NEW AND RESTRUCTURED POST-GRADUATE CURRICULA & SYLLABI

Basic sciences

Agricultural Chemicals
Biochemistry
Chemistry
Microbiology
Plant Physiology

Education Division
Indian Council of Agricultural Research
New Delhi

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Contents

EXECUTIVE SUMMARY

Agricultural Chemicals

- The discipline of Agricultural Chemicals has an edge over chemistry or agricultural chemistry as it deals specifically with agrochemicals. The firstGreen Revolution could become a success story due to use of pesticides along with high yielding varieties. The present day scenario for interdisciplinary approach in teaching and research and demand for more eco-friendly pesticides and other agrochemicals has necessitated restructuring the course programmes and course contents at masters and doctoral level.
- Objectives of restructuring the course curricula is to develop, upgrade manpower of excellence in agrochemicals to undertake and execute research and teaching in the areas of agrochemical development, formulation and safety evaluation.
- The course AC 501 is designed for students from outside the discipline. Courses AC 503, 504, 505 and 602 may be joint interdisciplinary courses, wherever chemistry departments separately exist. Courses from AC 503 to 506, 507/508/ 509 series will be core courses for M. Sc. students (15 credits). 601, 602 and 605 series will be core courses for Ph.D. students (8 credits).
- Masters level courses are designed to provide basics in chemistry and synthetic agrochemicals. Almost every course has a practical component. Choosing any course from AC 507, 508 and 509 will provide a specialization to the student in controlling insects, fungi, nematodes or weeds. The doctoral degree level courses are advanced and research oriented.
- The courses designed will need equipments for extraction separations, estimations, structure determination and synthesis; to cite some of them are supercritical fluid extractor, GC-MS/LC-MS, HPTLC, equipment for organic synthesis etc. Thus a one time grant of nearly Rs. 1 crores with a recurring contingency of Rs. 5 lacs per annum will be needed to run effective masters and doctoral programmes in agricultural chemicals.

Biochemistry

- Course curricula and course outlines in biochemistry are designed in view of the fact that biochemistry courses are offered by students from almost all disciplines of faculties of agriculture, veterinary sciences, home science, forestry, fisheries and even technology. Thus the course Biochem 501 is a basic course to be offered to students taking biochemistry as a major or minor subject and also to students from other disciplines, who offer only one course in biochemistry.
- All courses are designed as per NCG guidelines and to cover all basic topics. New courses on Immunochemistry, Advanced Molecular Biology, Biochemistry of Biotic and Abiotic Stress, Functional Genomics and Metabolomics, Carbon and Nitrogen Metabolism, Current Topics in Biochemistry and Advanced Techniques in Biochemistry are framed in view of the recent developments in the subject.
- More emphasis is given on practicals at M. Sc level courses; the ratio of lectures to lab is 23:8 for 500 series and 14:2 for 600 series courses.
- Biochemistry courses are offered by a large number of students hence need small equipment in multiple numbers. To do quality teaching and research, sophisticated equipments like ultra low freezers, high speed refrigerated and ultra- centrifuges,

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 Biochemistry lab. Consumables will also be needed accordingly. In most of the SAUs, the biochemistry labs may also need renovation as per GLP norms. An approximate total budget of Rs. 5.0 lacs per annum apart from one time equipment grant of Rs. 50.00 lacs will be required.

Chemistry

- The present day scenario is to encourage the growth of high quality interdisciplinary research, which now thrives in many institutions. The interfaces between Chemistry (as a strong core discipline) and Physics, Biology, Materials and Engineering have strengthened. The interaction with biology for example, involves not just Synthetic Organic Chemistry but Spectroscopy, Physical, Inorganic, The oretical and Computational Chemistry. Such interactions are essential since the major task of deriving scientific and commercial value from recent advances in genomics and proteomics require massive inputs from chemistry and computing. Similar comments apply to Photonics, Molecular Electronics, Biomaterials and Nanotechnology. In view of useful interdisciplinary research, it is essential to revise the Chemistry Courses so that the outgoing student has a better grip on interdisciplinary teaching and research.
- There are several recent advances in Chemistry including Green Chemistry which deals with environmental like issues involving: chemical technology of waste, pollution, solventless reactions, catalysis, biocatalysis, benign syntheses and alternate energy sources. Another recent area is modern spectroscopy, which deals with techniques like GCMS, LCMS, FABMS, which enable us to determine the molecular mass from a pinch of the compound. It is possible to arrive at the structure of the naturally occurring organic molecule by using modern techniques like ^{1}H NMR, CMR and DNMR. The present courses have been revised to take care of the various such new areas.
- The revised courses cover the areas: Green Chemistry, Dynamics of Inorganic Reactions, Spectroscopy, Organic Syntheses, Computers in Chemistry, Quantum Mechanics, Polymers, Macromolecules, Catalysis, Bioorganic Chemistry, Drugs and Dyes, Reactions and Rearrangements, Photochemistry, Preparations, Analysis, Nuclear Chemistry, Nonaqueous Solvents, Colloidal Chemistry, Biophysical Chemistry; Experiments on pH meter, conductometer, potentiometer, flamephotometry, refractometer, polarography, chromatography; Natural Products Chemistry, Physical Organic Chemistry, Coordination Chemistry, Chemical Kinetics, Surface Chemistry and Thermodynamics.
- The UGC recommendations for PG courses have been taken into consideration in framing these courses. It is hoped that these will prove very useful to the future students.
- Chemistry courses are offered by a large number of students of Engineering stream besides Basic Science students. To do quality teaching and research, sophisticated equipments like GCMS, LCMS to determine molecular masss of a compound from a pinch of sample is required. NMR, CMR, can be used to determine the structure of naturally occurring organic molecule. An approximate total budget of Rs. 5.0 lacs per annum apart from one time equipment grant of Rs. 1 Crore will be required.

Microbiology

- 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 has been developed for the parallel, high-throughput identification of many microorganisms.
- Great emphasis is also being given 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, nemotodes have been developed and some of these are commercially available & being used by the farmers. Microbe – plant symbiosis within plant rhizosphere have come up as an effective clean up technology. Increased attention has been directed towards use of microorganisms (bioremediation) for wastewater treatment mainly decolorization of different industrial effluents, which include distillery waste, textile industries & paper & pulp industries. Microbial degradation & 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.
- 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 total budget of Rs. 5.0 lacs per annum apart from one time equipment grant of Rs. 50.00 lacs will be required.

Plant Physiology

- In agricultural universities and crop specific Institutes, the major mandate is crop improvement. Therefore, post graduate degree programme in plant physiology / crop Physiology was started in many Agricultural Universities with an objective to impart required training and adequate exposure to the graduates who ultimately assist in national and state level crop improvement programmes. From this context the course curricula is constantly being modified over the years to address the issues of crop improvement by exploiting well characterized crop physiological processes. Since, last 20 years phenomenal progress has taken place in understanding the plant physiological processes at molecular level and provided several comprehensive molecular biology options to modify growth and developmental processes. Adoption of these developments necessitates a strong exposure to tools of modern biology to address

specific issues of crop growth and developments. This emphasizes the need for reorientation of the courses to encompass molecular biology also as an integral component of plant and crop physiology. The course structure thus consists of:

- A basic course for both majoring in plant Physiology as a beginner course as well as for students choosing Plant physiology as minor subject or offering only single course.
- Courses are framed on various aspects of plant physiology that include physiology (with molecular bias) of plant growth and yield modeling, physiology of development, stress, post harvest, seed and weed, photosynthesis, mineral nutrition, morphogenesis, signal transduction, genome structure and functional genomics.
- Separate Courses on Climate Change and Crop Growth, Molecular Approaches for Improving Physiological Traits and Techniques in Plant Physiology are included as Ph. D. level courses.
- Plant Physiology 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-centrifuge, IRGA, Consumables will also be needed accordingly.. An approximate total budget of Rs. 5.0 lacs per annum apart from one time equipment grant of Rs. 50.00 lacs will be required.

