
- Preparation and characterization of a pesticide intermediate (oxime/oxime ether/ ester etc.)
- Phytotoxicity evaluation of insecticides through germination and growth inhibition
- study
- Bioefficacy of insecticides against stored grain insect pests
- Teaching methods/activities
- Lectures assignments
- Review of research documents
- Presentation of review
- Periodical quizzes

Suggested Reading

- Melnikov NN. 1971. Chemistry of Pesticides (Ed: Gunther, F. A., Gunther, J. D. (Eds.), Springer Nature, Springer-Verlag New York, 480 pp
- Eto M. 1979. Organophosphorus Pesticides: Organic and Biological Chemistry. CRC Press.
- Kuhr RJ &Dorough HW. (1979). Carbamate Insecticide Chemistry and Biochemistry. CRC Press

- Fest C, Schmidt KJ. 1982. The Chemistry of Organophosphorus Pesticides, pp 362,
- DOI10.1007/978-3-642-68441-8, Springer-Verlag Berlin Heidelber
- Leahey JP. 1985. The Pyrethroid Insecticides. Taylor & Francis.
- Matolcsy G, Nadasy M and Andriska V. 1988. Pesticide Chemistry. Elsevier.
- Matolcsy M, Nádasy V Andriska. 1989. Pesticide Chemistry, Volume 32 (1st Edition) G. eBook ISBN: 9780080874913, Elsevier Science, 1989, pp 805
- Buchel KH. (Ed.). 1992. Chemistry of Pesticides. John Wiley & Sons.
- Cremlyn RJ. 1990. Pesticides: Preparation and Mode of Action. Wiley.
- Stenersen J. 2004. Chemical Pesticides Mode of Action and Toxicology. (ISBN-13: 978-0748409105), CRC Press; 1 edition., 296 pages.
- Ohkawa H, Miyagawa H and Lee PW. (Ed). 2007. Pesticide Chemistry: Crop Protection,Public Health, Environmental Safety. DOI: 10.1002/9783527611249 Wiley VCH Verlag GmbH & Co. KGaA., pp 489.
- Singh DK. 2012. Pesticide Chemistry and Toxicology (Book Series: Toxicology: Agriculture
- and Environment) Volume 1, pp 142. DOI: 10.2174/9781608051373 1120101 (Benntham eBook)
- Hassall KA. 2013. The Chemistry Of Pesticides Their Metabolism, Mode Of Action And Uses In Crop Protection (ISBN: 9789386237118, 9386237113), Scientific Publishers India, pp
- 372.
- ICAR Institute/SAU Practical Manual on Agrochemicals for Insect, Mite and Termite Management

Course Title : Agrochemicals for Disease Management
Course Code : AC 507
Credit Hours : 2+1

Why this course?
Plant diseases are caused by a diverse group of microorganisms which include fungi, bacteria, viruses, plant parasitic nematodes, etc. Besides reducing crop yield, they also reduce quality of the crop produce. Students must learn about diverse range of fungicidal and nematicidal products and their use in plant disease control

Aim of the course
To teach students about the chemistry and use of synthetic fungicides and nematicides and their role in plant diseases and nematode management.
The course is organized as follows:

No.	Blocks	Units
1.	Introduction to Fungicides and Plant Disease Management	1. Important Plant Pathogenic Fungi, Diseases and Fungicides 2. Classification of Fungicides
2.	Chemical Control of Plant Diseases	1. Inorganic and Dithiocarbamate Fungicides 2. Heterocyclic and Organophosphorus Fungicides 3. Strobilurin (ß-Methoxy-Acrylate) Group Fungicides 4. Miscellaneousand New Emerging Fungicides
3.	Chemical Control of Plant Parasitic Nematodes	1. Chemistry, Use and Mode of Action ofChemical Nematicides
4.	Fungicide Resistance	1. Fungicide Resistance and its Management

Theory
Block 1: Introduction to Fungicides and Plant Disease Management
Unit 1: Important Fungicides, Plant Pathogenic Fungi and Diseases
Historical development of fungicides, Some important plant pathogenic fungi and crop diseases, Fungicide movement (translocation) in plant
Unit 2: Classification of Fungicides
Fungicide classification based on chemical nature, Fungicide classification based on mode of action.

Block 2: Chemical Control of Plant Diseases
Unit 1: Inorganic and Dithiocarbamate Fungicides
Chemistry, use and mode of action of inorganic fungicides (S, Cu, Hg, Sn, As), Dithiocarbamate fungicides.
Unit 2: Heterocyclic and Organophosphorus Fungicides
Chemistry, use and mode of action of heterocyclic fungicides (Imidazole, benzimidazole, triazole, oxazole, thiazole, pyridine, pyrimidine, quinoline, quinoxaline, morpholine etc.), Organophosphorus fungicides.
Unit 3: Strobilurin (â-methoxy-acrylate) Group Fungicides
Chemistry, use and mode of action of strobilurin (-methoxyacrylaye) group synthetic fungicides e.g. azoxystrobin, kresoximmethyl, picoxystrobin, fluoxastrobin, pyraclostrobin and trifloxystrobin.

Unit 4: Miscellaneous and New Emerging Fungicidal Molecules

Chemistry, use and mode of action of phenol, quinone, polyhalogen, alkane sulfenyl group, formamide, alkane, alkane carboxylic acid carboxamide and dicarboximide group of fungicides, Chemistry of newly discovered fungicide molecules

Block 3: Chemical Control of Plant Parasuitic Nematodes

Unit 1: Chemical Nematicides

Plant parasitic nematodes, Historical development of nematicides. Preparation, properties and uses of aliphatic halogen compounds, methyl isocyanate liberators, organophosphates and carbamates for nematode control.

Block 4: Fungicide Resistance

Unit 1: Fungicide Resistance and its Management

Definition and development of fungicide resistance in crop pathogens, Fungicide Resistance Action Committee (FRAC) guidelines for resistance management, Fungicide resistance status in India

Practicals

- Preparation of chemical fungicide intermediate(s) like triazoles/ benzimidazoles
- Preparation and characterization of some important fungicides (e.g. Zineb, Bordeaux mixture, Burgundy mixture, dichlorophen, Glyodin, DBCP (nematicide), and an organophosphorus fungicide
- Determination of antifungal activity of the representative test agrochemical (bioassay)
- Characterization of the select fungicides by spectral (IR, UV, NMR or MS) analysis

Suggested Reading

- Matolcsy M, Nádasy V, Andriska. 1989. Pesticide Chemistry, Volume 32 (1st Edition) G. eBook ISBN: 9780080874913, Elsevier Science, 1989, pp 805
- Buchel KH. (Ed.). 1992. Chemistry of Pesticides. John Wiley & Sons.
- Cremlyn RJ. 1990. Pesticides: Preparation and Mode of Action. Wiley.
- Dehne HW, Deising HB, Gisi U, Kuck KH, Russell PE, Lyr H. (Eds.). 2008. Modern Fungicides and Antifungal Compounds V. Proceedings of the 15th International Reinhardsbrunn Symposium on Modern Fungicides and Antifungal Compounds. Friedrichroda, Germany (May 06 – 10, 2007), Deutsche Phytomedizinische Gesellschaft, Braunschweig, Germany,
- 2008 - ISBN 978-3-941261-02-0
- Ohkawa H, Miyagawa H and Lee PW. (Ed). 2007. Pesticide Chemistry: Crop Protection, Public Health, Environmental Safety. DOI: 10.1002/9783527611249 Wiley VCH Verlag GmbH & Co. KGaA., pp 489.
- Carisse O. 2010. (Ed) Fungicides, (ISBN 978-953-307-266-1) Publisher: InTechJanezaTrdine 9, 51000 Rijeka, Croatia. pp 538. (A free online edition of this book is available at www.intechopen.com)
- Lukens RJ. Chemistry of Fungicidal Action (ISBN: 9783662113134, 3662113139). Springer-Verlag, Berlin, Heidelberg, Germany.
- Singh DK. 2012. Pesticide Chemistry and Toxicology (Book Series: Toxicology: Agriculture
- and Environment) Volume 1, pp 142. DOI: 10.2174/97816080513731120101 (Benntham eBook)
- Hassall KA. 2013. The Chemistry of pesticides, their metabolism, mode of action and uses in

- Crop Protection (ISBN: 9789386237118, 9386237113) Scientific Publishers India, pp 372.
- Oliver and Hewitt H. (Eds). 2014. Fungicides in Crop Protection, CABI, Oxfordshire, OX10 8DE, UK pp 200 Pages
- ICAR Institute/SAU. Practical Manual on Agrochemicals for Fungi and Nematode Management

Course Title : Agrochemicals for Weed and Crop Management
Course Code : AC 508
Credit Hours : 2+1

Why this Course?
Weeds compete with the crop plant for light, space, water and nutrients and hamper the overall growth of the desired crop. Chemical herbicides are employed to kill or control such weeds. This course provides detailed information about the chemistryand mode of action of diverse group of herbicides for weed management and PGRs for crop growth

Aim of the Course
To apprise the students about the chemistry, mode of action and use of different classes of herbicides for weed management, and plant growth regulators for crop growth.
The course is organized as follows:

No.	Blocks	Units
1.	Herbicides and Weed Management	1. Introduction to Herbicides and Weed Management
2.	Aliphatic, Aromatic, and other Group Herbicides	1. Aliphatic and Aromatic Acid Group Herbicides 2. Carbamate, Substituted phenyl urea, ands-Triazine group Herbicides 3. Diphenyl Ethers, Dinitroanilines, Amide 4. Anilide Group Herbicides
3.	Heterocyclic and Sulfonyl Urea Heterocyclic andHerbicides	1. Chemistry and Use of Sulfonyl Urea Group Herbicides
4.	Plant growth regulators, herbicide safeners, and newly discovered herbicidal molecules	1. Chemistry and Use of Plant Growth Regulators and Herbicide Safeners 2. Newly Discovered Herbicidal Molecules
5.	Herbicide resistance	1. Herbicide resistance and its management

Theory
Block 1: Herbicides and Weed Management
Unit 1: Introduction to Herbicides and Weed Management
Important crop weeds, Introduction to synthetic herbicides, Classification of herbicides based on time of application, mode of action and selectivity, Herbicide resistance and its management

Block 2: Aliphatic and Aromatic Group Herbicides
Unit 1: Aliphatic Acid and Aromatic Acid Group Herbicides
Chemistry, mode of action, and factors governing structure activity relationship of aliphatic and benzoic acid herbicides, phenoxy acid herbicides, phenoxy-phenoxy acid and phenoxy-phenoxy alkanoic acid herbicides
Unit 2: Carbamate, Substituted phenyl urea, and s-Triazine group Herbicides
Chemistry, mode of action, and factors governing structure activity relationship of carbamate, thiocarbamate, biscarbamate, oxime carbamate, sulfonyl carbamate, Substitutred phenyl urea

herbicides, s-Triazine group herbicides

Unit 3: Diphenyl Ethers, Dinitroanilines, Amide, and Anilide Group Herbicides

Chemistry, mode of action, and factors governing structure activity relationship ofdiphenyl ethers, dinitroanilines, amide, and anilide group herbicides

Block 3: Heterocyclic and Sulfonyl Urea Herbicides

Unit 1: Chemistry and Use of Heterocyclic and Sulfonyl Urea Group Herbicides

Chemistry, use, mode of action and factors governing structure activity relationship of triazine, pyridine, bipyridylium, pyridazine, pyrimidine, oxadiazole, imidazolinoneand sulfonylurea and sulfonylamides herbicides

Block 4: Plant Growth Regulators, Herbicide Safeners, and Newly Discovered Herbicidal Molecules

Unit 1: Chemistry and Use of Plant Growth Regulators and Herbicide Safeners

Chemistry and use of plant growth regulators (auxins, gibberallin, cytokinins, brassionosteroids, triacontanol, protein hydrolysates), Synthesis, structure activity relationships of auxins and gibberellins, Herbicide safeners and pro-safeners

Unit 2: Newly discovered Herbicidal Molecules

Structure and herbicidal activity of newly discovered herbicidal molecules

Block 5: Herbicide Resistance

Unit 1: Herbicide resistance and its management

History and types of herbicide resistance, Factors and mechanism of herbicide resistance, Management of herbicide resistance

Practicals

- Synthesis and characterization of 2,4-D by m.p, TLC, and NMR,
- Identification and collection of weed samples from Institute research farm.
- Preparation of propionyl chloride and its use in the synthesis of the propanil herbicide
- Synthesis of maleic hydrazide and its characterization by TLC, NMR,
- Estimation of 2,4-D, alachlor, propanil, simazine and/or other available herbicides by HPLC and spectrophotometry.

Suggested Reading

- Kearnay PC and Kaufman DD. 1975. Herbicides: Chemistry, Degradation and Mode of Action. Vols. I, II. Marcel Dekker.
- Matolcsy G, Nadasy M and Andriska V. 1989. Pesticide Chemistry, Volume 32 (1st Edition)
- G. eBook ISBN: 9780080874913, Elsevier Science, pp 805
- Cremlyn RJ. 1990. Pesticides: Preparation and Mode of Action. Wiley
- Kramer WK and Ulrich Schirmer. 2007. Modern Crop Protection Compounds. Wiley-vch Verlag Gmbh.
- Ohkawa H, Miyagawa H and Lee PW. (Ed). 2007. Pesticide Chemistry: Crop Protection, Public Health, Environmental Safety. DOI: 10.1002/9783527611249 Wiley VCH Verlag GmbH
- & Co. KGaA., pp 489.
- Sondhia S and Varshney JG. 2010. Herbicides. Satish Serial Publication House, New Delhi. P 567.
- Rao VS. CRC Press, 2000. Principles of Weed Science, 2nd Edition, 566 pp, ISBN 9781578080694 - CAT# N00115
- ICAR Institute/SAU. Practical Manual on Agrochemicals for Weed and Crop Management

Course Code : Chromatographic and Spectroscopic Techniques
Course Title : AC 509
Credit Hours : 2+1

Why this course?
The chromatographic (GC, HPLC) and spectroscopic (IR, UV, NMR) methods are necessary tools for the detection, identification, and quantitation of organic molecules. The knowledge of such analytical techniques is necessary for the students pursuing research in R & D of pesticides and allied agrochemicals

Aim of the course
To acquaint the students with the chromatographic and spectroscopic techniques and their use in analysis and characterization of organic compounds.
The course is organized as follows:

No.	Blocks	Units
1.	Chromatographic Techniques	1. Introduction to Separation Science Techniques 2. Gas Chromatography (GC) and its Application 3. High Performance Liquid Chromatography(HPLC) and Its Application
2.	Spectroscopic Techniques	1. UV, Visible and IR Spectrophotometry, And its Application 2. NMR (^{1}H, ^{13}C) Spectroscopy and its Application 3. Mass Spectroscopy (MS) and its Application 4. Tandem Chromatographic and SpectroscopicTechniques

Theory
Block 1: Chromatographic Techniques
Unit 1: Introduction to Separation Science Techniques
Principles of separation science, GC, GPC, and LC chromatography, Super critical fluid chromatograph (SCFC), and Ion exchange chromatography (IEC)
Unit 2: Gas Chromatography and its Application
Theory, principle and instrumentation of GC, GC detectors and columns of different types, Application of GC in analysis of organic compounds, Advantages and limitations of GC
Unit 3: High Performance Liquid Chromatography (HPLC) and its Application
Theory, principle and instrumentation of HPLC, LC detectors and columns of different types, Mobile phase, Application of HPLC in separation and analysis of organic compounds. Advantages and limitations of HPLC

Block 2: Spectroscopic Techniques

Unit 1: UV, Visible and IR Spectrophotometry and its Application

Theory, principle, and instrumentation of absorption (UV, Visible and IR) spectroscopy, Application of UV and IR in structure elucidation of organic compounds

Unit 2: NMR (1H, 13C) Spectroscopy and its Application

Theory, principal and instrumentation of NMR (1H, 13C) spectroscopy, Application of NMR spectroscopy in characterization of organic compounds

Unit 3: Mass Spectroscopy (MS) and its Application

Theory, principal, instrumentation of mass spectroscopy, Mass fragmentation pattern, Application of MS in structure elucidation and confirmation

Unit 4: Tandem GC-MS and LC-MS Techniques

Tandem chromatographic and spectroscopic techniques (GCMS-MS/LCMS-MS), Application of tandem techniques for confirmation of the chemical structure of the analyte constituents.

Practicals

- Separation of organic compound mixture by GC and HPLC
- Application of UV and IR spectrophotometry for detection of organic compounds
- Identification and structure elucidation of organic compounds by NMR (1H, 13C) and MS
- Identification and structure elucidation of organic compounds by GC-MS, LC-MS and MS fragmentation pattern

Suggested Reading

- Sharma JM and Follweiler J. 1984. CRC. Handbook of Chromatography: Pesticides and Related Organic Chemicals. CRC Press
- Friebolin H and Becconsall JK. 1993. Basic One- and Two-Dimensional NMR Spectroscopy. John Wiley & Sons.
- Dyer JR. 1994. Application of Absorption Spectroscopy of Organic Compounds. Prentice
- Hall of India.
- Silverstein RM, Bassler GC and Morrill TC. 2005. Spectrometric Identification of Organic Compounds. 4th Ed. John Wiley & Sons. pages 512.
- Braithwaite A, Smith JF. 1999. Chromatographic Methods DOI 10.1007/978-94-011-0599-
- 6, Springer Netherlands, pp 580
- Cazes J and Scott RPW. 2002. Chromatography Theory (Chromatographic Science, 88), CRC Press; 1 edition, 496 pages
- Williams DH and Fleming I. 2004. Spectroscopic Methods in Organic. Chemistry, Tata
- McGraw-Hill Education, New Delhi, India, pages 322.
- Nikalje. 2017. A Handbook of Chromatography (Editor: Marco Braga), Publisher: Scholar's Press Verlag Omniscriptam, Deutschland, Germany. (ISBN: 978-3-330-65032-9).
- Practical Manual on Chromatographic and Spectroscopic Techniques developed by the ICAR Institute/SAU.

Course Title : Pesticide Residue Chemistry
Course Code : AC 510*
Credit Hours : 2+1

Why this course?
Pesticides are inherently toxic and their non-judicious use leaves behind toxic residues. Therefore it needs to be ensured that food commodities we consume are devoid of residues. This course provides exposure to analysis of pesticide residues in food commodities as well as in the soil and aquatic environment. It also provide information about consumer risk assessment and MRL fixation

Aim of the course
To teach the students extraction, cleanup, recovery and analysis techniques, develop and validate analytical methodology for risk assessment and MRL fixation.
The course is organized as follows:

No.	Blocks	Units
1.	Introduction to Pesticide Residue Chemistry	1. Pesticide Residue – Concept and Significance 2. Laboratory Data and Proficiency Testing
2.	Analysis of Pesticide Residues	1. Extraction, Clean Up and Recovery 2. Method Development and Validation 3. Monitoring of Pesticide Residue in FoodCommodities
3.	Consumer Risk Assessment and MRL Fixation	1. Consumer Risk Assessment 2. MRL Fixation of Pesticides in Food Commodities

Theory
Block 1: Introduction to Pesticide Residue Chemistry
Unit 1: Pesticide Residue – Concept and Significance
Pesticide residue definition, source, Significance of Certified Reference Materials (CRMs) in pesticide residue analysis, Planning and layout of experiments, Good agricultural practices (GAP) and experimental design, Post-harvest interval (PHI)
Unit 2: Laboratory Data Documentation and Proficiency Testing
Documentation and audit of laboratory data, Inter laboratory comparison and laboratory proficiency testing, legal implications of pesticide residue data

Block 2: Analysis of Pesticide Residues
Unit 1: Extraction, Clean Up and Recovery
Sampling, sample processing and testing, Different extraction and clean up techniques for optimum recovery
Unit 2: Method Development and Validation
Method development, Validation and performance verification through linearity, sensitivity, matrix effect, limit of quantification (LOQ), limit of detection (LOD), accuracy and precision of recovery, Measurement uncertainty (MU)

Unit 3: Monitoring of Pesticide Residue

Monitoring of pesticide residue in agricultural produce and environment, Multi residue analysis by quick, easy, cheap, effective, rapid and safe (QuEChERS) method, GC/LC, GC-MS, LC-MS method. ELISA and Radiotracer techniques in residue analysis.

Block 3: Consumer Risk Assessment and MRL Fixation

Unit 1: Consumer Risk Assessment

Hazard and risk, Ecological and human health risk assessment, Acceptable daily intake (ADI), theoretical maximum daily intake (TMDI),estimated daily intake, Maximum Residue Limit, No Observed Adverse Effect level (NOAEL), Food factor.

Unit 2: MRL fixation of Pesticides in Food Commodities

Safe waiting period, Lowest, highest and median residue data, OECD MRL Calculator, Significance of Codex, EU and FSSAI MRLs.

Practicals

- Collection, storage and preparation of samples for pesticide residue analysis
- Extraction and clean-up of food, soil and water sample prior to analysis of pesticide residues
- Study the percent recovery of pesticide residues from vegetable, soil, and/or water
- samples fortified with the standard pesticide analyte
- Validation of analytical method by studying linearity, matrix effect, LOD, LOQ, accuracy (recovery) and precision as per SANTE guidelines
- Identification of organochlorine insecticides in soil and water by TLC/GC/HPLC
- Identification of Carbamate insecticides in water by TLC/GC/HPLC,
- Estimation of carbamate insecticide residues in vegetable by visible spectroscopic method and HPLC
- Estimation of OP insecticide residues in soil by spectroscopic method and HPLC.

Suggested Reading

- Handa SK, Agnihotri NP and Kulshrestha G. 2000. Pesticide Residue Analysis, Significance, Management and Analysis.
- Gupta A. 2006. Pesticide Residue in Food Commodities. Agrobios (India).
- FAO. 2009b. Submission and evaluation of pesticide residues data for the estimation of maximum residues levels in food and feed (FAO Plant production and protection paper 197)
- <http://www.fao.org/ag/AGP/AGPP/Pesticide/p.htm>.
- FAO/WHO. 2013. Codex Pesticides Residues in Food Online Database. Pesticide Residues in Food and Feed, doi: http://www.codexalimentarius.net/pestres/data
- Sharma KK. 2013. Pesticide Residue Analysis Manual (Second edition), Directorate of Knowledge Management in Agriculture, ICAR, KAB-I, Pusa, New Delhi-110012, India. pp 248
- Sondhia S. 2014. Herbicides residues in soil, water, plants and non-targeted organisms and human health implications: an Indian perspective. Indian Journal of Weed Science 46(1): 66–85.
- FSSAI. 2015. Food Safety Standard Authority of India, Fixation of MRL.
- Mohidus SK and Mohammad SR. (Eds.). 2017. Pesticide Residue in Foods: Sources, Management and Control. DOI 10.1007/978-3-319-52683-6, Springer Interntnl. Publishing, pp 200.

- SANTE. 2017. Guidance document on analytical quality control and validation procedures for pesticide residues analysis in food and feed. European Commission Health and Consumer Protection Directorate–General. SANTE/11813/2017 Supersedes SANCO/11945/2015.
- ICAR Institute/SAU. Practical Manual on Pesticide Residue Chemistry

Course layout and Credit Load of Ph.D.

Course Code	Course Title	Credit Hours
AC 601*	Agrochemical Formulation Technology	2+2
AC 602*	Chemistry of Biopesticides	2+1
AC 603	Advanced Organic Chemistry	2+1
AC 604	Pesticide Metabolism, Persistence, and Decontamination	2+1
AC 605	Term Paper (Special Topics In Agrochemicals)	1+0
AC 691	Doctoral Seminar-I	1+0
AC 692	Doctoral Seminar-II	1+0
AC 699	Doctoral Research	75

*Core courses

Minor Courses offered from the following departments:

1. Soil Science
2. Plant Pathology
3. Microbiology
4. Agriculture Entomology
5. Organic Farming
6. Natural Resource Management
7. Statistics

Suggested list of minor courses with minimum 5 credits:

Sr. No.	Course Code	Course Title	Credit hours
1	BIOCHEM 602	Advanced Molecular Biology	3+0
2	ENT 606	Insect Toxicology and Residues	2+1
3	ENT 609	Molecular Entomology	1+1
4	PL PATH605	Principles & Procedures of Certification	1+0

Supporting courses offered from the following departments:

Supporting/optional courses of 500/ 600 series (05 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Soil Science
3. Biochemistry
4. Plant Pathology
5. Microbiology
6. Organic Farming
7. Computer Science and Information Technology

Suggested list of supportive courses with minimum 5 credits:

Sr. No.	Course Code	Course Title	Credit Hours
1	SOIL 503	Soil Chemistry	2+1
2	SOIL 605	Bio-chemistry of soil organic matter	2+0
3	MICRO 602	Microbial physiology and regulation	2+0
4	SOIL 603	Physical chemistry of soil	2+0
5	SOIL 605	Bio-chemistry of soil organic matter	2+0

Course Contents and Syllabus

Course Title : Agrochemical Formulation Technology
Course Code : AC 601*
Credit Hours : 2+2

Why this course?
Several advancements have been reported in pesticide formulation technology. The course intends to cover recent developments on the subject and will be useful to students interested in pursuing research in R & D of pesticide formulation technology

Aim of the course
To apprise the students about the recent developments in formulation technology and delivery systems. The course is organized as follows:

No.	Blocks	Units
1.	Conventional Pesticide Formulations	1. Overview of Conventional Pesticide Formulations 2. Selection of Adjuvants and Synergists inFormulation Chemistry 3. Physico-Chemical Properties of PesticideFormulations
2.	New Generation Pesticide Formulations	1. Water and Oil Based Novel Formulation 2. Dry, Controlled Release, and Other Novel Formulations 3. Pesticide Application and Delivery Systems
3.	Nanotechnology and its Application Pesticide Formulation	1. Production and Characterization of Nano-in Materials 2. Application of Nanotechnology in Pesticide Formulation and Delivery

Theory
Block 1: Conventional Pesticide Formulations
Unit 1: Overview of Conventional Pesticide Formulations

Solid and liquid formulation, Conventional pesticide formulations such as Dust (D), Granule, pallet (P), Wettable Powder (WP), Emulsifiable Concentrate (EC), and Solution (S). Biopesticide formulations-specifications and types, Limitations of conventional formulations

Unit 2: Selection of Adjuvants and Synergists in Formulation Chemistry

Role of adjuvants (carriers, diluents, surfactants, emulsifiers, dispersing agent, wetting agents, stickers and spreaders, penetrants, safeners, encapsulants etc.), synergists, antioxidants, stabilizers etc. in formulation chemistry.

Unit 3: Physico-chemical Properties of Pesticide Formulations

Physico-chemical properties (solubility, octanol-water partition coefficient, vapor pressure, soil adsorption coefficient, emulsion stability, half-life, shelf-life etc.) and their testing, Formulant-toxicant interactions.

Block 2: New Generation Pesticide Formulations

Unit 1: Water and Oil Based Novel Formulation

Water soluble concentrates (WSC), Suspension concentrates (SC), Oil-in-water emulsion (EW), suspo-emulsion (SE), Micro-emulsion (ME), Water soluble bags and packets(WSB/WSP), Oil dispersion (OD), Aqueous flowable (AF).

Unit 2: Dry, Controlled Release, and Other Novel Formulations

Water soluble powder, liquid and dispersible granules, Dispersion concentrates, Effervescent tablets, Control/time release formulations. Aerosols, baits, fumigants, and formulations of pesticide mixtures, Seed treatment formulations, Seed dressing.

Unit 3: Pesticide Application and Delivery Systems

Packaging and labelling of pesticide formulations, Machinery and equipment for pesticide formulation, Pesticide application and delivery systems - principles, distribution and coverage.

Block 3: Nanotechnology and its Application in Pesticide Formulation

Unit 1: Production and Characterization of Nanomaterials

Development of nanomaterials – bottom up and top-down approach, nano-sizing of inorganic materials, Techniques for characterization of nanomaterials [Zeta sizer, Dynamic light scattering (DLS), X-ray diffraction (XRD), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), and Scanning tunneling microscopy (STM)].

Unit 2: Application of Nanotechnology in Pesticide Formulation and Delivery

Production and use of nano-enabled pesticide formulation (nanoemulsions, nanodispersions, nanoencapsulation, and other polymer based formulations), Nanocarriers for targeted and controlled release, Benefits and environmental risks of nanopesticides.

Practicals

- Study of liquid carriers for the determination of (i) flash point, (ii) specific gravity, (iii) viscosity, and (iv) micelle formation with the surfactants
- Study of solid carriers: Determination of (i) Surface acidity by volumetric method, (ii), surface area, (iii) Sorptivity, and (iv)particle size, of the solid carriers
- Preparation of solid formulations: wettable powder (WP)/granules (G)/WDG/WSG
- Physico-chemical analysis of solid formulations based on BIS/CIPAC/FAO guidelines.
- Physico-chemical analysis of liquid/gel formulations based on BIS/CIPAC/FAO Guidelines
- Preparation of toxicant based insect repellent formulations.
- Preparation of liquid and gel formulations: EC/SC/SL/OD/EW/gel, etc.
- Preparation and characterization of a nanopesticide formulation
- Preparation of controlled release (CR) formulation and the release of active ingredient in soil and water

Suggested Reading

- Chester L. Foy, David W. 1996. Pritchard Pesticide Formulation and Adjuvant Technology. ISBN-13: 978-0849376788. CRC Press, 384 pages

- Knowles DA. 1998. Chemistry and technology of Agrochemical Formulations DOI https://doi.org/10.1007/978-94-011-4956-3 Kluwer Academic Publishers, Springer Nature Switzerland AG.
- Alan K. Viets, Jane C. Mueninghoff (Editors). 2001. Pesticide Formulations and Application
- Systems, 20 ASTM International, 2001, 196 pages.
- Jane C. Mueninghoff, Alan K. Viets (Editors) Pesticide Formulations and Application Systems: A New Century for Agricultural Formulations. 21, (1414), ASTM publication.
- Journal of ASTM International: Selected technical papers, ISSN 1040-1695, 260 pages.
- Parmar BS and Tomar SS. 2004. Pesticide Formulation Theory and Practice, CBS Publishers & Distributors-New Delhi, ISBN: 9788123911243, 8123911246
- Valkenburg WV. 2008. Pesticide Formulation: Recent Developments and Their Applications in Developing Countries (ISBN-13: 978-8122410693) New Age International (P) Limited,
- Publishers; First edition (2008) pp 488.
- Goss GR (Editor). 2014. Pesticide Formulation and Delivery Systems: 35th Volume, Pesticide Formulations, Adjuvants, and Spray Characterization. ISBN-13: 978-0803176195 (Publisher: ASTM International 2016), 93 pages .
- Teicher HB. 2017. Pesticides and Biopesticides: Formulation and Mode of Action (Publisher:
- BioComm Press) pp 166.
- Practical Manual on Pesticide Formulation Technology developed by the ICAR Institute/ SAU.

Course Title : Chemistry of Biopesticides
Course Code : AC 602*
Credit Hours : 2+1

Why this course?
Biopesticides derived from natural sources (plant, animal, nematodes, bacteria, fungi, virus, natural minerals) are considered as safer alternative to chemical pesticides. In view of their safety, such ecologically sound products are increasingly sought after for use in agriculture, veterinary and public health.

Aim of the course
To apprise the students about the usefulness of phytochemical biopesticides, microbial pesticides insect behaviour modifying chemicals, and role of biotechnology in pest management.
The course is organized as follows:

No.	Blocks	Units
1.	Phytochemical Biopesticides	1. Conventional Botanical Pesticides 2. New Generation Botanical Pesticides
2.	Insect Behaviour Modifying Chemicals	1. Insect Hormones and Related Products 2. Pheromones and Allelochemicals 3. Insect Feeding Deterrents and Repellents
3.	Microbial Pesticides and Bioagents	1. Microbial Fungicides and Herbicides 2. Microobial Insecticides 3. Entomopathogenic Nematodes, Fungi, and Plant Inhabiting Fungal Endophytes 4. Application of Biotechnology in Pest Management

Theory

Block 1: Phytochemical Biopesticides

Unit 1: Conventional botanical pesticides

Isolation, characterization, use and mode of action of natural pyrethrins, tenones, nicotine and neem based azadirachtiniods

Unit 2: New generation botanical pesticides

Isolation, characterization, use and mode of action of toosendanin, ryanodine, rocaglamides, annonins, isobutylamides, quassinoids, and sugar esters from plant sources, Plant essential oils and their constituents as botanical pesticides, Photo- activated pesticides like á-terthieyl, acetylenes and acetylenic thiophenes

Block 2: Insect Behaviour Modifying Chemicals

Unit 1: Insect hormones and related products

Insect hormones (Juvenile hormones, Moulting hormones, Brain hormones), their chemistry, mode of action and use in insect pest control)

Unit 2: Pheromones and Allelochemicals

Pheromones (sex, alarm, trail, territorial, aggregation, etc.), Semiochemicals, Allelochemicals – allomones, kairomones, synomones, apneumones, Phytoalexins

Unit 3: Insect feeding deterrents and repellents

Sources, chemistry and mode of action of feeding deterrent and insect repellents

Block 3: Microbial Pesticides And Bioagents

Unit 1: Microbial Insecticides

Pesticides of microbial origin, Bacillus (Bt, Bs) and NPV based Insecticides. Chemistry and mode of action of macrolides such as avermectins, milbimycins and spinosyns

Unit 2: Microbial Fungicides and Herbicides

Natural fungicides like strobilurins and other methoxyacrylates, Bioherbicides like biolaphos and phosphonothricin

Unit 3: Entomopathogenic Nematodes, Fungi, and Plant Inhabiting Fungal Endophytes

Entomopathogenic nematodes and entomopathogenic fungi in insect control, Pesticidal secondary metabolites (biotoxins) from EPN (Photorhabdus and Xenorhabdus) and EPF (Metarrahiza etc.), Plant inhabiting fungal endophytes and their role in plant protection

Unit 4: Application of Biotechnology in Pest Management

Plant incorporated protectants, Recombinant DNA technology, Genetically- modified (GM) herbicide resistant crops, Genetically-modifiedinsect resistant crops, Potential benefits and risks of GM crops

Practicals

- Isolation of curcuminoids from turmeric rhizome and their characterization,
- Extraction of tobacco leaves, isolation of nicotine and its identification,
- Extraction of neem seed kernels to isolate neem oil
- Saponification of neem oil
- Isolation of azadirachtin concentrate from neem seed kernel powder
- Quantification of azadirachtin content in isolated azadirachtin powder
- Characterization of biopesticides by chromatographic and spectral analysis

Suggested Reading

- Jacobson M. 1970. *Naturally Occurring Insecticides*. Wiley Khan SU. 1980. Pesticides in the Soil Environment. Elsevier.
- Parmar BS and Devakumar C. 1990. *Botanical and Biopesticides*. Westvill Publ. House
- Copping LG. 1996. *Crop Protection Agents from Nature: Natural Products and Analogues*. Royal Soc. Chem., London.
- Dev S and Koul O. 1997. *Insecticides of Natural Origin*. Harwood Acad. Publ. Godfrey CRA.

  1995. Agrochemicals from Natural Products. Marcel Dekker.
- Schmutterer H. 2002. *The Neem Tree: Source of unique natural products for integrated pestmanagement, medicine, industry and other purposes.* (2nd edition) Neem Foundation, Mumbai-400 049, India
- Parmar BS, Walia S, Anupama and Kumar J. 2008. *Neem Pesticides in India, An update of*
  the recent developments. SPS Publication No. 15, Society of Pesticide Science, India 50pp
- Parmar BS and Walia S. 2001. *Prospects and problems of phytochemical pesticides*. In: O.
  Koul and G.S. Dhaliwal (eds) Phytochemical Biopesticides, Harwood Academic Publishers Gmbh. Netherlands pp 133-210.
- Koul. 2004. *Insect antifeedants*. CRC Press LLC Boca Raton, Florida 33431, USA, pp 1005

- Franklin R. Hall and Julius J. Menn (Ed) *Biopesticides: Use and Delivery*. DOI 10.1385/0896035158, 2010 edition, 626 pages. Humana Press, Springer Nature. Switzerland. AG
- Singh D. 2014. *Advances in Plant Biopesticides*, Springer Nature India Private Limited, DOI 10.1007/978-81-322-2006-0. Pages 421.
- Leo ML. Nollet and Rathore HS. 2017. Green Pesticides Handbook: Essential Oils for Pest Control (ISBN-13: 978-1498759380), CRC Press pp 570.
- ICAR Institute/SAU. Practical Manual on Chemistry of Biopesticides.