BSMA Committee on Basic Sciences

(Pl. Biochemistrty/Chemistry/Agricultural Chemicals/ Plant Physiology/ Agricultural Microbiology)

(Constituted by ICAR vide Office order No. F. No. 13 (1)/2007 EQR - dated January 14, 2008)

Name	Address	Specialization
Dr. Sanjeev Agrawal **Convenor**	Prof. & Head, Biochemistry, GBPUA&T, Pantnagar	Biochemistry
Dr. K. R. Koundal Jt. Director of Research	IARI, New Delhi-110 012	Biochemistry
Dr. M. Udaya Kumar Senior Professor	Department of Crop Physiology, UAS, GKVK, Bangalore 560 065	Pl. Physiology
Dr. P. S. Deshmukh Professor & Head	Division of Plant Physiology, IARI, New Delhi- 110 012	Pl. Physiology
Dr. B. S. Parmar Ex. Head	Division of Agricultural Chemicals, IARI, New Delhi – 110 012	Agr. Chemicals
Dr. S. G. Sharma Head	Dept. of Biochemistry, Plant Physilogy & Env. Studies, Cuttack, Orissa	Biochemistry
Dr. A. K. Gupta	Dept. of Biochemistry, COBS & H, PAU Ludhiana 1410 04	Biochemistry
Dr. K. Balakrishnan Professor	Dept. of Plant Breeding, Agril. College, Madurai 625 104	Pl. Physiology
Dr. Neeru Narula Professor **Member Secretary**	Dept. of Microbiology, COBS, CCS HAU, Hisar 125 004	Micribiology

PREAMBLE

Importance of the Subject to Agriculture/ Farming Society/ Society in General

The role of science in agriculture is to abet the age old craft of agriculture, which made commonsense the yardstick of development. Development of genetics and pesticides in 19th century paved way to crop breeding and prevention of crops from insect pests, respectively. After 1930s, discovery of chemical fertilizers resulted in an increased yield hence, breeding for high yielding varieties, use of pesticides and chemical fertilizers collectively made it possible to have the "First Green Revolution". Understanding the structures and functions of proteins, DNA, RNAs and other biomolecules, mechanisms of photosynthesis, photorespiration, nitrogen fixation and other metabolic pathways, behaviour of enzymes, development of fermentation technologies and modern biology tools have changed the trend in agricultural research and hence it has been possible to have - (i) marker assisted breeding, (ii) identification of seed varieties and animal breeds on the basis of molecular markers, (iii) molecular taxonomy of plants, microbes and other organisms, (iv) development of transgenics resistant to biotic and abiotic stresses, (v) production of edible vaccines, neutraceuticals, pharmaceuticals, plantibodies, (vi) diagnostic techniques based on molecular and immunological tools, (vii) production of biofertilizers and biopesticides, and (viii) bioremediation of xenobiotics and heavy metals.

Further decoding the whole genomes will permit a better management of the soil, plant and animal health and to have designer organisms. Also the development of refined and automated techniques of separation and estimation of molecules have not only speeded up the pace of work but also helped detect compounds present in minute amounts. Thus at a point where the agricultural production also reached a plateau, a "Second Green Revolution" is on anvil through basic Sciences technologies.

Present Status of Agricultural Education *vis-à-vis* State of Agriculture

The advancement made in last few decades in the basic sciences is now reflected in teaching and research in agricultural sciences. There has been more use of modern biology and chemistry techniques in crop breeding, mineral nutrition, chemical analysis of soil, plant and various agricultural products. Students from plant sciences and plant protection disciplines offer basic sciences courses as minor or supporting courses. With increasing interest of students from agriculture disciplines in basic sciences the contents of basic sciences courses have also been modified but it has been limited at the level of respective teachers and a variation is there from teacher to teacher. The new curricula should overcome this deficiency.

Need for Revision of Course Curricula and Syllabi

It is expected that by the year 2050, the world population explosion would become ten billion. The population explosion would lead to continuous deterioration of our environment and natural resources. The challenges faced by agriculture are enormous. Therefore agriculture needs new initiatives. There are also serious concerns about the quality of graduates passing out in terms of their knowledge, skill and entrepreneurship. Revisit of contents, delivery mechanisms, unification of degree nomenclature, and coherence in examination and evaluation systems, trans-institutional activities through sustainable linkages are important for developing quality human resources. Development in basic Science is very fast. It is important to reorient our program to impart the latest

knowledge to our students. Reorientation of courses has, therefore, become imminent for upgrading the knowledge, skill and aptitude of our agricultural graduates.

Revision process adopted by BSMAC

- In the first meeting of all BSMAC conveners and secretaries guidelines to prepare the document were given.
- First meeting of the BSMA on basic sciences was held at G. B. Pant University of Agriculture & Technology, Pantnagar on 04- 04- 2008 which was convened by Dr Sanjeev Agrawal under the chairmanship of Dr. D. P. Mishra, Member National Core Group on Basic Sciences.The meeting was attended by 6 members of BSMAC and faculty members of related disciplines from College of Basic Sciences and humanities, GBPUA&T, Pantnagar. The documents prepared by member experts in different areas were reviewed in respect of course structures, credits for core, supporting, minor and optional courses and course outlines of various courses. Drafts for Chemistry and agrochemicals were not available for review hence the Convener and Secretary, BSMAC and Dr. Parmar were requested to get the drafts ready before next meeting/workshop of the BSMAC. Members were then kept contacted through email for developments in preparation of the draft.
- Since Basic Sciences consist of five different disciplines viz Biochemistry, Microbiology, Plant Physiology, Chemistry and Agrochemicals. The following BSMA members were requested to act as Co-convener to review and modify the course contents of their discipline. They were requested to co-opt 3-4 subject experts from any part of the country, as per need.

Co -conveners	Designation	Subject
Dr. Sanjeev Agrawal	Professor & Head, Biochemistry, G.B.P.U.A.&T., Pantnagar	Biochemistry
Dr. Neeru Narula	Professor & Head, Microbiology, CCSHAU, Hisar	Microbiology
Dr. Udaya Kumar	Senior Professor, Plant Physiology, UAS, GKVK campus, Bangalore	Plant Physiology
Dr. B. S. Parmar	Ex. Joint Director (Res.) and Ex.-Head, Division of Agricultural Chemicals, IARI, New Delhi	Agrochemicals
Dr. Rajvir Singh (Opted member)	Associate Professor, Chemistry, CCS, HAU, Hisar	Chemistry

- Subject expert committee on Plant Physiology met at Bangalore (3rd May, 2008) and the sub group of experts on plant physiology met at IARI (20th May, 2008). After a lot of deliberations over the contemporary development in this area came to the conclusion to recommend changing the nomenclature of the Master and Doctoral degree programme as Plant/ Crop Physiology & Molecular Biology. It is desirable that this programme is included under agricultural faculty since the major mandate is crop improvement. However at the combined BSMA meeting on basic science subjects conducted at IARI (21st May, 2008), it was decided to retain the nomenclature as Plant physiology. In the II meeting of conveners and secretaries under the chairmanship of Dr. J. C. Katyal, Chairman, NCG, held on June 23-24, 2008 at New Delhi it was suggested to keep it Plant Physiology.