Course Title : Advanced Organic Chemistry
Course code : AC 603
Credit Hours : 2+1

Why this course?
This course provides a deeper understanding of organic chemistry and covers advanced topics of stereochemistry, photochemistry, pericyclic reactions, name reactions, chemical reagents etc. The knowledge of advanced organic chemistry is essential to students interested in synthesis and technology development of organic compounds including pesticides

Aim of the course
The course aims to equip the students with the advanced knowledge about stereochemistry, chemical reactions, chemical reagents in organic synthesis, and photochemistry.
The course is organized as follows:

No.	Blocks	Units
1.	Stereochemistry	1. Understanding Spatial Arrangement ofOrganic Molecules 2. Application Of Stereochemistry
2.	Important Chemical Reactions and Substitutiontheir Mechanisms	1. Electrophilic and Nucleophilic Reactions 2. Elimination and Addition Reactions 3. Pericyclic Reactions 4. Organic Name Reactions
3.	Reagents in Organic Synthesis	1. Different Reagents and their Application In organic Synthesis 2. Protection and Deprotection of FunctionalGroups
4.	Photochemistry	1. Basic Principles and Application of Photochemistry

Theory
Block 1: Stereochemistry
Unit 1: Understanding Spatial Arrangement of Organic Molecules
Enantimerism and diastereoisomerism, mesomers, Racemic mixture (racemate), Different methods of resolution of enantiomers (optical resolution), Walden inversion, Asymmetric synthesis of stereoisomers
Unit 2: Application of Stereochemistry
Nomenclature of stereo-chemicals with particular reference to agrochemical molecules, Stereospecific and stereoselective reactions, Chiral synthesis

Block 2: Important Chemical Reactions and their Mechanisms

Unit 1: Electrophilic and Nucleophilic Substitution Reactions

Electrophilic aromatic and Electrophilic aliphatic substitution reactions, Nucleophilic substitution reactions, (SN1, SN2 and SNi), Reactions involving carbonium ion, carbanion, carbene and free radicals.

Unit 2: Elimination and Addition Reactions

Elimination reactions (syn vs. anti-elimination, orientation in elimination reaction, molecular rearrangement, decarboxylation reactions, etc.). Addition reactions. Electrophilic addition of bromine. hydrogenation, hydroboration

Unit 3: Pericyclic Reactions

Cyclic transition states, Types of pericyclic reactions - cycloadditions, sigmatropic rearrangements, and electrocyclic reactions.

Unit 4: Organic Name Reactions

(i) Diels Alder reaction, (ii) Grignard reaction, (iii) Aldol, condensation, (iv) Perkin reaction, (v) Benzoin condensation, (vi) Friedel Craft alkylation and acylation reaction, (vii) Fries rearrangement (viii) Reformatsky reaction, (ix) Wittig Reaction and Sandmeyer reaction (x) Oppenaeur oxidation, (xi) Ziegler Natta reaction

Block 3: Reagents in Organic Synthesis

Unit 1: Different Reagents and their Application in Organic Synthesis

Reagents in organic synthesis: complex metal hydrides, Gilman's reagent, lithium dimethyl curparate, lithium di-isopropyl amide (LDA), dicyclohexylcarbodimide, 1,3-di-thiane, trimethyl selyl iodide, triselenium dioxide, tri-butyl tin hydride, osmium tetroxide, dichlorodicyano quinone etc. Organometallic reagents in organic synthesis, phase transfer catalysis, crown ethers and Merrifield resins

Unit 2: Protection and Deprotection of Functional Groups

Different methods of protection of functional groups in organic synthesis with examples, Deprotection to release the functionality

Block 4: Photochemistry

Unit 1: Basic Principles and Application of Photochemistry

Definition and laws of photochemistry, Light-induced excitation of organic molecules, Singlet and triplet state of oxygen, Application of photochemistry in biological systems, agriculture and industry. Role of light in degradation of pesticides and related xenobiotics

Practicals

- One experiment each of methylation, acetylation, elimination, oxidation, reduction, and hydrolysis
- Preparation of acid chlorides, amides, esters,
- Friedal craft reaction (Alkylation/Acylation),
- Aldol/Claisen/Schmidt reaction,
- Pechmann condensation/Perkin reaction,
- Characterisation of prepared organic compounds by NMR and IR spectroscopy

Suggested Reading

- Finar IL. Organic Chemistry, Longman Publishing Group
- Corey FA and Sundberg RJ. 1983. Advanced Organic Chemistry. Subseries: Part A. Structure & Mechanism. Part B. Reaction and Synthesis. 2nd Ed. Plenum Press,
- Morrison RT, and Boyd RN. 1992. Organic Chemistry, 6th edition, ISBN
- 0136400612 (ISBN13: 9780136436690) Prentice Hall, 1278 pages.
- Eliel EL and Wilen SH. 1994. Stereochemistry of Organic Compounds. John Wiley & Sons. Finar IL. 1959. Text book of Organic Chemistry. Vols. I, II. 25th Ed. Pearson Edu.
- Kalsi PS. 1996. Stereochemistry and Mechanism through Solved Problems. 2nd Ed. New Age International Publ.
- Peter Sykes. 1996. Organic Chemistry. Guidebook to Mechanism in Organic Chemistry. 6th Ed. Prentice Hall.
- Vogel AI. 1996. Vogel's Textbook of Practical Organic Chemistry. 5th Ed. Printice Hall.
- Ahluwalia VK and Aggarwal R. Comprehensive Practical Organic Chemistry - Preparation and Quantitative Analysis. Universities Press.
- Bahl A and Bahl BS. 2005. A Textbook of Organic Chemistry, S Chand and Company, New Delhi, India, 1074 pages.
- Smith MB and March J. 2007. March's Advanced Organic Chemistry Reactions, Mechanisms, And Structure, John Wiley & Sons, Inc., Hoboken, New Jersey, 2190 pages
- Clayden J, Geeves N, Warren S. 2012. Organic Chemistry 2nd Edition (ISBN: 978-0199270293), Oxford University Press, Pages 1234.
- ICAR Institute/SAU Practical Manual on Advanced Organic Chemistry

Course Title : Pesticide Metabolism, Persistence and Decontamination
Course Code : AC 604
Credit Hours : 2+1

Why this course?
The study of pesticide metabolism and dynamics is necessary to understand behaviour of pesticides in the biological systems and the environment. The course is designed to provide deep understanding of the biotic and abiotic transformations affecting fate of the pesticides in the environment

Aim of the course
To acquaint the students about the persistence, dissipation, and fate of pesticides in the crops and the environment. and about bio-remedial measures to decontaminate pesticide residues.
The course is organized as follows:

No.	Blocks	Units
1	Pesticide Movement in the Plant, Soil Environment	1. Translocation of Pesticides in the and Aquatic Environment 2. Different Phases of Pesticide Metabolism
2	Abiotic and Biotic Transformations of Pesticides Pesticides	1. Abiotic Transformation of 2. Microbial Degradation of 3. Metabolism of Pesticides in the Living Systems
3	Pesticide Persistence and Environment Dissipation Kinetics	1. Persistence of Pesticides in the (Soil, Water and Crops) 2. Pesticide Dissipation and Fate in the Environment
4.	Decontamination and Residues Bioremediation Measures Pesticide	1. Decontamination of Pesticide 2. Bioremediation of Pesticides and contaminated sites

Theory
Block 1: Pesticide Movement in the Environment
Unit 1: Translocation of Pesticides in the Plant, Soil and Aquatic Environment
Introduction to pesticide metabolism, penetration, uptake, translocation, excretion, and mineralization etc. (Highlight the role of physico-chemical parameters). Uptake, bio-accumulation, bio-concentration, and biomagnifications of pesticides in the plant and the environment.
Unit 2: Different Phases of Pesticide Metabolism
Fate of pesticides in the plant, animal and other living systems, Phase I metabolism (oxidation, reduction, hydrolysis, enzymatic degradation, etc.), Phase II metabolism (conjugation with sugar, amino acid, glutathione, etc.), Phase III metabolism (further conjugation of phase II metabolites), Non-extractable (Bound) residues.

Block 2: Abioticand Biotic Transformations of Pesticides

Unit 1: Abiotic Transformations of Pesticides

Physical and chemical factors affecting fate of pesticides in the environment, Photochemical transformation of pesticides, Role of photosensitizers, quenchers, and light filters in pesticide degradation.

Unit 2: Metabolism of Pesticides in the Living Systems

Biotic transformations and metabolic pathways of different group pesticides in thecrops, insects, animal models.

Unit 3: Microbial Degradation of Pesticides

Types of pesticides-degrading microorganisms in the environment, Factors affecting microbial degradation, Microbial degradation of different group pesticides.

Block 3. Pesticide Persistence and Dissipation in the Environment

Unit 1: Persistence of Pesticides in the Environment

Low, moderate and high persistent pesticides, Persistent organic pollutants, Physical, chemical, biochemical and environmental factors affecting pesticide persistence in the environment.

Unit 2: Pesticide Dissipation and Fate in The Environment

Various dissipation processes, Role of drift, volatilization, adsorption, desorption, runoff etc.in pesticide dissipation, Leaching and risk of groundwater pollution, Dissipation time (Half-life-DT50, DT90), Rate kinetics (1st order, 2nd order), Behaviour and fate of pesticides in soil and crops.

Block 4: Decontamination and Bioremediation Measures

Unit 1: Decontamination of Pesticide Residues

Decontamination of pesticide residues in water and food (vegetables and fruits) commodities, Effect of different processing/culinary methods on reduction pesticide residues, safer methods of pesticide decontamination.

Unit 2: Bioremediation of Pesticides and Pesticide Contaminated Sites

Bioremediation-advantages and applications, Biodegradation and bioremediation of pesticides and related xenobiotic compounds, Microbe-mediated bioremediation, Use of enzymes in bioremediation, bioremediation of pesticide polluted sites.

Practicals

- Synthesis of a pesticide metabolite
- Photodegradation of pesticides on glass and leaf surface,
- Microbial degradation of pesticides in soil.
- Leaching of pesticides in soil columns,
- Recovery of residues from pesticide-spiked farm soil

Suggested Reading

- Schnoor JL. (Ed). 1992. Fate of pesticides and chemicals in the environment. Wiley New York. 436 pages:
- Alexander M. 1999. Biodegradation and bioremediation. 2nd Ed. Academic Press.
- Racke KD, Skidmore MW, Hamilton DJ, Unsworth JB, Miyamoto J and Cohen SZ. 1997.
- Pesticide Fate in Tropical Soils. Pure and Appl. Chem. 69 (6): 1349-1371.
- Hall JC, Hoagland RE and Zablotowicz RM. 2001. Pesticide Biotransformation in Plants and Microorganisms: Similarities and Divergences. ACS Symposium Series 777. Washington, DC.
- Shahamat U Khan. 1980. Pesticides in the Soil Environment (Editor: R. J. Wakeman)

Elsevier. 248 pages.
- Perry AS, Yamamoto I, Ishaaya I, Perry RY. 1998. Insecticides in Agriculture and Environment- Retrospects and Prospects, DOI: 10.1007/978-3-662-03656-3 pp 261. Springer- Verlag Berlin Heidelber.
- Wheeler WB. (Ed) 2002. Pesticides in Agriculture and the Environment (1st Edition), CRC Press.
- Matsumura F (Ed) 2013. Biodegradation of Pesticides (ISBN-13: 978-1468440904) Publisher: Springer, pp 312 pages.
- ICAR Institutes/SAU. Practical Manual on Pesticide Residues and Dynamics in the Environment

Course Title : Term Paper (Special Topics in Agro Chemicals)
Course code : AC 605
Credit Hours : 1+0

Aim of the course
To develop proficiency of the student in his/her area of specialization. The teacher will give a topic relevant to the area of specialization of the student as a term paper to develop proficiency in his field of research. The term paper can be based on one of the selected current topics in agrochemicals

Suggested Reading
Literature on the relevant subject of the term paper in his area of research Journals

- Archives of Environmental Contamination and Toxicology
- Biopesticide International
- Bulletin of Environmental Contamination and Toxicology
- Chemosphere
- Crop Protection
- Current Science
- Environment Monitoring and Assessment
- Environmental Toxicology and Chemistry
- Food Additives and Contaminants
- Food Chemistry
- Indian Journal of Agricultural Chemistry
- Industrial Crops and Products
- Integrated Pest Management Reviews
- International Journal of Pest Management
- International Journal of Pesticide Reform
- Journal of Agriculture and Food Chemistry
- Journal of AOAC
- Journal Environ. Science and Health Part A & B
- Journal of Essential Oil Bearing Plants
- Outlooks on Pest Management
- Pest Management Science
- Pesticide Biochemistry and Physiology
- Pesticide Research Journal
- Pesticide Science Japan
- Weed Research
- Weed Science
- Weed Technology

e-Resources

- Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Plant Protection, Quarantine & Storage. http://ppqs.gov.in/about-us/about-department
- Central Insecticide Board and Registration Committee (CIB&RC) www.cibrc.nic.in; http:// ppqs.gov.in/contactus/central-insecticide-board-and-registration-committee-cibrc
- The Food Safety and Standards Authority of India (FSSAI) https://www.fssai.gov.in/home
- Insecticides in Agriculture and Environment- Retrospects and Prospects, Authors: Perry, A.S., Yamamoto, I., Ishaaya, I., Perry, R.Y. (1998) DOI: 10.1007/978-3-662-03656-3 pp 261. Springer-Verlag Berlin Heidelber
- CRC Handbook of pest management in agriculture, Volume 1. Author: Pimentel, D., CRC
- Series in Agriculture; Editor: Hanson, A.A.]. 1981. 597 pp.
- Food and Agricultural Organization Statistics (FAOSTAT) Pesticides Use. http://www.fao.org/ faostat/en/#data/RP
- Food and Agricultural Organization (FAO/WHO) Codex Pesticides Residues in Food Online Database. Pesticide Residues in Food and Feed, doi: http://www.codexalimentarius.net/ pestres/data
- European Food Safety Authority: http://www.efsa.europa.eu/en/pesticides/mrls.htm
- Pest Management Regulatory Agency Canada. https://www.canada.ca/en/health-canada/ corporate/about-health-canada/branches-agencies/pest-management-regulatory-agency.html
- OECD (Organization for Economic Co-operation and Development), (2011). OECD MRL calculator: spreadsheet for single data set and spreadsheet for multiple data set, 2 March
- 2011. In: Pesticide Publications/Publications on Pesticide Residues. http://www.oecd.org.
- Bureau of Indian Standards (BIS), New Delhi, India. http://www.bis.org.in/cert/bis_proc_obt_ lic.htm
- EU. http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=pesticide.
- residue.CurentMRL&language=EN&pestResidueID=69. (accessed 21 October 2016).
- US Environment Protection Agency (USEPA) https://www.epa.gov, https://www.epa.gov/ pesticide-registration/about-pesticide-registration

Suggested broad topics for master's/ doctoral research

- ✓ New generation pesticides (insecticides, fungicides, herbicides, nematicides), plant growth stimulants, and other allied agrochemicals from synthetic and botanical sources
- ✓ Biopesticides from natural sources (plants, fungi, bacteria, algae, nematodes, etc),
- ✓ Novel insect antifeedants and other insect behaviour modifying chemicals (pheromones and other semio-chemicals)
- ✓ Novel pesticide formulations, time-release formulations, and delivery systems for enhanced
- ✓ activity and stability of single and combination pesticides
- ✓ Analysis of pesticide residues (multi-class pesticides, metabolites, degradation products, impurities) in soil, water, food commodities as well as in technical materials and formulations
- ✓ Investigations on safety evaluation, fixation of MRLs and safe waiting periods, and risk
- ✓ assessment
- ✓ Biotechnological and nanotechnological intervention for developing ecologically sound agrochemicals
- ✓ Pesticide-environment (plant, air, water, microbes) interaction, Pesticide persistence,
- ✓ degradation (biotic, abiotic)
- ✓ Impact of pesticides on the non-target organisms.
- ✓ Pesticide detoxification, decontamination and disposal, Bioremediation of pesticide contaminated sites for safe environment
- ✓ Increasing agricultural input (pesticides, water, fertilizers, micronutrient etc.) use-efficiency through technological interventions.

Restructured and Revised Syllabi of Post Graduate Programmes

M. Sc. and Ph. D. (Agriculture)

In

Biochemistry

Compiled
by

Broad Subject Co-ordinator
Associate Dean,
College of Agriculture,
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Discipline Coordinator
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Department of Biochemistry,
Post Graduate Institute,
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CONTENTS

Preamble:

The global advancement of agriculture in the fields of crop production and improvement, crop protection, development of newer and high yielding varieties of different crops are all going hand-in-hand with the advancement and applications of biochemistry. Education and research in agriculture, specifically in the fields of photosynthetic efficiency, nitrogen fixation ,applications of recombinant DNA technology, genomics and proteomics in varietal development and plant protection, animal and human nutrition and health and the environmental impact of agricultural chemicals are some examples of the wide array of topics in which biochemistry plays significant contributions.

Restructuring the courses of biochemistry associated with agricultural education in our country has become demand of the day to keep pace with the rapid development of the subject as well as to fulfill the objective of doubling farmer's income through use of these cutting edge developments under the global context. Keeping this in view the ICAR has initiated modification of the existing courses both of M.Sc. and Ph.D. curricula in biochemistry. These alterations will not only help the students to understand the subject better but will also create ample scope to gather advanced knowledge in different areas of the subject which will enable them to proceed a step further towards excelling in advanced studies and research and also serving the industrial field causing benefit to the mankind.

M.Sc. courses

A total of eleven courses belonging to five different categories have been proposed for M.Sc. programme:

1. Basic and fundamental course: BIOCHEM 501 (Basic Biochemistry) deals with the basic and fundamental aspects of biochemistry. It is one of the core courses of M.Sc. study programme which has the objective to enrich the students of biochemistry as well as other disciplines with the knowledge of the basics of the subject. The students will gather basic idea and will have a strong footing prior to entering into the vast realm of the subject. The topic of photosynthesis in this course is replaced by plant secondary metabolites, PR proteins and immune globulins. Several relevant and new practicals have also been introduced.

2. Courses covering the major areas of the subject including one of analytical aspects:

This category includes four courses, BIOCHEM 502 (Intermediary Metabolism),BIOCHEM 503 (Enzymology), BIOCHEM 504 (Molecular Biology) and BIOCHEM 505(Techniques in Biochemistry). Students will be able to have a comprehensive idea of themetabolic processes occurring in the living cells, the catalytic activity of the enzymes in the biological systems and the molecular basis of transmission of hereditary information through generations. These courses will appraise the students about the basic biochemical activities occurring in the living systems and will also help them to choose the avenues of their future research programmes with the knowledge of essential tools of analytical techniques being extremely helpful for the students of other disciplines besides those belonging to biochemistry itself. The qualitative and quantitative estimation of the plant metabolites is also an important aspect of crop improvement programmes.

In BIOCHEM 502, topics such as, biochemical reaction types, bioavailability of nutrients, defined metabolic processes, and nucleotide metabolism are newly introduced. Course outlines in BIOCHEM 503 are redefined in broader aspects with introduction of enzyme kinetic models and large scale production technology of enzymes in theory and effect of inhibitors on enzyme activity and electrophoretic analysis of isozymes in practical. New topics for theory have also been added to BIOCHEM 504, such as genome editing, DNA sequencing, *in vitro* mutagenesis and techniques in molecular biology. The course BIOCHEM505 is redesigned with introduction of several modern and widely used techniques, *viz*., mass spectroscopy-MS/MS, LC-MS, GC-MS, MALDI-TOF, atomic absorption spectrophotometry, microscopic techniques, imaging techniques – MRI and CT scan and immunochemical techniques. Emphasis is also given to practicals with introduction of several important techniques – separation and analysis of fatty acids/lipids by GC, $(NH_4)_2SO_4$precipitation and dialysis, PCR, ELISA and Western blotting/Dot blotting. So the course BIOCHEM 505 will enable the students to acquaint with the methods to estimate the phytochemicals and cellular constituents along with their theoretical backgrounds.

3. Courses related to plant metabolism: Two courses within this category are BIOCHEM 507 (Plant Biochemistry) and BIOCHEM 510 (Nitrogen and Sulphur Metabolism). Understanding the basic plant metabolic processes is of prime importance for improvement of crop plants. So these courses will give the basic idea in this field and willhelp the students to explore further for development of the crops. Credit load in BIOCHEM507 is changed from 3 (3+0) to 3 (2+1) with one credit for practicals and with introduction of new topic - effect of biotic and abiotic factors on plant metabolism. For BIOCHEM 510 also, the course title is changed from Carbon and Nitrogen metabolism to Nitrogen and Sulfur metabolism as the topics under carbon metabolismhave been well addressed in BIOCHEM 501 and BIOCHEM 507. An elaborative course outline on nitrogen as well as sulfur metabolism covering all the aspects is prescribed. New practicals like estimation of cysteine, methionine, pyruvate and glutathione and assay ofAPS activity are introduced.

4. Courses dealing with diverse specialized areas: Three courses, *viz*., BIOCHEM506 (Immunochemistry), BIOCHEM 509 (Nutritional Biochemistry) and BIOCHEM 511(Biochemistry on Xenobiotics) under this category address the biochemical aspects of immunity, nutrition and environmental applications of biochemistry respectively. These courses will widen the area of understanding as well as application of the subject on environmental components and human health as a whole .In BIOCHEM 506 course outline, aspects on plant immunity, proteasome mediated process, plantibodies, and additional immunological techniques: immune blotting, FACS; basics of PCR and hybridization based methods of detection, microarray based detection, multiplexing is newly introduced. Similarly ELISA, Western blotting, Fluorescent Abtest and Hybridoma technique are newly introduced in the practical part. Course title for BIOCHEM 509 is changed from Food and Nutritional Biochemistry to Nutritional Biochemistry and the course outline is modified to suit the present aspects innutrition science with inclusion of phytonutrients, prebiotics and probiotics, interrelationship in nutrient functions, mineral deficiency diseases; nutraceuticals, factors affecting bioavailability of nutrients and food sensitivity. New practicals are also introduced. A new course, Biochemistry on

xenobiotics(BIOCHEM511) is proposed considering the pollution from industrial chemicals and waste water leading to heavy metals contamination of the agricultural crops and the biological and non-biological remediation techniques.

5. Animal Biochemistry (BIOCHEM 508): Agriculture is a multidisciplinary stream and includes animal husbandry. So study of the topics related to animal system will be of immense help for the students. The Unit–II in the earlier syllabus under BIOCHEM 508 (Animal Biochemistry) is restructured with inclusion of vitamins, energy nutrients, bioactive peptides and functional oligosaccharides with deletion of biochemistry of reproduction from the Unit-III.

Ph. D. courses

- There are seven (7) courses at the Ph. D. level, most of which are of advanced nature.No new course is proposed in the syllabus. Modification of the courses was done as persuggestions from different experts from state agricultural universities and ICAR institutions.
- Units under BIOCHEM 601 (Advanced Enzymology) are redefined within corporation of new topics such as pseudo enzyme and enzyme promiscuity ,extremozymes, catalytic nucleic acids (ribozymes, catalytic DNA), immobilization of enzymes, semi-synthetic enzymes and their use as industrial biocatalysts and their practical significance, modern information technologies in enzyme engineering.
- In BIOCHEM 602 (Advanced Molecular Biology), the units are redefined with inclusion of several new topics like concept of epigenome, role of histones, riboswitches, genome sequencing technologies, gene silencing technologies, genome editing – TALENs, CRISPRcas, ZFN and their application and a new unit Aspects of molecular breeding.
- The different units are newly addressed for BIOCHEM 603 (Biochemistry of Biotic and Abiotic Stresses), a course having enormous importance for understanding the interfering effects of stresses especially with crop growth and development.
- The course title and the credit load for BIOCHEM 604 are changed with new title Frontier topics in biochemistry and with credit load of (2+0). The broad topics fororal presentations to be delivered by the students registering this course are divided into eight major heads.
- The course title for BIOCHEM 605 is changed to Concepts and Application of Omics in Biological Science with fresh inclusion of ionomics part.
- The course title for BIOCHEM 607 is changed to Application of Techniques in Biochemistry. The entire course is divided into five units with Molecular biology and immunochemical techniques in the fifth unit.

Biochemistry courses are offered to a large number of students hence need for a few common types of equipment in multiple numbers cannot be avoided. Moreover, with the advancement of techniques and to cater quality teaching and research, sophisticated equipment like ultra-low freezers, high speed refrigerated- and ultra-centrifuges, automated bio separation systems like GLC or HPLC, GC-MS, LC-MS; UV-Vis spectrophotometers suitable for enzyme studies, AAS for minerals, PCRs, electrophoresis systems for proteins and DNA are required as essentials in a Biochemistry laboratory.

Additional funds may also be required for purchasing spare parts and for AMC for the instruments. Provisions for training to the teachers to the new areas in the field of Biochemistry

and exposure to modern laboratories within and outside the country become a primary need with the changing academic scenario. Moreover, funds may also be required for the proposed exposure visits of the students to other institutes. Financial assistance for these non-recurring and recurring expenses is the need to effectively run Master's and Doctoral programmes in the Discipline of Biochemistry at Maharashtra State Agricultural Universities.

State level Committee for revision in Course and Syllabus of Masters and Doctoral Degree in Biochemistry

Sr. No.	Name	Designation	Office Address
1	Dr. A. A. Kale	Discipline Coordinator & Professor and Head	Department of Biochemistry, MPKV, Rahuri
2	Dr. H. B. Patil	Associate Dean	College of Agriculture Business Management, Chakur-413513 Dist. Latur
3	Dr. N. B. Gokhale	Ex-Professor of Biochemistry (CAS)	MCAER Recruitment Board, Maharashtra Council of Agriculture Education and Research, Bhosale Nagar, Pune-411007
4	Dr. P. K. Lokhande	Professor (CAS)	Department of Biochemistry, PGI, MPKV, Rahuri
5	Dr. D. P. Kachare	Professor (CAS)	Department of Biochemistry, PGI, MPKV, Rahuri
6	Dr. S. V. Damame	Forage Biochemist	AICRP on Forage Crops, MPKV, Rahuri
7	Dr. U. S. Dalvi	Sorghum Biochemist	AICRP on Sorghum, MPKV, Rahuri
8	Dr. B. M. Bhalerao	Assistant Professor	Department of Biochemistry, MPKV, Rahuri
9	Dr. T. J. Bedse	Assistant Professor	Rice Research Station, Karjat, Dist. Raigad
10	Dr. R. D. Satbhai	Assistant Professor	College of Agriculture, Yawatmal
11	Dr. B. R. Bhite	Assistant Professor	Department of FST, MPKV, Rahuri
12	Mrs. R. R. Jadhav	Senior Research Assistant	Department of Biochemistry, MPKV, Rahuri
13	Miss. S. G. Mohite	Senior Research Assistant	Department of Biochemistry, MPKV, Rahuri

Organization of Course layout and residential requirement

Framework of the courses

The following nomenclature and Credit Hrs as per BSMA ICAR Guideline will be followed while executing the syllabus of Biochemistry discipline.

Minimum Credit Requirement for Post Graduate Programme as per BSMA ICAR Guideline

Sr.No.	Particulars	Masters' Programme	Doctoral Programme
I	**Course Work**		
i	Major Courses	20	12
ii	Minor Courses	08	06
iii	Supporting Courses	06	05
iv	Common Courses	05	-
v	Seminar	01	02
II	**Thesis Research**	30	75
	Total	**70**	**100**

Mandatory requirement of Seminars:

It has been decided to have mandatory seminars **one in Master (One Credit) and two in Doctoral Programmes (Two Credits)**

Residential Requirements:

The minimum and maximum duration of residential requirement for Master and Ph. D. degree programme shall be as follows:

PG Programme	Duration of Residential Requirement	
	Minimum	**Maximum**
Master's Degree	2 Academic Years(04 Semesters)	5 Academic Years(10 Semesters)
Ph. D.*	3 Academic Years(06 Semesters)	7 Academic Years(14 Semesters)

*Student may be allowed to discontinue temporarily only after completion of coursework.

Course Layout
M.Sc. (Ag) in Biochemistry

Course Title with Credit Load M.Sc. (Ag) in Biochemistry

Sr. No.	Course Number	Title of the Course	Course Credits
1	BIOCHEM 501*	Basic Biochemistry	3+1
2	BIOCHEM 502*	Intermediary Metabolism	3+0
3	BIOCHEM 503*	Enzymology	2+1
4	BIOCHEM 504	Molecular Biology	2+1
5	BIOCHEM 505*	Techniques in Biochemistry	2+2
6	BIOCHEM 506	Immuno Chemistry	2+1
7	BIOCHEM 507	Plant Biochemistry	2+1
8	BIOCHEM 508	Animal Biochemistry	3+0
9	BIOCHEM 509	Nutritional Biochemistry	2+1
10	BIOCHEM 510	Nitrogen and Sulphur Metabolism	2+1
11	BIOCHEM 511	Biochemistry of Xenobiotics	2+0
12	BIOCHEM 591	Master's Seminar	1+0
13	BIOCHEM 599	Master's Research	30

***Core courses**

Suggested major courses from above list with minimum credits (20):

Sr.No.	Course Code	Course Title	Credit Hours
1	BIOCHEM 501*	Basic Biochemistry	3+1 = 4
2	BIOCHEM 502*	Intermediary Metabolism	3+0 = 3
3	BIOCHEM 503*	Enzymology	2+1 = 3
4	BIOCHEM 505*	Techniques in Biochemistry	2+2 = 4
5	BIOCHEM 507	Plant Biochemistry	2+1 = 3
6	BIOCHEM 510	Nitrogen and sulfur Metabolism	2+1 = 3
		Total Credits	**14+6=20**

***Core courses**

Minor Courses offered from the following departments:

1. Plant Physiology
2. Molecular Biology and Biotechnology
3. Microbiology
4. Soil Science

Suggested list of minor courses with minimum 8 credits:

Sr. No.	Name of Department	Course Code	Course Title	Credit Hours
1	Plant Physiology	PP 504	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1 = 3
2	Microbiology	MICRO 504	Microbial Genetics	2+1 = 3
3	Molecular Biology and Biotechnology	MBB 502*	Fundamentals of Molecular Biology	3+0 = 3
			Total Credits	**7+2=9**

Supporting courses offered from the following departments:

1. Statistics
2. Plant Physiology
3. Microbiology

Suggested list of supportive courses with minimum 6 credits:

Sr. No.	Name of Department	Course Code	Course Title	Credit Hours
1	Statistics	STAT 522	Data Analysis using Statistical Packages	2+1=3
2	Plant Physiology	PP 501*	Principles of Plant Physiology-I	2+1 = 3
3	Microbiology	MICRO 507*	Food Microbiology	2+1 = 3
			Total Credits	**4+2= 6**

Common Compulsory PGS Courses:

Sr.No.	Course Code	Course Title	Credit Hours
1	PGS 501	Library and Information Services	0+1 = 1
2	PGS 502	Technical Writing and Communication Skills	0+1 = 1
3	PGS 503	Intellectual Property and Its Management in Agriculture	1+0 = 1
4	PGS 504	Basic Concept in Laboratory Techniques	0+1 = 1
5	PGS 505	Agricultural Research, Research Ethics and Rural Programmes	1+0 = 1
		Total Credits	**2+3 = 5**

Course Layout
Ph. D. in Biochemistry

Course Title with Credit Load Ph.D. in Biochemistry

Sr. No.	Course Code	Course Title	Credit Hours
1	BIOCHEM 601*	Advanced Enzymology	2+1 = 3
2	BIOCHEM 602	Advanced Molecular Biology	3+0 = 3
3	BIOCHEM 603	Advanced molecular Biology	3+0 = 3
4	BIOCHEM 604	Frontier Topics in Biochemistry	2+0 = 2
5	BIOCHEM 605	Concepts and Applications of Omics in Biological Science	3+0 = 3
6	BIOCHEM 606	Biomembranes	2+0 = 2
7	BIOCHEM 607*	Applications of Techniques in Biochemistry	1+2 = 3
8	BIOCHEM 691	Doctoral Seminar I	1+0 = 1
9	BIOCHEM 692	Doctoral Seminar II	1+0 = 1
10	BIOCHEM 699	Doctoral Research	75

***Core courses**

Suggested major courses from above list with minimum credits (12):

Sr.No.	Course Code	Course Title	Credit Hours
1	BIOCHEM 601*	Advanced Enzymology	2+1 = 3
2	BIOCHEM 602	Advanced Molecular Biology	3+0 = 3
3	BIOCHEM 603	Advanced Molecular Biology	3+0 = 3
4	BIOCHEM 605	Concepts and Applications of Omics in Biological Science	3+0 = 3
5	BIOCHEM 607*	Applications of Techniques in Biochemistry	1+2 =3
		Total Credits	**12+3 = 15**

***Core courses**

Minor Courses offered from the following departments:

1. Plant Physiology
2. Microbiology
3. Seed Sciences and Technology
4. Soil Science
5. Organic Farming
6. Processing an d Food Engineering
7. Statistics
8. Computer Science and Information Technology
9. Food Technology

Suggested list of minor courses with minimum 6 credits:

Sr. No.	Name of Department	Course Code	Course Title	Credit Hours
1	Plant Physiology	PP 607*	Physiological and Molecular Aspects of Source and Sink for Enhancing Yield	2+1 = 3
2	Microbiology	MICRO 607	Plant Microbe Interactions	2+1 = 3
			Total Credits	**4+2=6**

Supporting courses offered from the following departments:

1. Plant Physiology
2. Genetics and Plant Breeding
3. Seed Sciences and Technology
4. Microbilogy
5. Processing and Food Engineering

Suggested list of supportive courses with minimum 5 credits:

Sr. No.	Name of Department	Course Code	Course Title	Credit Hours
1	Plant Physiology	PP 602*	Signal Perceptions and Transduction and Regulation of Physiological Processes	2+0=2
2	Genetics and Plant Breeding	GP 605*	Genomics in Plant Breeding	3+0 =3
			Total Credits	**5+0=5**

Summary of course credits proposed for Ph.D.

Sr. No.	Particulars	Proposed	As per BSMA guidelines
1	Major	15	12
2	Minor	6	6
3	Supportive	5	5
4	Common	--	--
5	Seminars	2	2
6	Total	28	25
7	Research	75	75
	Grand Total	**103**	**100**

Semester Wise Layout Of Courses For M.Sc.

Semester I

	Course No.	Course Title	Credits (T+P=Total)
Major	BIOCHEM 501	Basic Biochemistry	3+1 =4
	BIOCHEM 503	Enzymology	2+1 =3
		Total Credits	**5+2 = 7**
Minor	MBB 502	Fundamentals of Molecular Biology	3+0=3
	MICRO 504	Microbial Genetics	2+1 = 3
		Total Credits	**5+1 = 6**
Supporting	PP 504	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1=3
		Total Credits	**2+1 = 3**
Common	PGS-501	Library and Information services	0+1=1
	PGS-504	Basic concepts in laboratory techniques	0+1=1
		Total Credits	**0+2 = 2**
		Total Credits of semester	**12+6 = 18**

Semester II

	Course No.	Course Title	Credits (T+P=Total)
Major	BIOCHEM-502	Intermediary Metabolism	3+0=3
	BIOCHEM-505	Techniques in Biochemistry	2+2=4
	BIOCHEM-507	Plant Biochemistry	3+0=3
		Total Credits	**8+2 = 10**
Minor	PP 501	Principles of Plant Physiology- I	3+0=3
		Total Credits	**3+0 = 3**
Supporting	STAT 522	Data Analysis using Statistical Packages	2+1=3
		Total Credits	**2+1 = 3**
Common	PGS-502	Technical Writing and Communication Skills	0+1=1
	PGS-503	Intellectual Property and its Management in Agriculture	1+0=1
		Total Credits	**1+1 = 2**
		Total Credits of semester	**14+4 = 18**

Semester III

	Course No.	Course Title	Credits (T+P=Total)
Major	BIOCHEM-510	Nitrogen and Sulfur Metabolism	2+1 =3
		Total Credits	**2+1 = 3**

Minor	-	-	-
Supporting	-	-	-
Common	PGS-505	Agricultural Research, Research Ethics and Research Development Programme	1+0=1
		Total Credits	**1+0 = 1**
Research	BIOCHEM-599	-	0+10 = 10
		Total Credits of semester	**3+11 = 14**

Semester IV

	Course No.	**Course Title**	**Credits (T+P=Total)**
Major	-	-	-
Minor	-	-	-
Supporting	-	-	-
Seminar	BIOCHEM-591	Master's Seminar	0+1=1
		Total Credits	**0+1=1**
Research	BIOCHEM-599	-	0+20 = 10
		Total Credits of semester	**0+21 = 21**
		Grand Total	**29+42 = 71**

Semester Wise Layout Of Courses For Ph.D.