- The different stakeholders were contacted by various members of the committee by email. The following stakeholders have responded.
    1. Dr. Rakesh K Jain, Dy. Director, IMT Chandigarh
    2. Dr. Alok Satlewal, R & D Biotechnology, Jubiliant Orangosis, JP Nagar
    3. Dr. S. N. Jogdand, Karmaveer Bhaurao Patil College, Vashi, Navi Mumbai
    4. Dr. Vibhu Jain, Millpore India Ltd.
    5. Dr. Akhilesh Tyagi, (Entrepreneur)
- The second meeting of BSMAC members was convened by Dr. Deshmukh, Head, Department of Plant Physiology, IARI, at New Delhi under the chairmanship of Dr. K. R. Koundal, Director Research, IARI.The meeting was attended by all BSMA members, Dr. Vibhu Jain and many of the co-opted members. The meeting continued for two days from May 20 to 21, 2008. Subject wise groups were formed to review the respective drafts under the guidelines of framework provided by NCG. These were pooled by the Secretary, BSMAC and were presented by the secretary at the II meeting of the conveners and secretaries of BSMACs on June 23 and 24, 2008.
- Dr. Vibhu Jain from Millipore attended the meeting. Dr. Vibhu Jain suggested that for industrial point of view, emphasis should be given on following topics. Purification of biomolecules Fermentation, Enzyme Technology and Recombinant DNA Technology. These aspects were given due care while revising the course curricula.

Salient features of the new Curricula/Syllabi along with justification

- The BSMA on Basic Sciences consists of Agricultural Chemicals. Biochemistry, Chemistry, Microbiology and Plant Physiology.
- The course structure of each discipline is formulated to have one basic course, compulsory and optional courses
- Master's level courses are numbered in 500 series and doctoral level courses in 600 series as the doctoral degree courses are advanced than master's degree courses.
- In master's level courses practical component is more to provide them better laboratory training.
- Courses and course contents are designed in accordance to recent advances in the subject as well with an agricultural and industrial bias. Hence nearly one-third of the courses are new.
- As per NCG guidelines four compulsory non credit courses are also included in the all master's degree course programmes.

Career Opportunities

The new course programmes are more inclined to agriculture and industry and have been designed in accordance to recent developments in the subject concerned hence will be helpful to fetch teaching, research and R&D jobs in colleges/universities, research institutions and industries.

ORGANIZATION OF COURSE CONTENTS
&
CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level. A Ph. D. student must take a minimum of two 600 series courses, but may also take 500-series courses if not studied during Master's programme.
- 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.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

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 unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Subject	Master's programme	Doctoral programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	**55**	**75**
Compulsory Non Credit Courses	See relevant section	

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph. D. students may be exempted from these courses if already studied during Master's degree.

AGRICULTURAL CHEMICALS

Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
AC 501	INTRODUCTION TO AGROCHEMICALS	2+0
AC 503*	BASIC CHEMISTRY I	2+1
AC 504*	BASIC CHEMISTRY II	2+1
AC 505*	CHEMICAL LABORATORY TECHNIQUES	1+2
AC 506*	AGROCHEMICAL REGULATION, QUALITY CONTROL AND MANAGEMENT	3+0
AC 507	SYNTHETIC AGROCHEMICALS FOR INSECT AND MITE MANAGEMENT	2+1
AC 508	SYNTHETIC AGROCHEMICALS FOR DISEASE AND NEMATODE MANAGEMENT	2+1
AC 509	SYNTHETIC AGROCHEMICALS FOR WEED MANAGEMENT	2+1
AC 510	SPECTROSCOPIC AND CHROMATOGRAPHIC TECHNIQUES	2+2
AC 511	PESTICIDE RESIDUE CHEMISTRY	2+2
AC 591	MASTER'S SEMINAR	1+0
AC 599	MAASTER'S RESEARCH	20
AC601**	AGROCHEMICAL FORMULATION	2+2
AC602**	CHEMISTRY OF BIOPESTICIDES	2+1
AC603	SYNTHETIC ORGANIC CHEMISTRY	2+1
AC604	XENOBIOTIC MOVEMENT, TRANSFORMATION AND METABOLISM	2+1
AC605**	SPECIAL TOPICS IN AGROCHEMICALS	1+0
AC 691	DOCTORAL SEMINAR I	1+0
AC 692	DOCTORAL SEMINAR II	1+0
AC 699	DOCTORAL RESEARCH	45

AC 501 is designed for students from outside the discipline
AC 503, 504, 505 and 602 may be joint interdisciplinary courses, wherever chemistry departments exist separately
* 503-506, 507/508/509 Compulsory courses for M.Sc. students (15 credits)
** 601, 602 and 605 Compulsory courses for Ph.D. students (8 credits)

AGRICULTURAL CHEMICALS

Course contents

AC 501 INTRODUCTION TO AGROCHEMICALS 2+0

Objective

To give an overview of pesticides with reference to their classification, structure, mode of action, synthesis and formulations and pesticide residue analysis.

Theory

UNIT I

Definition, IUPAC approved terminology, statistics of production and consumption. Classification, plant production chemicals - an overview, nitrification regulators, soil conditioners, chemical hybridizing agents, hydrogels, seed coats etc. fertilizer control order. Plant protection chemicals: Pesticides – classification (both synthetic and natural), Insecticides Act.

UNIT II

History of botanical insecticides, structure, properties, mode of action and uses of conventional insecticides such as nicotine, pyrethrins and rotenones. Insect antifeedants and growth regulators including Drimane sesquiterpenoids, withanilides, clerodanes, quassinoids and limonoids, hormone analogues (JH, anti-JH, JH-mimics, moulting hormones), Semiochemicals - pheromones and allelochemicals.

UNIT III

Structure, properties, mode of action and uses of synthetics:

Insecticides- chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids and others (ex neo-nicotinoids). Fungicides - inorganic, organic- heterocyclic, formamide, alkane, alkane carboxylic acid and miscellaneous groups. Strobilurin fungicides and antibiotics. Nematicides - aliphatic halogen compounds, methyl isocyanate liberators, organophosphates and carbamates.

UNIT IV

Formulation of pesticides - definition, classification, objectives, process, product development. Formulation codes, conventional formulations such as EC, WP, Dust, Granule etc. Pesticide adjuvants: synergists**.**

UNIT V

Pesticide residue: Concept definition, significance and analysis as per BIS specifications, Agrochemicals in water, soil, air and non-target organisms-status, impact, monitoring, etc.

Suggested Readings

Baker DR, Fenyes JG & Steffens JJ. (Eds.). 1992. *Synthesis and Chemistry of Agrochemicals.* Vols. I-III. ACS Symposium Series 504, ACS Washington D.C.

Buchel KH. (Ed.). 1992. *Chemistry of Pesticides.* John Wiley & Sons.

Hassal K. 1982. *The Chemistry of Pesticides*. The Macmillan Press.

Marrs TC & Bryan BT. (Eds.). 2004. *Pesticide Toxicology and International Regulation*. John Wiley & Sons.

Murayama T. 1987. *Japan Pesticide Information*. Japan Plant Protection Association, Tokyo.
Parmar BS & Tomar SS. 2004. *Pesticide Formulation: Theory & Practice*. CBS Publ.
Roberts HA. (Ed.). 1982. *Weed Control Handbook: Principles.* Blackwell Scientific Publ.
Tomar SS & Parmar BS. 1992. *Dictionary of Agricultural Chemicals*. Academic India Publ.
Handa SK 2004. *Principles of Pesticide Chemistry*. Agrobios.

AC 503 BASIC CHEMISTRY I 2+1

Objective

To acquaint the students with atomic structure, stereochemistry, nomenclature of organic compounds, their chemistry and properties.

Theory

UNIT I

Properties of molecules: Structure of atom, electronic theory of valency. Dipole moments, electron-displacements (inductive, electromeric, mesomeric effects). Hydrogen-bonding, atomic and molecular orbitals. Shapes of molecules. General nature of organic reactions. Acids and bases.

UNIT II

Stereochemistry: Isomers, chiral molecules, optical isomerism. Symmetry elements, asymmetry, chirality a combined look conventions describing configurations D-L and R-S system. Stereoisomerism resulting from more than one centre (diastereoisomers). Geometrical isomerism, E-Z system of nomenclature. Conformations of acyclic and cyclic systems.

UNIT III

Nomenclature, general methods of preparation, properties and uses of alkanes, alkenes and all the functional groups like halogenated hydrocarbons, alcohols, ethers, aldehydes, ketones, acids and the mechanisms of associated reactions.

UNIT IV

Nomenclature, preparation, properties and uses of alicyclic compounds. Diel-Alder reaction, Theories of aromaticity, substitution in benzene ring, orientation for further substitution. Preparation, properties and uses of substituted aromatic compounds (halogenated, nitro, amino-compounds, diazonium salts, aromatic sulphonic acids, phenols, quinones and aromatic acids). Bicyclic – naphthalene and naphthaquinone.

UNIT V

Heterocyclic chemistry: Nomenclature of furan, thiophene, pyrrole, indole, pyrazole, midazole, oxazole, thiazole, pyridine, piperidine, quinnoline, isoquinnoline, pyran, pyrone, diazine etc. Introduction to natural products: Chemistry of terpenoids, alkaloids, flavonoids, carbohydrates, amino acids, proteins and nucleic acid and dyes.

Practical

General aspects and Introduction, Detection of elements in organic compounds, Detection of functional groups and preparation of their derivatives, Separation and identification of organic compounds in binary mixtures.

Suggested Readings

Clarke HT & Hayes WC. 1964. *Handbook of Organic Analysis*. Edward Arnold.

Ernest L Eliel & Samuel H Wilen. 1994. *Stereochemistry of Organic Compounds.* Wiley-Interscience.

Finar IL. 1989. *Organic Chemistry.* Vols. I, II. Longmans.

James B Hendrickson, Donald J Cram & George S Hammond 1970. *Organic Chemistry.* McGraw-Hill.

Robert T Morrison & Robert N Boyd. 1992. *Organic Chemistry.* 6th Ed. Prentice Hall.

Vogel AI, Tatchell AR, Furnis BS & Hannaford AJ. 1996. *Vogel Textbook of Practical Organic Chemistry*. Forestmillbooks,UK.

AC 504 BASIC CHEMISTRY II 3+1

Objective

To teach the students kinetic theory of gases and chemical kinetics, thermodynamics, chemical and phase equilibrium and electrochemistry.

Theory

UNIT I

Atomic structure - fundamental particles, Bohr's theory of hydrogen atom, wave-particle duality, uncertainty principles, Schrodinger's wave equation, quantum numbers, shapes of orbitals, Hund's rule and Pauli's exclusion principle.

UNIT II

Kinetic theory of gases, Maxwell - Boltzmann distribution law, equipartition of energy.

UNIT III

Chemical thermodynamics - reversible and irreversible processes, first law and its application to ideal and non-ideal gases, thermochemistry, second law, entropy and free energy, criteria for spontaneity.

UNIT IV

Surface chemistry - chemical and phase equilibria, law of mass action, Kp, Kc, Kx and Kn, effect of temperature on K, ionic equilibria in solutions, sorption- adsorption, desorption, disperse systems, pH and buffer solutions, hydrolysis, solubility product, phase equilibria, Phase rule and its application to one- and two- component systems, colligative properties. Electrochemistry, redox, reactions, chemical analysis - principles, classification, volumetric, gravimetric and potentiometric analyses.

UNIT V

Chemical kinetics - reactions of various order, Arrhenius equation, Collision theory, theory of absolute reaction rate, chain reactions, normal and branched chain reactions, enzyme kinetics, photo-physical and photo-chemical processes, catalysis.

Practical

Rate kinetics, UV visible spectroscopy, and Colligative properties.

Suggested Readings

Clyde R Metz 1988. *Schaum's Outline of Physical Chemistry.* 2nd Ed. McGraw-Hill.

Negi AS & Anand SC. 2003. *A Text Book of Physical Chemistry*. Wiley Eastern.

Robert A Alberty & Robert J Silbey 1996. *Physical Chemistry*. 2nd Ed. John Wiley & Sons.

Samuel Glasstone & David Lewis. 1946. *Advanced Physical Chemistry*. Macmillan Education.

Walter J Moore 1987. *Basic Physical Chemistry*. Prentice Hall of India.

AC 505 CHEMICAL LABORATORY TECHNIQUES 1+2

Objective

To acquaint students with laboratory hygiene, upkeep and maintenance of laboratory, glassware and handling of chemicals, purification and drying of solvents, distillation and chromatographic techniques.

Theory

UNIT I

Laboratory hygiene and safety, laboratory accidents and their management. Human safety and protection, handling and storage of flammable, volatile, health hazardous and corrosive chemicals, glassware safety, emergency response. Precautions and safety while carrying out reactions and handling reaction wastes.

UNIT II

Different types of glassware and their use. Laboratory notebook upkeep, maintenance and importance. Melting and boiling points, their determination, apparatus used and allied informations. Distillation, fractional distillation, crystallization. Vacuum filtration.

UNIT III

Purification and drying of solvents. Solvent removal by distillation, evaporation, reduced pressure evaporation and rotary evaporation (Buchi type). Vacuum pumps, water aspirators etc.and their use.

UNIT IV

Hydro distillation, steam distillation, supercritical fluid extraction, extraction of volatiles by Clevenger apparatus and solid phase extraction.

UNIT V

Chromatography - principle and practice, types etc. Partition and adsorption chromatography with examples (TLC, Paper, GLC, HPLC, Gel, HPTLC etc.). Spot visualization, chromogenic reagents etc. Column chromatography, Introduction to gas chromatography and HPLC.

Practical

Introduction to Laboratory equipment and cleaning of glassware, Assembling of simp apparatus and finding density, Purification of solvents, Crystallization,identification and sublimation, Extraction, Chromatography: Paper, Column, TLC,Preparative TLC Column HPTLC, Steam Distillation, Elemental Analysis, New Practical-Use of stirrer, pump and presentations.

Suggested Readings

Joan S Fessenden, Ralph J Fessenden & Patty Feist 2001. *Organic Laboratory Techniques.* 3rd Ed. Brooks/Cole.

Patty Feist 2002. *Handbook for Organic Chemistry Lab*. 6th Ed. Brooks/Cole

Shriver DF & Drezdzon MA.1986. *The Manipulation of Air-Sensitive Compounds*. 2nd Ed. John Wiley & Sons.
Vogel AI. 1996. *Vogel's Textbook of Practical Organic Chemistry.* 5th Ed. Prentice Hall.