Semester I

	Course No.	Course Title	Credits (T+P=Total)
Major	BIOCHEM-601	Advanced Enzymology	2+1=3
	BIOCHEM-602	Advanced Molecular Biology	3+0=3
	BIOCHEM-607	Applications of Techniques in Biochemistry	1+2=3
		Total Credits	**6+3 = 9**
Minor	MICRO 605	Plant Microbe Interactions	2+1=3
		Total Credits	**2+1 = 3**
Supporting	PP 602	Signal Perception and Transduction and Regulation of Physiological Processes	2+0=2
	GPB 605	Genomics in Plant Breeding	3+0=3
		Total Credits	**5+0 = 5**

Semester-II

	Course No.	Course Title	Credits (T+P=Total)
Major	BIOCHEM-603	Biochemistry of Biotic & Abiotic Stresses	3+0=3
	BIOCHEM-605	Concepts and Applications of Omics in Biological Science	3+0=3
		Total Credits	**6+0 = 6**
Minor	PP 607	Physiological and Molecular Aspects of Source and Sink Capacity for enhancing Yield	3+0=3
		Total Credits	**3+0 = 3**
Supporting	-	-	-

Semester III

	Course No.	Course Title	Credits (T+P=Total)
Major	-	-	-
Minor	-	-	-
Supporting	-	-	-
Doctoral Seminar	BIOCHEM-691	Doctoral Seminar-I	0+1=1
		Total credit	**0+1 = 1**
Research	BIOCHEM-699	-	0+15 = 20
		Total credit	**0+21 = 21**

Semester IV

	Course No.	**Course Title**	**Credits (T+P=Total)**
Major	-	-	-
Minor	-	-	-
Supporting	-	-	-
Doctoral Seminar	BIOCHEM-691	Doctoral Seminar-II	0+1=1
		Total credit	**0+1 = 1**
Research	BIOCHEM-699	-	0+20 = 20
		Total credit	**0+21 = 21**

Semester V

	Course No.	**Course Title**	**Credits (T+P=Total)**
Major	-	-	-
Minor	-	-	-
Supporting	-	-	-
Doctoral Seminar	-	-	-
Research	BIOCHEM-699	-	0+20 = 20
		Total credit	**0+20 = 20**

Semester VI

	Course No.	**Course Title**	**Credits (T+P=Total)**
Major	-	-	-
Minor	-	-	-
Supporting	-	-	-
Doctoral Seminar	-	-	-
Research	BIOCHEM-699	-	0+15 = 15
		Total credit	**0+15 = 15**

Course Content and Syllabus of Master Degree

I. Course Title : Basic Biochemistry
II. Course Code : BIOCHEM 501
II. Credit Hours : 3+1

IV. Why this course?

To impart the fundamental knowledge on structure and function of cellular components involved in biological processes and an elementary introduction to the study of molecular biology.

V. Aim of the course

The course is designed to provide elementary knowledge/overview of structure and function of proteins, carbohydrates, lipids, nucleic acids and other biomolecules and their metabolism.

No.	Blocks	Units
1.	Introduction to Biochemistry	1.Scope and importance of biochemistry 2. Foundation of life 3.Water 4.Physical techniques for structure determination
2.	Structure and function of biomolecules	1.Biomolecules 2.Immunoglobulins and PR proteins 3. Plant secondary metabolites
3.	Metabolism-the basics	1.Molecules aiding metabolism 2.Thermodynamics-principles and energetic of life
4.	Catabolism and its regulation	1.Catabolism of energy molecules 2.ATP formation
5.	Fundamentals of Molecular biology genetic engineering	1.Molecular biology processes and 2.Recombinant DNA technology

VI. Theory

Block 1: Introduction to Biochemistry

Unit 1: Scope and importance of biochemistry (1 Lecture)

Biochemistry as modern science and its various divisions. Scope and importance of biochemistry in agriculture and allied sciences.

Unit 2: Foundation of life (2 Lectures)

Fundamental principles governing life, supra molecular structures, significance of weak non covalent interactions in biology

Unit 3: Water (4 Lectures)

Structure of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship.

Unit 4: Physical techniques for structure determination (2 Lectures)

General introduction to physical techniques for determination of structure of biopolymers.

Block 2: Structure and Function of Biomolecules

Unit 1: Biomolecules (11 Lectures)

Structure, classification, properties and functions of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Unit 2: Immunoglobulins and PR proteins (2 Lectures)

Structure, formation and different forms of immunoglobulins, PR proteins and their classification.

Unit 3: Plant secondary metabolites (3 Lectures)

Structure, classification and function of plant secondary metabolites.

Block 3: Metabolism – The Basics

Unit 1: Molecules aiding metabolism (4 Lectures)

structure and biological functions of vitamins and coenzymes, enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Hormones: animal and plants.

Unit 2: Thermodynamics –principles and energetic of life (2 Lectures)

Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

Block 4: Catabolism and its regulation

Unit 1: Catabolism of energy molecules (6 Lectures)

Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation.

Unit 2: ATP formation (4 Lectures)

Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemi-osmotic theory and proton motive force.

Block 5: Fundamentals of Molecular Biology and Genetic Engineering

Unit 1: Molecular biology processes (5 Lectures)

Overview of replication, transcription and translation.

Unit 2: Recombinant DNA technology (4 Lectures)

Restriction enzymes, DNA cloning, applications of cloning, transgenics.

VII. Practicals

- Preparation of standard and buffer solutions
- Detection of carbohydrates, amino acids and proteins
- Extraction and estimation of sugars
- Extraction and estimation of amino acids
- Extraction and estimation of proteins
- Estimation of acid value of fat/oil
- Estimation of peroxide value of fat/oil
- Estimation of saponification value in fats and oils
- Fatty acid composition in fat/oil by GC
- Estimation of DNA and RNA by spectroscopic methods
- Estimation of ascorbic acid
- Separation of biomolecules by TLC and Paper chromatography
- Estimation of alpha amylase activity
- Qualitative tests for secondary plant metabolites.

VIII. Teaching methods/activities

- Classroom lectures (oral +audio-visual)
- Assignment(Reading/Writing)
- Oral presentation by students on specified topics
- Class room quiz

IX. Learning outcome

With this course, the students are expected to be able to understand the actual chemical concepts and fundamental processes of biology at molecular level.

X. Suggested Reading

- Nelson DL and Cox MM. 2017. *Lehninger Principles of Biochemistry*. 7thedition. W. H. Freeman &CoLtd
- Satyanarayana U and Chakrapani U. 2017. *Biochemistry*. 5thedition,Elsevier
- Moran LA, Horton HR, Scrimgeour KG and Perry MD. 2012. *Principles of Biochemistry*. 5theditionPearson.
- Voet D and Voet JG. 2011. *Biochemistry*. 4thedition JohnWiley.
- Pratt CW and Cornely K. 2014. *Essential Biochemistry*. 3rdEdition.Wiley
- Moorthy K. 2007. *Fundamentals of Biochemical Calculations*. 2ndedition. CRCPress

- Conn EE, Stumpf PK, Bruening G and Doi RH. 2006. *Outlines of Biochemistry*. 5th edition. Wiley.

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No. of Lectures	Weightage (%)
	Block 1: Introduction to Biochemistry **Unit 1: Scope and importance of biochemistry**	**1**	**3**
1.	Biochemistry as modern science and its various divisions. Scope and importance of biochemistry in agriculture and allied sciences.	1	2
	Unit 2: Foundation of life	**2**	**4**
2.	Fundamental principles governing life, supra molecular structures	1	2
3.	Significance of weak non covalent interactions in biology.	1	2
	Unit 3: Water	**4**	**8**
4.	Structure of water, ionization of water.	1	2
5.	Acid -base concept, pH and buffers.	2	4
6.	Significance of structure-function relationship between acid and base.	1	2
	Unit 4: Physical techniques for structure determination	**2**	**4**
7.	General introduction to physical techniques for determination of structure of biopolymers.	2	4
	Block 2: Structure and Function of Biomolecules **Unit 1: Biomolecules**	**11**	**22**
8.	Structure, classification, properties, function and metabolism of carbohydrates	3	6
9.	Classification, structure, function and metabolism of lipids	3	6
10.	Classification, structure, function and metabolism of amino acids and proteins	3	6
11.	Structure, function and metabolism of nucleic acids	2	4
	Unit 2: Immunoglobulins and PR proteins	**2**	**4**
12.	Structure, formation and different forms of immune globulins.	1	2
13.	PR proteins and their classification.	1	2
	Unit 3: Plant secondary metabolites	**3**	**6**
14.	Structure, classification and function of plant secondary metabolites.	3	6
	Block 3: Metabolism – The Basics **Unit 1: Molecules aiding metabolism**	**4**	**8**
15.	Structure, biological functions and classification of vitamins and coenzymes	1	2

16.	Enzyme classification, factors affecting on enzyme action	1	2
17.	Mechanism of action of enzymes, regulation of enzyme	1	2
18.	Hormones: animals and plants	1	2
	Unit 2: Thermodynamics –principles and energetic of life	**2**	**4**
19.	Fundamentals of thermodynamic principles applicable to biological processes.	1	2
20.	Bioenergetics.	1	2
	Block 4: Catabolism and its Regulation **Unit 1: Catabolism of energy molecules**	**6**	**12**
21.	Important and basic degradative metabolic pathways of carbohydrates and their regulation.	2	4
22.	Important and basic degradative metabolic pathways of lipids and their regulation.	2	4
23.	Important and basic degradative metabolic pathways of proteins and their regulation.	2	4
	Unit 2: ATP formation	**4**	**7**
24.	Formation of ATP, substrate level phosphorylation, electron transport chain	2	3
25.	Oxidative phosphorylation	1	2
26.	Chemi osmotic theory and proton motive force.	1	2
	Block 5: Fundamentals of molecular biology and genetic engineering **Unit 1: Molecular biology processes**	**5**	**10**
27.	DNA replication	1	2
28.	Transcription	2	4
29.	Translation	2	4
	Unit 2: Recombinant DNA technology	**4**	**8**
30.	Restriction enzymes, DNA cloning,	2	4
31.	Applications of cloning, transgenic	2	4
	Total	**50**	**100**

Practicals

Sr. No	Name of the practical	No. of practical classes	Weightage (%)
1.	Preparation of standard and buffer solutions	2	13
2.	Detection of carbohydrates, amino acids and proteins	1	6

3.	Extraction and estimation of sugars	1	6
4.	Extraction and estimation of aminoacids	1	6
5.	Extraction and estimation of proteins	1	6
6.	Extraction and estimation of acid value of fat/oil, peroxide value off at/oil and saponification value in fats and oils	2	13
7.	Fatty acid composition in fat/oil by GC	2	13
8.	Isolation and estimation of DNA and RNA by spectroscopic methods	2	13
9.	Estimation of ascorbic acid	1	6
10.	Separation of biomolecules by TLC and Paper chromatography	1	6
11.	Estimation of alpha amylase activity	1	6
12.	Qualitative tests for secondary plant metabolites.	1	6
	Total	**16**	**100**

I. Course Title : Intermediary Metabolism

II. Course Code : BIOCHEM 502*

III. Credit Hours : 3+0

IV. Why this course?

To understand the inter conversion of chemical compounds in the living system, the pathways taken by individual molecules, their interrelationships and the mechanisms that regulate the flow of metabolites through the pathways.

V. Aim of the course

The course is designed to give an insight into the different metabolic pathways, their interrelationship, regulation, metabolic disorders in human and pathway engineering in plants**.**

No.	Block	Units
1	Introduction to metabolism	1. Overview of metabolism 2. Metabolic pathways
2	Metabolism of energy nutrients	1. Carbohydrate metabolism 2. Lipid metabolism 3. Protein metabolism 4. Energy transduction and oxidative phosphorylation
3	Sulfur and nucleotide metabolism	1. Sulfur metabolism 2. Nucleotide metabolism
4	Metabolic regulation and defects in metabolism	1. Regulation of metabolic pathways 2. Defects in metabolism

Theory

Block 1: Introduction to Metabolism

Unit I- Overview of metabolism (07 Lectures)

The living cell-aunique chemical system, biochemical reaction types, bioenergetics, bioavailability of nutrients, transport mechanism, signal transduction.

Unit II – Metabolic pathways (08 Lectures)

Catabolism and anabolism, compartments of metabolic pathways, Interlinking between various metabolic pathways, experimental approaches to study metabolism, metabolic profiles of major organs.

Block 2: Metabolism of Energy Nutrients

Unit I- Carbohydrate metabolism (05 Lectures)

Digestion and absorption of carbohydrate, Major catabolic and anabolic pathways of

carbohydrate metabolism, the glyoxylate pathway.

Unit 2: Lipid metabolism (05 Lectures)

Digestion and absorption of lipid, Fatty acid oxidation, ketone bodies, fatty acid biosynthesis, synthesis of triacylglycerols, cholesterol, eicosanoids.

Unit 3: Protein metabolism (05 Lectures)

Digestion and absorption of protein General reactions of amino acid metabolism, degradative and biosynthetic pathways of amino acids, urea cycle, amino acids as metabolic precursors.

Unit 4: Energy transduction and oxidative phosphorylation (04 Lectures)

Mechanisms of energy transduction, electron transport system, oxidative phosphorylation, control of ATP production.

Block 3. Sulfur and Nucleotide Metabolism

Unit 1: Sulfur metabolism (06 Lectures)

Sulphate reduction and incorporation of sulphur in to amino acids.

Unit 2: Nucleotide metabolism (03 Lectures)

Synthesis and degradation of purine and pyrimidine nucleotides.

Block 4: Metabolic Regulation and Defects in Metabolism

Unit 1: Regulation of metabolic pathways (03 Lectures)

Regulation of carbohydrate, lipid, protein, nucleotide metabolism and oxidative phosphorylation. Disorders of carbohydrates, lipids, amino acids and nucleic acid metabolism, and inborn errors of metabolism. Metabolic pathway engineering.

Unit 2: Defects in metabolism (04 Lectures)

Disorders of carbohydrates, lipids, amino acids and nucleic acid metabolism, and inborn errors of metabolism. Metabolic pathway engineering.

VII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz – Case study

VIII. Learning outcome

With this course, the students are expected to learn the set of life-sustaining chemical processes that enables organisms transform the chemical energy stored in molecules into useful form and the process by which organisms respond to stimuli and metabolic disorders.

IV. Suggested Reading:

- Nelson,D.L.andCox,M.M.2017.*LehningerPrinciplesofBiochemistry*.7th edition.W. H. Freeman &Co Ltd
- Satyanarayana,U.andChakrapani,U.2017.*Biochemistry*.5thedition, Elsevier
- CampbellM.K.andFarrellS.O.2009.*Biochemistry*.6thedition Thomson Higher Education.

- Moran L. A., Horton H. ,Scrimgeou. G. and Perry, M.D.2012. *Principles of Biochemistry*. 5thedition Pearson,
- Voet, D. andVoetJ.G.2011.*Biochemistry*.4thedition. John Wiley.
- Pratt, C.W. andCornely,K.2014.*Essential Biochemistry*.3rdEdition. Wiley
- Moorthy, K.2007. *Fundamentals of BiochemicalCalculations*.2ndedition. CRC Press

Teaching Schedule (Theory)

Sr. No.	Name of the topic	No. of Lectures	Weightage (%)
	Block 1: Introduction To Metabolism **Unit I- Overview of metabolism**	**07**	**14**
1	The living cell-aunique chemical system, biochemical reaction types	02	04
2	Bioenergetics, bioavailability of nutrients	02	04
3	Transport mechanism	01	02
4	Signal transduction	02	04
	Unit II – Metabolic pathways	**08**	**16**
5	Catabolism and anabolism, compartments of metabolic pathways	02	04
6	**Interlinking between various metabolic pathways**	02	04
7	Experimental approaches to study metabolism	02	04
8	Metabolic profiles of major organs.	02	04
	Block 2: Metabolism of Energy Nutrients **Unit I- Carbohydrate metabolism**	**05**	**10**
9	**Digestion and absorption of carbohydrate**	02	04
10	Major catabolic and anabolic pathways of carbohydrate metabolism	02	04
11	Glyoxylate pathway	01	02
	Unit 2: Lipid metabolism	**05**	**10**
12	**Digestion and absorption of lipid**	02	04
13	Fatty acid oxidation, ketone bodies,	01	02
14	Fatty acid biosynthesis, synthesis of triacylglycerols, cholesterol, eicosanoids	02	04
	Unit 3: Protein metabolism	**05**	**10**
15	**Digestion and absorption of protein** General reactions of amino acid metabolism	01	02
16	Degradative and biosynthetic pathways of amino acids	02	04

17	Urea cycle, amino acids as metabolic precursors.	02	04
	Unit 4: Energy transduction and oxidative phosphorylation	**04**	**08**
18	Mechanisms of energy transduction	01	02
19	Electron transport system	01	02
20	Oxidative phosphorylation, control of ATP production.	02	04
	Block 3.Sulfur and Nucleotide Metabolism **Unit 1: Sulfur metabolism**	**06**	**12**
21	Sulfur metabolism: Sulfate reduction and incorporation of sulfur in to amino acids.	06	12
	Unit 2: Nucleotide metabolism	**03**	**06**
22	Nucleotide metabolism: Synthesis of purine and pyrimidine nucleotides.	02	04
23	Nucleotide metabolism: Degradation of purine and pyrimidine nucleotides.	01	02
	Block 4: Metabolic Regulation and Defects in Metabolism **Unit 1: Regulation of metabolic pathways**	**03**	**06**
24	Regulation of carbohydrate and lipid	02	04
25	Regulation of protein, nucleotide metabolism and oxidative phosphorylation.	01	02
	Unit 2: Defects in metabolism	**04**	**08**
26	Disorders of carbohydrates and lipids, amino acids and nucleic acid metabolism	02	04
27	Inborn errors of metabolism. Metabolic pathway engineering.	02	04
	Total	**50**	**100**

I. Course Title :Enzymology
II. Course Code :BIOCHEM 503*
III. Credit Hours :2+1

IV. Why this course?

Being highly specific and incredibly efficient biological catalysts, enzymes are responsible for bringing about almost all of the chemical reactions in living organisms. Otherwise these reactions will take place at a rate far too slow for the pace of metabolism. The course will help students in understanding the physical, chemical and kinetic properties of enzymes.

V. Aim of the course

To impart knowledge about the catalytic role of enzymes, their structure, physicochemical, kinetic and regulatory properties and mechanism of action.

No. Blocks	Units
1. Introduction to enzymes	1. Structure and function of enzyme
	2. Extraction and purification of enzymes
2. Enzyme structure and function	1. Chemical nature of enzyme
	2. Cofactors and coenzymes
	3. Nature of active site
3. Enzyme kinetics	1. Single substrate kinetics
	2. Enzyme inhibition
	3. Kinetics of allosteric enzymes
	4. Regulation of enzyme activity
4. Application of enzymology	1. Industrial application of enzymes
	2. Biotechnological application of enzymes

VI. Theory

Block 1: Introduction to Enzymes

Unit 1: Structure and function of enzyme (2 Lectures)

Historic perspective, general properties of enzymes, enzyme compartmentalization in cell organelles, nomenclature and classification of enzymes, ribozymes, isozymes, abzymes.

Unit 2: Extraction and purification of enzymes (2 Lectures)

Extraction of soluble and membrane-bound enzymes, purification of enzymes, measurement of enzyme activity.

Block 2: Enzyme Structure and Function

Unit 1: Chemical nature of enzyme (3 Lectures)

Enzyme specificity, monomeric and oligomeric enzymes, catalytic mechanism, mechanism of enzyme action, pseudoenzymes, enzyme promiscuity.

Unit 2: Cofactors and coenzymes (2 Lectures)

Chemical nature and involvement of cofactors and coenzymes in enzyme catalyzed eactions, metal activated enzymes and metaloenzymes, mechanism of enzyme catalyzed reactions without cofactors.

Unit 3: Nature of active site (2 Lectures)

Active site, identification of binding sites and catalytic sites.

Block 3. Enzyme Kinetics

Unit 1: Single substrate kinetics (4 Lectures)

Relationship between initial velocity and substrate concentration, Michaelis-Menton equation, Lineweaver-Burk and Eadie-Hofstee plots, analysis of kinetic data, numerical exercises.

Unit 2: Enzyme inhibition (2 Lectures)

Reversible and irreversible enzyme inhibition, uses of enzyme inhibition.

Unit 3: Kinetics of allosteric enzymes (3 Lectures)

Nature of allosteric enzymes, sigmoidal kinetics, MWC model and allostericregulation, KNF model and allosteric regulation.

Unit 4: Regulation of enzyme activity (3 Lectures)

Feedback regulation, regulatory enzymes, control of enzymatic activity, symmetry and sequential model, reversible covalent modification of enzymes.

Block 4: Application of enzymology

Unit 1: Industrial application of enzymes (3 Lectures)

Industrial application of enzyme catalysis in sectors like food processing, detergents, biofuels, paper and pulp, biosensors and clinical applications of enzymes.

Unit 2: Biotechnological application of enzymes (2 Lectures)

Large scale production and purification of enzymes, immobilization of enzymes.

VII. Practicals

- Soluble protein estimation
- Enzyme assay by taking any model enzyme
- Isolation and purification of any model enzyme
- Study of the effect of enzyme and substrate concentrations on enzyme activity
- Determination of Km and Vmax
- Determination of pH and temperature optima
- Effect of inhibitors on enzyme activity
- Determination of pH and temperature stability of enzyme
- Electrophoretic analysis of isozymes.

VIII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)

– Oral presentation by students on specified topics
– Class room quiz
– Case study

IX. Learning outcome

After completion of this course students are expected to have knowledge on and insight into the chemical principles of enzyme catalysis, action of enzymes as biocatalysts and factors that influence enzyme activity and understand the kinetics of enzymatic reactions. Students will have experience with purification, handling and characterization of proteins and also get exposure of wide applications of enzymes and their future potential.

X. Suggested Reading

• Palmer T and Bonner PL. 2007. *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry*.2nd edition.Woodhead Publishing
• Okotore RO. 2015. *Essentials of Enzymology*. XLIBRIS
• Herald J. 2016. *Essentials of Enzymology*.Syrawood Publishing House
• Suzuki, H. 2015. *How Enzymes Work: From Structure to Function*. Jenny Stanford Publishing.
• Bugg TDH. 2012. *Introduction to Enzyme and Coenzyme Chemistry*, 3rd Edition. WILEY
• Guo Y. 2014. *Enzyme Engineering*. Science Press
• Bisswanger H. 2011. *Practical Enzymology*. Wiley-Blackwell

Teaching Schedule (Theory)

Sr. No.	Name of topics	No. of Lectures	Weightage (%)
	Block 1: Introduction to Enzymes **Unit 1: Structure and function of enzyme**	**3**	**9**
1	Historic perspective, General properties of enzymes, enzyme compartmentalization in cell organelles	1	3
2	Nomenclature and classification of enzymes,	1	3
3	Ribozymes, abzymes.	1	3
	Unit 2: Extraction and purification of enzymes	**2**	**6**
4	Extraction of soluble and membrane-bound enzymes,	1	3
5	Purification of enzymes, measurement of enzyme activity.	1	3
	Block 2: Enzyme Structure and Function **Unit 1: Chemical nature of enzyme**	**4**	**12**
6	Enzyme specificity, monomeric and oligomeric enzymes,	1	3
7	Catalytic mechanism, mechanism of enzyme action.	2	6
8	Pseudo enzymes, enzyme promiscuity.	1	3
	Unit 2: Cofactors and coenzymes	**2**	**6**

9	Chemical nature and involvement of cofactors and coenzymes in enzyme catalyzed reactions,	1	3
10	Metal activated enzymes and metallo enzymes, mechanism of enzyme catalyzed reactions without cofactors.	1	3
	Unit 3: Nature of active site	**2**	**6**
11	Active site, Identification of binding sites and catalytic sites	2	6
	Block 3. Enzyme Kinetics **Unit 1: Single substrate kinetics**	**6**	**18**
12	Relationship between initial velocity and substrate concentration,	2	6
13	Michaelis-Menton equation,	1	3
14	Lineweaver-Burk and Eadie-Hofstee plots, analysis of kinetic data	2	6
15	Numerical exercises.	1	3
	Unit 2: Enzyme inhibition	**2**	**6**
16	Reversible and irreversible enzyme inhibition, uses of enzyme inhibition.	2	6
	Unit 3: Kinetics of allosteric enzymes	**3**	**9**
17	Nature of allosteric enzymes, sigmoidal kinetics,	1	3
18	MWC model and allosteric regulation, KNF model and allosteric regulation	2	6
	Unit 4: Regulation of enzyme activity	**4**	**12**
19	Feedback regulation, regulatory enzymes, control of enzymatic activity,	2	6
20	Nature of allosteric enzymes, sigmoidal kinetics, symmetry and sequential model, reversible covalent modification of enzymes.	2	6
	Block 4: Application of Enzymology **Unit 1: Industrial applications of enzymes**	**5**	**15**
21	Industrial application of enzyme catalysis in sectors like food processing, detergents, biosensors	2	6
22	Industrial application of enzyme catalysis in sectors like biofuels, paper , pulp,	2	6
19	Clinical applications of enzymes.	1	3
	Unit 2: Biotechnological applications of enzymes	**2**	**6**
20	Large scale production of enzymes	1	3
21	Immobilization of enzymes	1	3
	Total	**35**	**100**

Practicals

Sr. No.	Name of topics	No. of Practicals	Weightage (%)
1	Soluble protein estimation	1	6
2	Enzyme assay by taking any model enzyme	2	12
3	Isolation and purification of any model enzyme	2	12
4	Study of the effect of enzyme and substrate concentrations on enzyme activity	2	12
5	Determination of Km and Vmax	2	12
6	Determination of pH and temperature optima	2	12
7	Effect of inhibitors on enzyme activity	2	12
8	Determination of pH and temperature stability of enzyme	2	12
9	Electrophoretic analysis of isozymes.	2	12
	Total	**17**	**102**

I. Course Title : Molecular Biology
II. Course Code : BIOCHEM 504
III. Credit Hours : 2+1

IV. Why this course?

Molecular biology is the study of biology at a molecular level. The concepts and techniques of molecular biology are the foundation for the studies of all aspects of biology in modern time. This course is designed to provide an intensive exposure to the theoretical concepts and experimental techniques of molecular biology and the interrelationship of DNA, RNA and protein synthesis and their regulation.

V. Aim of the course

To provide knowledge of life processes at the molecular and cellular levels, including the storage, transfer and regulation of genetic information and specialist theoretical knowledge and practical experience of gene manipulation and the analysis of nucleic acids and proteins.

No.	Blocks	Units
1.	Introduction to nucleic acids	1. History
		2. Properties of nucleic acid
		3. Genes and genome
2.	Synthesis of nucleic acids	1. DNA replication
		2. Transcription
3.	Protein synthesis	1. Translation machinery
		2. Mechanism of protein synthesis
		3. Post-translational events
4.	Gene manipulation	1. DNA sequencing
		2. Recombinant DNA technology
		3. Techniques in molecular biology

VI. Theory

Block 1: Introduction to Nucleic Acids

Unit 1: History (1 Lecture)

Historical development of molecular biology, nucleic acids as genetic material.

Unit 2: Properties of nucleic acid (2 Lectures)

Nucleic acid structure, chemical and physical properties of nucleic acids, spectroscopic and thermal properties of nucleic acids, DNA supercoiling.

Unit 3: Genes and genome (4 Lectures)

Concept of genes and genome, genome complexity**,** genome organization in prokaryotes and eukaryotes, chromatin structure and function, repetitive and non repetitive DNA, satellite DNA central dogma, genome editing.

Block 2: Synthesis of Nucleic Acid

Unit 1: DNA replication (4 Lectures)

Modes of replication, DNA polymerases, topoisomerases, DNA ligase, model of replisome, semi conservative replication in prokaryotes and eukaryotes, inhibitors of replication, DNA damage and repair.

Unit 2: Transcription (3 Lectures)

Basic principles of transcription, transcription initiation, elongation and termination, RNA processing, RNA interference, siRNAs, miRNAs and other ncRNAs, DNA/RNA editing. regulation of transcription, reverse transcription.

Block 3. Protein Synthesis

Unit 1: Translation machinery (2 Lectures)

Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacylt RNA synthases.

Unit 2: Mechanism of protein synthesis (3 Lectures)

Initiation, chain elongation and termination of translation, energetics, inhibitors of translation.

Unit 3: Post-translational events (3 Lectures)

Post translational modifications of nascent polypeptide, protein targeting and turnover, regulation of gene expression in prokaryotes and eukaryotes, nucleases and restriction enzymes.

Block 4: Gene Manipulation

Unit 1: DNA sequencing (3 Lectures)

Importance, Sanger method, High-Throughput Sequencing (HTS) techniques, applications of DNA sequencing.

Unit 2: Recombinant DNA technology (5 Lectures)

Vectors, isolation of genes, recombinants vector, selection of recombinants, characterization and expression of cloned DNA, transformation, transgenesis, mutation, molecular mechanism of mutation, site directed mutagenesis, *in vitro* mutagenesis.

Unit 3: Techniques in molecular biology (4 Lectures)

Polymerase chain reaction (PCR), expression cloning, gel electrophoresis, molecular markers, macromolecule blotting and probing, arrays (DNA array and protein array) – principles and application.

VII. Practicals

- Isolation and purification of DNA and RNA
- To check the purity of isolated DNA and RNA
- Restriction fragmentation of genomic DNA
- Separation of oligos by agarose gel electrophoresis
- Southern blotting experiments

- Northern blotting experiments
- Cloning of DNA fragment in vector
- Selection of recombinant
- SSR analysis of DNA
- cDNA synthesis using RT- PCR
- Basic tools in bioinformatics analysis

VIII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz
– Case study

IX. Learning outcome

After completion, the student should be able to explain central cell biological processes and how they are regulated and quality assured and understands how molecular cell biology forms the foundation of biotechnology.

X. Suggested Reading

- Snape A, Papachristodoulou D, Elliott, W. H. and Elliott, C. 2014. *Biochemistry and Molecular Biology*. Oxford University Press.
- Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. 2018. *Lewin's GENES XII*. Jones & Bartlett Learning.
- Lodish, H.,Berk, A., Kaiser, C. A., Krieger, M. And Bretscher, A. 2016. *Molecular Cell Biology*.W H Freeman & Co.
- Hoffmann, A. And Clokie, S. 2018. *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*.Cambridge University Press.
- Primrose SB, Twyman RM and Old RW.2002. *Principles of Gene Manipulation*: 6th Ed. Wiley
- Karp, G. 2013. *Cell and Molecular Biology*. Wiley.
- Neidle, S. 2008. *Principles of Nucleic Acid Structure*. Elsevier Inc.
- Watson J, Baker TA, Bell SP, Gann A, Levine M and Losick, R. 2014. *Molecular biology of the gene* 7th edition, Pearson.

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No. of lectures	Weightage (%)
	Block 1: Introduction to Nucleic Acids **Unit 1: History**	**1**	**3**
1.	Historical development of molecular biology, nucleic acids as genetic material.	1	3

	Unit 2: Properties of nucleic acid	**2**	**6**
2.	Nucleic acid structure, chemical and physical properties of nucleic acids, spectroscopic and thermal properties of nucleic acids, DNA supercoiling.	2	6
	Unit 3: Genes and genome	**4**	**12**
3.	Concept of genes and genome, genome complexity**.**	1	3
4.	Genome organization in prokaryotes and eukaryotes,	1	3
5.	Chromatin structure and function, repetitive and nonrepetitive DNA, satellite DNA central dogma, genome editing.	2	6
	Block 2: Synthesis of Nucleic Acid **Unit 1: DNA replication**	**4**	**12**
6.	Modes of replication, DNA polymerases, topoisomerases, DNA ligase, model of replisome,	1	3
7.	Semi conservative replication in prokaryotes and eukaryotes,	1	3
8.	Inhibitors of replication, DNA damage and repair.	2	6
	Unit 2: Transcription	**3**	**9**
9.	Basic principles of transcription: transcription initiation, elongation and termination,	1	3
10.	RNA processing, RNA interference, siRNAs, miRNAs and other ncRNAs,	1	3
11.	DNA/RNA editing, regulation of transcription, reverse transcription.	1	3
	Block 3. Protein Synthesis **Unit 1: Translation machinery**	**2**	**6**
12.	Ribosomes structure and function, organization of ribosomal proteins and RNA genes.	1	3
13.	Genetic code, aminoacylt RNA synthases.	1	3
	Unit 2: Mechanism of protein synthesis	**3**	**9**
14.	Initiation, chain elongation and termination of translation,	2	6
15.	Energetics, inhibitors of translation.	1	3
	Unit 3: Post-translational events	**3**	**9**
16.	Post translational modifications of nascent polypeptide, protein targeting and turnover.	1	3
17.	Regulation of gene expression in prokaryotes and eukaryotes,	1	3
18.	Nucleases and restriction enzymes.	1	3
	Block 4: Gene Manipulation **Unit 1: DNA sequencing**	**3**	**9**
19.	Importance, Sanger method,	1	3
20.	High-Throughput Sequencing (HTS) techniques, applications of	2	6

	DNA sequencing.		
	Unit 2: Recombinant DNA technology	**5**	**15**
21.	Vectors, isolation of genes, recombinants vector, selection of recombinants,	1	3
22.	Characterization and expression of cloned DNA, transformation, transgenesis,	2	6
23.	Mutation, molecular mechanism of mutation, site directed mutagenesis, *in vitro* mutagenesis.	2	6
	Unit 3: Techniques in molecular biology	**4**	**12**
24.	Polymerase chain reaction (PCR), expression cloning, gel electrophoresis, molecular markers,	2	6
25.	Macromolecule blotting and probing, arrays (DNA array and protein array) –principles and application.	2	6
	Total	**34**	**100**

Practicals

Sr. No.	**Name of the practicals**	**No. of practical**	**Weightage (%)**
1.	Isolation and purification of DNA and RNA and check the purity of isolated DNA and RNA	2	12
2.	Restriction fragmentation of genomic DNA	1	6
3.	Southern blotting experiments	2	12
4.	Northern blotting experiments	2	12
5.	Cloning of DNA fragment in vector	2	12
6.	Selection of recombinant	2	12
7.	SSR analysis of DNA	2	12
8.	cDNA synthesis using RT- PCR	2	11
9.	Basic tools in bioinformatics analysis	2	11
	Total	**17**	**100**

I. Course Title : Techniques in Biochemistry
II. Course Code : BIOCHEM 505*
III. Credit Hours : 2+2

IV. Why this course?

Biochemical studies rely on the availability of appropriate analytical techniques and their applications. This course will examine modern methods and technologies that are used in biochemical analysis with emphasis on instrumentation, underlying principles, aims, strategies and current applications.

V. Aim of the course

To provide hands-on experience to different biochemical techniques commonly usedin research along with the knowledge on principles and the instrumentation**.**

No.	Blocks	Units
1.	Separation techniques	1. Chromatography techniques
		2. Electrophoretic technique
		3. Hydrodynamic methods
		4. Centrifugation
2.	Spectroscopic techniques	1. Spectrophotometry
		2. Mass spectroscopy
		3. Atomic absorption spectrophotometry
3.	Microscopy	1. Microscopic techniques
4.	Tracer, imaging, immunochemical and other techniques	1. Tracer techniques and other techniques
		2. Imaging techniques
		3. Immunochemical techniques
		4. Other techniques

VI. Theory

Block 1: Separation Techniques

Principles and applications of separation techniques.

Unit 1: Chromatography techniques (5 Lectures)

Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity, column& HPTLC, GC, HPLC and FPLC.

Unit 2: Electrophoretic technique (3 Lectures)

General principles, paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE,capillary electrophoresis.

Unit 3: Hydrodynamic methods (2 Lectures)

Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation velocity, - their principles.

Unit 4: Centrifugation (2 Lectures)

Basic principles of sedimentation, type, care and safety aspects of centrifuge preparative and analytical centrifugation.

Block 2: Spectroscopic Techniques

Unit 1: Spectrophotometry (4 Lectures)

Principles and applications of UV-visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

Unit 2: Mass spectroscopy (4 Lectures)

MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry in biochemistry.

Unit 3: Atomic absorption spectrophotometry (2 Lectures)

Principle, function and instrumentation of atomic absorption spectrophotometry.

Block 3. Microscopy

Unit 1: Microscopic techniques (3 Lectures)

Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy, flow cytometry.

Block 4: Tracer, Imaging, Immunochemical and Other Techniques

Unit 1: Tracer technique (3 Lectures)

Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of α, β and γ emitters, scintillation counters, γ-ray spectrometers, autoradiography, applications of radioactive tracers in biology.

Unit 2: Imaging techniques (2 Lectures)

Principles and applications of phosphor imager, MRI and CT scan.

Unit 3: Immunochemical technique (2 Lectures)

Production of antibodies, immune precipitation, immune blotting, immune assays,RIA and ELISA.

Unit 4: Other techniques (2 Lectures)

Cryopreservation, polymerase chain reaction (PCR), FACS.