AC 506 AGROCHEMICAL REGULATION, QUALITY CONTROL AND MANAGEMENT 3+0

Objective

To acquaint students about the insecticide laws, fertilizer control order, meaning of quality and quality control, business and financial management and IPR

Theory

UNIT I

Current status of plant production and plant protection agro-chemicals, Fertilizer Control Order, The Insecticides Act, laws, acts and regulations for the social security and welfare of industrial labour, Acts relating to protection of air, water and the general environment.

UNIT II

Quality, quality control, role of industry, government etc., imitation and adulteration in the developing world, hints for the set up of a quality control laboratory in pesticide formulation as per BIS specifications.

UNIT III

Business management including market, budget and financial management, manpower planning, etc.

UNIT IV

Interaction with industry for practical knowledge on the above topics.

Suggested Readings

Fred Luthans. 2000. *Organizational Behavior*. McGraw-Hill.
George Ware & David Whitacre 2004. *The Pesticide Book.* Meister Publ.
Gnther Voss, Gerardo Ramos & Gü Nther Voss. 2003. *Chemistry of Crop Protection: Progress and Prospects in Science and Regulation.* Wiley-vch Verlag Gmbh.
Philip Kotler 1988. *Marketing Management – Analysis Planning and Control*. Prentice Hall of India.
Prasad D. (Ed.). 2005. *Crop Protection: Management Strategies*. Daya Publ.
Prasad LM. 1990. *Principles and Practice of Management.* S. Chand & Sons.
Zahir MA. 2003. *Facets of Business Management*. Medallion Press.

AC 507 SYNTHETIC AGROCHEMICALS FOR INSECT AND MITE MANAGEMENT 2+1

Objective

A course to deal with the chemistry, mode of action and synthesis of different classes of pesticides like organochlorines, organophosphorus, neonicotinoids, acaericides and pyritroides

Theory

UNIT I

Introduction and classification of synthetic insecticides, chemistry of conventional organochlorine insecticides: DDT, HCH, Lindane, uses, mode of action and present status, cyclodiene insecticides. : Nomenclature, uses, synthesis and mode of action of aldrin, dieldrin and endosulfan, chemistry of carbamate insecticides: Classification, mode of action, structure activity relation, synthesis and uses of carbofuran, carbaryl, aldicarb, methomyl and propaxur.

UNIT II

Organophosphorus insecticides: Chemistry, classification, mode of action. Important reactions namely Michaelis- Arbuzov reaction, Perkow reaction, Thiono-thiolo rearrangement. Preparation, properties and uses of eidfenphos, fenthion, trichlorfon, DDVP, monocrotophos, phosphamidon, chlorfenvinfos, malathion, methyl and ethyl parathion. fenitrothion, quinalphos, triazophos, diazinon, chlorpyrifos, phorate, difulfoton, dimethoate, ethion, methamidophos, acephate, azinphosmethyl.

UNIT III

Synthetic pyrethroids: Chemistry, classification, mode of action, structure activity relationship, history and evolution from natural pyrethrins. Preparation, synthesis, uses and properties of cypermethrin, deltamethrin, fenvalerate, fluvalinate, cyfluthrin, trifenthrin, non-ester pyrethroids-ethofenprox.

UNIT IV

Neonicotinoids: Chemistry, classification, mode of action and uses. Preparation, properties and uses of imidacloprid, acetamiprid, thiomethoxam, thiocloprid.

UNIT V

Synthesis insect growth regulators: juvenile hormones and juvenile hormone mimics, anti-juvenile hormone. General introduction and mode of action of ecdysones and ecdysoids. Inhibitors of chitin synthesis. Chemosterilants, alkylating agents, pheromones.

UNIT VI

Acaricides: Chemistry, classification, mode of action etc. Properties: 2, 4-dinitrophenols and esters, benzoic acid esters, dicofol, spinomeisifen.

Practical

Preparation and characterization of DDT, DDE, and Methoxychlor, Preparation of organophosphorus insecticide-Part A –phosphorodichloridite and Part B -phosphonate, Preparation and characterization of oxime ether, Preparation of DDVPls

Suggested Readings

Brooks GT. 1976. *Chlorinated Insecticides.* Vols. I, II. CRC Press.

Buchel KH. (Ed.). 1992. *Chemistry of Pesticides.* John Wiley & Sons.

Cremlyn RJ. 1990. *Pesticides: Preparation and Mode of Action*. Wiley.

Eto M. 1979. *Organophosphorus Pesticides: Organic and Biological Chemistry.* CRC Press.

Kuhr RJ & Dorough HW. 1979. *Carbamate Insecticide Chemistry and Biochemistry.* CRC Press.

Leahey JP. 1985. *The Pyrethroid Insecticides*. Taylor & Francis.

Matolcsy G, Nadasy M & Andriska V. 1988. *Pesticide Chemistry*. Elsevier.
Perry AS, Yamamoto I, Ishaaya I & Perry R 1998. *Insecticides in Agriculture and Environment. Retrospects and Prospects*. Narosa.

AC 508 SYNTHETIC AGROCHEMICALS FOR FUNGI AND NEMATODE MANAGEMENT 2+1

Objective

To teach students about the plant disease causing fungi and nematodes and synthetic fungicides and nematicides.

Theory

UNIT I

Introduction to important plant pathogenic fungi and historical development of fungicides. Classification based on chemical nature and mode of action, S, Cu, Hg, Sn, As and dithiocarbamate fungicides.

UNIT II

Benzene derivatives, phenol, quinone, polyhalogen, alkane sulfenyl group, carboxamide and dicarboximide group of fungicides.

UNIT III

Organophosphorus fungicides (examples, heterocyclic fungicides: Imidazole, benzimidazole, triazole, oxazole, thiazole, pyridine, pyrimidine, quinoline, quinoxaline, morpholine etc.).

UNIT IV

Fungicides of formamide group, alkane, alkane carboxylic acid and other miscellaneous groups. Strobilurin fungicides and antibiotics.

UNIT V

Introduction to important plant parasitic nematodes and historical development of nematicides. Preparation, properties and uses of aliphatic halogen compounds. Methyl isocyanate liberators, organophosphates and carbamates.

Practical

Preparation of Zineb (Z), Preparation, purification and characterization of dichlorophen (D), Salicylanilide (S), an organophosphorus/heterocyclic fungicide (OP), Glyodin (G) and DBCP, a nematicide (DB) and fungicide bioassay (FB)

Suggested Readings

Bell CV & Alford DV. 2000. *Pest and Disease Management Handbook*. British Crop Protection Council. Wiley-Blackwell.
Buchel KH. (Ed.). 1992. *Chemistry of Pesticides.* John Wiley & Sons.
Copping LG, Hewitt HG & Leonard G Copping 1998. *Chemistry and Mode of Action of Crop Protection Agents*. Royal Society of Chemistry.
Cremlyn RJ. 1990. *Pesticides: Preparation and Mode of Action*. Wiley.
Matolcsy G, Nadasy M & Andriska V. 1988. *Pesticide Chemistry.* Elsevier.
Nene YL & Thapliyal PN. 1989. *Fungicides in Plant Disease Control*. India Book House.
Roy NK. 2002. *Chemistry of Pesticides*. CBS Publ.
Vyas SC. 1984. *Hand book of Systemic Fungicides*. Tata Mc Graw Hill.

AC 509 SYNTHETIC AGROCHEMICALS FOR WEED MANAGEMENT 2+1

Objective

To teach classification, chemistry, synthesis and mode of action of different classes of herbicides, plant growth regulators.

Theory

UNIT I

Introduction to agrochemicals for weed management or herbicides; classification of herbicides based on time of application, mode of action and selectivity; chemistry of phenoxy acid herbicides - 2,4-D, MCPA, Dichlorprop, Mecoprop, Fenoprop, Phenoxy butyric acid. Factors governing the activity or structure activity relationship of urea derivatives - Linuron, Monuron, Diruon, Metoxuron, Isoproturon, their synthesis and mode of action; chemistry of bipyridylium herbicides - Diquat, Paraquat; organoarsenicaes and organophosphates.

UNIT II

Aliphatic and benzoic acid herbicides - Dalapon, Dicamba, Tricamba, Amiben; 2,4-Dinitro phenols, Dintro-orthocresol, Chemistry of carbamates and thiocarbamates – Isopropyl N-phenyl carbamate, Isopropyl N(3-chloro phenyl) carbamate, Methyl-N-(3,4-dichlorophenyl) carbamate, S-Ethyl N,N-dipropyl thiocarbamate, Diallate, Triallate, Molinate, Oxime carbamates, Sulfonyl carbamates, Biscarbamates; Chemistry of amides and anilides - Propanil, Pentanochlor, Allidochlor, Propachlor, Alachlor, Butachlor, Metolachlor.

UNIT III

Triazines - Simazine, Atrazine, Propazine, Metribuzin, Atratone, Prometone, Ametryne, Prometryne; Dinitroanilines - Trifluralin, Fluchloralin, Pendimethalin; Pyridines - Pyrichlor, Picloram, Triclopyr. Pyridazines- Pyrazones, Metflurazon, Norflurazon, Pyridate. Pyrimidines - Terbacil, Isocil, Bromacil; Oxadiazoles - Thiazole and Triazole herbicides.

UNIT IV

Diphenyl ethers - Flurodifen, Acifluorfen, Oxyfluorfen; Phenoxy-phenoxy acid herbicides - Fluazifop, Fenoxaprop, Clodinafop, Quizalofop (fop herbicides); Sulfonyl ureas - Chlorsulfuron, Metsulfuron methyl, Sulfosulfuron, Pyrazosulfuron ethyl, structure activity relation, mode of action, selectivity; Imidazolinones - Imazethapyr, Imazaquin, Imazapyr.

UNIT V

Herbicide uptake, translocation and selectivity, Herbicide safeners – Naphthalic anhydride, Phthalic anhydride, N,N-diallyl Chloroacetamide (Allidochlor), Dichloroacetamides, Cyometrinil, Flurazole, Fenchlorozole ethyl, Cloquinocet mexyl; Relative potency, Prosafeners, Safeners .

UNIT VI

Plant Growth Regulators, Auxins, Gibberallin - synthesis, determination of structures and structure activity relationships. Biosynthesis of Auxins and Gibberallin, Wain's three-point attachment theory, Cytokinins, Brassionosteroids.

Practical

Synthesis of 2,4-D, Its m.p, TLC, NMR, Preparation of nitrosomethyl urea, Preparation of diazomethane and derivatization of 2,4-D, GC of methyl

derivative, Introduction to Weeds: Field visit, Synthesis of propionyl chloride and its distillation, TLC, NMR, Synthesis of Propanil, m.p, TLC, NMR, Synthesis of Maleic hydrazide, m.p, TLC, NMR, Educational Tour to some Agrochemical Factory/ Laboratory, if any.

Suggested Readings

Audus LJ. 1964. *The Physiology and Biochemistry of Herbicides*. Academic Press.

Buchel KH. (Ed.). 1992. *Chemistry of Pesticides.* John Wiley & Sons.

Cremlyn RJ. 1990. *Pesticides: Preparation and Mode of Action*. Wiley.

Kearnay PC & Kaufman DD. 1975. *Herbicides: Chemistry, Degradation and Mode of Action.* Vols. I, II. Marcel Dekker.

Kramer WK & Ulrich Schirmer 2007. *Modern Crop Protection Compounds*. Wiley-vch Verlag Gmbh.

Matolcsy G, Nadasy M & Andriska V. 1988. *Pesticide Chemistry*. Elsevier.

Unger TA. 1996. *Pesticide Synthesis Hand Book*. William Andrew.

AC 510 SPECTROSCOPIC AND CHROMATOGRAPHIC TECHNIQUES 2+2

Objective

To acquaint students with the techniques used in separation, estimation and structure elucidation of agrochemicals.

Theory

UNIT I

Absorption spectroscopy: (UV, Visible and IR Spectrophotometry their theory, principle, instrumentation and application in structure elucidation of organic compounds and analysis).

UNIT II

Theory, principal, instrumentation and application of NMR and mass spectroscopy in structure elucidation of organic compounds.

UNIT III

Separation science and technology: Paper, column, thin-layer, ion-exchange and flash chromatography - principle, adsorbents, their preparation, properties mechanism of retention and application in isolation of organic compounds. GC, LC and HPTLC - principle, instrumentation and application for separation of organic compounds.

UNIT IV

Theory and practice of recent techniques in NMR: C^{13} and 2D for structure elucidation of organic compounds. Tandem techniques such as GC-MS, LC-MS for validation of results of analysis by GC, LC, GPC and HPTLC.

Practical

Spectroscopy UV-Vis Spectroscopy IR Spectroscopy Mass Spectrometry NMR Spectrometry Conventional Chromatography. Advances in Chromatography. Structure elucidation using tandem techniques.

Suggested Readings

Dyer JR. 1994. *Application of Absorption Spectroscopy of Organic Compounds*. Prentice Hall of India.

Friebolin H & Becconsall JK. 1993. *Basic One- and Two-Dimensional NMR Spectroscopy.* John Wiley & Sons.

Jack D. 1993. *Gray Beal Molecular Spectroscopy*. McGraw-Hill.
McLafferty FW & Venkataraghavan R. 1982. *Mass Spectral Correlations.* Oxford University Press.
Scott RPW. *Chrom-Ed Series* http://www.chromatography-online.org/
Sharma JM & Follweiler J. 1984. *CRC Handbook of Chromatography: Pesticides and Related Organic Chemicals*. CRC Press.
Silverstein RM, Bassler GC & Morrill TC. 1983. *Spectrometric Identification of Organic Compounds.* 4th Ed. John Wiley & Sons.

AC 511 PESTICIDE RESIDUE CHEMISTRY 2+2

Objective

To teach students the concept of pesticide residue, planning, layout and design of experiments, instruments and techniques involved, data analysis and legal issues of pesticide residue analysis.

Theory

UNIT I

Pesticide residue – concept, types, source, significance and safety considerations: risk assessment and management, hazard identification etc. Definitions with examples: Aged residue, immbolized residue, dislodgable residue, exposure, adverse effect, bioaccumulation, food chain, acceptable daily intake, theoretical daily intake, estimated daily intake, estimated maximum daily intake, biomagnification, food chain, zero tolerance, persistence, dissipation, predicted no effect concentration, raw agricultural commodity. Monitoring of pesticide residue in agricultural produce and environment.

UNIT II

Planning and layout of experiments. Application of analytical techniques for residue analysis such as spectrophotometry, chromatography including GC, HPLC, GC-MS, LC-MS and ELISA.

UNIT III

Qualitative and quantitative analysis. Accuracy and precision. Standardization of extraction and clean up conditions to achieve maximum recovery. Limit of quantification, limit of detection, limit of determination, multiresidue analysis by quick, easy, cheap, effective, rapid and safe (QuEChERS) method and GC/LC-MSMS method. Radiotracer techniques in residue analysis.