VII. Practicals

- Expression of concentration in terms of dilution, molarity, normality, percent expression
- pH measurement and buffer preparation
- Determination of absorption maxima of biomolecules
- Estimation of biomolecules through spectrophotometry and other methods
- Separation of carbohydrates and amino acids by paper chromatography

- Separation and analysis of fatty acids/lipids by GC
- Separation/estimation of biomolecules through HPLC and FPLC
- Separation of proteins using ion exchange, gel filtration and affinity chromatography
- Electrophoretic separation of proteins and nucleic acids
- Centrifugation- differential and density gradient
- (NH4)2SO4 precipitation and dialysis
- Use of radioisotopes in metabolic studies
- PCR
- ELISA
- Western blotting/ Dot blotting

VIII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz
– Case study

IX. Learning outcome

At the end of the course, the student will acquire the basic knowledge of the main biochemical methods used in the separation, identification, characterization and analysis of biomolecules.

X. Suggested Reading

- Boyer R. 2011. *Biochemistry Laboratory: Modern Theory and Techniques* 2nd Edition. Pearson
- Hofmann A and Clokie S. 2010. *Wilson and Walker's Principles and Techniques ofBiochemistry and Molecular Biology*. 7th edition. Cambridge University Press.
- Sawhney SK and Singh R. 2000. *Introductory Practical Biochemistry*. 2nd Ed. Narosa
- Katoch R. 2011. *Analytical Techniques in Biochemistry and Molecular Biology*. Springer
- Boyer R. 2009. *Modern Experimental Biochemistry*. Fifth impression. Pearson
- Lottspeich F and Engels JW. (Eds). 2018. *Bioanalytics: Analytical Methods and Concepts inBiochemistry and Molecular Biology.* Wiley-VCH
- Wilson K and Walker J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*, 7th Edition. Cambridge University Press

Teaching Schedule (Theory)

Sr. No.	Name of the topic	No. of lectures	Weightage (%)
	Block 1: Separation Techniques **Unit 1: Chromatography techniques**	**5**	**15**
1.	Principles and applications of separation techniques, Plate and rate theory.	1	3

2.	Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity, column & HPTLC.	2	6
3.	Principles and applications of GC, HPLC and FPLC.	2	6
	Unit 2: Electrophoretic technique	**3**	**9**
4.	General principles, paper and gel electrophoresis, native-and SDS-PAGE.	2	6
5.	2D-PAGE, capillary electrophoresis.	1	3
	Unit 3: Hydrodynamic methods	**2**	**6**
6.	Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation velocity, - their principles. Effect of clearing (*k*) factor for the rotor on sedimentation.	2	6
	Unit 4: Centrifugation	**2**	**6**
7.	Basic principles of sedimentation, type, care and safety aspects of centrifuge preparative and analytical centrifugation. Determination *g* force and revolutions per minute (rpm) by use of a nomogram. Forces acting on a particle in a centrifugal field.	2	6
	Block 2: Spectroscopic Techniques Unit 1: Spectrophotometry	**4**	**12**
8.	Principles and applications of UV-visible.	1	3
9.	Fluorescence, IR and FTIR, Raman, NMR and FTNMR.	2	6
10.	ESR and X-Ray spectroscopy.	1	3
	Unit 2: Mass spectroscopy	**4**	**12**
11.	MS/MS, LC-MS, GC-MS.	2	6
12.	MALDI-TOF, applications of mass spectrometry in biochemistry.	2	6
	Unit 3: Atomic absorption spectrophotometry	**2**	**6**
13.	Principle, function and instrumentation of atomic absorption spectrophotometry.	2	6
	Block 3. Microscopy **Unit 1: Microscopic techniques**	**3**	**9**
14.	Principles and applications, light, UV, phase contrast.	1	3
15.	Principles and applications, fluorescence and electron microscopy, flow cytometry.	2	6
	Block 4: Tracer, Imaging, Immunochemical and Other Techniques **Unit 1: Tracer technique**	**3**	**9**
16.	Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of α, β and γ emitters,	1	3
17.	Scintillation counters, γ-ray spectrometers, autoradiography, applications of radioactive tracers in biology.	2	6

	Unit 2: Imaging techniques	**2**	**6**
18.	Principles and applications of phosphor imager, MRI and CT scan.	2	6
	Unit 3: Immunochemical technique	**2**	**6**
19.	Production of antibodies, immunoprecipitation, immunoblotting, immunoassays, RIA and ELISA.	2	6
	Unit 4: Other techniques	**2**	**6**
20.	Cryopreservation, polymerase chain reaction (PCR), fluorescence-activated cell sorting (FACS).	2	6
	Total	**34**	**100**

Practicals

Sr. No.	**Name of the practicals**	**No. of practicals**	**Weightage (%)**
1.	Expression of concentration in terms of dilution, molarity, normality, percent expression	1	3
2.	pH measurement and buffer preparation	1	3
3.	Determination of absorption maxima of biomolecules	1	3
4.	Estimation of soluble through spectrophotometry and other methods	1	3
5.	Separation of carbohydrates and amino acids by paper chromatography	1	3
6.	Separation of active principals in medicinal and commercial crops by TLC and RP-HPLC	3	9
7.	Separation and analysis of fatty acids/lipids by GC	3	9
8.	Separation/estimation of biomolecules through HPLC and FPLC	3	9
9.	Separation of proteins using ion exchange chromatography	1	3
10.	Separation of proteins using gel filtration chromatography	1	3
11.	Separation of proteins using affinity chromatography	1	3
12.	Electrophoretic separation of proteins and nucleic acids	2	9
13.	Electrophoretic separation of nucleic acids	1	
14.	Centrifugation- differential and density gradient	1	3
15.	Ammonium sulphate [$(NH_4)_2SO_4$] precipitation and dialysis	2	6
16.	Use of radioisotopes in metabolic studies	3	9
17.	Isolation of genomic DNA and PCR amplification	3	9
18.	Detection of antibodies by ELISA	2	6
19.	Western blotting/ Dot blotting	3	9
	Total	**34**	**100**

I. Course Title: Immunochemistry
II. Course Code: BIOCHEM506
III. Credit Hours: 2+1

Why this course?

This is an introduction to the field of immunology with emphasis on the biochemical aspects of the systems. This course is intended to equip the student with the knowledge and understanding of the vertebrate immune system, its component and mechanism of immune responses with specific reference to the human immune defense system and plant immunity

IV. Aim of the course

To give an insight into the biochemical basis of immunity

No.	Blocks	Units
1.	Basics of Immunology	1.Introductiontoimmunology 2. Antibodies 3. The immuneresponses 4.Immunoregulation and immunological techniques

V. Theory

Block 1: Basics of immunology

Unit 1: Introduction to immunology (9 Lectures)

History and scope of immunology, antigens, adjuvants, immune system, organs, tissues and cells, immunoglobulins, molecular organization of immunoglobulin. Haptens, Ag-Abinteraction, plant immunity, proteasome mediated process, plantibodies

Unit 2: Antibodies (6 Lectures)

Classesofantibodies,antibodydiversity,theoriesofgenerationofantibodydiversity, vaccine, monoclonal and polyclonal antibodies, hybridoma, recombinant antibodies, complement system-classical and alternate.

Unit 3: The immune responses (9 Lectures)

Cellular interactions in immune response, major histocompatibility complex, cell mediated immune response, cytokines.

Unit 4: Immunoregulation and immunological techniques (10 Lectures)

Immunoregulation, immunological tolerance, hypersensitivity, mechanisms of immunity, innate resistance and specific immunity, current immunological techniques – ELISA, RIA, immunoblotting, FACS; basics of PCR and hybridization based methods of detection,

microarray based detection, multiplexing.

VI. Practicals

- Handling, inoculation and bleeding of laboratory animals
- Preparation of antigens and antisera, natural antibodies
- Carbon clearance test
- Lymphoid organs of the mouse
- Morphology of the blood leucocytes
- Separation of lymphocytes from blood, viable lymphocyte count
- Antigen-antibody interaction,
- Precipitation and agglutination
- Direct and indirect haemagglutination
- Immunoelectrophoresis
- Complement fixation
- Quantitation of immunoglobulins by zinc sulphate turbidity and single radial immunodiffusion
- ELISA
- Western blotting
- Fluorescent Abtest
- Hybridoma technique

VII. Teaching methods/activities

- Classroom lectures (oral +audio-visual)
- Assignment(Reading/Writing)
- Oral presentation by students on specified topics
- Class room quiz
- Case study

VIII. Learning outcome

It is expected that the student should understand and explain the structure, functioning and importance of human immune system in term of health and disease.

IX. Suggested Reading

- PuntJ,StranfordS,JonesPandOwenJ.2018.KubyImmunology.8th edition.W.H.Freeman
- Renshaw S. 2016. *Immunohistochemistry and Immunocytochemistry: Essential Methods*, 2nd Edition. John Wiley & Sons,Ltd.
- AbbasAK,LichtmaAHandPillaiS.2018.*CellularandMolecularImmunology*.9th edition.
- Elsevier
- Delves PJ, Martin SJ, Burton DR and Roitt IM. 2017. *Roitt's Essential Immunology*, 13th Edition.Wiley-Blackwell

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No. of Lectures	Weightage (%)
	Block 1: Basics of immunology **Unit 1: Introduction to immunology**	**9**	**27**
1.	History and scope of immunology	1	3
2.	Antigens, adjuvants, immune system, organs, tissues and cells.	2	6
3.	Immunoglobulins.	1	3
4.	Molecular organization of immunoglobulin.	2	6
5.	Haptens, Ag-Abinteraction,	1	3
6.	Plant immunity, proteasome mediated process,	1	3
7.	Plantibodies	1	3
	Unit 2: Antibodies	**6**	**18**
8.	Classes of antibodies, antibody diversity	2	6
9.	Theories of generation of antibody diversity,	1	3
10.	Vaccine, monoclonal and polyclonal antibodies,	1	3
11.	Hybridoma, recombinant antibodies complement system-classical and alternate.	2	6
	Unit 3: The immune responses	**9**	**26**
12.	Cellular interactions in immune response	3	9
13.	Major histo-compatibility complex	3	8
14.	Cell mediated immune response,	2	6
15.	Cytokines	1	3
	Unit 4: Immunoregulation and immunological techniques	**10**	**29**
16.	Immunoregulation, immunological tolerance, hypersensitivity	2	6
17.	Mechanisms of immunity, innate resistance and specific immunity	2	6
18.	Current immunological techniques – ELISA,RIA, immune blottingfacs	3	8
19.	Basics of PCR and hybridization based methods of detection,	2	6
20.	Microarray based detection, multiplexing	1	3
	Total	**34**	**100**

Practicals

Sr. No	Name of the practical	No. of practicals	Weightage (%)
1.	Handling, inoculation and bleeding of laboratory animals	1	6
2.	Preparation of antigens and antisera, natural antibodies	1	6
3.	Carbon clearance test	1	6
4.	Lymphoid organs of the mouse, Morphology of the bloodleucocytes	1	6

5.	Separation of lymphocytes from blood, viable lymphocyte count, Antigen-antibody interaction	1	6
6.	Precipitation and agglutination, Direct and indirect haemagglutination	1	6
7.	Immuno electrophoresis	2	10
8.	Complement fixation	1	6
9.	Quantitation of immunoglobulins by zinc sulphate turbidity and single radial immune diffusion	2	12
10.	ELISA	2	12
11.	Westernblotting	2	12
12.	Fluorescent antibody test	1	6
13.	Hybridoma technique	1	6
	Total	**17**	**100**

I. Course Title :Plant Biochemistry
II. Course Code :BIOCHEM507
III. Credit Hours :2+1

IV. Why this course?

Harnessing sunlight, plants produce a diverse array of chemical compounds to survive in challenging ecological niches. Plant-derived metabolites are major sources of human food, fibre, fuel, and medicine. This course covers topics related to plant metabolism and discusses how plants generate carbon and energy sources by photosynthesis and synthesize various compounds through complex networks of metabolic pathways.

V. Aim of the course

To provide an understanding of metabolic processes in plants and the role of different biosynthetic pathways in plant growth and development.

No.	Blocks	Units
1.	Photosynthesis	1. Photosynthetic machinery 2. Carbon reduction
2.	Conversion of photosynthate	1. Synthesis of major biomolecules 2. Nitrogen and sulphur metabolism
3.	Growth and development	1. Germination and fruit ripening 2. Phytohormones
4.	Secondary metabolites	1. Biochemistry of plant secondary metabolites

VI. Theory

Block1: Photosynthesis

Unit1:Photosynthetic machinery (6Lectures)

Structure and function of plant cell and its organelles, phytochromes, chloroplast morphology structure, structure and chemistry of photosynthetic pigments, light reaction of photosynthesis.

Unit2:Photosynthesis–the process (7Lectures)

Carbon reduction in C_3, C_4 and CAM plants, photorespiration, sucrose-starch interconversion.

Block2: Conversion of Photosynthates

Unit1:Synthesis of major biomolecules (6Lectures)

Biosynthesis of structural carbohydrates, storage proteins and lipids.

Unit2:Nitrogen and sulfur metabolism (9Lectures)

Basic concepts of nitrogen and sulfur metabolism: biological nitrogen fixation, nitrate assimilation in plants, sulfur chemistry and function, reductive sulfur assimilation pathway, sulfur compounds.

Block3: Growth and Development

Unit1: Germination and fruit ripening (7Lectures)

Biochemistry of seed germination– stages, requirements, metabolism and mobilization of storage material; Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production.

Unit2:Phytohormones (6Lectures)

Different classes of phytohormones, their biosynthesis and mode of action.

Block4:Secondary Metabolites

Unit1:Biochemistry of plant secondary metabolites (11Lectures)

Biochemistry and significance of plant secondary metabolites – phenolics, terpenoids, alkaloids, cyano genicglycosides and glucosinolates, effect of biotic and abiotic factors on plant metabolism and plant defense system.

VII. Practicals

- Fractionation of cell organelles,
- Estimation of starch,
- Assay of ADPG pyrophosphorylase/ starch synthase,
- Assay of PAL/SOD
- Assay of PPO/LOX,
- Estimation of individual amino acids,
- Qualitative tests of secondary metabolites (alkaloids, sterols etc.)
- Content and composition of carotenoids, anthocyanin and chlorophylls
- Determination of polyphenols/ phenolics
- Fractionation of storage proteins
- Estimation of glucosinolates
- Estimation of cyanogenic compounds.

VIII. Teaching methods/activities

- Classroom lectures(oral + audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Classroom quiz
- Case study

IX. Learning outcome

Successful completion of this course will provide students with fundamental knowledge

of biochemistry and specific knowledge of compounds and biochemical pathways that occur in plant

X. Suggested Reading

- Buchannan BB, Gruissem W and Jones R.L. (eds.). 2000. Biochemistry and Molecular BiologyofPlants.2nd edition. WILEY Blackwell
- Heldt,H-W.2010.Plant Biochemistry and Molecular Biology.4th ed. Oxford University Press
- Goodwin TW and Mercer EI.2005. Introduction to Plant Biochemistry. 2nd edition. CBS
- Heldt,H-W.and Piechulla, B. 2010.Plant Biochemistry.4th Edition. Elsevier
- Harinda, Makkea and Klaus.2007.Plant Secondary Metabolites. Springer
- Cseke LJ, Kirakosyan A, Kaufman PB, Warber S, Duke JA, Brielmann HL. 2006. Natural Products from Plants. 2nd Edition. CRC Press

Teaching Schedule (Theory)

Sr. No.	Name of the topic	No. of lectures	Weightage (%)
	Block1: Photosynthesis **Unit1:Photosynthetic machinery**	**4**	**12**
1	Structure and function of plant cell and its organelles	1	3
2	Phytochromes, chloroplast morphology structure, structure and chemistry of photosynthetic pigments	1	3
3	Light reaction of photosynthesis	2	6
	Unit 2: Photosynthesis – the process	**5**	**14**
4	Carbon reduction in C3, C4 and CAM plants	2	6
5	Photorespiration	1	3
6	Sucrose-starch interconversion	2	6
	Block 2: Conversion of Photosynthates **Unit 1: Synthesis of major biomolecules**	**4**	**12**
7	Biosynthesis of structural carbohydrates	2	6
8	Biosynthesis storage proteins and lipids.	2	6
	Unit 2: Nitrogen and sulfur metabolism	**6**	**18**
9	Basic concepts of nitrogen and sulfur metabolism: biological nitrogen fixation,	2	6
10	Biochemistry of nitrate assimilation in plants	2	6
	Block 3: Growth and Development **Unit 1: Germination and fruit ripening**	**5**	**14**

11	Biochemistry of seed germination – stages, requirements, metabolism and	2	6
12	Mobilization of storage material	1	3
13	Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production	2	6
	Unit 2: Phytohormones	**4**	**12**
14	Different classes of phytohormones	1	3
15	Phytohormones biosynthesis	2	6
16	Phytohormones mode of action	1	3
17	Biochemistry and significance of plant secondary metabolites – phenolics	1	3
	Block 4: Secondary Metabolites **Unit 1: Biochemistry of plant secondary metabolites**	**7**	**20**
18	Biochemistry and significance of plant secondary metabolites –terpenoids	1	3
19	Biochemistry and significance of plant secondary metabolites –alkaloids	1	3
20	Biochemistry and significance of plant secondary metabolites – cyanogenic glycosides	1	3
21	Biochemistry and significance of plant secondary metabolites –glucosinolates	1	3
22	Effect of biotic and abiotic factors on plant metabolism and plant defense system	2	6
	Total	**35**	**100**

Practicals

Sr. No.	Name of the topic	No. of Practicals	Weightage (%)
1	Fractionation of cell organelles	1	6
2	Estimation of starch	1	6
3	Assay of ADPG pyrophosphorylase/ starch synthase	1	6
4	Assay of PAL/SOD	2	12
5	Assay of PPO/LOX	2	12
6	Estimation of individual amino acids	2	12
7	Qualitative tests of secondary metabolites (alkaloids, sterols etc.)	1	6
8	Content and composition of carotenoids, anthocyanin and chlorophylls	2	12

9	Determination of polyphenols/ phenolics	1	6
10	Fractionation of storage proteins	2	12
11	Estimation of glucosinolates	2	12
	Total	**17**	**100**

I. Course Title : Animal Biochemistry
II. Course Code : BIOCHEM 508
III. Credit Hours : 3+0

IV. Why this Course?

Biochemistry is one of the few basic sciences where animal and plant kingdoms meet. It provides the knowledge base for all human and animal health studies. Knowledge of biochemistry will enable one to study, or to pursue a line of research in applied sciences.

V. Aim of the Course

To impart knowledge regarding biochemistry of various physiological processes, specialized tissues and hormone action in animal system

No.	Blocks	Units
1.	Animal biochemistry	1. Biochemistry of assimilation 2. Nutrients and their biochemistry 3. Hormones and their role 4. Immune system

VI. Theory

Block 1: Animal Biochemistry

Unit 1: Biochemistry of assimilation (13 Lectures)

Digestion and absorption of food, Detoxification, biochemistry of specialized tissues– connective tissue, skin, muscle, nervous tissue and blood and other body fluids.

Unit 2: Nutrients and their biochemistry (13 Lectures)

Water, electrolyte and acid-base balance, structure, function and mechanism of major trace elements, vitamins, energy nutrients and biochemistry of respiration, bioactive peptides and functional oligosaccharides.

Unit 3: Hormones and their role (12 Lectures)

Hormones of thyroid, hypothalamus, pituitary, pancreas, adrenals and sex hormones, Membrane receptors of hormones, signal transduction.

Unit 4: Immune system (12 Lectures)

Immune systems, immunoglobulins, monoclonal antibodies, formation of antibody, antibody diversity, complement system – classical and alternate, major histocompatibility complexes, cell mediated immune response, mechanisms of immunity.

VII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz

– Case study

VIII. Learning outcome

Students can acquire essential foundation knowledge for further study in life sciences, agriculture, environmental science, health science, etc.

IX. Suggested Reading

- Bradley, A. 2018. Animal Physiology and Biochemistry. 1st edition. Edtech Press
- Agarwal RA, Srivastava, A.K. and Kumar, K. 2010. *Animal Physiology and Biochemistry*.Fifth revised edition S. Chand.
- Rodwell VA, Bender DA, Botham KM, Kennelly PJ and Weil PA. 2018. *Harper's IllustratedBiochemistry*, 31st edition. McGraw-Hill Education.

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No. of lectures	Weightage (%)
	Block 1: Animal Biochemistry **Unit 1: Biochemistry of assimilation**	**13**	**26**
1.	Digestion of food.	2	4
2.	Absorption of food.	2	4
3.	Detoxification.	3	6
4.	Biochemistry of specialized tissues–connective tissue, skin, muscle, nervous tissue.	3	6
5.	Blood and other body fluids.	3	6
	Unit 2: Nutrients and their biochemistry	**13**	**26**
6.	Water, electrolyte and acid-base balance.	2	4
7.	Structure, function and mechanism of major trace elements,	3	6
8.	Structure, function and mechanism of vitamins, energy nutrients.	2	4
9.	Biochemistry of respiration.	3	6
10.	Bioactive peptides and functional oligosaccharides.	3	6
	Unit 3: Hormones and their role	**12**	**24**
11.	Hormones of thyroid, hypothalamus, pituitary, pancreas.	3	6
12.	Adrenals and sex hormones.	3	6
13.	Membrane receptors of hormones.	3	6
14.	Signal transduction.	3	6
	Unit 4: Immune system	**12**	**24**
15.	Immune systems, immunoglobulins, monoclonal antibodies.	3	6
16.	Formation of antibody, antibody diversity.	3	6
17.	Complement system–classical and alternate, major histo-compatibility complexes.	3	6
18.	Cell mediated immune response, mechanisms of immunity.	3	6
	Total	**50**	**100**

I. Course Title :Nutritional Biochemistry
II. Course Code :BIOCHEM 509
III. Credit Hours :2+1

IV. Why this course?

Nutritional biochemistry deals with the structural and functional characteristics of macro and micronutrients in food consumed by humans. The course will eXpand understanding of the biological roles of nutrients and their metabolism using basic knowledge in physiology, biochemistry, cell biology and molecular biology. It will integrate information on the roles of nutrients in nutrition and health.

V. Aim of the course

To impart knowledge regarding the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration.

No.	Blocks	Units
1.	Nutritional biochemistry	1. Fundamentals of human nutrition 2. Biochemical functions of nutrients 3. Bio availability of nutrients 4. Food sensitivity

Theory

Block1:Nutritional Biochemistry

Unit1:Fundamentals of human nutrition (8 Lectures)

Fundamentals of human nutrition, concept of balanced diet, biochemical composition, energy and food value of various food grains (including cereals, pulses, oilseeds), fruits and vegetables. Physico-chemical, functional and nutritional characteristics of carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning etc.). Digestion and absorption, digestive secretions, their characteristic features and control, protection of micro flora of the GI tract

Unit2: Biochemical functions of nutrients (9Lectures)

Biochemical functions of nutrients, macro- and micronutrients- carbohydrates, fats and proteins, vitamins, water soluble and fat soluble vitamins, mineral and

phytonutrients, prebiotics and probiotics, enzymes and metabolic protein factors, cofactor role, electrolytic function, constituents of skeletal tissues, interrelationship in nutrient functions, mineral deficiency diseases; nutraceuticals, antinutritional factors, biochemistry of post harvest storage.

Unit3: Bioavailability of nutrients (8Lectures)

Factors affecting bioavailability of nutrients, biological value of proteins; effect of cooking, processing and preservation of different food products on nutrients, energy and micro nutrient malnutrition, deficiency diseases of macro and micro nutrients.

Unit4:Food sensitivity (9Lectures)

Food sensitivity: immunologically mediated food sensitivity, nature and properties of antigens in foods, mechanism of induction of allallergic reactions, diagnostic tests for food, hypersensitivity, non-immunologically mediated food sensitivity, food sensitivity due to metabolic diseases, gastro intestinal diseases, food additives, pharmacologic agents, food toxins and poisonous and psychological factors.

VI. Practicals

- Estimation of amylase and amylopectin
- Estimation of resistant starch
- Estimation of u3, u6 and transfatty acid
- Estimation of phenols in plant tissue/sample
- Estimation of carotenoids
- Estimation of amylase, trypsin and chymotrypsin inhibitor activities
- Estimation of Vitamin C in fruits
- Estimation of reducing & non reducing sugar in fruits
- Estimation of protein contents
- Estimation of dietary fibre
- Determination of limiting amino acids
- Estimation of phytate/oxalate
- Estimation of total antioxidant activity by different methods
- Estimation of curcumin.

VII. Teaching methods/activities

- Classroom lectures(oral+ audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Classroom quiz
- Case study

VIII. Learning outcome

On successful completion of this course students should be able to critically analyze

and evaluate concepts in nutritional biochemistry that are important for understanding of human nutrition, provide nutritional advice based on sound scientific findings, discuss the efficacy and appropriate use of functional foods and critically evaluate nutrition information appearing in popular magazines and other forms of media.

IX. Suggested Reading

- Damodaran S.and Parkin KL(ed.) 2017.Fennema's Food Chemistry.CRC Press
- Gibney MJ, Lanham-New SA, Cassidy,A and Voster HH (ed.)2009. Introduction to Human Nutrition. Wiley-Blackwell
- Trueman, P.2007. Nutritional Biochemistry. MJP Publishers
- Cox, C. 2015. Nutritional Biochemistry: Current Topics in Nutrition Research. Apple Academic Press Inc.
- Haugen, S.and Meijer, S.2010. Handbook of Nutritional Biochemistry: Genomics, Metabolomics & Food Supply. Nova Science Publishers Inc.

Teaching Schedule (Theory)

Sr. No.	Name of the topic	No. of lectures	Weightage (%)
	Block1:Nutritional Biochemistry **Unit1:Fundamentals of human nutrition**	**8**	**24**
1	Fundamentals of human nutrition, concept of balanced diet, biochemical composition, energy and food value of various food grains (including cereals, pulses, oil seeds), fruits and vegetables	2	6
2	Physico-chemical, functional and nutritional characteristics of carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning etc.)	3	9
3	Digestion and absorption, digestive secretions, their characteristic features	2	6
4	Control, protection of micro flora of the GI tract	1	3
	Unit2: Biochemical functions of nutrients	**9**	**26**
5	Biochemical functions of nutrients, macro- and micronutrients-carbohydrates, fats and proteins,	1	3
6	Biochemical functions of vitamins, water soluble and fat soluble vitamins, mineral and phytonutrients	1	3
7	Prebiotics and probiotics, enzymes and metabolic protein factors, cofactor role, electrolytic function	2	6
8	Constituents of skeletal tissues, interrelationship in nutrient functions, mineral deficiency diseases	2	6
9	Nutraceuticals, antinutritional factors,	1	2
10	Biochemistry of postharvest storage	2	6
	Unit3:Bioavailability of nutrients	**8**	**24**

11	Factors affecting bioavailability of nutrients, biological value of proteins;	2	6
12	Effect of cooking and processing of different food products on nutrients, energy-and micronutrient	2	6
13	Effect of preservation of different food products on nutrients, energy-and micronutrient	1	2
14	Malnutrition, deficiency diseases of macro and micro nutrients	3	9
	Unit4:Food sensitivity	**9**	**26**
15	Food sensitivity: immunologically mediated food sensitivity	1	2
16	Nature and properties of antigens in foods, mechanism of induction of allallergic reactions	2	6
17	Diagnostic tests for food, hypersensitivity, non-immunologically mediated food sensitivity	2	6
18	Food sensitivity due to metabolic diseases, gastrointestinal diseases	2	6
19	Food additives, pharmacologic agents, food toxins and poisonous and psychological factors	2	6
	Total	**34**	**100**

Practicals

Sr. No.	Name of the topic	No. of Practicals	Weightage (%)
1	Estimation of amylase and amylo pectin	1	6
2	Estimation of resistant starch	1	6
3	Estimation of u3,u6 and transfatty acid	2	13
4	Estimation of phenols in plant tissue/ sample	1	6
5	Estimation of carotenoids	1	6
6	Estimation of amylase, trypsin and chymotrypsin inhibitor activities	2	13
7	Estimation of Vitamin C in fruits	1	6
8	Estimation of reducing & non reducing sugar in fruits	1	6
9	Estimation of protein contents	1	6
10	Estimation of dietary fibre	1	6
11	Determination of limiting amino acids	1	6
12	Estimation of phytate /oxalate	1	6
13	Estimation of total antioxidant activity by different methods	1	6
14	Estimation of curcumin.	1	6
	Total	**16**	**100**

I. Course Title: Nitrogen and Sulfur Metabolism
II. Course Code: BIOCHEM 510
III. Credit Hours: 2+1

IV. Why this course?
Nitrogen and sulfur compounds are continuously synthesized, degraded and converted into other forms in nature. They coexist in the biosphere as free elements or in the form of oxyanions which are to be reduced before undergoing anabolic processes to form N and S containing compounds. This course will provide the students a fundamental understanding of their reduction, assimilation and metabolism in plants.

V. Aim of the course
To impart knowledge of general nitrogen and sulfur metabolism in plants and the assimilatory pathways.

No. Blocks Units

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1. Nitrogen and sulfur metabolism 1. Nitrogen metabolism
2. Sulfur metabolism

VI. Theory
Block 1: Nitrogen and Sulfur Metabolism
Unit 1: Nitrogen metabolism (18 Lectures)
Nitrogen cycle, assimilation of inorganic nitrogen, nitrate uptake and transporters, enzymology of nitrate reduction - Nitrate reductase (NR) and Nitrite reductase (NiR), NR regulation, nitrate signaling. Assimilation of inorganic nitrogen and N-transport amino acids – glutaminesynthetase (GS), glutamate synthase (GOGAT), glutamate dehydrogenase (GDH) aspartate amino transferase (AspT) and asparagine synthetase (AS), interaction between carbon metabolism and amino acid synthesis, biosynthesis of amino acids.Nitrogen fixation - an overview, enzymology of nitrogen fixation - nitrogenase, *nif*-genes and their regulation, symbiotic nitrogen fixation - biochemical basis of rhizobial infection, nodule development. Mechanism of creation of micro aerobic environment for nitrogen fixation. Metabolic exchange between host plant and bacteroids.
Unit 2: Sulfur metabolism (10 Lectures)
Overview of sulfate assimilation, sulfur chemistry and function, sulfate uptake and transport, reductive sulfate assimilation pathway, synthesis and function of sulfur containing amino acids, glutathione and its derivatives, role of sulfated compounds in metabolism.

VII. Practicals
- Estimation of nitrite content,
- Estimation of nitrate content,
- *In vivo* assay of nitrate reductase activity,

- *In vitro* assay of nitrate reductase activity,
- *In vitro* assay of nitrite reductase activity,
- *In vitro* assay of glutamine synthetase activity,
- *In vitro* assay of glutamate synthase and glutamate dehydrogenase activity,
- Estimation of ureides and amides,
- Assay of nitrogenase activity by acetylene reduction method,
- Estimation of hydrogen evolution by legume nodules,
- Estimation of cysteine, methionine, pyruvate and glutathione,
- Assay of APS activity.

VIII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz
– Case study

IX. Learning outcome

Students will get an insight into the nitrogen and sulfur metabolism in plants and the coordination between nitrogen (N) and sulfur (S) assimilation.

X. Suggested Reading

• Bothe, H. and Trebst, A. (eds.). 1981. *Biology of Inorganic Nitrogen and Sulfur*. Conference proceedings. Springer-Verlag
• De Kok*et al*. 2012.*Sulfur Metabolism in Plants*. Part of the Proceedings of the International Plant Sulfur Workshop book series. Springer
• Bray CM. 1983. *Nitrogen Metabolism in Plants*. Longman.
• Bidwell, R.G.S. 1983. *Plant Physiology: A Treatise*, Vol. 8: Nitrogen Metabolism. Academic Press
• Foyer. C. H. and Zhang, H. 2010. *Nitrogen Metabolism in Plants in the Post- Genomic Era.* Annual Plant Reviews, Vol.42. Wiley-Blackwell
• Buchanan B.B., Gruissem W. and James R. L. (Eds.). 2000. *Biochemistry and Molecular Biology of Plants.* American Society of Plant Physiologists.

Teaching Schedule (Theory)

Sr. No.	Name of topics	No. of Lectures	Weightage (%)
	Block 1: Nitrogen and Sulfur Metabolism **Unit 1: Nitrogen metabolism**	**23**	**68**
1	Nitrogen cycle, assimilation of inorganic nitrogen, nitrate uptake	2	9

	and transporters,		
2	Enzymology of nitrate reduction - Nitrate reductase (NR) and Nitrite reductase (NiR),	2	9
3	NR regulation, nitrate signaling.	1	3
4	Assimilation of inorganic nitrogen and N-transport amino acids	2	9
5	Glutamine synthetase (GS), glutamate synthase (GOGAT), glutamate dehydrogenase (GDH),	2	9
6	Aspartate amino transferase (AspT) and asparagine synthetase (AS),	2	9
7	Interaction between carbon metabolism and amino acid synthesis, Biosynthesis of amino acids,	2	9
8	Nitrogen fixation - an overview	1	3
9	Enzymology of nitrogen fixation - nitrogenase	2	9
10	*Nif*-genes and their regulation,	2	9
11	Symbiotic nitrogen fixation - biochemical basis of rhizobial infection, nodule development	2	9
12	Mechanism of creation of micro aerobic environment for nitrogen fixation,	2	9
13	Metabolic exchange between host plant and bacteroids.	1	3
	Unit 2: Sulfur metabolism	**11**	**32**
14	Sulfur chemistry and function,	2	9
15	Overview of sulfate assimilation	1	3
16	Sulfate uptake and transport	2	9
	Reductive sulfate assimilation pathway	1	3
17	Synthesis and function of sulfur containing amino acids,	2	9
18	Synthesis and function of glutathione and its derivatives	1	3
18	Role of sulfated compounds in metabolism.	2	
	Total	**34**	**100**

Practicals

Sr. No.	**Name of topics**	**No. of Practicals**	**Weightage (%)**
1	Estimation of nitrite content,	1	6
2	Estimation of nitrate content,	1	6
3	*In vivo* assay of nitrate reductase activity,	1	6
4	*In vitro* assay of nitrate reductase activity,	2	12
5	*In vitro* assay of nitrite reductase activity,	1	6
6	*In vitro* assay of glutamine synthetase activity,	1	6
7	*In vitro* assay of glutamate synthase and glutamate	1	6

	dehydrogenase activity,		
8	Estimation of ureides and amides,	1	6
9	Assay of nitrogenase activity by acetylene reduction method,	2	12
10	Estimation of hydrogen evolution by legume nodules,	1	6
11	Estimation of cysteine	1	6
12	Estimation of methionine	1	6
13	Estimation of pyruvate	1	6
14	Estimation of glutathione	1	6
15	Assay of APS activity.	1	6
16	Estimation of nitrite content,	1	6
	Total	**17**	**100**

I. Course Title : Biochemistry on Xenobiotics

II. Course Code : BIOCHEM 511

III. Credit Hours : 2+0

IV. Why this course?

Xenobiotics are compounds that are foreign to an organism that include compounds like drugs, food additives, and environmental pollutants. Knowledge on metabolic conversion of xenobiotics, especially drugs and environmental contaminants in living system becomes pertinent in present day scenario with increased levels of pollution.

V. Aim of the course

To impart knowledge on xenobiotics and the mechanism of their metabolism and detoxification in living system.

No.	Block	Units
1	Biochemistry on xenobiotic	1. Xenobiotics 2. Mode of degradation 3. Plant metabolism of xenobiotics 4. Phytoremediation

Theory

Block 1: Biochemistry on Xenobiotics

Unit1:Xenobiotics (09Lectures)

Xenobiotics: classification and their effects on biological systems, Problems related to Xenobiotics degradation, potential effects of toxic agents on immune system function, biotic metabolism of Xenobiotics - biodegradation/biotransformation

Unit 2: Mode of degradation (10 Lectures)

Mode of degradation - Enzymatic and Non-enzymatic, Metabolism of toxic compounds with reference to role of detoxifying enzymes, Mechanism of xenobiotics detoxification - in animal using the enzymes of Phase I and Phase II, Role of microbes in xenobiotics degradation and co-metabolism, Biodegradation and its genetics, manipulation of xenobiotic degradative genes.

Unit 3: Plant metabolism of xenobiotics (10 Lectures)

Plant metabolism of Xenobiotics - transformation, conjugation and compartmentation, Metabolic responses of pesticides in plants, Impact, metabolism, and toxicity of heavy metals in plants, Regulation of Xenobiotics in higher plants: signalling and detoxification.

Unit 4: Phyto remediation (07 Lectures)

Phytoremediation, advances in development of transgenic plants for remediation of Xenobiotic pollutants, safety assessment of Xenobiotics

VI. Teaching methods/activities

– Classroom lectures (oral + audio-visual)

– Assignment (Reading/Writing)

– Oral presentation by students on specified topics
– Class room quiz – Case study

VII. Learning outcome

Students will gain the basic knowledge and perspectives of bioelimination of xenobiotic compounds.