UNIT IV

Method validation and performance verification. Documentation and audit of laboratory data. Laboratory proficiency testing, Codex Alimentarius Commission and its functions, Calculation of MRL. Introduction to ISO 17025. GLP principles, quality control and assurance in pesticide residue laboratories, system suitability test. Biosensors.

UNIT V

Basic statistics and experimental design. Residue data and legal implications.

Practical

Laboratory mills/ equipment used in formulation research, Preparation of standard hard water, Determination of acidity of a pesticide, Determination of alkalinity of a pesticide, Preparation of controlled release formulation, Release of active ingredient from CR formulation in soil and water,

Preparation of toxicant based creams, Study of solid carriers: Determination of I. Surface acidity by volumetric method, II. Surface area, Study of solid carriers: III. Sorptivity and IV. Particle size, Preparation of dust, wettable powder and granules, Determination of wettability and suspensibilty of wettable powder, Study of liquid carriers I: Flash point and specific gravity, Study of liquid carriers II: Determination of viscosity, Study of surfactants: Micelle formation, Preparation of liquid formulations, Determination of emulsion stability of an emulsifiable concentrate, Application technology : Sprayers.

Suggested Readings

Gupta A. 2006. *Pesticide Residue in Food Commodities.* Agrobios (India).

Handa SK, Agnihotri NP & Kulshrestha G. 2000. *Pesticide Residue Analysis, Significance, Management and Analysis.* Vedams eBooks.

Moye HA. 1981. *Analysis of Pesticide Residues*. John Wiley.

AC 601 AGROCHEMICAL FORMULATION 3+1

Objective

To teach general aspects along with latest developments of formulations, chemistry, classification and properties of formulants, machinery and equipment involved in packaging and labeling and cioefficacy of formulations.

Theory

UNIT I

General aspects - definition, objectives, process, product spectrum, classification, formulation codes etc. Solid and liquid formulations including the latest developments - preparation, properties, specifications, use situations etc.

UNIT II

Formulants - carriers/ diluents, surfactants, synergists, safeners, encapsulants, antioxidants, stabilizers etc. highlighting chemistry, classification, properties, uses etc., formulant-toxicant interactions, pesticide mixtures.

UNIT III

Machinery and equipment, packaging and labelling. Packaging- standards, requirement, materials, disposal, decontamination etc. Labeling - content, specifications, needs for low literacy regions, etc.

UNIT IV

Application - principles, distribution and coverage, recent developments. Brief coverage of machinery and equipment. Precautions in use of pesticides.

UNIT V

Bio-efficacy - basic considerations and applied aspects, physico-chemical basis pesticide antidotes.

Practical

Identification of Organochlorine insecticides in water by TLC, Identification of Carbamate insecticides in water by TLC, Estimation of carbamate insecticide residues in vegetable by visible spectroscopic

method, Estimation of Organophosphorus insecticide residues in soil by visible spectroscopic method.

Suggested Readings

Parmar BS & Tomar SS. 2004. *Pesticide Formulation -Theory and Practice*. CBS Publ.

Wade Van Valkenburg, Sugavanam B & Khetan SK.1998. *Pesticide Formulation*. New Age International.

AC 602 CHEMISTRY OF BIOPESTICIDES 2+1

Objective

To teach chemistry of conventional biopesticides, semiochemicals and allelochemicals, phytoalexins, pesticides of microbial origin and application of biotechnology in pest management.

Theory

UNIT I

Conventional natural insect control agents such as pyrethrins, rotenones, nicotine, ryanodine, isobutylamides, drimane sesquiterpenoids, withanolides, clerodanes, quassinoids and limonoids - sources, isolation, characterization, synthesis, application and mode of action.

UNIT II

Insect behaviour modifying chemicals (Semiochemicals) – pheromones (sex, alarm, trail, territorial, aggregation, etc.). Allelochemicals – allomones, kairomones, synomones, apneumones. Insect hormones – JH, Anti – JH, JH-mimics, feeding deterrents and repellents – both natural and synthetic: Sources, chemistry, mode of action wtc.

UNIT III

Phytoalexins, stress metabolites: Sources such as Leguminosae, Solanaceae etc. Acetylene and polyacetylene phytoalexins. Chemistry, use and mode of action natural fungicides, nematicides including photo-activated pesticides like α-terthieyl.

UNIT IV

Pesticides of microbial origin : Sources, chemistry and mode of action of tetranactin, avermectins, milbimycins and spinosad. Herbicides like biolaphos and phosphonothricin. Phytotoxins like Alternaria alternata toxin, tentoxin, cornexistin, hydantoxidin. Other microbials such as NPV based insecticides.

UNIT V

Allelochemicals and chemical ecology. Application of biotechnology in pest management (ex. *Bt*).

Practical

Extraction by hydrodistillation, isolation of pure compounds, their characterization, Extraction of tobacco leaves, isolation of nicotine and its identification, Extraction of neem seed kernels, enrichment of azadirachtin, analysis of azadirachtin and its analysis.

Suggested Readings

Alexander M. 1999. *Biodegradation and Bioremediation*. 2nd Ed. Academic Press.

Copping LG. 1996. *Crop Protection Agents from Nature: Natural Products and Analogues*. Royal Soc. Chem., London.

Dev S & Koul O. 1997. *Insecticides of Natural Origin*. Harwood Acad. Publ.
Godfrey CRA. 1995. *Agrochemicals from Natural Products*. Marcel Dekker.
Hall JC, Hoagland RE & Zablotowicz RM. 2001. *Pesticide Biotransformation in Plants and Microorganisms: Similarities and Divergences.* ACS Symposium Series 777. Washington, DC.
Hassal KA. 1990. *The Biochemistry.* Plenum.
Jacobson M. 1965. *Insect Sex Attractants*. Wiley.
Jacobson M. 1970. *Naturally Occurring Insecticides*. Wiley
Khan SU. 1980. *Pesticides in the Soil Environment*. Elsevier.
Leahey JP. 1985. *The Pyrethroid Insecticides*. Taylor & Francis.
Matsumura F. 1975. *Toxicology of Insecticides.* Plenum Press.
Menzie CM. 1980. *Metabolism of Pesticides.* Update III US Fish and Wildlife Service Special Scientific Report.
Parmar BS & Devakumar C. 1990. In: *Botanical and Biopesticides*. Westvill Publ. House.
Racke KD, Skidmore MW, Hamilton DJ, Unsworth JB, Miyamoto J & Cohen SZ. 1997. *Pesticide Fate in Tropical Soils*. Pure and Appl. Chem. 69 (6): 1349-1371.

AC 603 ADVANCED ORGANIC CHEMISTRY 2+1

Objective

To teach stereochemistry, mechanisms of stereospecific and streoselective reactions, reagents in organic synthesis, elucidation of structure of organic compounds.

Theory

UNIT I

Stereochemistry: Chiral synthesis, Walden inversion, optical resolution, racemic modification. Stereospecific and stereoselective reactions. Nucleophilic substitution reactions, SN_2 with inversion, SN_1 with partial inversion. Reactions involving carbonions and free radicals. The SNi mechanism.

UNIT II

Stereochemistry of eliminations (syn elimination vs. anti-elimination, orientation in elimination reaction, molecular rearrangement, decarboxylation reactions etc.). Stereo-chemistry of addition reactions of alkenes and alkynes. Electrophilic addition of bromine. Formation and reactions of epoxides, epoxide opening, orientational preferences etc.). Addition of carbons to alkenes, hydrogenation, hydroboration Oppenaeur oxidation.