IX Suggested Reading:

- Richardson, M. 1996. Environmental Xenobiotics. CRC Press
- Singh, A., Prasad, S.M. and Singh, R.P.(eds). 2016. Plant Responses to Xenobiotics. Springer.
- Chang, Y-C. (ed). 2019. Microbial Biodegradation of Xenobiotic Compounds. CRC Press
- Costas Ioannides (ed). 2002. Enzyme Systems that Metabolise Drugs and Other Xenobiotics. Wiley
- Lee, P., Aizawa, H., Gan, L., Prakash, C. And Zhong, D. 2014. Handbook of Metabolic Pathways of Xenobiotics. –
- Emerson, M.L. 2012. Xenobiotics: New Research. Nova Science
- Shamaan, N.A. 2008. Biochemistry of xenobiotics: towards a healty lifestyle and safe environment. PenerbitUniversiti Putra Malaysia.

Teaching Schedule(Theory)

Sr. No.	Name of the topics	No. of Lectures	Weightage (%)
	Block 1: Biochemistry on Xenobiotics **Unit 1: Xenobiotics**	09	25
1	Xenobiotics: classification and their effects on biological systems	02	06
2	Xenobiotics: Problems related to Xenobiotics degradation	01	03
3	Potential effects of toxic agents on immune system function	03	08
4	Biotic metabolism of Xenobiotics biodegradation	01	03
5	Biotic metabolism of Xenobiotics biotransformation	02	05
	Unit 2: Mode of degradation	10	28
6	Mode of degradation - Enzymatic and Non-enzymatic	01	03
7	Metabolism of toxic compounds with reference to role of detoxifying enzymes	02	06
8	Mechanism of Xenobiotics detoxification - in animal using the enzymes of Phase I	01	03
9	Mechanism of Xenobiotics detoxification - in animal using the enzymes of Phase II	02	05
10	Role of microbes in xenobiotics degradation and co-	02	05

	metabolism.		
11	Biodegradation and its genetics.	01	03
12	Manipulation of xenobiotic degradative genes	01	03
	Unit 3: Plant metabolism of xenobiotics	10	28
13	Plant metabolism of Xenobiotics – transformation.	01	03
14	Plant metabolism of Xenobiotics – conjugation.	01	03
15	Plant metabolism of Xenobiotics - compartmentation.	01	03
16	Metabolic responses of pesticides in plants.	01	03
17	Impact, metabolism, and toxicity of heavy metals in plants.	02	05
18	Regulation of Xenobiotics in higher plants: signalling.	02	05
19	Regulation of Xenobiotics in higher plants: detoxification.	02	06
	Unit 4: Phytoremediation	07	19
20	Phytoremediation	03	08
21	Advances in development of transgenic plants for remediation of Xenobiotic pollutants.	02	06
22	Safety assessment of Xenobiotics.	02	05
	Total	36	100

Course content and Syllabus of Ph. D.

I. Course Title: Advanced Enzymology
II. Course Code: BIOCHEM 601*
III. Credit Hours: 2+1

IV. Why this course?
The course will make the students able to make a conceptual analysis of theenzymatic reaction mechanism and know the principles of the application of enzymesin analytical biochemistry, and some industrial applications.

V. Aim of the course
To provide advanced knowledge about the structure of enzymes, mechanism, kineticsand regulation of enzymatic reactions and use of enzymes as biosensors.

No.	Blocks	Units
1.	Enzymology and enzyme engineering	1. Enzyme catalysis and specificity 2. Enzyme kinetics 3. Enzyme mechanism and regulation 4. Industrial enzymology

I. Theory

Block 1: Enzymology and Enzyme Engineering

Unit 1: Enzyme catalysis and specificity (Seven Lectures)

Theory of enzymatic catalysis, Specificity and editing mechanisms, concept of active site and enzyme substrate complex, active site mapping, factors associated with catalytic efficiency, mechanism of enzyme reactions, detection of intermediates in enzymatic reactions.

Unit 2: Enzyme kinetics (7 Lectures)

Transition state theory, Arrhenius equation, Determination of energy of activation, effect of pH and temperature on enzyme kinetics, pre-steady state and steady state kinetics, single substrate kinetics, allosteric enzymes and mixed inhibition, substrate and product inhibition, numerical exercises.

Unit 3: Enzyme mechanism and regulation (7 Lectures)

Mechanism determination by radioisotope exchange, role of enzymes in regulation of metabolism, bifunctional enzymes, pseudoenzyme and enzyme promiscuity, extremozymes, catalytic nucleic acids (ribozymes, catalytic DNA).

Unit 4: Industrial enzymology (7 Lectures)

Advantages and disadvantages of biocatalysis in technology driven processes, stabilization and regeneration of enzyme systems used in biotechnology, protein engineering of enzymes, creation of chimeric, bifunctional, immobilization of enzymes, semisynthetic

enzymes and their use as industrial biocatalysts, and theirpractical significance, modern information technologies in enzyme engineering.

VII. Practicals

- Purification and characterization of some model enzymes (peroxidise, α-amylase,lipase)
- Study kinetics of inhibited and uninhibited enzyme catalysed reactions
- Determination of Km values of single substrate reactions
- Determination of enzyme activity by coupled assay
- Electrophoretic separation of isozymes
- Enzyme immobilization.

VIII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz
– Case study

IX. Learning outcome

After completing the course students will understand the mode of action of enzymes,mechanisms of enzymatic catalysis and also possible applications of enzymes invarious technological processes.

X. Suggested Reading

- Aehle, W. 2007. Enzymes in Industry. Production and Application.(Third, Completely Revised Edition).Wiley-VCH Verlag GmbH & Co. KGaA
- Buchholz, K., Bornscheuer, U., Kasche, V. 2012. Biocatalysts and Enzyme Technology. UK: Wiley-VCH Verlag GmbH
- Fessner, W. and Anthonsen, T. 2009. Modern Biocatalysis. Germany: Wiley-VCH Verlag GmbH
- Frey, P.A. and Hegeman, A.D. 2007. Enzymatic Reaction Mechanisms. Oxford University Press
- Young Je Yoo, Yan Feng, Yong-Hwan Kim, Camila Flor J. Yagonia. 2017. Fundamentals of Enzyme Engineering. Springer

Teaching Schedule (Theory)

Sr. No.	Name of topics	No. of Lectures	Weightage (%)
	Block 1: Enzymology and Enzyme Engineering **Unit 1: Enzyme catalysis and specificity**	**7**	**20**
1	Theory of enzymatic catalysis, specificity and editing mechanisms,	2	6

2	Concept of active site and enzyme substrate complex, active site mapping	2	6
3	Factors associated with catalytic efficiency,	1	3
4	Mechanism of enzyme reactions, detection of intermediates in enzymatic reactions.	2	6
	Unit 2: Enzyme kinetics	**10**	**29**
5	Transition state theory, Arrhenius equation, Determination of energy of activation,	2	6
6	Effect of pH and temperature on enzyme kinetics, pre-steady state and steady state kinetics,	2	6
7	Single substrate kinetics, single substrate kinetics,	2	6
8	Allosteric enzymes and mixed inhibition,	2	6
9	Substrate and product inhibition,	1	3
10	Numerical exercises	1	3
	Unit 3: Enzyme mechanism and regulation	**7**	**20**
11	Mechanism determination by radioisotope exchange,	2	6
12	Role of enzymes in regulation of metabolism,	2	6
13	Bi-functional enzymes, pseudo enzymes	2	6
14	Enzyme promiscuity, extremozymes,	1	3
	Unit 4: Industrial enzymology	**11**	**31**
15	Advantages and disadvantages of bio catalysis in technology driven processes,	2	6
16	Stabilization and regeneration of enzyme systems used in biotechnology	2	6
17	Protein engineering of enzymes,	2	6
18	Creation of chimeric, bi-functional, immobilization of enzymes,	2	6
19	Semisynthetic enzymes and their use as industrial biocatalysts, and their practical significance,	2	6
20	Modern information technologies in enzyme engineering.	1	3
	Total	**35**	**100**

Practicals

Sr. No.	Name of topics	No. of Practicals	Weightage (%)
1	Purification and characterization of peroxidase,	1	18
2	Purification and characterization of α-amylase	1	
3	Purification and characterization of lipase	1	

4	Study kinetics of inhibited and uninhibited enzyme catalysed reactions	2	12
5	Determination of Km values of single substrate reactions	2	12
6	Determination of enzyme activity by coupled assay	3	18
7	Electrophoretic separation of isozymes	3	18
8	Enzyme immobilization.	4	24
	Total	**17**	**102**

I. Course Title : Advanced Molecular Biology
II. Course Code : BIOCHEM 602
III. Credit Hours : 3+0

IV. Why this course?

To impart knowledge on genome organization and analysis, gene expression and its regulation and modern techniques for genome.

V. Aim of the course

To provide latest information on structure and organization of genetic materials; genes, their expression in plants and biochemical approaches employed in genetic engineering.

No.	Blocks	Units
.	Genome organization and manipulation	1. Concepts of gene and genome 2. Regulation of gene expression 3. Techniques in genome analysis 4. Techniques for gene transfer and genome Manipulation 5. Aspects of molecular breeding

VI. Theory

Block 1: Genome Organization and Manipulation

Unit 1: Concepts of gene and genome (8 Lectures)

Genes, their relationship with chromosomes, gene number hypothesis; Genome – definition, variation and organization in plants and animals, structure of organelle genomes; concept of epigenome, genome size and genome evolution.

Unit 2: Regulation of gene expression (10 Lectures)

Prokaryotic and eukaryotic gene regulation, transcriptional and post transcriptional regulation; regulation at genome level, role of histones, riboswitches.

Unit 3: Techniques in genome analysis (12 Lectures)

Genome sequencing technologies, Sanger sequencing, next generation sequencing, nanopore sequencing; genome mapping – genetic map construction, physical mapping.

Unit 4: Techniques for gene transfer and genome manipulation (12 Lectures)

Methods of gene isolation and transfer in plants and animals, agrobacterium mediated and direct transfer of genes in plants and animals; gene silencing technologies: virus induced gene silencing, RNA interface; genome editing -TALENs, CRISPR/cas, ZFN and their application, site directed mutagenesis, Application of genetic engineering in different fields, gene therapy.

Unit 5: Aspects of molecular breeding (8 Lectures)

Genome browsing, primer design, marker application for breeding, application of MAS in case studies. Bioethics and bio safety guidelines, IPR in recombinant DNA research

VII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz
– Case study

VIII. Learning outcome

On completion of this course, students will get an insight into the genome structure its organization and means for its manipulation for applications in areas such as human and animal health, agriculture, and the environment.

IX. Suggested Reading

- Brown, T. A. 2018. Genomes 4. Garland Science
- Rippe, K. 2011. Genome Organization and Function in the Cell Nucleus. Wiley VCH Verlag
- Primrose, S. B. and Twyman, R.2006. Principle of Gene Manipulation and Genomics. 7th edition. Blackwell Publishing
- Christopher Howe. 2007. Gene Cloning and Manipulation. 2nd edition. Cambridge University Press
- Mohan Jain, S., Brar, D. S .(eds.). 2009. Molecular Techniques in Crop Improvement. 2nd edition. Springer
- Boopathi, N. M. 2013. Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits. Springer
- Brown, T. A. 2010. Gene Cloning and DNA Analysis. An Introduction. Wiley-Blackwell
- Singh, K. K. 2015. Biotechnology and Intellectual Property Rights. Legal and Social Implications. Springer

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No. of lectures	Weightage (%)
	Block 1: Genome Organization and Manipulation **Unit 1: Concepts of gene and genome**	**8**	**16**
1.	Genes, their relationship with chromosomes, gene number hypothesis.	2	4
2.	Genome –definition, variation and organization in plants and animals.	2	4
3.	Structure of organelle genomes.	2	4

4.	Concept of epigenome, genome size and genome evolution.	2	4
	Unit 2: Regulation of gene expression	**10**	**20**
5.	Prokaryotic and eukaryotic gene regulation,	3	6
6.	Transcriptional and posttranscriptional regulation;	3	6
7.	Regulation at genome level,	2	4
8.	Role of histones, riboswitches.	2	4
	Unit 3: Techniques in genome analysis	**12**	**24**
9.	Genome sequencing technologies, Sanger sequencing,	3	6
10.	Next generation sequencing,	3	6
11.	Nanopore sequencing;	1	2
12.	Genome mapping – genetic map construction.	3	6
13.	Physical mapping.	2	4
	Unit 4: Techniques for gene transfer and genome manipulation	**12**	**24**
14.	Methods of gene isolation and transfer in plants and animals.	1	2
15.	Agrobacterium mediated and direct transfer of genes in plants and animals;	1	2
16.	Gene silencing technologies: virus induced gene silencing.	3	6
17.	RNA interface.	1	2
18.	Genome editing: TALENs, CRISPR/cas, ZFN and their application.	3	6
19.	Site directed mutagenesis,	1	2
20.	Application of genetic engineering in different fields, gene therapy.	2	4
21.	**Unit 5: Aspects of molecular breeding**	**8**	**16**
22.	Genome browsing, primer design, marker application for breeding,	3	6
23.	Application of MAS in case studies.	1	2
24.	Bioethics and bio safety guidelines.	2	4
25.	IPR in recombinant DNA research.	2	4
	Total	**50**	**100**

I. Course Title : Biochemistry of Bioticand Abiotic Stresses
II. Course Code : BIOCHEM 603
III. Credit Hours :3+0

IV. Why this course?

Plants are constantly confronted to both abiotic and biotic stresses that seriously reduce their productivity. Plant responses to these stresses involve numerous physiological, biochemical, molecular, and cellular adaptations. This course will help to have an insight into the mechanism underlying the stress tolerance and to elucidate the molecular basis of stress adaptation.

V. Aim of the course

To impart knowledge on biochemistry of biotic and abiotic stresses in plants.

No.	Blocks	Units
1.	Biochemistry of biotic And abiotic stresses	1. Plant-pathogen interaction and disease development 2. Biochemistry of plant defense mechanisms 3. Plant host-virus interaction 4. Biochemical basis of abiotic stresses 5.Tolerance against biotic and abiotic stress

VI. Theory

Block1:Biochemistry of Biotic and Abiotic Stresses

Unit 1: Plant-pathogen interaction and disease development (7 Lectures)

Molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

Unit 2: Biochemistry of plant defense mechanisms (12 Lectures)

Role of secondary metabolites, Plant defense response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance, pathogen derived resistance.

Unit 3: Plant host-virus interaction (7 Lectures)

Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids.

Unit 4: Biochemical basis of abiotic stresses (12 Lectures)

Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.

Unit 5: Tolerance against stress (11 Lectures)

Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes of defense system. Role of calcium, nitric oxide and salicylic acid in plant development. Molecular strategies for imparting tolerance against biotic and abiotic stress.

VII. Teaching methods/activities

- Classroom lectures (oral+ audio-visual)
- Assignment (Reading/Writing)
- Oralpresentation by students on specified topics
- Classroom quiz
- Case study

VIII. Learning outcome

Upon completion of the course, students will get the suite of molecular and cellular processes that are triggered by plant stress responses.

IX. Suggested Reading

- Buchanan, Bob B., Gruisem, WandJones, R.2015. Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley Blackwell.
- Basra AS. 1997. Stress Induced Gene Expression in Plants. Harwood Academic Publ.
- Chessin M, DeBorde D & Zipf A. 1995. Antiviral Proteins in Higher Plants. CRC Press.
- Crute IR, Burdon JJ & Holub EB. (Eds.). 1997. Gene-for-Gene Relationship in Host-Parasite Interactions. CABI.
- Dresselhaus,T.andHückelhoven,R.(Eds.)2019.BioticandAbioticStressResponsesinCropPlants .MDPI.https://doi.org/10.3390/agronomy8110267
- Khan, M.I.R.and Khan, N.A. (Eds.). 2017. Reactive Oxygen Species and Antioxidant Systems in Plants: Role and Regulation under Abiotic Stress. Springer
- Rout, G.R. and Das,A.B.2013. Molecular Stress Physiology of Plants. Springer. DOI10.1007/978-81-322-0807-5
- Ramakrishna, A .and Gill, S.S. 2018 Metabolic Adaptations in Plants During Abiotic Stress. CRC Press
- Shanker, A.K and Shanker, C. (Eds.)2016. Abiotic and Biotic Stress in Plants-Recent Advances and Future Perspectives In Tech .http://dx.doi.org/10.5772/60477
- Smirnoff, N. (ed.) 2005. Antioxidants and reactive oxygen species in plants, Blackwell

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No of Lectures	Weightage (%)
	Unit 1: Plant-pathogen interaction and disease development	**7**	**14**
1.	Molecular, mechanisms of fungal and bacterial infection in plants	2	04
2.	Changes in metabolism, cell wall composition and vascular transport in diseased plants	5	10

	Unit 2: Biochemistry of plant defense mechanisms	**12**	**24**
3.	Role of secondary metabolites	2	04
4.	Plant defense response, antimicrobial molecules	2	04
5.	Genes for resistance	2	04
6.	Hypersensitive response and cell death	2	04
7.	Systemic and acquired resistance	2	04
8.	Pathogen derived resistance	2	04
	Unit 3: Plant host-virus interaction	**7**	**14**
9.	Plant viruses, host-virus interactions, disease induction	3	06
10.	Virus movement, and host range determination	3	06
11.	Viroids	1	2
	Unit 4: Biochemical basis of abiotic stresses	**12**	**24**
12.	Biochemical basis of abiotic stresses namely drought and salinity	3	06
13.	Biochemical basis of abiotic stresses namely temperature and heavy metals	3	06
14.	Biochemical basis of abiotic stresses namely air and water polluntants	2	04
15.	Synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses	3	06
16.	Stress adaptation	1	02
	Unit 5: Tolerance against stress	**11**	**24**
17.	Reactive oxygen species and biotic and abiotic stress,	2	04
18.	Antioxidants	1	02
19.	Enzymes of defense system	3	07
20.	Role of calcium, nitric oxide and salicylic acid in plant development	3	07
21.	Molecular strategies for imparting tolerance against biotic and abiotic stress	2	04
	Total	**49**	**100**

I.Course Title :Frontier Topics in Biochemistry
II.Course Code :BIOCHEM 604
III.Credit Hours :2+0

IV. Why this course?

To update the students to the recent developments in various fields of biochemistry. Aim of the Course To acquaint the students with the advanced developments in the field of biochemistry and to inculcate the habit of searching and reading the topics of current importance.

No.	Block	Units
1	Frontier topics in Biochemistry	1. There will be 8 Units related to different areas in Biochemistry

V. Theory

Unit1: Advances in metabolic nutrition.
Unit2: Advances in environmental and industrial biochemistry.
Unit3: Advances in molecular biology techniques.
Unit4: Latest development/ Advances in metabolic pathway engineering.
Unit5: Advances in regulation of gene expression.
Unit6: Advances in biotic and abiotic stress response in plants.
Unit7: Advances in protein chemistry.
Unit8: Topics related to recent approaches concerning application of Biochemical tools and techniques

VI. **Teaching methods/activities**

– Oral presentation by students on specified topics based on recent published research paper
– Group discussion

VII. Learning outcome

Students will build up the habit of searching and studying the topics of current importance and the recent developments in the field of biochemistry.

VIII. Suggested Reading

- Selected articles from recent issues of Thomson Reuters and NAAS rated journals

I. Course Title : Concepts and Application of Omics in Biological Science
II. Course Code : BIOCHEM 605
III. Credit Hours : 3+0

IV. Why this course?

Omics is a rapidly evolving, multi-disciplinary, and emerging field that encompasses genomics, epigenomics, transcriptomics, proteomics, and metabolomics. This course will be helpful for the students to understand the scope of omics research and methods therein.

V. Aim of the course

To impart knowledge in the upcoming areas of biochemistry and to understand the recent developments in omic technologies.

No.	Blocks	Units
1.	Concepts and application of omics in biological science	1. Protein and nucleic acid sequencing 2. Genomics–methods of analysis and application 3. Proteome technology 4. Metabolomics and ionomics

VI. Theory

Block 1: Concepts and Application of Omics in Biological Science

Unit 1: Protein and nucleic acid sequencing (12 Lectures)

Various methods of sequencing including automated sequencing and microarrays,whole genome sequence analysis.

Unit 2: Genomics – methods of analysis and application (13 Lectures)

Comparative genomics, functional genomics, nutrigenomics, transcriptomics, gene identification, gene annotation, pairwise and multiple alignments, application of genomics, quantitative PCR, SAGE, MPSS, microarray, role of bioinformatics in functional genomics.

Unit 3: Proteome technology (12 Lectures)

2D-PAGE, MSMS, MALDI-TOF, comparative proteomics and structural proteomics

Unit 4: Metabolomics and ionomics (13 Lectures)

Elucidation of metabolic pathways, Sample preparation for metabolomics. Techniques involved in metabolite identification- LCMS, NMR, FTIR, MS. Metabolomics inbiotic and biotic stress in crop plants, SPE, SPME, metabolic pathway engineering and its application, Concept and application of ionome and ionomics.

VII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz
– Case study

VIII. Learning outcome

The applications of omics allow the complete profiling of genes, proteins and metabolites to understand the intricacy, complexity and dynamics of biological system. This course serves as an applied course for understanding the applications, research methodologies and data analysis of omics approaches enabling students to apply such skills in their respective projects

IX. Suggested Reading

- Lieber D.C. 2002. Introduction to Proteomics - Tools for the New Biology. Humana Press.
- Leung, H.E. 2012. Integrative Proteomics. In Tech
- Lesk, A.M. 2012. Introduction to Genomics, 2nd Edition. Oxford University Press
- Aizat, W.M., Goh, H-H. and Baharum, S.N. (Eds.) 2018. Omics Applications for Systems Biology. Springer International Publishing
- Arivaradarajan, P., Misra, G. (Eds.) 2018. Omics Approaches, Technologies and Applications. Springer Singapore
- Fan TWM, Lane AN and Higashi RM. (Eds.) 2012. The Handbook of Metabolomics. Humana Press, Totowa, NJ

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No. of lectures	Weightage (%)
	Block 1: Concepts and Application of Omics in Biological Science **Unit 1: Protein and nucleic acid sequencing**	**12**	**24**
1.	Various methods of sequencing including automated sequencing.	3	6
2.	Microarrays.	3	6
3.	Whole genome sequence analysis.	3	6
4.	Shotgun genome sequence analysis.	3	6
	Unit 2: Genomics – methods of analysis and application	**13**	**26**
5.	Comparative genomics, functional genomics, nutria genomics, transcriptomics,	3	6
6.	Gene identification,	3	6

7.	Gene annotation, pairwise and multiple alignments,	3	6
8.	Application of genomics, quantitative PCR, SAGE, MPSS, microarray.	2	4
9.	Role of bioinformatics in functional genomics.	2	4
	Unit 3: Proteome technology	**12**	**24**
10.	2D-PAGE.	1	2
11.	MSMS.	2	4
12.	MALDI-TOF.	3	6
13.	Comparative proteomics and structural proteomics.	3	6
14.	Structural proteomics.	3	6
	Unit 4: Metabolomics and ionomics	**13**	**26**
15.	Elucidation of metabolic pathways, Sample preparation for metabolomics.	3	6
16.	Techniques involved in metabolite identification- LCMS, NMR, FTIR, MS.	3	6
17.	Metabolomics in biotic and biotic stress in crop plants, solid-phase extraction (SPE), solid-phase micro extraction (SPME),	3	6
18.	Metabolic pathway engineering and its application,	2	4
19.	Concept and application of ionome and ionomics.	2	4
	Total	**50**	**100**

I. Course Title :Biomembranes
II. Course Code :BIOCHEM 606
III. Credit Hours :2+0

IV. Why this course?

Biomembranes define the boundaries of cells and their internal organelles and, consequently, are fundamental to the compartmentalization of vital enzymatic reactions. This course will help the students to acquire an integrated overview of the structure, function and biogenesis of biological membranes and their components and their impacts on different cell activities.

V. Aim of the course

to impart knowledge on the molecular basis of the structure, function and biogenesis of eukaryotic cell membranes.

No.	Block	Units
1	Biomembrane	There will be 4 Units relating to biomembrane structure, organization, movement and signal transduction.

VI. Theory

Block 1: Biomembranes

Unit1:(6Lectures)

Concept of biomembranes and their classification based on cellular organelles; physico-chemical properties of different biological and artificial membranes, cell surface receptors and antigen. Membrane stability and factor affecting on membrane stability.

Unit2:(11Lectures)

Membrane biogenesis and differentiation; membrane ecomponents-lipids, their distribution and organization; proteins, intrinsic and extrinsic, their arrangement; carbohydrates in membranes and their function

Unit3:(09Lectures)

Various membrane movements; Membrane transport: Organization of transport at plant membranes, pumps, carriers, ion channels, diffusion, osmosis water transport through aquaporins, transport of macro molecules: exocytosis and endocytosis, energy transduction.

Unit 4: (10Lectures)

Role of membrane in cellular metabolism, cell recognition and cell-to-cell interaction; and signal transduction, recent trends and tools in membrane research.

Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Assignment (Reading/Writing)
– Oral presentation by students on specified topics
– Class room quiz – Case study

VII. Learning outcome

This course summarizes the structure and functions of membranes and the proteins within them, and describes their role in trafficking and transport, control the passage of selected compounds, thus maintaining the biochemical integrity of cytosol; communication, allowing the exchange of information between the extra- and intracellular environments, and the physical interaction with the extracellular phase.

Suggested Reading:

- Watson, H. 2015. Biological membranes. Essays Biochem. 59, 43–70: doi: 10.1042/ BSE0590043
- Shinitzky,M.2008. Biomembranes: Structural and Functional Aspects. VCH.DOI:10.1002/9783527616114
- Berk, A.,Kaiser, C.A.,Lodish, H., Amon ,A. Ploegh, H., Bretscher, A., Krieger, M. and Martin, K.C .2016. Molecular Cell Biology. Macmillan Learning. Stillwell, W.2013. An Introduction to Biological Membrane: From Bilayersto Rafts. Elsevier
- Yeagle, P.2016. The Membranes of Cell. 3rd edition. Academic Press

Teaching Schedule(Theory)

Sr. No.	Name of the topics	No. of lectures	Weightage (%)
	Block 1: Biomembranes **Unit I:**	**06**	**17**
1	Concept of biomembranes and their classification based on cellular organelles	02	06
2	Physico-chemical properties of different biological and artificial membranes	01	03
3	**Membrane stability and factors affecting on Membrane stability**	01	03
4	Cell surface receptors and antigen	02	05
	Unit2:	**11**	**32**
5	Membrane biogenesis and differentiation	02	05
6	Membran ecomponents-lipids their distribution and organization	03	09

7	Membrane components proteins, intrinsic and extrinsic, their arrangement	03	09
8	Membran ecomponents carbohydrates in membranes and their function.	03	09
	Unit3:	**09**	**25**
9	Various membrane movements	02	05
10	Membrane transport: Organization of transport at plant membranes	01	03
11	Membrane transport: pumps, carriers, ion channels, diffusion, osmosis**,** water transport through aquaporins	01	03
12	Membrane transport: diffusion, osmosis**,** water transport through aquaporins	01	03
13	Transport of macro molecules: exocytosis and endocytosis	02	05
14	Energy transduction	02	06
	Unit4:	**10**	**26**
15	Role of membrane in cellular metabolism	03	08
16	Role of membrane in cell recognition and cell-to-cell interaction	02	05
17	Role of membrane in signal transduction	03	08
18	Recent trends and tools in membrane research.	02	05
	Total	**36**	**100**

I. Course Title : Application of Techniques in Biochemistry
II. Course Code : BIOCHEM 607*
III. Credit Hours : 1+2

IV. Why this course?

This course will provide the students the theoretical basis of various separation techniques and their application with practical experience in the use of different biochemical and molecular biology techniques.

V. Aim of the course

To train students the application of cutting edge laboratory techniques in research in biochemistry and molecular biology.

No.	Blocks	Units
.	Application of techniques in Biochemistry	1. Isolation, purification and analysis of metabolites 2. Electrophoretic separation 3. Application of centrifugation 4. Enzyme techniques 5. Molecular biology and immunochemical techniques

VI. Theory

Block 1: Application of Techniques in Biochemistry

Unit 1: Isolation, purification and analysis of metabolites (4 Lectures)

Isolation and purification of important metabolites from microbial/plant/animal source, Applications of paper, thin layer and gas liquid chromatography, PAGE,FPLC and HPLC in the separation of biomolecules. Determination of molecular weight of protein using PAGE/gel filtration method.

Unit 2: Electrophoretic separation (4 Lectures)

Electrophoretic separation of protein, Experiments on DNA: Isolation, agarose gel electrophoresis and restriction analysis of DNA. Techniques in DNA-protein and protein-protein interaction.

Unit 3: Application of centrifugation (2 Lectures)

Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation.

Unit 4: Enzyme techniques (4 Lectures)

Isolation, purification and characterization of enzymes, isozymic analysis and enzyme immobilization.

Unit 5: Molecular biology and immunochemical techniques (3 Lectures)

Application of PCR, yeast 2 hybrid system, Antigen-Antibody interaction, ELISA, Chromatin immune precipitation, gel based and gel free proteasome tools.

VII. Teaching methods/activities

– Classroom lectures (oral + audio-visual)
– Demonstration and hands on training
– Exposure visit to institutions equipped with modern facilities

VIII. Learning outcome

This course will help the students in acquiring the laboratory skills required for success in experimental biochemistry and molecular biology.

IX. Suggested Reading

- Katoch, R. 2011. Analytical Techniques in Biochemistry and Molecular Biology. Springer
- Wilson, K. and Walker, J. 2010. Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition. Cambridge University Press
- Hegyi, G., Kardos, J., Kovács, M., Málnási- Csizmadia, A., Nyitray, L. Pál, G., Radnai, L., Reményi, A. and Venekei, I. 2013. Introduction to Practical Biochemistry. EötvösLor ánd University

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No. of lectures	Weightage (%)
	Block 1: Application of Techniques in Biochemistry **Unit 1: Isolation, purification and analysis of metabolites**	**4**	**24**
1.	Isolation and purification of important metabolites from microbial/plant/animal source,	1	6
2.	Applications of paper, thin layer and gas liquid chromatography, PAGE, FPLC and HPLC in the separation of biomolecules.	1	6
3.	Determination of molecular weight of protein using PAGE	1	6
4.	Determination of molecular weight of protein using gel filtration method.	1	6
	Unit 2: Electrophoretic separation	**4**	**24**
5.	Electrophoretic separation of protein.	1	6
6.	Experiments on DNA: Isolation, agarose gel electrophoresis and restriction analysis of DNA.	2	12
7.	Techniques in DNA-protein and protein-protein interaction.	1	6
	Unit 3: Application of centrifugation	**2**	**12**
8.	Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation.	2	12
	Unit 4: Enzyme techniques	**4**	**24**
9.	Isolation, purification and characterization of enzymes.	1	6

10.	Isozyme analysis of enzyme.	1	6
11.	Enzyme immobilization.	2	12
	Unit 5: Molecular biology and immunochemical techniques	**3**	**18**
12.	Application of PCR, yeast 2 hybrid system,	1	6
13.	Antigen-Antibody interaction, ELISA, Chromatin immune precipitation,	1	6
14.	Gel based and gel free proteasome tools.	1	6
	Total	**17**	**100**

Practicals

Sr. No.	Name of the practicals	No. of practical	Weightage (%)
1.	Isolation and quantification of soluble sugars by HPLC.	3	9
2.	Isolation and quantification of amino acids by HPLC.	3	9
3.	Isolation, purification and quantification of curcuminoids, mangiferin and other active principals from medicinal plants.	5	15
4.	Isolation and fractionation of soluble proteins by PAGE.	3	9
5.	Assay of nitrogenase activity by acetylene reduction method	3	9
6.	Estimation of fatty acid profile by gas liquid chromatography	2	6
7.	Isolation, purification and quantification genomic DNA.	2	6
8.	Isolation and purification of plasmid DNA and restriction digestion analysis.	3	9
9.	Isolation of mitochondrial fraction by differential centrifugation and assay for mitochondrial membrane integrity.	3	9
10.	Isolation, purification and isozyme analysis of peroxidase enzyme	4	12
11.	Antigena-antibody interaction determination by ELISA.	3	9
	Total	**34**	**100**

E Resources and Journals:

- Annual Review of Biochemistry
- Annual Review of Genetics
- Annual Review of Plant Physiology and Plant Molecular Biology
- Biochemical and Biophysical Research Communication
- Biochemical Journal
- Biochimica Biophysica. Acta
- Cell
- Current Science
- Federation of European Biochemical Society
- Food Chemistry
- Indian Journal of Experimental Biology
- Journal of Agriculture and Food Chemistry
- Journal of Biological Chemistry
- Journal of Immunology
- Journal of Molecular Modelling
- Journal of Plant Biochemistry and Biotechnology
- Nature
- Physiologia Plantarum
- Plant Physiology
- Plant Science
- Planta
- Proceedings of National Academy of Sciences, USA
- Protein Science
- RNA
- Science
- Scientific American
- Trends in Biochemical Sciences
- Trends in Biotechnology
- Trends in Plant Sciences

Restructured and Revised Syllabi of Post Graduate Programmes

M. Sc. and Ph. D. (Agriculture)

In

Microbiology

Compiled by

Broad Subject Co-ordinator
Associate Dean,
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DR. PDKV, Akola

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Professor of Plant Pathology (CAS)
Department of Plant Pathology & Microbiology,
Mahatma Phule Krishi Vidyapeeth, Rahuri,

CONTENTS

Preamble

World is experiencing a rapid shift of national priorities in research and development. Biological science is emerging as one of the top priorities in the field of science, and among the biological sciences microbiology has gained new stature. Microoganisms and their activities are increasingly central to many of the concerns of the society both nationally and internationally. The problem of global environment, the recognition of the need to recycle natural resources, the discovery of genetic engineering – these and other development have placed microbiology in limelight. It is required to restructure and modify the curriculum and the syllabus to enable graduate students to be reacquainted with the developments through providing comprehensive exposure to the M.Sc and Ph.D. students, on new developments in different areas of microbial science. With this background the structure of curriculum for M.Sc. and Ph.D. programmes and syllabi for the courses needs to be developed keeping in view the mandate of agriculture universities and ICAR institutes.

Microbes are indispensable to our life. Interactions of microbes involved in soil, environment, food, fermentation, medical, or agriculture has been studied using modern techniques. New antibiotics, vaccines are also being produced. Moreover, genome sequence of important genes of interest or complete sequence of microbes, plants, human beings or animals has further paved the ways for detailed study of interactions and their manipulations in the desired direction. Molecular analysis of relevant factors in the plant and microbes and components that modulate plant-microbe interactions for soil and plant health for sustaining crop productivity is now being revealed using different molecular techniques. Microbial diagnostic micro arrays have been developed for the parallel, high-throughput identification of many microorganisms.

There is growing recognition in the potential of microorganisms in many applied areas. The ability of microorganisms to decompose materials such as herbicides, pesticides and oilin oils pills; the potential of microorganisms as food supplements; the exploitation of microbial activity to produce energy such as methane gas for natural consumption; and the potential of new therapeutic substances produced by microorganisms – these and other uses of microorganisms are becoming increasingly attractive. Increased attention has been directed towards use of microorganisms (bioremediation) for wastewater treatment involving decolorization of different industrial effluents, which include distillery waste, textile industries and paper and pulp industries. Microbial degradation and decolorization holds promise and can be exploited. But genetic improvement of strains can be explored in future for improving
their decolorization efficiency. Some of the agro wastes are being used for the production of biofuels. Use of recombinant microorganisms for industrial production of useful compounds has reached at commercial levels. All these aspects are covered in the course curricula.

For MSc programme, 14 courses including master's seminar and master's research are finalized, out of which minor changes have been done in existing 9 courses and one course MICRO 506, Microbial biotechnology, is completely reframed and

modified. The aim is to teach students about industrially useful microorganisms and use of fermenter for the production of various primary and secondary metabolites, this course is job oriented. The students can be absorbed by various agro-industries. One new course MICRO501 entitled Techniques in microbiology has been newly introduced in the syllabus. This course aims to introduce various techniques and instrumentation methods required for the study of microorganisms. This course provides understating on techniques and methods of microscopy, spectroscopy, chromatography and electrophoresis. Courses MICRO 503 and MICRO 504 entitled Microbial physiology and Microbial genetics, respectively, include recombinant DNA technology, commonly related to as genetic engineering, as one of the principal thrust of the emerging technologies in the biological and agricultural sciences. Recombinant DNA technology makes it feasible to consider genetically manipulated (engineered) microorganisms for commercial production of new and valuable products for variety of purposes, e.g., medicinal, fuel and food. Course No MICRO 505, Soil Microbiology and MICRO 604 Recent approaches in environmental microbiology are introduced with certain important changes with great emphasis on integrated use of chemical fertilizers, pesticides, herbicides along with biofertilizers, biopesticides and biocontrol agents for sustaining modern agriculture and soil health. Biocontrol agents for control of plant diseases, insects, nematodes have been developed and some of these are commercially available and being used by the farmers. Microbe-plant symbiosis within plant rhizosphere have come up as an effective clean up technology.From the earlier syllabus one course entitled Plant microbe interactions has been upgraded from master's programme to Ph.D. level (MICRO 605).

In Ph.D. programme, 8 courses are finalized (including doctoral seminar and research) out of which 3 are the thorough modifications of existing courses. MICRO 602 Microbial physiology and regulation has been formulated keeping in view following important concepts:

- Basic metabolic pathways can lead to different metabolic groups such as heterotrophs/ phototrophs, etc.
- Measurement of growth as influenced by various factors such as media andenvironmental factor can help to design specific culture media.
- The role of environmental factors in key regulatory points in microorganisms isimportant in their adoption to the environment
- Enzyme regulation occurs for the cell to adopt in different conditions.
- Role of enzymes in the microorganisms for degradation of substrates for their growth through metabolic pathways may be inductive or conservative determinestheir expression.

Course No. MICRO 604 Recent Approaches in environmental microbiology has been introduced with the concept:

- How microbes contribute to successful colonization in environment and their interaction with the environment
- Microbiological prospective of public health.
- Certain process like adsorption, immobilization, mobilization and transformation of metal are main processes that can be mediated by action of several microorganisms.

- Microbial bioremediation, biodegradation through species or strains or consortia which are specific to the degradation of one or more types of contaminants forreclamation of environment or remediate polluted sites.

New course MICRO 605 Plant microbe Interaction has been introduced with the concept that–

- The dynamics of plant community is influenced by the microbial association andactivity.
- In the plant ecosystems microbes play a defined role to ascertain that plants benefit through provision of nutrients and growth promoting factors.
- At times pathogenic microbes play havoc on the plants, sometimes threatening their very existence.
- The plant serves as habitat for microbial communities. It is the interplay of the interaction between the plant and the microbiome it hosts, that is critical for the establishment and the maintenance of host-microbial homeostasis and defines the overall health and productivity

With a degree in microbiology, students can get opportunities to work in both government as well as private sector, in various fields like healthcare organizations, forensic science laboratories, environmental organizations, higher education institutions, publicly funded research organizations, pharmaceuticals, food and beverages industries, chemical industries, agriculture department, agro-industries, etc.

Microbiology courses are offered by a large number of students hence need small equipment in multiple numbers. To do quality teaching and research, sophisticated equipment like ultra-low freezers, high speed refrigerated-automated bioseparation systems like GLC or HPLC and UV-Vis spectrophotometers suitable for enzyme studies, PCRs, electrophoresis systems for proteins and DNA are required for Microbiology lab. Consumables will also be needed accordingly. An approximate recurring budget of Rs. 20 lacs per annum apart from one time equipment and maintenance grant of Rs. 2 crore will be required.

DEGREE NOMENCLATURE

- **M.Sc. (Ag) in Microbiology**
- **Ph.D. (Ag) in Microbiology**

- **Eligibility**
  i.M.Sc. (Ag) Microbiology
  Degree- Bachelor's degree in Agriculture/Horticulture or equivalent (4 years programme).

  ii.Ph.D. Microbiology Degree- M.Sc. (Ag) Microbiology

State level Committee for revision of M.Sc. (Ag) syllabus in Microbiology

BSMA Discipline	Course Co-ordinators	Discipline Co-ordinators	Approved Degrees
Basic Sciences	Dr. Mane S.S. PDKV, Akola	Dr. A.M. Navale Dr. K. T. Apet	Microbiology

Course Title with Credit load M.Sc. (Ag) in Microbiology

Course Code	Course Title	Credit Hours
MICRO-501	Techniques in Microbiology	0+2
MICRO-502*	Principles of Microbiology	3+1
MICRO-503*	Microbial physiology and metabolism	3+1
MICRO-504	Microbial Genetics	2+1
MICRO-505*	Soil Microbiology	2+1
MICRO-506	Microbial Biotechnology	2+1
MICRO-507*	Food Microbiology	2+1
MICRO-508	Bacteriophages	1+1
MICRO-509	Environmental Microbiology	2+1
MICRO-510	Industrial Microbiology	2+1
MICRO-511	Biofertilizer Technology	2+1
MICRO-512	Cyanobacterial and Algal Biotechnology	2+0
MICRO-591	Master's Seminar	1+0
MICRO-599	Master's Research	30

*** Core Courses**

Proposed courses for M.Sc. degree programme

Major Courses	Title			Credits
MICRO-502*	Principles of Microbiology			3+1=4
MICRO-503*	Microbial physiology and metabolism			3+1=4
MICRO-504	Microbial Genetics			2+1=3
MICRO-505*	Soil Microbiology			2+1=3
MICRO-506	Microbial Biotechnology			2+1=3
MICRO-507*	Food Microbiology			2+1=3
Total Credits				**20**
Minor Courses				
BIOCHEM 501	Basic Biochemistry			3+1=4
BIOCHEM 505	Techniques in Biochemistry			2+2=4
SOILS 506	Soil Biology and Biochemistry			2+1=3
Total Credits				**11**
Supporting Courses				
BIOCHEM 510	Nitrogen And Sulphur Metabolism			2+1=3
STAT 511	Experimental Design			2+1=3
	Total Credits			**06**
Seminar				
MICRO 591	Master's Seminar			1+0=1
Total Credits				**01**
Grand Total				**38**
Master's Research				**30**
Major Credits	**Minor Credits**	**Supporting Credits**	**Seminar**	**Total Credits**
As per BSMA Credits				
20	08	06	01	35
Actually Offered Credits				
20	11	06	01	38

Course Title with Credit load Ph.D. in Microbiology

Course Code	Course Title	Credit Hours
MICRO 601*	Improvement in fermentation Technology	2+1
MICRO 602	Microbial physiology and regulation	2+0
MICRO 603*	Recent development in Soil Microbiology	2+0
MICRO 604	Recent approaches in environmental microbiology	2+0
MICRO 605*	Plant microbe interactions	2+1
MICRO 691	Doctoral seminar I	1+0
MICRO 692	Doctoral seminar II	1+0
Total		12+2=14
MICRO 699	Doctoral Research	75
***Core Courses**		

Proposed courses for Ph.D. degree programme

Major Courses	Title	Credits
MICRO 601*	Improvement in fermentation Technology	2+1=3
MICRO 602	Microbial physiology and regulation	2+0=2
MICRO 603*	Recent development in Soil Microbiology	2+0=2
MICRO 604	Recent approaches in environmental microbiology	2+0=2
MICRO 605*	Plant microbe interactions	2+1=3
Total Credits		**12**
Minor Courses		
BIOCHEM 601	Advanced Enzymology	2+1=3
BIOCHEM 602	Advanced Molecular Biology	3+0=3
BIOCHEM 603	Biochemistry of Biotic and Abiotic Stresses	3+0=3
Total Credits		**09**
Supporting Courses		
BIOCHEM 607	Application of Techniques in Biochemistry	1+2=3
MBB 512	Immunology and Molecular Diagnostics	2+1=3
	Total Credits	**06**
Seminar		
MICRO 691	Doctoral Seminar I	1+0=1
MICRO 692	Doctoral Seminar II	1+0=1
Total Credits		**02**
Grand Total		**29**
MICRO 699	Doctoral Research	**75**

Major Credits	Minor Credits	Supporting Credits	Seminar	Total Credits
12	**09**	**06**	**02**	**29**

Semester wise course layout of M.Sc. (Ag) in Microbiology

Semester No.	Course No.	Title	Credits
I	**Major Courses**		
	MICRO 502	Principles of Microbiology	3+1=4
	MICRO 503	Microbial Physiology and Metabolism	3+1=4
	MICRO 504	Microbial Genetics	2+1=3
	Minor Courses		
	BIOCHEM 501	Basic Biochemistry	3+1=4
	Supporting Courses – Nil		
	Total		**11+4=15**
	Non Compulsory Courses (NCCC)		
	PGS 501	Library and Information Services	0+1=1
	PGS 504	Basic Concepts in Laboratory Techniques	0+1=1
II	**Major Courses**		
	MICRO 505	Soil Microbiology	2+1=3
	MICRO 506	Microbial Biotechnology	2+1=3
	Minor Courses		
	BIOCHEM 505	Techniques in Biochemistry	2+2=4
	SOILS 506	Soil Biology and Biochemistry	2+1=3
	Supporting Courses		
	STAT 511	Experimental Design	2+1=3
		Total	**10+8=18**
	Non Credit Compulsory Courses (NCCC)		
	PGS 502	Technical Writing and Communication Skills	0+1=1
	PGS 503	Intellectual Property and its Management in Agriculture	1+0=1
III	**Major Courses**		
	MICRO 507	Food Microbiology	2+1=3
	Minor Courses Nil		
	Supporting Courses		
	BIOCHEM 510	Nitrogen and Sulphur Metabolism	2+1=3
		Total	**4+2=6**
	Non Credit Compulsory Courses (NCCC)		
	PGS 506	Disaster Management	1+0=1
	PGS 505	Agricultural Research Ethics and Rural Development Programmes	1+0=1
IV	**Major Courses**		
	Micro 591	Master's Seminar	1+0=1
	Micro 599	Master's Research	30
	Minor Courses Nil		
	Supporting Courses Nil		
	Total		**1+0=1**
	Grand Total		**26+12=38**

Major- 21 Minor- 11 PGS -5 Supporting – 06 Master's Seminar-01 Master's Research-30

Total = 39+30+5=74

Semester wise course layout of Ph.D. Microbiology

Semester	Code	Course Title	Credits
I Major courses			
I	MICRO 601*	Improvement in fermentation Technology	2+1=3
	MICRO 602	Microbial physiology and regulation	2+0=2
	MICRO 603*	Recent development in Soil Microbiology	2+0=2
Minor courses			
	BIOCHEM 601	Advanced Enzymology	2+1=3
	BIOCHEM 602	Advanced Molecular Biology	3+0=3
Supporting courses			
	Biochem 607	Application of Techniques in Biochemistry	1+2=3
Total			**12+4=16**
Non Credit Compulsory Courses (NCCC)- Nil			
	PGS 501	Library and Information Services	0+1=1
	PGS 504	Basic Concepts in Laboratory Techniques	0+1=1
II Major courses			
II	MICRO 604	Recent approaches in environmental microbiology	2+0=2
	MICRO 605*	Plant microbe interactions	2+1=3
Minor courses			
	BIOCHEM 603	Biochemistry of Biotic and Abiotic Stresses	3+0=3
Supporting courses			
	MBB 512	Immunology and Molecular Diagnostics	2+1=3
Total			**09 +02=11**
Non Credit Compulsory Courses (NCCC)- Nil			
	PGS-502	Technical writing and communication skills	0+1=1
	PGS 503	Intellectual Property and its Management in Agriculture	1+0=1
III Major courses Nil			
Doctoral Seminar			
	MICRO 691	Doctoral Seminar I	1+0=1
Minor courses -Nil			
Supporting courses - Nil			
Total			**1+0=1**
Non Credit Compulsory Courses (NCCC)			
	PGS 505	Agricultural Research Ethics and Rural Development Programmes	1+0=1
	PGS 506	Disaster Management	1+0=1
IV Major courses -Nil			
Doctoral Seminar			
	MICRO 692	Doctoral Seminar II	1+0=1
Minor courses -Nil			
	MICRO 699	Doctoral Research	75
Total			**1+0=1**
Non Credit Compulsory Courses (NCCC)-Nil			
Supporting courses-Nil			
V Major, Minor, supporting- Nil			
VI	**Major, Minor, supporting- Nil**		
Grand Total			**23+6=29**

Major-12 Minor- 09 Supporting –6, Doctoral seminar -2 Total =29 + Research- 75
Grand Total 29+75=104

Course Content and Syllabus of Masters Programme

Course Title : Techniques in Microbiology

Course Code : MICRO 501

Credit Hours : 0+2

Why this course?

The science of microbiology is the study of microorganisms and their activities. Itis concerned with their form, structure, reproduction, physiology, metabolism and identification. It includes the study of their distribution in nature, their relationship to each other and to their living things, their beneficial and detrimental effects on agriculture and the physical and chemical change they make in their environment. In microbiology laboratories, some special equipment and apparatus are commonly used. Students of microbiology should have a general idea of these equipmentregarding their constructive features, operation, precaution for use and also the maintenance of the equipment.

Aim of the course

This course aims to introduce various techniques and instrumentation methods required for the study of microorganisms. This course provides understating on techniques and methods of microscopy, spectroscopy, chromatography and electrophoresis.

The course is organized as follows:

No.	Blocks	Units
1	Techniques in microbiology	1. Practical include estimation of microbiological contents of samples likewater, soil, air, etc. 2. Operation and care of microscopes 3. Preparation of smears and their \ morphological observation using microscope 4. Performance of various staining techniques, study of biochemical activities, Identificationof microorganisms, preparation of culture media etc.

Practicals

- Awareness about lab safety measures
- Study of general microbiological equipment, cleaning of glassware and apparatus for laboratory use
- Methods of sterilization used in microbiology laboratory
- Use of simple techniques in laboratory (Colorimetry, Centrifugation, electrophoresisand chromatography)

- Types of culture media
- Isolation techniques and direct microscopic count
- Environmental factors affecting bacterial growth: physical chemical, temperature, pH, osmotic pressure, light (UV) and bacteriostatic agents. Bacteriology of air, water, and soil.
- Characteristics of important types of micro-organisms: major functional groups of bacteria, lactic acid, spore forming and coliforms bacteria, fungi, yeast and mold.
- Assessment of microbial quality of portable water.
- Working in microscope

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Publication Review
- Student presentation
- Group discussion
- Case Analysis and case studies
- Guest Lectures
- Review of policy documents

Learning outcome

After successful completion of this course, the students are expected to be able to:

- Appreciate the scientific foundation of general microbiology and relate the key learning to the job of an microbiologist professional
- Utilise methods and tools for microbial agricultural development for the nation.
- Increase the probability of use of different microbial cultures for the benefits ofagriculture production

Suggested Reading

- Roy A.K. 2010. *Laboratory Manual of Microbiology* (Practical Manual Series).
- Goldman E and Green LH. 2015. *Practical Handbook of Microbiology.* 3rd Edition. http/ www. CRC press life science Microbiolgy
- Brock, T.D. 2008. *Biology of microorganisms* (Ed.) Madigan MT, Martinko J M, Dunlap P V, Clark D.P., 12th ed. Pearson, New Jersey.
- Pelczar, M.J. Jr., Chan, E.C.S. and Kreig, N.R. 1997. *Microbiology, Concepts and Application*,5th edition, Tata McGraw Hill, New York.
- Prescott, L.M., Harley and Klein. 2002. *Microbiology* 5th Edition, Tata McGraw Hill, New York.
- Bhatia, M.S. 2009. *Principles of Microbiology*. Swastik Publishers., DeIhi.
- Madigan, M.T., J.M. Martinko, P.V. Dunlap and D.P. Clark. 2001. *Brock biology of Microorganism* 10th Ed. Pearson Education lnc, USA.
- Singh, U.S. and K. Kapoor 2010. *Introductory microbiology* Oxford Book Company., Jaipur
- Tortora, G.J., B.J. Funke and C.L. Case. 2010. *Microbiology: an introduction*.10th Ed. Benjamin Cummings., New York.

Course Title :- Principles of Microbiology
Course No.- MICRO 502
Credit – 3+1

Theory

Block 1: Scope and History of Microbiology and Microscopy

Unit1: Scope of microbiology

Scope of microbiology, microbes and microbiologist. Emergence of Special Fields of Microbiology.

Unit2: History Routes

The Germ Theory of Disease, Early Studies: Pasteur's Further Contributions, Koch's Contributions, Work Toward Controlling Infections, spontaneous generation theory.

Unit3: Staining and microscopy

Microscopy; Bright field, Dark field, Phase contrast, Confocal, Fluorescence, TEM,SEM – Working Principles and applications; Properties of light; Simple staining, differential and special staining.

Block 2: Evolutionary Link of Prokaryotes

Unit1: Phylogenetic classification

Evolutionary relationship among prokaryotes. Prokaryotes and Eukaryotes, Phylogenetic and numerical taxonomy. Species concept.

Unit2: Methods of sequencing

Use of DNA and r-RNA sequencing in classifications.

Block 3: Microbial Growth, Characterization And Regulation

Unit1: Microbial growth and reproduction

Microbial growth and reproduction-communication, bacteria, yeast and virus growth, Replication, Cultivation methods, Normal micro flora of Human body; Immune response-specific and non-specific host resistance.

Unit2: Sterilization techniques

Physical and chemical methods of sterilization.

Unit3: Nutritional requirements for microbial growth

Classification of microbes: electron, energy and carbon sources.

Practicals

- Working principles and handling of different types of microscopes–Bright and Dark field microscopy
- Working principles and handling of different types of microscope-SEM and TEM
- Methods of isolation from different environments–soil, water, milk and food
- Use of selective media for isolation
- Purification techniques of bacteria and fungi
- Enumeration and Quantification techniques
- Maintenance and preservation of cultures
- Assessment of microbial quality of portable water.
- Morphological characterization of Bacteria
- Morphological characterization of fungi
- Biochemical characterization of bacteria

- Biochemical characterization of fungus

Suggested Reading

- Brock TD. 2008. *Biology of microorganisms* (Ed.) Madigan MT, Martinko JM, Dunlap PV, Clark DP, 12th ed. Pearson, New Jersey.
- Pelczar MJ.Jr., Chan, ECS and Kreig NR. 1997. *Microbiology, Concepts and Application*, 5th edition, Tata McGraw Hill, New York.
- Prescott, L.M., Harley and Klein. 2002. *Microbiology* 5th Edition, Tata McGraw Hill, New York.
- Bhatia, M.S. 2009. *Principles of Microbiology*. Swastik Publishers., DeIhi.
- Madigan, M.T., J.M. Martinko, P.V. Dunlap and D.P. Clark. 2001. *Brock biology of Microorganism* 10th Ed. Pearson Education lnc, USA.
- Singh, U.S and K. Kapoor 2010. *Introductory microbiology* Oxford Book Company., Jaipur
- Tortora, G.J., B.J. Funke and C.L.Case. 2010. *Microbiology :anintroduction*. 10th Ed. Benjamin Cummings., New York
- Davis BD, Dulbecco R, Eisen HN and Ginsberg HS. 1990. *Microbiology* (4th edition).
- J.B. Lippincott company, New york.
- Alexopoulus CJ and CW. Mims. 1993. *Introductory Mycology* (3rd edition). Wiley Eastern Ltd, New Delhi.
- Elizabeth Moore-Landecker. 1996. *Fundamentals of the fungi*. (4th edition). Prentice Hall International, Inc, London.
- Heritage, J.Ev ans E.G.V. and Killington, R.A. 1996. *Introductory Microbiology*. Cambridge University Press.
- Webster J. 1993. Introduction to Fungi. (2nd edition). Cambridge University press, Cambridge.
- Prescott LM, Harley JP and Klein DA. 2006. Microbiology (7th edition) McGraw Hill, New york.
- Schaechter M and Leaderberg J. 2004. The Desken cyclopedia of Microbiology. Elseiver Academic press, California.
- Nester, E.W., Roberts, C.V. and Nester, M.T. 1995. *Microbiology: A human perspective*. IWOA, U.S.A.
- Pelczar Jr, M.J. Chan, E.C.S. and Kreig, N.R.1993. *Microbiology*, Mc.Graw Hill. Inc, New York.
- Holt J G and Bergey DH. 1994. *Bergey's Manual of Determinative Bacteriology* (9th Edition), Williams and Wilkins, Baltimore.
- Mara D. and Horan N. 2003. *The Handbook of Water and waste water Microbiology*. Academic Press-Anim print of Elsevier.
- Madigan MT, Bender KS, Buckley HD, Sattley WM, Stahl DA 2017. *Brock Biology of Microorganisms*- 15th edition. Pearson Education, USA.

Teaching schedule: Theory

Lecture No.	Topic
1 - 5	**Scope and History of Microbiology and Microscopy** **Scope of microbiology** Scope of microbiology: microbes and microbiologist. Emergence of Special Fields of Microbiology.
6-11	**History Routes** The Germ Theory of Disease, Early Studies: Pasteur's Further Contributions, Koch's Contributions, Work Toward Controlling Infections, spontaneous generation theory.
12-18	Staining and microscopy **Microscopy; Bright field, Dark field, Phase contrast, Confocal, Fluorescence, TEM,SEM – Working** Principles and applications; Properties of light; Simple staining, differential and special staining.
19-23	**Evolutionary Link of Prokaryotes** **Phylogenetic classification** Evolutionary relationship among prokaryotes. Prokaryotes and Eukaryotes, Phylogenetic and numerical taxonomy. Species concept.
24-27	**Methods of sequencing** Use of DNA and r-RNA sequencing in classifications.
28-35	**Microbial Growth, Characterization And Regulation** **Microbial growth and reproduction** Microbial growth and reproduction-communication, bacteria, yeast and virus growth, Replication, Cultivation methods, Normal micro flora of Human body; Immune response-specific and non-specific host resistance.
36-40	**Sterilization techniques** Physical and chemical methods of sterilization.
41-46	**Nutritional requirements for microbial growth** Classification of microbes: electron, energy and carbon sources.

Practical

Practical No	Topic
1 - 2	Working principles and handling of different types of microscopes–Bright and Dark field microscopy
3 - 4	Working principles and handling of different types of microscope-SEM and TEM
5 - 6	Methods of isolation from different environments–soil, water, milk and food
7	Use of selective media for isolation
8	Purification techniques of bacteria and fungi
9	Enumeration and Quantification techniques
10	Maintenance and preservation of cultures
11	Assessment of microbial quality of portable water
12	Morphological characterization of Bacteria
13	Morphological characterization of fungi
14-15	Biochemical characterization of bacteria

15-16	Biochemical characterization of fungus

Course No.: MICRO 503
Course Title: Microbial Physiology and Metabolism
Credit: 3+1=4

Theory
Block1: Scope of Microbial Growth and Physiology
Unit1: Structure, function and biosynthesis of cellular components

Microbial nutrition– Chemical composition of microbial cell– Structure, function and assembly of cell membrane in prokaryotes, archaea and fungi– Macro and Micro- nutrients and their physiological functions – Transport of solutes across the membrane

Block 2: Pathways and their Significance; Growth Kinetics and Nutritional Classifications
Unit 1: Growth Kinetics, cell cycle, cell division, pathways and fermentation metabolism

Microbial growth. Cell cycle and cell division. Bioenergetics- carbohydrate utilization via EMP, HMP, ED, TC Apathways, Aerobic and anaerobic respiration. Fermentative metabolism. Assimilation of nitrogen and sulphur - Oxygenic and anoxygenic photosynthesis-Mechanisms of carbon-dioxide fixation in prokaryotes. Ethanol, lactic acid, butanol, acetone and mixed acid fermentation. Fermentation of nitrogenous organic compounds Regulation of microbial metabolism.

Unit2: Growth and factors affecting growth and culture systems

Effects of physical, chemical and other environmental factors on growth Continuous culture, Diauxic growth and Synchronous culture. Method of growth measurement. Morphogenesis and cellular differentiation.

Unit3: Nutritional classification and spore formation and germination

Metabolic diversity in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs. Nutritional grouping/classification of microorganisms. Bacterial endospore-types, morphology, biochemistry and regulation of formation and germination

Block3: Enzymes and Microbial Metabolisms
Unit1: Kinetics and Mechanism of Enzymes

Enzyme kinetics: Michaelis Menten kinetics- mechanisms of inhibition of enzyme activity-coenzymes and prosthetic groups.

Unit2: Microbial metabolism

Methods to determine free energy of biochemical reactions - high energy compounds. Microbial metabolism: generation of ATP, reducing power, development of proton gradient and biosynthesis of ATP.

Block4: Synthesis of Macromolecules
Unit1: Biosynthesis of macromolecules

Biosynthesis of macromolecules –Synthesis and assembly of cell wall components
–Methods of studying biosynthesis- regulation of microbial metabolism.

Suggested Reading

- Moat, A.G. and J.W. Foster. 2002. *Microbial Physiology*. John Wiley & Sons, New York, USA.

11th ed. Prentice- Hall, Inc. Englewood Cliffs, New Jersey.
- Madigan, M.T, J.M. Martinko and J.Parker. 2006. *Brock: Biology of Microorganisms*, 11th ed. Prentice-Hall, Inc. Englewood Cliffs, NewJersey.
- White, D.2007. *The Physiology and Biochemistry of Prokaryotes*, 3rd Edition. Oxford
- University Press.
- Downs, D.M.2006. *Understanding microbial metabolism*. Annual Review of Microbiology 60, 533–559.
- Hosler*etal.* 2006. *Energy Transduction: Proton Transfer Through the Respiratory Complexes*.
- Annual Review of Biochemistry 75, 165-187.
- Okuno *et al.* 2008. *Correlation between the conformational states of F1-ATPaseasde termined from its crystal structure and single- molecule rotation*. PNAS105 (52): 20722-20727.
- Itohetal (2004) Mechanically driven ATP synthesis by F1-ATPase. Nature427, 465-468.
- Doelle HW.1969. *Bacterial Metabolism*. Academic Press.
- Gottschalk G.1979. *Bacterial Metabolism.* Springer Verlag.
- NelsonDLandCoxMM.2017.*Lehninger,Principles of Biochemistry,* 4th Edition, W.H. Freeman & Company, 2004.(T1)
- Voet D and Voet JG. 2002. *Fundamentals of Biochemistry*, Upgrade Edition, Wiley.

Practicals

- Use of simple techniques in laboratory (Colorimetry, Centrifugation, electrophoresis and GLC, etc.).
- Determination of viable and total number of cells.
- Measurement of cellsize.
- Gross cellular composition of microbial cell. Growth– Factors affecting growth.
- Study of bacterial spores and factors affecting germination.
- Enzyme activity and kinetics– calculating Km and V_{max} of enzyme.
- Demonstration of thermos-, meso-, and psychrophilic micro-organisms.
- Production and testing of inducible enzymes in bacteria.
- Sporulation and spore germination in bacteria.
- Protoplasts formation and regeneration.
- Estimation of generation time and specific growth rate for bacteria and yeast.
- Diauxic growth curve.
- Production of synchronous cells.
- Effect of chemicals and environmental factors on bacterial growth.
- Isolation and Identification of reserve food material (Glycogen/polyphosphates, PHB) from bacteria (*Azotobacter, Bacillus megaterium*).
- Growth of microorganisms on various carbon and nitrogen sources.

TEACHING SCHEDULE
THEORY

Lecture No.	Topic
1-7	**Scope of Microbial Growth and Physiology** **Structure, function and biosynthesis of cellular components** Microbial nutrition– Chemical composition of microbial cell– Structure, function and assembly of cell membrane in prokaryotes, archaea and fungi– Macro and Micro- nutrients and their physiological functions – Transport of solutes across the membrane.
8-14.	**Pathways and their Significance; Growth Kinetics and Nutritional Classifications** **Growth Kinetics, cell cycle, cell division, pathways and fermentation metabolism** Microbial growth. Cell cycle and cell division. Bioenergetics- carbohydrate utilization via EMP, HMP, ED, TCA pathways
15-18	Aerobic and anaerobic respiration. Fermentative metabolism. Assimilation of nitrogen and sulphur - Oxygenic and anoxygenic photosynthesis-Mechanisms of carbon-dioxide fixation in prokaryotes.
19-22	Ethanol, lactic acid, butanol, acetone and mixed acid fermentation. Fermentation of nitrogenous organic compounds Regulation of microbial metabolism.
23-27	**Growth and factors affecting growth and culture systems** Effects of physical, chemical and other environmental factors on growth Continuous culture, Diauxic growth and Synchronous culture. Method of growth measurement. Morphogenesis and cellular differentiation.
28-34	**Nutritional classification spore formation and germination** Metabolic diversity in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs. Nutritional grouping/classification of microorganisms. Bacterial endospore-types, morphology, biochemistry and regulation of formation and germination
35-39	**Enzymes and Microbial Metabolisms** **Kinetics and Mechanism of Enzymes** Enzyme kinetics: Michaelis Menten kinetics- mechanisms of inhibition of enzyme activity-coenzymes and prosthetic groups
40-42	**Microbial metabolism** Methods to determine free energy of biochemical reactions - high energy compounds. Microbial metabolism: generation of ATP, reducing power, development of proton gradient and biosynthesis of ATP.
43-48	**Synthesis of Macromolecules** **Biosynthesis of macromolecules** Biosynthesis of macromolecules –Synthesis and assembly of cell wall components –Methods of studying biosynthesis- regulation of microbial metabolism

Course No.- MICRO 504
Course Title – Microbial Genetics
Credit – 2+1=3

Theory

Block1: Introduction to Microbial Genetics

Unit1: Historical perspectives of microbial genetics

Introduction to Microbial genetics; Historically important events and major contributions of scientists in the field of Microbial genetics; Terminologies employed in microbial genetics and definitions; Nucleic acid–overview DNA, RNA.

Unit2: Genome of prokaryote, eukaryote (fungi) and virus

Bacterial genome Eukaryotic genome; Viral genome; Difference between prokaryotic and eukaryotic genome; Mechanisms and role of prokaryotic genome-an overview.

Unit3: Genetic elements- chemical structure and property, enzymes associated and replication

Structure of DNA–A form, B form, Z form; RNA- tRNA, mRNA, rRNA; Role and Replication of DNA and RNA; Enzymes involved in Replication and its role.

Unit 4: Extra-chromosomal DNA in bacteria and eukaryotic cells

Plasmids, Mitochondrial DNA, Chloroplast DNA–structure and function.

Block 2: Gene Expression and Regulation

Unit1: Introduction to gene structure and expression

Gene structure and expression, principles of operon, gene expression in prokaryote and eukaryotes, intron and exons, post transcriptional modifications.

Unit2: Regulation of gene expression

Regulation of gene expression, negative expression (lac operon and trp operon), positive regulation (cAMP).

Block3: Mutation, Genetic Recombination and Sequencing

Unit1: Principles of mutation and types

Principles of mutation, spontaneous and Induced mutation, different types of mutations, selection principles of mutants.

Unit2: Mutagens and their mode of action

Mutagens and their mode of action, transposable elements and insertion sequences.

Unit3: DNA damage-DNA repair mechanisms

DNA damage, DNA repair mechanisms in bacteria.

Unit4: Genetic recombination in bacteria

Genetic recombination in bacteria, mechanisms of recombination, transformation, conjugation, transduction.

Unit 5: Gene sequencing

Gene cloning and gene sequencing. Impact of gene cloning, polymerase chain reaction, DNA sequencing, recombinant DNA technology.

Practical

- Isolation of genomic DNA from pure cultures of bacteria and fungi.
- Visualization of mega plasmids of bacteria.
- Isolation of bacterial plasmids and Plasmid curring.
- Qualitative and quantitative assay of DNA by spectrometry and gel- electrophoresis.

- Inducing mutation by chemicals, physical and biological agents.
- Transformation and selection of transformants.
- Amplification of gene of interest by PCR– cloning and expression.
- Isolation of metagenomic DNA from environmental samples.

Suggested Reading

Brown TA. 2001. Gene Cloning and DNA Analysis: An Introduction. Fourth Edition. Black well Science Inc., Oxford, UK.

Levin B. 2002. Gene VIII. Oxford Univ. Press, New York. p.990.

Maloy SR, Cronan JE, Freifelder D. 2008. Microbial Genetics-second edition. Narosa Publising house, New Delhi. p.525.

Omoto CK and Lurquin PF.2004. Genes and DNA: abeginner's guidetogeneticsandits applications. Colambia University Press, USA.

Sambrook J, Fritsch EF,ManiatisT.2000.Molecular Cloning:A laboratory Manuel. Third Edition.Cold Spring Harbor Press, NewYork.

Streips UN,Yasbin RE. 2006. Modern Microbial Genetics.Wiley–Liss. John Wiley & sons,Inc. Publication, NY.

Birge EA.1981.Bacterial and Bacteriophage Genetics. Springer Verlag.

Gardner JE, Simmons MJ and Snustad DP.1991.Principles of Genetics. John Wiley & Sons.

Lewin B.1999.Gene.Vols.VI-IX.JohnWiley & Sons.

Maloy SR,Cronan JE and Friedfelder D.2008.Microbial Genetics.Narosa.

ScaifeJ, Leach Dand Galizzi A 1985. Genetics of Bacteria. Academic Press.William Hayes1981. Genetics of Bacteria. Academic Press.

Strips UN, Yasbin RE*2006.Modern Microbial Genetics.Wiley-Liss,NY.

Teaching schedule : Theory

Lecture No.	Topics
1-2	**Introduction to Microbial Genetics** **Historical perspectives of microbial genetics** Introduction to Microbial genetics; Historically important events and major contributions of scientists in the field of Microbial genetics;
3-4	Terminologies employed in microbial genetics and definitions; Nucleic acid–overview DNA, RNA.
5-6	**Genome of prokaryote, eukaryote (fungi) and virus** Bacterial genome Eukaryotic genome; Viral genome;
7-8	Difference between prokaryotic and eukaryotic genome; Mechanisms and role of prokaryotic genome-an overview.
9-11	**Genetic elements- chemical structure and property, enzymes associated and replication** Structure of DNA–A form, B form, Z form; RNA- tRNA, mRNA, rRNA; Role and Replication of DNA and RNA; Enzymes involved in Replication and its role.
12-13	**Extra-chromosomal DNA in bacteria and eukaryotic cells** Plasmids, Mitochondrial DNA, Chloroplast DNA–structure and function.

14-16	**Gene Expression and Regulation** **Introduction to gene structure and expression** Gene structure and expression, principles of operon, gene expression in and eukaryotes, intron and exons, post transcriptional modifications.
17-18	**Regulation of gene expression** Regulation of gene expression, negative expression (lac operon and trp operon), positive regulation (cAMP).
19-21	**Mutation, Genetic Recombination and Sequencing Principles of mutation and types** Principles of mutation, spontaneous and Induced mutation, different types of mutations, selection principles of mutants
22-23	**Mutagens and their mode of action** Mutagens and their mode of action, transposable elements and insertion sequences.
24-26	**DNA damage-DNA repair mechanisms** DNA damage, DNA repair mechanisms in bacteria
27-29	**Genetic recombination in bacteria** Genetic recombination in bacteria, mechanisms of recombination, transformation, conjugation, transduction.
30-32	**Gene sequencing** Gene cloning and gene sequencing. Impact of gene cloning, polymerase chain reaction, DNA sequencing, recombinant DNA technology.

Practical

Practical No.	Topics
1 - 2	Isolation of genomic DNA from pure cultures of bacteria and fungi.
3- 4	Visualization of mega plasmids of bacteria.
5 - 6	Isolation of bacterial plasmids and Plasmid curing.
7 - 8	Qualitative and quantitative assay of DNA by spectrometry and gel- electrophoresis.
9 - 10	Inducing mutation by chemicals, physical and biological agents
11 - 12	Transformation and selection of transformants
13 -14	Amplification of gene of interest by PCR– cloning and expression
15-16	Isolation of metagenomic DNA from environmental samples

Course No.: MICRO 505
Course Title: Soil Microbiology
Credit: 2+1=3

Theory

Block 1: Developments in Soil Microbiology and Soil Parameters

Unit 1: Historical prospective of soil microbiology. Factors affecting soil microflora.

Landmarks in the history of soil microbiology. Abiotic factors (physical and chemical) affecting soil microflora as pH, chemicals, moisture, air, temperature etc.

Unit 2: Ecology of soil microbiology

Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.

Block 2: Microbiology and Biochemistry of Plant Parts

Unit 1: Plant parts and soil interface interaction

Microbiology and biochemistry of root-soil interface; phyllosphere, plant growth promoting rhizobacteria, soil enzyme activities and their importance.

Block 3: Role of Microorganisms in Nutrient Biocycle

Unit 1: Microbial transformation of various nutrients

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials.

Unit 2: Microbial degradation of organic matter

Biochemical composition and biodegradation of soil organic matter and crop residues.

Unit 3: Microbial diversity

Endophytic microorganisms Mycorrhizae, types and role in phosphate mobilization.
Potassium releasing bacterium. Microbes in biotic and abiotic stress management.

Unit 4: Role of microorganisms in biodegradation of xenobiotics and pesticides

Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures: Biotic factors in soil development.

Practical

- Determination of soil microbial population Basic Sciences: Microbiology
- Determination of Soil microbial biomass
- Decomposition studies in soil, Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification
- N2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect
- Microbial diversity Endophytic microorganisms
- Mycorrhizae, types and role in phosphate mobilization Potassium releasing bacterium
- Microbes in biotic and abiotic stress management

Suggested Reading

- Paul EA. 2015. *Soil Microbiology, Ecology and Biochemistry*. Elsevier
- Jan Dirk Van Elsas, Trevors JT and Elizabeth M.H. Wellington, 1997. *Modern Soil Microbiology*. Marcel Dekker, Inc.
- Paul EA. 2007. *Soil Microbiology and Biochemistry* 3rd Edition. Academic Press.

• Cardon ZG and Whitbeck JL. 2007. *The Rhizosphere An Ecological Perspective*. Academic Press.
• Schulz BJE, Boyle CJC and Sieber TN (Edrs). 2006. *Microbial Root Endophytes*. Pub Springer.
• Magesin R and Schinner F. (Edrs). 2005. *Manual of soil analysis monitoring and assessing soil Bioremediation*. Pub: Springer.
• Pinton R, Varanini Z and Nannipiers P. The Rhizosphere Biochemistry & organic substances at the soil-plant interface. Pub: CRC Press.
• Prasad TV. 2011. *A Text Book of Soil Microbiology*. Dominant Publishers & Distributors, New Delhi.
• Mukerji KG, Manoharachary C and Singh J. 2006. *Microbial activity n the Rhizosphere.* Pub: Springer.

Teaching Schedule : Theory

Lecture No.	Topic
1-4	**Developments in Soil Microbiology and Soil Parameters** **Historical prospective of soil microbiology. Factors affecting soil microflora.** Landmarks in the history of soil microbiology. Abiotic factors (physical and chemical) affecting soil microflora as pH, chemicals, moisture, air, temperature etc.
5-9	**Ecology of soil microbiology** Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.
10-13	**Microbiology and Biochemistry of Plant Parts** **Plant parts and soil interface interaction** Microbiology and biochemistry of root-soil interface; phyllosphere, plant growth promoting rhizobacteria, soil enzyme activities and their importance.
14-18	**Role of Microorganisms in Nutrient Biocycle** **Microbial transformation of various nutrients** Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials.
19-22	**Microbial degradation of organic matter** Biochemical composition and biodegradation of soil organic matter and crop residues.
23-28	**Microbial diversity** Endophytic microorganisms, Mycorrhizae, types and role in phosphate mobilization. Potassium releasing bacterium. Microbes in biotic and abiotic stress management.
29-32	**Role of microorganisms in biodegradation of xenobiotics and pesticides** Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures: Biotic factors in soil development

Course No. - MICRO 506
Course Title – Microbial Biotechnology
Credit – 2+1=3

Theory

Block 1: Scope of Microbial Technology and Fermentation Metabolism

Unit1: Microbial Biotechnology:

Introduction, Scopes, historical development, application and challenges.

Unit 2: Fermentation Metabolism

Fermentative metabolism, isolation, preservation screening and genetic improvement of industrially important microbes; Microbial growth kinetics.

Unit 3: Fermenter/bioreactor design and operation

Fermenters – types of fermenter, stirred tank reactor, bubble column reactor, airlift reactor, packed bed reactor, fluidized bed reactor and trickle bed reactor, agitation and aeration in a reactor, mass transfer. Foam formation and control.

Unit 4: Fermentation system

Types, Batch, Fed batch and continuous fermentation- multistage system. Solid state fermentation, Overproduction of primary and secondary metabolites e.g. amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, etc. Immobilization of enzymes; and cells; Scale-up principles; Down-stream processing, etc.

Block 2: Recombinant Products

Unit 1: Production of recombinant

Current advances in production of antibiotics, vaccines, and biocides; Steroid Basic Sciences: Microbiology transformation; Bioprocess engineering; Production of recombinant DNA products, Immobilization techniques.

Block 3: Microbial Conversion and their Product Formation

Unit 1: Industrial production of beverages, acid and solvent

Production of alcohol (ethanol, wine and beer) and improvement by genetic engineering. Microbial production of acids (citric, acetic and gluconic acid) solvents (glycerol acetone and butanol) amino acids (lysine and glutamic acid).

Unit 2: New tools and recent advances in microbial biotechnology

Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Bioconversion of substrates, anti-nutritional factors present in feeds; Microbial detoxification of aflatoxins; Microbial polysaccharides: fermentative production of xanthan gums. Bacterial bioplastics, genetic engineering of microorganisms for the production of poly-3 hydroxyalkanoates. Single cell protein, Bio-insecticides; Bio-fertilizers; Waste as source of energy/food Microbiologically produced food, colours, and flavours. Retting of flax. Recent advances in microbial biotechnology

Practical Syllabus

- Isolation and maintenance of industrially important microbes
- Production of alcohol
- Production of beer
- Production of citric acid
- Production of lactic acid

- Standardization of physical factors for the higher production of citric acid
- Production and assay of antibiotics
- Production of pullulan
- SCP production
- Study of bioreactors and their operation

Suggested Reading

- Cruger W and Cruger A. 2004. *Biotechnology - A Textbook of Industrial*
- *Microbiology*. 2nd Ed. Panima.
- Ward OP. 1989. *Fermentation Biotechnology*. Prentice Hall.
- Wiseman A. 1983. *Principles of Biotechnology*. Chapman & Hall
- Restructured and Revised Syllabi of Post-graduate Programmes Vol. 2
- Peppler HJ and Perlman D.1979. *Microbial Technology*. 2nd Ed. Academic Pre

Teaching Schedule : Theory

Lecture No.	Topic
1-2	**Scope of Microbial Technology and Fermentation Metabolism Microbial Biotechnology:** Introduction, Scopes, historical development, application and challenges.
3-5	**Fermentation Metabolism** Fermentative metabolism, isolation, preservation screening and genetic improvement of industrially important microbes; Microbial growth kinetics.
6-10	**Fermenter/bioreactor design and operation** Fermenters – types of fermenter, stirred tank reactor, bubble column reactor, airlift reactor, packed bed reactor, fluidized bed reactor and trickle bed reactor, agitation and aeration in a reactor, mass transfer. Foam formation and control.
11-15	**Fermentation system** Types, Batch, Fed batch and continuous fermentation- multistage system. Solid state fermentation, Overproduction of primary and secondary metabolites e.g. amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, etc. Immobilization of enzymes; and cells; Scale-up principles; Down-stream processing, etc.
16-18	**Recombinant Products** **Production of recombinant** Current advances in production of antibiotics, vaccines, and biocides; Steroid transformation; Bioprocess engineering; Production of recombinant DNA products, Immobilization techniques.
19-23	**Microbial Conversion and their Product Formation** **Industrial production of beverages, acid and solvent** Production of alcohol (ethanol, wine and beer) and improvement by genetic engineering. Microbial production of acids (citric, acetic and gluconic acid) solvents (glycerol acetone and butanol) amino acids (lysine and glutamic acid).

24-27	**New tools and recent advances in microbial biotechnology** Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Bioconversion of substrates, anti-nutritional factors present in feeds; Microbial detoxification of aflatoxins;
28-32	Microbial polysaccharides: fermentative production of xanthan gums. Bacterial bioplastics, genetic engineering of microorganisms for the production of poly-3 hydroxyalkanoates. Single cell protein, Bio-insecticides; Bio-fertilizers; Waste as source of energy/food Microbiologically produced food, colours, and flavours. Retting offlax. Recent advances in microbial biotechnology

Practical

Practical No.	Topic
1	Isolation and maintenance of industrially important microbes
2	Production of alcohol
3	Production of beer
4	Production of citric acid
5	Production of lactic acid
6	Standardization of physical factors for the higher production of citric acid
7	Production and assay of antibiotics
8	Production of pullulan
9	SCP production
10	Study of bioreactors and their operation

Course No.: MICRO 507
Course Title: Food Microbiology
Credit: 2+1

Theory

Block 1: Historical Perspective and Scope of Microbiology in Relation to Food

Unit 1: Importance and significance of microorganisms in food

Introduction and scope; Food Microbiology Important microorganisms in food and their sources. Importance and significance of microorganisms in food.

Unit 2: Factors of special significance in Food Microbiology

Intrinsic and extrinsic factors influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria.

Unit 3: Microbial spoilage of different types of foods

Microbial spoilage of meat, milk, fruits, vegetables and their products. Food-borne pathogens (bacteria, fungi and viruses) and intoxication.

Block 2: Fermentation and Food Preservation Methods

Unit 1: Food fermentation

Fermented dairy, vegetable, meat products.

Unit 2: Preservatives and preservation methods

Physical methods, chemical preservatives and natural antimicrobial compounds. Biologically based preservation systems. Foods for Specified Health Probiotic bacteria; Bifidus factor. Bacteriocins and their applications; Pre-, probiotics and symbiotics. Microbes as food single cell protein.

Block 3: Food Safety and Quality Management Systems

Unit 1: Advanced techniques in detecting food-borne pathogens and toxins

Food safety and Quality Management Systems- General principles of food safety risk management, Recent concerns on food safety- Safe food alternatives (Organic foods), Good agricultural Practices (GAP), Food Indicators of water and food safety and quality Advanced techniques in detecting food-borne pathogens and toxins. HACCP (Hurdle technology and Hazard analysis. Critical control point) CODEX, FSSAI (Food Safety and Standard Authority of India) systems in controlling microbiological hazards in foods. Food safety regulations

Practical Syllabus

- Statutory, recommended and supplementary tests for microbiological analysis of various foods
- Infant foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers, normal, spoiled, processed, fermented food and water
- Testing of antimicrobial agents
- Analysis of water
- HACCP Plan
- Visit to Food processing Industries

Suggested Reading

• Bibek Ray. 1996. *Fundamentals of Food Microbiology*. CRC Press.
• Frazier W.C. and Westhoff D.C. 1991. *Food Microbiology*. 3rd Ed. Tata McGraw Hill.
• George J Banwart. 1989. Basic Food Microbiology. AVI. James M Jay. 1987. Modern Food Microbiology. CBS.
Restructured and Revised Syllabi of Post-graduate Programmes Vol. 2
• Peppler H.J. and Perlman D. 1979. *Microbial Technology*. 2nd Ed. Academic Press.
• Adams, M.R., and M. O. Moss 1996. *Food Microbiology*, New Age International (Rt) Ltd., New Delhi.
• Frazier, W.C. and D.C. Westhoff, 1988. *Food Microbiology* (Reprint 1995), Tata McGraw Hill Publishing Ltd., New Delhi.
• James M. Jay., Loessner, M.J. and Golden D.A. 2005. *Modern Food Microbiology*, Seventh edition.
• Verma, L.K. and Joshi, V.K. 2000. *Post Harvest Technology of Fruits and Vegetables*, Tata McGraw Hill Publication.
• Bhunia AK. 2008. *Foodborne Microbial Pathogens- Mechanisms and Pathogenesis, Food Science text Series*, Springer International, New York, USA.
• Benwart, G.J. 1987. *Basic Food Microbiology*, CBS Publishers & Distributors, New Delhi.
• Deak, T. and Beuchat LR. 1996. *Hand Book of Food Spoilage Yeasts*, CRC Press, New York.
• Doyle, M.P. and Beuchat, L. R. 2007. *Food Microbiology- Fundamentals and Frontiers*, ASM Press.
• Garbutt, J., 1997. *Essentials of Food Microbiology*, Armold – International Students edition, London.
• Marriott, N.G. and Gravani R. B. 2006. *Principles of Food Sanitation, Food Science textSeries*, Springer International, New York, USA.

Teaching schedule : Theory

Lecture No.	Topic
1-3	**Historical Perspective and Scope of Microbiology in Relation to Food** **Importance and significance of microorganisms in food** Introduction and scope; Food Microbiology Important microorganisms in food and their sources. Importance and significance of microorganisms in food.
4-6	**Factors of special significance in Food Microbiology** Intrinsic and extrinsic factors influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria.
7-9	**Microbial spoilage of different types of foods** Microbial spoilage of meat, milk, fruits, vegetables and their products. Food-borne pathogens (bacteria, fungi and viruses) and intoxication.
10-11	**Fermentation and Food Preservation Methods** **Food fermentation** Fermented dairy, vegetable, meat products.
12-17	**Preservatives and preservation methods** Physical methods, chemical preservatives and natural antimicrobial compounds. Biologically based preservation systems. Foods for Specified Health Probiotic bacteria; Bifidus factor. Bacteriocins and their applications; Pre-, probiotics and symbiotics. Microbes as food single cell protein.

18-25	**Food Safety and Quality Management Systems** **Advanced techniques in detecting food-borne pathogens and toxins** Food safety and Quality Management Systems- General principles of food safety risk management, Recent concerns on food safety- Safe food alternatives (Organic foods), Good agricultural Practices (GAP), Food Indicators of water and food safety and quality Advanced techniques in detecting food-borne pathogens and toxins.
26-32	HACCP (Hurdle technology and Hazard analysis. Critical control point) CODEX, FSSAI (Food Safety and Standard Authority of India) systems in controlling microbiological hazards in foods. Food safety regulations

Practical

Practical No.	Topic
1	Statutory, recommended and supplementary tests for microbiological analysis of various foods
2	Infant foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers, normal, spoiled, processed, fermented food and water
3	Testing of antimicrobial agents
4	Analysis of water
5	HACCP Plan
6	Visit to Food processing Industries

Course Title: Bacteriophages
Course Code: MICRO 508
Credit Hours: 1+1

Why this Course?
Bacteriophages are viruses that infect and reproduce in bacteria. Phages are inherently highly specific towards bacterial hosts. This characteristic has both negative and positive aspects in that it is beneficial in terms of avoiding negative effects on the host microbiota and a hindrance when it comes to detection and elimination of the target pathogen Course is formulated to demonstrate the complete sequence of host parasite reactions and provide a model by which virus –host cell reactions can be postulated for infection in higher plants and animals.

Aim of the course
To familiarize the students about phages and phage- bacterial interactions. Bacteriophages have been of intense value in elucidating many biological phenomena, including those concerned with genetics.
The course is organized as follows:

No.	Blocks	Units
1.	Bacteriophages	1. Historical prospective of bacteriophages 2. Biological processes of phage bacterial interaction 3. Life cycle of bacteriophages 4. Biotechnological Genetic manipulation

Theory

Block 1: Bacteriophages
Unit 1: Historical prospective of bacteriophages.
Historical developments and classification of bacteriophages.
Unit 2: Biological processes of phage bacterial interaction
Physiology, biochemistry, enzymology and molecular biology of phage- bacterial interactions.
Unit 3: Life cycle of bacteriophages.
Structure, functions and life cycles of P2 phage, Lambda phage, M13 phage, ÕX174 phage.
Unit 4: Biotechnological Genetic manipulation
Phages in the development of molecular biology and genetic engineering.

Practicals
- Titration of phages and bacteria.
- Absorption of phages.
- Preparation of phage stocks.
- Isolation of new phages and phage resistant bacteria.
- One step growth curve, phage bursts.
- Induction of lambda.
- Complementation of T4rII mutants etc.

Suggested Reading
Birge EA. 2000. Bacterial and Bacteriophage Genetics. Springer-Verlag. Mathew CK. 1972. Bacteriophage Biochemistry. Am. Chemical Soc.

Mathew CK, Kutter EM, Mosig G & Berget P. 1988. Bacteriophage T4. Plenum Press.
Nancy T and Trempy J. 2004. Fundamental Bacterial Genetics. Blackwell. Stent SG. 1963. Molecular Biology of Bacterial Viruses. WH Freeman and Co.
Winkler J, Ruger W and Wackernagel W. 1979. Bacterial, Phage and Molecular Genetics - An Experimental Course. Narosa.
Winkler U and Rugr W. 1984. Bacteria, Phage and Molecular Genetics. ALA.

Websites

- https://www.nature.com/scitable/definition/bacteriophage-phage-293
- https://www.phe-culturecollections.org.uk/news/nctc-news/the-rise-and-rise-of- bacteriophages.aspx
- https://www.khanacademy.org/science/biology/biology-of-viruses/virus-biology/a/ bacteriophages

Course Title: Environmental Microbiology
Course Code: MICRO 509
Credit Hours: 2+1

Why this Course?
This course deals with the study of composition and physiology of microbial communities in the environment. Diversity of microbial populations and their important roles in air, water, soils and sediments. Microbial community ecology and interactions with plants and animals. Microbial communities control nutrient cycles and transformation of compounds. Deeper understanding about the beneficial and harmful effects of microbial communities in the environment will help, so this course as been mandated.

Aim of the course
The course is designed to introduce students to diverse microbial population and their important roles in environmental processes in air, water, soils and sediments. Types of microorganisms found in the air, terrestrial and aquatic environments. Interaction of microbial communities with plants and animals. Geochemically and environmentally significant processes that are contributed by the activities of microorganisms. Methods that are used to identify and enumerate bacteria in natural environments and also how specific microbial activities. Impact of microbial degradation of organic contaminants and xenobiotics.
The course is organized as follows:

No.	Blocks	Units
1.	Microbial ecology	1. Scope of Environmental microbiology and Ecological Niche 2. Microorganisms and their natural habitats 3. Extremophiles
2.	Microbial interaction	1. Biogeochemical cycles 2. Waste water and solid waste treatment 3. Microbial upgradation in fossil fuels and interaction in rumen and gastrointestinal tract

Theory
Block 1: Microbial Ecology
Unit 1: Scope of Environmental microbiology and Ecological Niche

Scope of environmental microbiology, Microbial ecology: Microbial evolution and biodiversity – Ecological niches – Definitions, biotic and abiotic environment. Environmental segments. Composition and structure of environment. Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Food chains, food webs and trophic structures. Ecological pyramids.

Unit 2: Microorganisms and their natural habitats

Microorganisms and their natural habitats: Aeromicrobiology, Astrobiology, Methane and chlorates on Mars, terrestrial analogues. Biofilms and microbial mats, Aquatic ecosystems- Public Health Microbiology.

Unit 3: Extremophiles

Extremophiles: Definition and ecological aspects. Thermophiles, Xerophiles, Psychrophiles, Piezophiles, Alkaliphiles, Acidophiles- Halophiles and Barophiles. Environmental Distribution and Taxonomic Diversity, Physiology, Adaptive mechanisms, Enzymes, Applications.

Block 2: Microbial Interaction

Unit 1: Biogeochemical cycles

Biogeochemical cycling and its consequences. Global environmental problems.

Unit 2: Waste water and solid waste treatment

Microbiology of wastewater and solid waste treatment: - Waste-types-solid and liquid waste characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Anaerobic processes-Bioremediation of nuclear wastes. Bioconversion of Solid Waste and utilization as fertilizer. Bioaccumulation of heavy metal ions from industrial effluents. Biomining. Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behavior.

Unit 3: Microbial upgradation in fossil fuels and interaction in rumen and gastrointestinal tract.

Microbial upgradation of fossil fuels and coal gas. Microbial interaction in rumen and gastrointestinal tract.

Practicals

- Determination of indices of pollution by measuring BOD/COD of different effluents.
- Analysis of natural waters.
- Quality control tests, waste treatment and anaerobic digestion; Demonstration of waste water treatment processes such as activated sludge processes, biofilter and fluidized bed process.
- Bacterial reduction of nitrate from ground waters.
- Isolation and purification of degradative plasmid of microbes growing in polluted environments.
- Recovery of toxic metal ions of an industrial effluent by immobilized cells.
- Utilization of microbial consortium for the treatment of solid waste [Municipal Solid Waste]
- Biotransformation of toxic metal ions into non-toxic metals ions.
- Microbial dye decolourization/adsorption.
- Biotrap based isolation of selective functional microbes.
- Thermophlic enzyme in biomass deconstructions.
- Halophilic microbes from salt lake-Pesticide degradation by microbes

Suggested Reading

Campbell R. 1983. Microbial Ecology. Blackwell.
Hawker LE & Linton AH. 1989. Microorganisms Function, Form and Environment. 2nd Ed. Edward Arnold.
Richards BN. 1987. Microbes of Terrestrial Ecosystem. Longman.
Mitchell R. 1992. Environmental Microbiology. John Wiley & Sons.
Baker K.H. and Herson D.S. 1994. Bioremediation. McGraw Hill Inc., N.Y.
Metcalf and Eddy HP. 2004. Waste Water Engineering - Treatment, Disposal and Re-use Inc., Tata McGraw Hill, New Delhi.
McEldowney S Hardman DJ and Waite S. 1993. Pollution: Ecology and Biotreatment Longman Scientific Technical.
Mitchell R, and GuJi-Dong. 2010. Environmental Microbiology. John V, Wiley Sons. Inc.

Waste Water Microbiology 2nd Edition. Bitton. Chemistry and Ecotoxicology of pollution. Edited by Des. W. Connell, G.J. Miller. Wiley Interscience Publications.
Bitton G. 2010. Waste Water Microbiology 2nd Edition.
Connell OW and Miller GJ. 1984. Chemistry and Ecotoxicology of pollution. Wiley Interscience Publications.
Forster CF and John Wase DA. Environmental Biotechnology. Ellis Horwood Ltd. Publication.
Trivedi RK. 1998. Advances in Waste Water Treatment Technologies. Volumes II and I Global Science Publication.
Lawrence P, Wacekett C and Hershberger D. 2000. Biocatalysis and Biodegradation: Microbial transformation of organic compounds. ASM Publications.
Hurst CJ. 2001. A Manual of Environmental Microbiology. 2nd Edition. ASM Publications.

Websites

http://microbiology.ucsc.edu.
http://www.asm.org

Course Title: Industrial Microbiology
Course Code: MICRO 510
Credit Hours: 2+1

Why this Course?
The syllabus of industrial microbiology is oriented towards the industrial application of microorganisms and recent microbial products. After studying this course students will know the industrial aspects of microbiology.

Aim of the course
To expose the students to the commercial exploitation of microorganisms for production of useful products. Focus will be on understanding of the techniques involved and the application of microorganisms for agribusiness purpose.

The course is organized as follows

No.	Blocks	Units
1.	Basics of Industrial Microbiology	1. Historical account of microbes in industrial microbiology 2. Fermented Microbial products
2.	Bioplastics, Biopolymers & Biofuels	1. Biocontrol agents and Biopesticides 2. Industrial production of Bioplastics and biopolymers 3. Production of valuable products

Theory
Block 1: Basics of Industrial Microbiology
Unit 1: Historical account of microbes in industrial microbiology

Introduction to Industrial Microbiology. Sources and characters of industrially important microbes; their isolation, purification and maintenance. Types of fermentation and fermenters. Microbial growth kinetics in batch, continuous and fed-batch fermentation process.

Unit 2: Fermented Microbial products

Bioreactors: Types and configuration. Microbiology and production of alcoholic beverages; Malt beverages, distilled beverages, wine and champagne; Commercial production of organic acids like acetic, lactic, citric, and gluconic acids Commercial production of important amino acids (glutamic acid, lysine and tryptophan), vitamins (riboflavin and vitamin A), enzymes, antibiotics and single cell proteins.

Block 2: Bioplastics, Biopolymers and Biofuels
Unit 1: Biocontrol agents and Biopesticides

Biocontrol agents and Biopesticides: Biocontrol agents and their scope in control of plant diseases, nematodes and insect pests. Role of bioagents in sustainable agriculture.

Unit 2: Industrial production of Bioplastics and biopolymers

Introduction & industrial production of Bioplastics: Microorganisms involved in synthesis of biodegradable plastics and microbial pigments and biopolymers. Biosensors: Development of

biosensors to detect food contamination and environment pollution. Biofuels: Production of ethanol, biogas and hydrogen from organic residues, fuels from algae; Mushroom cultivation.

Unit 3: Production of valuable products

Genetic engineering of microbes, Role of recombinant microbes in industrial sectors for enhanced production of valuable products. Mechanisms of pesticide degradation by microbes. Biomining: Coal, mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from low-grade ores.

Practicals

- Isolation and purification of industrially important microbes (Bacteria, fungus and yeasts).
- Production of industrial compounds such as alcohol, beer, citric acid, lactic acid acetic acids gluconic acid and their recovery
- Demonstration of biogas production
- Production and assay of enzymes, organic acids and pigments
- Mass production of biocontrol agent
- Visit to industries

Suggested Reading

Sylvia DM, Fuhrmann JJ, Hartlly PT and Zuberer D. 2005. Principles and Applications of Soil Microbiology. 2nd Ed. Pearson Prentice Hall Edu.

Waites, M.J., Morgan, N.L., Rockey, J.S. and Higton, G. (2002). Industrial Microbiology: An Introduction. Blackwell Science Publishers.

Crueger W and Crueger A. Biotechnology: A Text Book of Industrial Microbiology Panima Publishing Corporation.

Reed G. 1999. Prescott and Dunn's Industrial Microbiology. CBS Publishers.

Demain AL. 2001. Industrial Microbiology and Biotechnology IInd Edition. ASM Press, Washington.

Stanbury PF, Whitaker W and Hall SJ. 1997. Principles of Fermentation Technology Aditya Books (P) Ltd., New Delhi.

Baltz RH, Davies JE and Demain AL. 2010. Manual of Industrial Microbiology and Biotechnology. 3rd Edition, ASM Press.

Forciniti D. 2008. Industrial Bioseparations: Principles and Practice. 1st Edition, Wiley-Blackwell.

OkaferN. 2007. Modern Industrial Microbiology and Biotechnology, Scientific Publishers, Enfield, USA.

Nduka O and Benedict OC. 2018. Modern Industrial Microbiology and Biotechnology, Taylor and Francis 465p.

ElMansi EMT, Bryce CFA, Dahhou A, Sanchez S, Demain AL, Allman AR. 2012. Fermentation Microbiology and Biotechnology 3rd Ed. CRC Press, Taylor and Francis, Boca Raton.

Stanbury AF and Whitaker A. 1984. Principles of Fermentation Technology –Oxford Pergamon press New York.

Moses V and Cape RE. 1991. Biotechnology - The Science and the Business Harwood Academic Publishers, USA.

Casida LE Jr. 1989. Industrial Microbiology Wiley Eastern Ltd., N. Delhi.

Miller BM and Litsky W. 1976. Industrial Microbiology, McGraw Hill Co., New York 451p.

Crueger W and Crueger A. 1984. Biotechnology – a Text book of Industrial Microbiology. Science Tech. Inc., Madison.

Glazer AN and Nikaido HN. 1995. Microbial Biotechnology: Fundamentals of Applied Microbiology, W.H.Freeman Co., New York.

Atkinson B and Marituna F. 1983. Biochemical Engineering and Biotechnology Handbook, McMillian Publishers.
Jones DG. 1983. Exploitation of Microorganisms. Chapman & Hall, Oxford.
Peppler HJ and Perlman D. 1979. Microbial technology Vol.1 Fermentation Tecnology, Vol.2, Academic Press.
Rehm HJ and Reed G. 1995. Biotechnology, a Comprehensive Treatise, 8 Vols. (Reference Book) Verlag Chemie,Wienheim. Also refer Second edition, 12 vols,1995 (Rehm,H.J.: Reed, G.: Puhler,A; Stadler, P Eds)
Moo-Young Y. 1985. Comprehensive Biotechnology- 5 vols. (Reference Book) Pergamon Press,
Oxford.
Arora DK. 1992. Handbook of Applied Mycology – 5 Vols. (Reference Book) Marcel Dekker, New York.
Glick BR and Pasternak JJ. 2003. Molecular Biotechnology-principles and applications of recombinant DNA,ASM press,Washington,760 pp.

Also consult latest issues of:
Advances in Applied Microbiology, Biotechnology Advances,
Biotechnology & Genetic Engineering Reviews, Advances in Biochemical Engineering & Biotechnology, Advances in Microbial Physiology

Websites
https://www.biomerieux.com/en/industrial-microbiological-control-0
https://icar.org.in/content/food-and-industrial-microbiology

Course Title: Biofertilizer Technology
Course Code: MICRO 511
Credit Hours: 2+1

Why this Course?
The exploitation of beneficial microbes as a biofertilizer is of prime importance in agriculture sector for their potential role in food safety and sustainable crop production. There is wide gap between nutrient removal and supplies. There is increase in cost of fertilizers due to deplete in the feed stock fossil fuels besides growing concern of environmental hazards due to chemical fertilizers. It is essential to exploit Biofertilizers having functional traits for enhancing plant growth and productivity, nutrient profile, plant defense and protection with special emphasis to its function to trigger various growth- and defense-related genes in signaling network of cellular pathways to cause cellular response and thereby crop improvement.
The syllabus Biofertilizers technology is oriented towards application of biofertilizer to trap atmospheric nitrogen to the soil and convert them into plant usable forms. They also convert the insoluble phosphate forms into plant available forms. They stimulate root growth by producing some hormones and antimetabolites. Improved Plants.

Aim of the course
To familiarize the students and farmers with mass scale production of different agriculturally important microorganisms which are being used as biofertilizers for maintaining the soil and plant health for sustaining crop productivity and their importance in organic farming.

The course is organized as follows:

No.	Blocks	Units
1.	Agriculturally important beneficial nitrogen Microorganisms	1. Agriculturally important beneficial nitrogen fixing microorganisms. 2. Agriculturally important beneficial microorganisms related to phosphorous, potassium, Sulphur and Zinc nutrition 3. Agriculturally important beneficial microorganisms having plant growth promoting rhizobacteria 4. Agriculturally important biocontrol microbial inoculants 5. Economics of biofertilizer production.
2.	Production of Biofertilizer	1. Production and quality control of biofertilizer

Theory
Block 1: Agriculture Important Beneficial Microorganisms
Unit 1: Agriculturally important beneficial nitrogen fixing microorganisms.

Different agriculturally important beneficial microorganisms: Chemical Vs Biofertilizers: Current Scenario in biofertilizer technology in world-In India-List of biofertilizers their applications in agriculture.

Brief introduction about Agriculturally beneficial microorganisms (free living, symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers including phosphobacteria, cyanobacteria, their types and importance taxonomic classification, Nitrogen fixing biofertilizers: nodule formation, competitiveness and quantification of N2 fixed and their use. Mechanism of phosphorous solubilization by photobacteria. BIS standards of biofertilizers

Unit 2: Agriculturally important beneficial microorganisms related to phosphorous, potassium, Sulphur and Zinc nutrition

Different agriculturally important beneficial microorganisms: phosphate solubilizing bacteria and fungi, including mycorrhiza; Mechanism of phosphorous solubilization by phosphobacteria. Bacteria for potassium, Sulphur and Zinc nutrition.

Unit 3: Agriculturally important beneficial microorganisms having plant growth promoting rhizobacteria.

Different agriculturally important beneficial microorganisms: plant growth promoting rhizobacteria. FCO norms and biofertilizer production and usage at national and international levels

Unit 4: Agriculturally important biocontrol microbial inoculants

Different agriculturally important beneficial microorganisms: Biocontrol microbial inoculants. Requirements for establishing bioinoculants production unit Economics of biofertilizers production Constraints in biofertilizers production and usage

Unit 5: Economics of biofertilizer production

Different agriculturally important beneficial microorganisms for recycling of organic waste and compositing, bioremediators and other related microbes.

Block 2: Production of Biofertilizer

Unit 1: Production and quality control of biofertilizer

Different agriculturally important beneficial microorganisms - selection, establishment, competitiveness, crop productivity, soil & plant health, mass scale production and quality control of bio inoculants. Biofertilizer inoculation and microbial communities in the soil. Different formulations of biofertilizers. Advantages and limitations of Liquid formulations.

Practicals

- Isolation of phosphate solubilizing microorganisms.
- Development and production of efficient microorganisms,
- Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, indole acetic acid (IAA), siderophore production etc,
- Bioinoculant production and quality control.
- Population dynamics in broth and carrier materials during storage.
- Development of cultures from starter.
- Preparation of broth for large scale cultivation in fermenter/ large containers. Inoculation and development of culture.
- Mass production of carrier based and liquid biofertilizers. Mass production of important two or three biocontrol agents (Trichoderma viride, Pseudomonas fluorescens and Metarhizium anisopliae).
- Form, dose and method of application.

- Mass production of AM fungi in pot and root organ culture.
- Quality control and BIS standards.
- Mass production of Azolla and BGA.
- Visit to a biofertilizer production plant

Suggested Reading

Alexander M. 1977. Soil Microbiology. John Wiley.
Bergerson FJ. 1980. Methods for Evaluating Biological NitrogenFixation. John Wiley & Sons.
Sylvia DM, Fuhrmann JJ, Hartlly PT and Zuberer D. 2005. Principles and Applications of Soil Microbiology. 2nd Ed. Pearson Prentice Hall Edu.
Van Elsas JD, Trevors JT and Wellington EMH. 1997. Modern Soil Microbiology. CRC Press.
Panwar JDS and Jain AK. 2016. Organic farming scope and use of biofertilizers. Pub: NIPA, New Delhi.
Gaur AC. 2010. Biofertilizers in Sustainable Agriculture, ICAR, New Delhi.
Chanda P and Srivathsa RSH. 2005. Liquid Biofertilizers. Ministry of Agriculture Department of Agriculture & Cooperation, GOI.
Deshmukh AM, Khobragade RM and Dixit PP. 2007. Handbook of Biofertilizers & Biopesticides. Oxford Book Company, Jaipur, India.
Gupta RP, Kalia A and Kapoor S. 2007. Bioinoculants a Step towards Sustainable Agriculture .NIPA, New Delhi.
Somani LL, Shilkar P and Shilpkar D. 2011. Biofertilizers Commercial Production Technology & Quality Control. AgroPublishing Acadamy, Udaipur.
Srivastava HS and Singh RP. 1995. Nitrogen nutrition in higher plants. Associated Publishing Company, New Delhi.
Kannaiyan S and Kumar K. 2005. Azollabiofertiliser for sustainable Rice Production. Daya Publishing House, Delhi.
Kannaiyan S, Kumar K and Govindarajan K. 2010. Biofertilizer Technology. Scientific Publishers (India), Jodhpur.
Vora MS, Shelat HN and Vyas RV. 2013. Handbook of Biofertilizers & Microbial Pesticides.
Chanda JK. 2008. Biofertilizer Statistics 2006-07. The fertilizer Association of India, New Delhi.

Journals

Journal of Biofertilizer & Biopesticides
Journal of Botanical Sciences

Websites

Biofertilizer in organic Agriculture (www.Journalphytology.com)
Microbial biofertilizers (www.Boffinaccess.com)
Biofertilizer as a prospective input for sustainable agriculture in India.
http://www.krishisewa.com/articles/organic-agriculture/115-biofertilizers.html
Handbook of Microbial Biofertilizers M. K. Rai, PhD Editor Pub: Food Products Press, NY.
Bio fertilisers
https://www.worldcat.org/search?q=biofertilisers&fq=dt%3Abks&dblist=638&qt =sort&se= yr&sd=desc&qt=sort_yr_desc

Course Title: Cyanobacterial and Algal Biotechnology
Course Code: MICRO 512
Credit Hours: 2+0

Why this Course?
Cyanobacteria and algal biomass contribute major role in carbon cycle in turn influencing the climate. The blooms of cyanobacteria and algae in different ecosystems is worth exploiting due to their wide biodiversity. They play an important role in agriculture by contributing to the fertility of soil in terms of biomass, biofertilizer, and act as herbicides, insecticides and in bioremediation. Their physiological and biochemical properties disclose their significant potential for colorants, polysaccharides, pharmaceutical & nutraceutical compounds, and valuable biomolecules of industrial importance. With the population explosion and scarcity of land, these can provide better feed stock due to their high protein content, easy cultivation, and versatile growth and easy to harvest. It is challenging for designing bioreactor and utilizes waste waters for growing and harvesting cyanobacteria and algae for these purposes. They are capable of producing and accumulating lipids which can be the source for biodiesel in future. This course will help the student to understand taxonomy and molecular biology methods of cyanobacteria. The course will give knowledge on cyanobacterial and algal fuels,

Aim of the course
The aim is togive exposure on the potential applications of cyanobacteria and algae in Agriculture, Industry and Environment; to inculcate knowledge on algal mass production techniques and their valuable products of commercial importance and to introduce the R&D and entrepreneurial opportunities algae. Students will learn about biodiversity of cyanobacteria and their classification, the biotechnological applications in agriculture – biofertilizers, biocontrol, bioenergy and bioprocessing,
their applications in pharmaceuticals, production of antioxidative enzymes and pigments, as source of food, etc.
The course is organized as follows:

No.	Blocks	Units
1.	Importance of cyanobacteria and and algae	1. Ecology and evolution of algae cyanobacteria
2.	Physiology and culturing of cyanobacteria and algae	1. Algal pigments, storage products 2. Metabolism of carbon and nitrogen Culturing methods.
3.	Role of cyanobacteria and algae in agriculture and their products of industrial importance	1. Importance as fuels, neutraceuticals and industrial importance 2. Role of algae related to environment

Theory
Block 1: Importance of Cyanobacteria and Algae
Unit 1: Ecology and evolution of algae and cyanobacteria

Introduction to cyanobacteria and algae. Definition, occurrence and distribution, thallus structure, reproduction, life cycles, origin and evolution of cyanobacteria, molecular evolution; role of algae in evolution of land plants and horizontal transfer of genes. Brief classification of algae: different classes, occurrence and distribution.

Block 2: Physiology and Culturing of Cyanobacteria and Algae

Unit 1: Algal pigments, storage products.

Algal pigments, storage products, physiology and metabolism including photosynthesis.

Unit 2: Metabolism of carbon and nitrogen

Ecology of algae –primary colonizers and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism carbon metabolism

Unit 3: Culturing methods

Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photobioreactors, algal density and growth, seaweed cultivation.

Block 3: Role of Cyanobacteria and Algae in Agriculture and their Products of Industrial Importance

Unit 1: Importance as fuels, neutraceuticals and industrial importance.

Cyanobacterial and algal fuels, Fine chemicals (restriction enzymes etc.) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology, sustainable aquaculture. Ecology of algae- distribution in soil and water; primary colonizers, carbon sequestration and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism.

Unit 2: Role of algae related to environment.

Algae in pollution control - as pollution indicators, eutrophication agents and role in Bioremediation and reclamation of problem soils. Cyanobacterial and algal toxins, allelopathic interactions, Algae in global warming and environmental sustainability. Cyanobacteria and selected microalgae in agriculture – biofertilizers &algalization; soil conditioners; reclamation of problem soils.

Suggested Reading

- Ahluwalia AS. 2003. Phycology: Principles, Processes and Applications. Daya Publ.
- Barsanti L and Gualtieri P. 2006. Algae: Anatomy, Biochemistry and Biotechnology. Taylor & Francis, CRC Press.
- Carr NG and Whitton BA. 1982. The Biology of Cyanobacteria. Blackwell.
- Herrero A and Flores E. 2008. The Cyanobacteria Molecular Biology,Genomics and Evolution. Calster Academic Press
- Kumar HD. 2005. *Introductory Phycology*. East West Press. Linda E Graham & Lee WWilcox. 2000. *Algae*. Prentice Hall.
- Andersen RA. 2005. *Algal Culturing Techniques.* Academic Press.
- Venkataraman LV and Becker EW. 1985. *Biotechnology and Utilization of Algae: the Indian Experience*. DST.
- Das MK. 2010. *Algal Biotechnology*. Daya Publishing House.
- Tiwari. 2014. *Cyanobacteria: Nature, Potentias and Applications*. Daya Publishing House.
- Khattar JIS, Singh DP, Kaur G. 2009. *Algal Biology and Biotechnology*. I.K. International Publishing HousePvt. Ltd.
- Bhatnagar SK, Saxena A, Kraan S. 2011. *Alga Biofuels*. Stadium Press (India) Pvt. Ltd.
- Sahoo D and Kaushik BD. 2012. *Algal Biotehcnolgoy and Environment*. I.K. International Publishing House Pvt. Ltd.

Journals

- *Journal of Phycology*
- *Journal of Applied Phycology*
- *Frontiers in Microbiology*

Websites

- Cyanbacterial and algal Biotechnology
- https://www.worldcat.org/search?q=cyanobacterial+and+algal+biotechnology&qt=results_page#%2528x0%253Abook%2Bx4%253Aprintbook%2529format
- www.cyanosite.bio.purdue.edu
- http://www.asmscience.org
- http://www.asm.org
- http://www.microbiologyonline.org.uk
- http://www.microbeworld.org
- http://www.bbsrc.ac.uk/organisation/policies/reviews/scientific-areas/1107-algal-research. aspx
- http://asulightworks.com/resources/videos/arizona-center-algae-technology-and-innovation. html

Course Credit and Layout for Ph.D. degree programme

Major Courses	Title	Credits
MICRO 601*	Improvement in fermentation Technology	2+1=3
MICRO 602	Microbial physiology and regulation	2+0=2
MICRO 603*	Recent development in Soil Microbiology	2+0=2
MICRO 604	Recent approaches in environmental microbiology	2+0=2
MICRO 605*	Plant microbe interactions	2+1=3
Total Credits		**12**
Minor Courses		
BIOCHEM 601	Advanced Enzymology	2+1=3
BIOCHEM 602	Advanced Molecular Biology	3+0=3
BIOCHEM 603	Biochemistry of Biotic and Abiotic Stresses	3+0=3
Total Credits		**09**
Supporting Courses		
BIOCHEM 607	Application of Techniques in Biochemistry	1+2=3
MBB 512	Immunology and Molecular Diagnostics	2+1=3
	Total Credits	**06**
Seminar		
MICRO 691	Doctoral Seminar I	1+0=1
MICRO 692	Doctoral Seminar II	1+0=1
Total Credits		**02**
Grand Total		**29**
MICRO 699	Doctoral Research	**75**

Major Credits	Minor Credits	Supporting Credits	Seminar	Total Credits
As per BSMA Credits				
12	06	05	02	25
Actually Offered Credits				
12	09	06	02	29

Semester wise course layout of Ph.D. Microbiology

Semester	Code	Course Title	Credits
I Major courses			
I	MICRO 601*	Improvement in fermentation Technology	2+1=3
	MICRO 602	Microbial physiology and regulation	2+0=2
	MICRO 603*	Recent development in Soil Microbiology	2+0=2
Minor courses			
	BIOCHEM 601	Advanced Enzymology	2+1=3
	BIOCHEM 602	Advanced Molecular Biology	3+0=3
Supporting courses			
	Biochem 607	Application of Techniques in Biochemistry	1+2=3
Total			**12+4=16**
Non Credit Compulsory Courses (NCCC)- Nil			
	PGS 501	Library and Information Services	0+1=1
	PGS 504	Basic Concepts in Laboratory Techniques	0+1=1
II Major courses			
II	MICRO 604	Recent approaches in environmental microbiology	2+0=2
	MICRO 605*	Plant microbe interactions	2+1=3
Minor courses			
	BIOCHEM 603	Biochemistry of Biotic and Abiotic Stresses	3+0=3
Supporting courses			
	MBB 512	Immunology and Molecular Diagnostics	2+1=3
Total			**09 +02=11**
Non Credit Compulsory Courses (NCCC)- Nil			
	PGS-502	Technical writing and communication skills	0+1=1
	PGS 503	Intellectual Property and its Management in Agriculture	1+0=1
III Major courses Nil			
Doctoral Seminar			
	MICRO 691	Doctoral Seminar I	1+0=1
Minor courses -Nil			
Supporting courses - Nil			
Total			**1+0=1**
Non Credit Compulsory Courses (NCCC)			
	PGS 505	Agricultural Research Ethics and Rural Development Programmes	1+0=1
	PGS 506	Disaster Management	1+0=1
IV Major courses -Nil			
Doctoral Seminar			
	MICRO 692	Doctoral Seminar II	1+0=1
Minor courses -Nil			
	MICRO 699	Doctoral Research	75
Total			**1+0=1**
Non Credit Compulsory Courses (NCCC)-Nil			
Supporting courses-Nil			
V Major, Minor, supporting- Nil			
VI	**Major, Minor, supporting- Nil**		
Non Credit Compulsory Courses (NCCC)-Nil			
Total			**0+0=0**
Grand Total			**23+6=29**

Major-12 Minor- 09 Supporting –6, Doctoral seminar -2 Total =29 + Thesis 75 Grand Total 29+75=104

Course Content and Syllabus of Doctoral Degree

Course No.: MICRO 601
Course Title: Improvement in Fermentation Technology
Credit: 2+1=3

Theory

Block 1: Rise of Fermentation Technology

Unit 1: Development in Fermentation

Definition of fermentation – rise of fermentation technology –current trends in fermentation industry – scope and importance of fermentation technology.

Unit 2: Types of fermenters

Continuous, batch and fed batch culture –anaerobic fermentation - range of fermentation process – microbial growth cycle – diauxic growth – growth kinetics substrate uptake kinetics (Jacob and Monod) - primary and secondary metabolites future prospects of fermentation microbiology

Block 2: Fermenter

Unit 1: Components of fermenter and use

Peripheral parts and accessories – alternative vessel designs –containment in fermentation – fermenter preparation and use - aeration and agitation –instrumentation and control – biosensors in monitoring – computer applications in fermentation technology

Block 3: Fermentation Process

Unit 1: Types of Fermentation

Solid state and submerged fermentation – acidic/alcoholic fermentation – recovery of product – effluent treatment – Economics of fermentation

Block 4: Recombinant Strategies Followed

Unit 1: Strategies for isolation of industrially important microbes

New strategies for isolation of industrially important microbes and their genetic manipulations; Antibiotic fermentation research; steroid transformation; Yeast technology – classification, genetics, strain improvement for brewing, baking and distilleries

Practicals

- Studying the various components of fermenter
- exposure to different types of fermenter
- sterilization and operating procedures
- designing the production medium
- isolation and purification of industrially important microbes
- Genetic manipulations in microbes
- Fermentation by improved strains of yeast for production of alcohol
- microbial production of enzymes by solid state fermentation
- Microbial production of important antibiotics
- Bioremediation of industrial effluents

Suggested Reading

• Stanbury PF, Whitaker A and Hall SJ. *Principles of fermentation technology*, Second edition
• Patel AH. *Industrial Microbiology*
• ElMansi EMT and Bryce CFA. *Fermentation Microbiology and Biotechnology*
• Srivastava ML. *Fermentation Technology*
• Singh T and Purohit SS. *Fermentation Technology*
• ElMansi EMT, Bryce CFA, Demain AL and Allman AR. *Fermentation Technology – Microbiology and Biotechnology*
• Peppler HJ and Perlman D. 1979. *Microbial Technology*. 2nd Ed. Academic Press.
• Reed G. 1987. *Presscott& Dunn's Industrial Microbiology.* 4th Ed. CBS.
• Stanbury PF and Whitaker A. 1987. *Principles of Fermentation Technology*. Pergamon Press.
• Wiseman A. 1983. *Principles of Biotechnology*. Chapman & Hall

Teaching schedule : Theory

Lecture No.	Topic
1-3	**Rise of Fermentation Technology** **Development in Fermentation** Definition of fermentation – rise of fermentation technology –current trends in fermentation industry – scope and importance of fermentation technology.
4-10	**Types of fermenters** Continuous, batch and fed batch culture –anaerobic fermentation - range of fermentation process – microbial growth cycle – diauxic growth – growth kinetics– substrate uptake kinetics (Jacob and Monod) - primary and secondary metabolites – future prospects of fermentation microbiology
11- 16	**Fermenter** **Components of fermenter and use** Peripheral parts and accessories – alternative vessel designs –containment in fermentation – fermenter preparation and use - aeration and agitation – instrumentation and control – biosensors in monitoring – computer applications in fermentation technology
17- 23	**Fermentation Process** **Types of Fermentation** Solid state and submerged fermentation – acidic/alcoholic fermentation – recovery of product – effluent treatment – Economics of fermentation
24-32	**Recombinant Strategies Followed** **Strategies for isolation of industrially important microbes** New strategies for isolation of industrially important microbes and their genetic manipulations; Antibiotic fermentation research; steroid transformation; Yeast technology – classification, genetics, strain improvement for brewing, baking and distilleries

Practical

Practical No.	Topics
1	Studying the various components of fermenter
2	Exposure to different types of fermenter
3	Sterilization and operating procedures

4	Designing the production medium
5-6	Isolation and purification of industrially important microbes
7-8	Genetic manipulations in microbes
9-10	Fermentation by improved strains of yeast for production of alcohol
11-12	Microbial production of enzymes by solid state fermentation
13-14	Microbial production of important antibiotics
15-16	Bioremediation of industrial effluents

Course No.: MICRO 602
Course Title: Microbial Physiology and Regulation
Credit: 2+0=2

Theory
Block 1: Historical Evaluation of Microbial Physiology
Unit 1: Molecular aspects of various cell component

Origin, evolution, structure, function and molecular aspects of various cell components. Differentiation in bacteria, slime molds, yeasts. Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria.

Block 2: Regulation and Pathways
Unit 1: Regulatory Pathways

Regulation of initiation, termination and anti-termination of transcription. Global regulation and differentiation by sigma factor. Regulatory controls in bacteria - inducible and biosynthetic pathways. Oxidative stress control. Fermentative and respiratory regulatory pathways.

Unit 2: Regulatory control

Ribosomal RNA and ribosomal proteins regulation under stress condition. Specific regulatory systems; SOS regulatory control; Antisense RNA regulation of gene expression. Biosynthesis of micro molecules (Nucleotides and Amino acids) macromolecules (DNA, RNA, Proteins) Global nitrogen control and regulation of nitrogen fixation

Unit 3: Current topics

Topics of current interest in Molecular microbiology and regulatory systems.

Suggested Reading
Websites

- https://www.frontiersin.org/journals/microbiology/sections/microbial-physiology-andmetabolism
- https://www.sciencedirect.com/bookseries/advances-in-microbial-physiology
- https://www.researchgate.net/journal/0065-2911_Advances_in_Microbial_Physiology
- https://bmb.psu.edu/undergraduate/courses/course-archive/2016/fall- 2016/ microbiology micrb/ micrb-401-fall-2016/micrb-401-microbial-physiology-and-structure
- Selected articles from journals.

Teaching schedule : Theory

Lecture No.	Topic
1-3	**Historical Evaluation of Microbial Physiology** **Molecular aspects of various cell component** Origin, evolution, structure, function and molecular aspects of various cell components.
4-8	Differentiation in bacteria, slime molds, yeasts. Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria.
9-12	**Regulation and Pathways** **Regulatory Pathways** Regulation of initiation, termination and anti-termination of transcription. Global regulation and differentiation by sigma factor.

13-16	Regulatory controls in bacteria -inducible and biosynthetic pathways. Oxidative stress control. Fermentative and respiratory regulatory pathways.
17-21	**Regulatory control** Ribosomal RNA and ribosomal proteins regulation under stress condition. Specific regulatory systems; SOS regulatory control; Antisense RNA regulation of gene expression.
22-26	Biosynthesis of micromolecules (Nucleotides and Amino acids) macromolecules (DNA, RNA, Proteins) Global nitrogen control and regulation of nitrogen fixation
27-32	**Current topics** Topics of current interest in Molecular microbiology and regulatory systems

Course No. - MICRO 603
Course Title :- Recent Developments in Soil Microbiology
Credit – 2+0

Theory
Block 1: Recent Developments in Soil Microbiology
Unit 1: Ecology and microorganisms diversity

Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms. Interaction between agricultural chemicals, pollutants and soil microorganism

Unit 2: Role of microorganisms in soil

Successions and transformation of organic matter; Role of microorganisms in soil fertility. Soil health and quality: Microbial indicators

Unit 3: Bioremediation

Bioremediation of polluted soils; Biological control. Other topics of current interest

Suggested Reading
Websites
• https://www.springer.com/in/book/9789811073793
• https://www.researchgate.net/publication/322952969_Advances_in_Soil_Microbiology_Recent_ Trends_and_Future_Prospects_Volume_2_Soil-Microbe-Plant_Interaction
• Selected articles from journals.

Teaching schedule : Theory

Lecture No.	Topic
1-4	**Recent Developments in Soil Microbiology** **Ecology and microorganisms diversity** Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms.
5-7	Interaction between agricultural chemicals, pollutants and soil microorganism
8-12	**Role of microorganisms in soil** Successions and transformation of organic matter; Role of microorganisms in soil fertility.
13-17	Soil health and quality: Microbial indicators
18-21	**Bioremediation** Bioremediation of polluted soils; Biological control.
22-27	Other topics of current interest Microbial transformation of Carbon, Nitrogen sulphur, phosphorous
28-30	Role of soil enzymes for nutrient transformation
31-32	Role of microbes for carbon sequestration

Course No. : MICRO 604
Course Title : Recent Approaches in Environmental Microbiology
Credits : 2+0=2

Theory

Block 1: Recent Environmental Issue

Unit 1: Basic concept and environmental issues

Types of environmental pollution; problems arising from high-input agricultural residues. Air and water pollution.

Unit 2: Methodology of environmental management

Waste water treatment -physical, chemical, biological and microbial processes; need for water and natural resource.

Unit 3: Microbial waste treatment

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents, etc.; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc.); anaerobic processes: digestion, filtration, etc.

Block 2: Energy Harnessing from Organic Waste

Unit 1: Pollution through conventional fuel

Conventional fuels and their environmental impact.

Unit 2: Renewable sources of energy.

Energy from solid waste; ; biogas; land filling, microbial hydrogen production; use of agro-industrial waste, agricultural waste for sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture, etc.

Block 3: Treatment of Waste for Safe Disposal

Unit 1: Disposal of domestic and industrial wastes.

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by micro-organisms.

Unit 2: Global environmental problems

Ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; Microbial and biotechnological approaches for the management of environmental problems.

Teaching Schedule : Theory

Lecture No.	Topics
1-4	**Recent Environmental Issue** **Basic concept and environmental issues** Types of environmental pollution; problems arising from high-input agricultural residues. Air and water pollution.
5-8	**Methodology of environmental management** Waste water treatment -physical, chemical, biological and microbial processes; need for water and natural resource.
9-12	**Microbial waste treatment** Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents, etc.;

13-17	Aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc.); anaerobic processes: digestion, filtration, etc.
18-21	**Energy Harnessing from Organic Waste** **Pollution through conventional fuel** Conventional fuels and their environmental impact.
22-26	**Renewable sources of energy.** Energy from solid waste; ; biogas; land filling, microbial hydrogen production; use of agro-industrial waste, agricultural waste for sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture, etc.
27-30	**Treatment of Waste for Safe Disposal** **Disposal of domestic and industrial wastes.** Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by micro-organisms.
30-32	**Global environmental problems** Ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; Microbial and biotechnological approaches for the management of environmental problems.

Suggested Reading

• Evans GM and Furlong JC. 2002. *Environmental Biotechnology: Theory and Application*. Wiley International.

• Jordening HJ and Winter J. 2006. *Environmental Biotechnology: Concepts and Applications*. Wiley-VCH Verlag.

Course No. - MICRO 605
Course Title - Plant Microbe Interactions
Credit– 2+1=3

Theory

Block 1: Types of Ecosystem and Microbial Interaction

Unit 1: Different interfaces of interactions

Plant-microbe, microbe-microbe, soil- microbe, soil-plant-microbe interactions leading to symbiotic (rhizobial and mycorrhizal, *Azolla-Anabaena*), associative, endophytic and pathogenic interactions.

Unit 2: Ecosystem- Concept and Dynamics

Types of ecosystems: Concept and dynamics of ecosystem, Food chain and energy flow, Microbial communities in the soil. Community dynamics and population interactions employing DGGE, TGGE, T-RFLP.

Block 2: Signaling and Interaction among Microbes

Unit 1: Microbial interaction

Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized.

Block 3: Genomic and Proteomic Study in Plant Microbe Interaction

Unit 1: Methodology/resources in plant-microbe interaction

Methodology/resources to study plant-microbe interaction, biosensors, transcriptome profiling, metabolic profiling, genomics, and proteomics Induced systemic resistance against pathogens and tolerance against abiotic stress: Molecular basis; Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants

Practicals

- Phylochip based microbial community analyses-
- Endophytic and phyllosphere microbial community
- PCR-DGGE-Rhizosecretion
- secretome -FT-IR, HPLC
- Multifunctional protein identification and characteriation-2DE, MALDI-TOF.
- Examination of mycorrhizal infection in roots of different plants.
- Characterization of PGPR; Quantification of siderophores, HCN and IAA

Suggested Reading

- Kosuge T and Nester, E.W. 1989. *Plant Microbe Interactions: Molecular and Genetic Perspectives*, Vol.I-IV, McGraw Hill.
- Paul Eldor, A. 2007. *Soil Microbiology, Ecology and Biochemistry*
- Robert L. Tate III. 1995. *Soil Microbiology*, John Wiley & Sons, INC.
- Sylvia David, M., Fuhrmann, T.A., Hartel, P.G. and Zuberer, D.A. 2005. *Principles and Applications in Soil Microbiology* (II nd Edition).
- Verma, D.P.S. and Kohn, T.H. 1984. *Genes involved in Microbe-Plant Interactions*, Springer- Verlag
- Jaya Kumar Arjun, Kumarapillai Harikrishnan. 2011. Metagenomic analysis of bacterial diversity in the rice rhizosphere soil microbiome. *Biotechnol. Bioinf. Bioeng*. 1(3): 361-367
- Andrea Porras-Alfaro and Paul Bayman.2011. Hidden Fungi, Emergent Properties: Endophytes and Microbiomes. *Annu. Rev. Phytopathol*. 49: 291-315.

• Eleonora Rolli *et al*. 2014. Improved plant resistance to drought is promoted by the rootassociated microbiome as a water stress-dependent trait. *Environmental Microbiology*. doi: 10.1111/1462- 2920.12439
• Roeland L. Berendsen, Corne´ M.J. Pieterse and Peter A.H.M. Bakker. 2012. The rhizosphere microbiome and plant health. *Trends in Plant Science*, Vol. 17, No. 8.
• Josep Penuelas and Jaume Terradas. 2014. The foliar microbiome. *Trends in Plant Science*. http://dx.doi.org/10.1016/j.tplants.2013.12.007

Teaching Schedule : Theory

Lecture No.	Topic
1-5	**Types of Ecosystem and Microbial Interaction Different interfaces of interactions** Plant-microbe, microbe-microbe, soil- microbe, soil-plant-microbe interactions leading to symbiotic (rhizobial and mycorrhizal, *Azolla-Anabaena*), associative, endophytic and pathogenic interactions.
6-10	**Ecosystem- Concept and Dynamics** Types of ecosystems: Concept and dynamics of ecosystem, Food chain and energy flow,
11-16	Microbial communities in the soil. Community dynamics and population interactions employing DGGE, TGGE, T-RFLP.
17-21	**Signaling and Interaction among Microbes Microbial interaction** Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized.
22-26	**Genomic and Proteomic Study in Plant Microbe Interaction** **Methodology/resources in plant-microbe interaction** Methodology/resources to study plant-microbe interaction, biosensors, transcriptome profiling, metabolic profiling, genomics, and proteomics
27-30	Induced systemic resistance against pathogens and tolerance against abiotic stress:
31-32	Molecular basis; Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants

Practical

Practical. No.	Topic
1 - 2	Phylochip based microbial community analyses-
3 - 4	Endophytic and phyllosphere microbial community
5 - 6	PCR-DGGE-Rhizosecretion
7-8	Secretome -FT-IR, HPLC
9-10	Multifunctional protein identification and characteriation-2DE, MALDI-TOF.
11-12	Examination of mycorrhizal infection in roots of different plants.
13-16	Characterization of PGPR; Quantification of siderophores, HCN and IAA

E Resources and Journals

- *Advances in Microbial Physiology*
- *Annual Review of Genetics/Biochemistry*
- *Annual Review of Microbiology*
- *Applied and Environmental Microbiology*
- *Biology and Fertility Soils*
- *Indian Journal of Microbiology*
- *Journal of Bacteriology*
- *Journal of Basic Microbiology*
- *Microbiology and Molecular Biology Reviews*
- *Nature/Science/EMBO Journal*
- *Reviews in Microbiology and Biotechnology*
- *Soil Biology and Biochemistry*
- *Trends in Biotechnology*
- *Trends in Microbiology*
- *Trends in Plant Sciences*

Websites

- http://testweb.science.uu.nl/pmi/
- popups.ulg.ac.be/1780-4507/index.php?id=7578
- www.researchgate.net/...The_rhizosphere_microbiome_and_plant_health...
- journal.frontiersin.org/Journal/10.3389/fpls.2013.00165/abstract
- http://www.aw-bc.com/microplace/
- http://www.personal.psu.edu/jel5/micro/index.htm
- http://microbiology.ucsc.edu/
- http://www.suite101.com/links.cfm/microbiology
- http://www.microbeworld.org/resources/links.aspx
- http://www.asm.org/
- http://www.microbiologyiworld.com/
- http://www.sciencemag.org/cgi/collection
- http://www.latrobe.edu.au/microbiology/links
- www.uwstout.edu/lib/subjects/microbi
- http://www.aemtek.com

Journal related to Microbiology

- http://www.fems-microbiology.org/website/nl/default.asp
- http://www.blackwellpublishing.com/journal
- http://www.springer.com/
- http://www.e-journals.org/microbiology/
- http://pubs.nrc-cnrc.gc.ca/
- http://www.elsevier.com/
- http://www.academicjournals.org/ajmr/
- http://www.horizonpress.com/gateway/journals.html
- http://www.scielo.br/bjm
- http://www.jmb.or.kr/
- http://microbiologybytes.wordpress.com/
- http://www.topix.net/science/microbiolog

Common PGS Courses: (Non Credit)

PGS 501 LIBRARY AND INFORMATION SERVICES 0+1

Objective To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

Practicals

Practical No	Topic
1	Library and Its Services
2	Role of Library in Education, Research and Technology Transfer
3	Library Classification System
4	Organisation of University Library
5	Sources of Information
6	Library Cataloguing System
7	Abstracting and Indexing Services
8	CD-ROM Databases and Computerised Library Services
9	Information on E Resources Viz. KOHA, OPAC,
10	Literature Survey and Citation Techniques
11	Tracing Information from Reference Sources
12	Internet and Search Engines
13	E-Resources Access Methods
14	Literature References and Thesis Search on CeRA, KrishiPrabha, AgriCat, KrishiKosh, e-KrishiShiksha
15	Citation techniques/Preparation of bibliography
16	Other Open Access Resources Available in the Field of Agricultural Sciences

Suggested Readings:

1. Narula, Kanwal (2011): Library – A gateway to knowledge. PAU Ludhiana

2. Narula, Kanwal N. (2006): Quality Manual – Review of management and staff manual of Mohinder Singh Randhawa Library. PAU Ludhiana

3. Narula, Kanwal N. (2010): Introduction to Mohinder Singh Randhawa Library. PAU Ludhiana
4. Gates, Jean Key: Guide to the use of books and libraries. McGraw Hill New York
5. Ranganathan, S.R. (1957): Five laws of library science. Bombay: Asia Publishing
6. Kaushik, P. (2006): Library and information technology. Anmol , New Delhi
7. Kumar, P.S.G. (1998): Fundamentals of information science. S. Chand, New Delhi.
8. Prasher, R.G. (1991): Information and communication. New Delhi: Medallion Press
9. Ranganathan, S.R. (1989): Elements of library classification. Sharda Ranganathan Endowment for Library Science, Bangalore
10. Khan, M.T.M. (2005): Dewey Decimal Classification. New Delhi: Shree Pub.
11. Raju, A.A.N.(1995): Dewey Decimal Classification: Theory and Practice : A Practical Self Instructional Manual, Madras : T.R. Pub.
12. Satija, M.P. and Comaromi, John P., Introduction to the Practice of DDC, New Delhi, Sterling
13. Khan, M.A. (1997): Cataloguing in library services. New Delhi, Sarup pub.
14. Krishan Gopal (2000): Library online cataloguing in digital way. Delhi, Authors press.
15 Krishan Kumar (1996): Reference Service. Delhi, Vikas.
16. Ranganathan, S.R. (1961): Reference service. Bombay, Asia Pub. House.
17. Sewa Singh (2004): Manual of Reference and Information Sources. Delhi: B.R.Pub.
18. Sharma, Jagdish Saran and Grover D.R. (1987): Reference service and source of information. New Delhi, Ess Ess Pub.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 0+1

Objective To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing – Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Practicals

Practical No	Topic
1	Technical Writer , Technical Writing, Writing Structure and Writing Styles
2	Audience Analysis and communication
3	Research Interviews
4	Technical Communication Ethics and Grammar Intel
5	Writing Datasheet, Brochure Writing and Writing Business Plan
6	Writing Project Report and Writing Instruction Manual
7	Listening Skills
8	Speaking Skill
9	Personality Development
10	Presenting in GD, Seminars and Conferences.
11	Activities on Reading Comprehension
12	Activities on Interpersonal Communication and Building Vocabulary
13	Activities on Group Discussion and Interview Skills

Suggested Readings

1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
2. Collins' Cobuild English Dictionary. 1995.
3. Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.

4. Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
5. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
6. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East West Press.
7. Mohan K. 2005. Speaking English Effectively. MacMillan India.
8. Richard WS. 1969. Technical Writing.
9. Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
10. Abhishek. Sethi J &Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE **1+0**

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Teaching schedule: Theory

Lecture No.	Topic
1	Introduction: Introduction to Intellectual Property Rights, types of intellectual property, importance of intellectual property rights,
2	Evolution of IP acts and treaties, Agencies responsible for IPR registrations,
3	Role and value of IP in international commerce, Issues affecting IP internationally
4	Fundamentals of copyright law, originality of material, right of reproduction, right to perform the work publicly, copyright ownership issues, notice of copyright.
5	Foundation of patent law, patent searching process, Basic Criteria of Patentability
6	Kind of protection provided in Industrial design and layout
7	Purpose and function of trademarks, Acquisition of trade mark rights, transfer of rights, Selecting and evaluating trademark, registration of trademarks, claims.
8	Trade Secrets: Trade secret law, determination of trade secret status, liability for misappropriation of trade secrets, trade secret litigation.
9	Geographical Indication of Goods: Basic aspects and need for the registration
10	Information Technology Act, cyber crime and e-commerce, data security, confidentiality, privacy, international aspects of computer and online crime.
11	Acquiring IP Rights: letters of instruction, joint collaboration agreement,
12	Protecting IP Rights: non disclosure agreement, cease and desist letter, settlement memorandum.
13	Transferring IP Rights: Assignment contract, license agreement, deed of assignment

14	Important Indian Acts passed related to Environment and Bio Diversity
15	International Treaty on Plant Genetic Resources and Articles of Interest
16	The uniqueness of plant genetic resources for food and agriculture

Suggested Readings

1. Erbisch FH &Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.

2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill. 3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

5. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

7. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES **0+1**

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Practicals

Practical No	Topic
1	Chemical Use Guideline
2	Types of chemicals and their classification
3	Basic Tips of Safe Chemical Handling
4	Basic Rules of Chemical Safety
5	Safety rules of Chemistry Laboratory
6	Basic Glasswares and instruments used in Laboratory
7	Basic Laboratory Procedures
8	Safety equipments in laboratory
9	List of Instruments used in Agriculture, Horticulture and allied disciplines Laboratories.
10	Basic Laboratory Procedures: Cleaning of Glassware, Weighing and preparation of solutions
11	Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath
12	Preparation of buffers of different strengths and pH values
13	Seed viability testing, testing of pollen viability

Suggested Readings

1. Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.

2. Gabb MH &Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES **1+0**

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Cooperatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Teaching schedule: Theory

Lecture No.	Topic
1 - 4	History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.
5-8	Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.
9-10	Committees and its constitutions on Animal Ethics, Research ethics, and computer ethics

11-14	Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Cooperatives, Voluntary Agencies/Non-Governmental Organisations.
15	Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes. Evaluation of Rural Development Policies and Programmes and Constraints in implementation of Rural Development Programmes
16	Social programs viz. SC Sub Plan, Tribal Sub Plan.

Suggested Readings

1. Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh K.. 1998. Rural Development - Principles, Policies and Management. Sage Publ
5. Ableman, M. 2005. Fields of plenty: A farmer's journey in search of real food and the people who produce it. San Francisco: Chronicle Books.
6. Agarwal, A. 2005. Environmentality: Technologies of government and the making of subjects. Durham, NC: Duke University Press.
7. Gadgil, M. and Guha, R. 1995. Ecology and equity. The use and abuse of nature in contemporary India. New Delhi: Penguin Books.

8. Jain, L.C., Krishnamurthy, B.V. and Tripathi,P.M. 1986. Grass without roots under Government Auspices. Sage Publications, New Delhi.

9. Punia M. S. Manual on international Research and Research ethics. CCS, Hayana Agricultural University, Hisar.

10. RAO, B.S.V., 2007, Rural Development strategies and Role of Institutions-Issues, Innovations and Initiatives Mittal Publishers, New Delhi.

11. Rivera, Roberto and David Borasky 2009. Research Ethics Training Curriculum, Family Health International. P.O. Box 13950 Research Triangle Park, NC27709. USA.

12. Singh, K., 1998, rural Development Principles, Policies and Management Sage Publications, New Delhi.

13. Singh, Kartar 2001. Rural Development – Principles, Policies and Management.Sage Publications, New Delhi.

14. Thompson, P. 1997. The spirit of the soil: Agriculture and environmental ethics. New York: Routledge Press.

PGS 506	DISASTER MANAGEMENT	**1+0**

Theory

UNIT-I

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, Volcanic eruptions, Heat and cold waves, Climatic change: global warming, Sea level rise, ozone depletion.

UNIT-II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, air pollution, water pollution, deforestation, industrial waste water pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT-III

Disaster Management- Effect to migrate natural disaster at national and global levels. International strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community –based organizations and media. Central, state, district and local administration; Armed forces in disaster response; Disaster response; Police and other organizations.

Teaching schedule: Theory

Lecture No.	Topic
1	Important terminologies related to disaster management
2	Types of disaster : Earthquake, Flood, Urban Flood, Landslide, Cyclone and Volcanic Hazards
3	Disaster Management Cycle : Community Based Disaster & Risk Management (CBDRM)
4	Management of Disasters in India : Manmade Disasters - Chemical disasters, Nuclear disasters and Biological disasters
5	Man-made Disaster : Building fire, coal fire, oil fire, forest fire and deforestation
6	Man-made Disaster - Air pollution, water pollution, Industrial wastewater pollution
7	Man-made Disaster - Road accidents, rail accidents, air accidents, sea accidents
8	Combustible Dust Awareness - Fire and Explosions , Dust Storm, Burning of Farm Residues
9	Global and regional organizations working in disaster management
10	Institutional Structure of Disaster Management in India
11	national disaster management framework; financial arrangements;
12	role of NGOs, community –based organizations and media. Central, state, district and local administration;
13	Armed forces in disaster response; Disaster response; Police and other organizations.

Suggested Readings

- Prakash S; Begum I. and Rita. 2014. Activity Book on Disater Management for School students. National Institute of Disaster Management, New Delhi.
- National Disaster Management Guidelines.2007. National Disaster Management Authority, Government of India. Available on https://ndma.gov.in/en/ 2.
- Bouwer, L. M. 2011. Have disaster losses increased due to anthropogenic climate change? Bulletin of the American Meteorological Society, 92(1): 39-46.
- Cutter, S. L., M. Gall. and C. T. Emrich. 2008. Toward a comprehensive loss inventory of weather and climate hazards, in H. F. Díaz and R. J. Murnane (eds.), Climate Extremes and Society. Cambridge, UK: Cambridge University Press, pp. 279-295.
- Cutter, S. L. 2010. Social science perspectives on hazards and vulnerability science. In Geophysical Hazards (pp. 17-30). Springer Netherlands.
- Gall, M., K. Borden and S. L. Cutter. 2009. When do losses count? Six fallacies of natural hazards loss data. Bulletin of the American Meteorological Society, 90(6): 799-809. Hultman, N., Hassenzahl, D. M. and Rayner, S. 2010. "Climate Risk: A critical review of tools, techniques and approaches." Annual Reviews of Environment and Resources.
- McBean, G. and Rodgers, C. 2010. Climate hazards and disasters: the need for capacity building. Wiley Interdisciplinary Reviews: Climate Change, 1(6), 871-884.
- McBean, G. and Ajibade, I. 2009. Climate change, related hazards and human settlements. Current Opinion in Environmental Sustainability, 1(2), 179-186.
- Preston, B. L., Yuen, E. J. and Westaway, R. M. 2011. Putting vulnerability to climate change on the map: a review of approaches, benefits, and risks. Sustainability Science, 6(2), 177-202.
- Stern, P. C. and Feinberg, H. V.1996. Understanding Risk: Informing Decisions in a Democratic Society (eds). National Academies Press, Washington DC.
- World Economic Forum. 2014. Global Risks 2014. 9th Edition. Geneva, Switzerland.
- Zhou, H., Wan, J., and Jia, H. 2010. Resilience to natural hazards: a geographic perspective. Natural Hazards, 53(1): 21-41.
- Information and communication Technology for Disaster Management by Chanuka Wattegama, AsiaPacific Development Information Programme e-Primers for the Information Economy, Society and Polity
- India Disaster Report 2011. National institute of disaster management.
- NDMA news letter. 2015. Sambad-NDMA news letter, vol.1(1).
- Matt H. 2007. Security Management. Preventing the next campus shooting. Blog published in http://www. entrepreneur.com/tradejournals/article/171142115_1.html.
- Goel, Rahul (2018). "Modelling of road traffic fatalities in India". Accident Analysis & prevention Elsevier BV. 112: Prevention. Elsevier BV. 112: 105115 10.1016/j.aap. 2017.12.019 PMC 5792624PMID 29329015
- Road traffic deaths and proportion of road users by country/area, WHO (2015 Report). Homeland security. 2014. Bomb threat Procedures. Available at OBP@dhs.gov
- Kaulfersch, Joseph A. 2007. Preventing Dust Explosions. Control Engineering, January 11, 2007
- Adger, W. N. 2006. Vulnerability. Global Environmental Change, 16(3), 268-281.
- Borden, K. and S. L. Cutter. 2008. Spatial patterns of natural hazard mortality in the United States. International Journal of Health Geographics, 7(64):33.

- Economic survey of Delhi (2004), Planning Department, Government of National Capital Territory of Delhi, 6th level, New Delhi (India).

E Resources

42. www.thehindu.com/2006/02/04/stories/2006020416080100.htm
43. www.library.thinkquest.org
44. www.fao.org/forestry/
45. www.tnfrs.tn.nic.in//stns.htm