UNIT III

Reagents in organic synthesis: complex metal hydrides, Gilman's reagent, lithium dimethyl curparate, lithiumdiso-propyl amide (LDA), dicyclohexylcarbodimide, 1,3-di-thiane, trimethyl selyl iodide, triselenium dioxide, tri-butyl tin hydride, osmium testeraoxide, Dichloro dicyano quinone etc. Phase transfer catalysis, crown ethers and merrifield resins. Organometallic reagents in organic synthesis.

UNIT IV

Protective group in synthesis of organic compounds. Photochemistry, pericyclic reactions, sigma tropic rearrangements.

UNIT V

Application of UV, IR, NMR and mass spectroscopy in structural elucidation of organic compounds.

Practical

Friedal craft reaction (Alkylation/Acylation), Aldol/Claisen Schmidt reaction, Pechmann condensation/Perkin reaction, Methylation, acetylation, elimination, Oxidation, reduction, hydrolysis, Acid chlorides, amides, esters, Characterisation of Organic compounds (NMR and IR spectroscopy)

Suggested Readings

Ahluwalia VK & Aggarwal R. *Comprehensive Practical Organic Chemistry - Preparation and Quantitative Analysis*. Universities Press.

Corey FA & Sundberg RJ 1983. *Advanced Organic Chemistry*. Subseries: Part A. *Structure & Mechanism*. Part B. *Reaction and Synthesis*. 2nd Ed. Plenum.

Eliel EL & 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.

Hendrickson JB, Cram DJ & Hammond GS. 1970. *Organic Chemistry.* 3rd Ed. McGraw Hill.

Jeny M. 1992. *Advanced Organic Chemistry. Reactions, Mechanisms and Structure*. 4th Ed. John Wiley & Sons.

Kalsi PS. 1996. *Stereochemistry and Mechanism through Solved Problems.* 2nd Ed. New Age International Publ.

Morrison RT & Boyd RN. 1992. *Organic Chemistry*. 6th Ed. Prentice Hall.

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.

AC 604 XENOBIOTIC MOVEMENT, TRANSFORMATION AND METABOLISM 2+1

Objective

To acquaint students with fate of pesticides in environment-their movement in plants and food chain, persistence, transformation and other metabolic fates

Theory

UNIT I

Movement and fate of pesticides in the environment : Drift, volatilization, adsorption, desorption, leaching, runoff etc. Soil pesticide interactions. Movement in plant, animal and other living systems: Penetration, translocation, excretion etc. (Highlight the role of physico-chemical parameters).

UNIT II

Persistence – factors affecting (physical, chemical, biochemical etc.), primary and secondary metabolites in plants and animals with examples. Biotic and abiotic transformations. Bio-chemical transformations in living systems.

UNIT III

Photochemical transformation of pesticides: Introduction to photochemistry, direct and indirect photolysis, photosensitizers, quenchers, light filters. Quantum yield. Phototransformation products and their significance. Other abiotic factors transforming xenobiotics.

UNIT IV

Chemical transformation of xenobiotics – effect of pH, eH, moisture, environmental gases etc.

UNIT V

Food chain in environment – significance and implications.

Practical

Preparation of metabolites, Photodegradatin of pesticides, Leaching of pesticides, Biological degrdation in soil.

Suggested Readings

Alexander M. 1999. *Biodegradation and Bioremediation*. 2nd Ed. Academic Press.

Hall JC, Hoagland RE & Zablotowicz RM. 2001. *Pesticide Biotransformation in Plants and Microorganisms: Similarities and Divergences.* ACS Symposium Series 777. Washington, DC.

Hassal KA. 1990. *The Biochemistry.* Plenum.

Hassal KA. 1990. *The Biochemistry.* Plenum.

Khan SU. 1980. *Pesticides in the Soil Environment*. Elsevier.

Khan SU. 1980. *Pesticides in the Soil Environment*. Elsevier.

Matsumura F. 1975. *Toxicology of Insecticides.* Plenum Press.

Menzie CM. 1980. *Metabolism of Pesticides.* Update III US Fish and Wildlife Service Special Scientific Report.

Racke KD, Skidmore MW, Hamilton DJ, Unsworth JB, Miyamoto J & Cohen SZ. 1997. *Pesticide Fate in Tropical Soils*. Pure and Appl. Chem. 69 (6): 1349-1371.

AC 605 SPECIAL TOPICS IN AGRO CHEMICALS 1+0

Objective

To develop proficiency of the student in his/her area of specialization

Theory

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.

Suggested Readings

Selected topics from review books and journals.

AGRICULTURAL CHEMICALS

List of Journals

- Croplife
- Environmental Toxicology and Chemistry
- Integrated Pest Management Reviews
- International Journal of Pest Management
- International Journal of Pesticide Reform
- Journal of AOAC
- Pesticide Biochemistry and Physiology
- Pesticide Data Program Annual Summary Proceedings of the ... Wisconsin Fertilizer, Aglime and Pest Management Conference
- Weed Research
- Weed Science
- Weed Technology
- Pest management Sci
- Pesticide sci Japan
- Bull Chem toxicol
- Environmental Science and Technology
- Biodegradation
- J. Environ. Science and health
- Chemosphere
- Journal of Agriculture and food chemistry
- Environmental Science & Technology

e-Resources

- http://www.aic.ca/
- http://www.ars.usda.gov/
- http://www.aaea.org/
- http://www.aaas.org/
- http://www.scisoc.org/aacc/
- http://www.adsa.uiuc.edu/
- http://www.leatherchemists.org/
- http://www.meatscience.org/
- http://www.asae.org/
- http://www.agronomy.org/default.html
- http://www.biomass.org/
- http://www.nal.usda.gov/bic/
- http://www.cabi.org/
- http://www.csae-scgr.ca/
- http://www.cgiar.org/
- http://www.crsadmhdq.org/
- http://www.cast-science.org/
- http://www.crops.org/

- http://www.ers.usda.gov/
- http://www.faseb.org/
- http://www.ift.org/
- http://www.ishs.org/
- http://www4.nationalacademies.org/banr/ba.nsf
- http://www.nalusda.gov/
- http://www.usda.gov/nass/
- http://www.nas.edu/nrc/
- http://weedeco.msu.montana.edu/aero/home.htm
- http://www.attra.org/index.html
- http://csanr.wsu.edu/
- http://www.csa-efc.org/
- http://www.caff.org/
- http://www.thefoodalliance.org/
- http://www.hawiaa.org/
- http://www.mtn.org/iasa/
- http://www.ams.usda.gov/science/pdp/download.htm#reports

Suggested Broad Topics for Master's and Doctoral Research

1. Development of agrochemicals
   i. Synthesis and bioactivity of a series of compounds
   ii Isolation of chemical consituents from plants and their bioactivity
   iii. Isolation of secondary metabolites from biocontrol agents such as microbes and fungi

2. Development of formulation
   .i. Development of new formulations
   Ii Pesticide auxillary interaction

3. Risk assessment
   i. Persistence of various pesticides
   ii. Environment fate of pesticides
   iii. Abiotic and biotic transformations of pesticides
   iv. Adsorption and desorption of pesticides in soil
   v. Leaching behaviour of pesticides in various soils
   vi. Decontamination of pesticides by various methods

BIOCHEMISTRY

Course Structure –at a Glance

CODE	COURSE TITLE	CREDITS
BIOCHEM 501*^	BASIC BIOCHEMISTRY	3+1
BIOCHEM 502*	INTERMEDIARY METABOLISM	3+0
BIOCHEM 503*	ENZYMOLOGY	2+1
BIOCHEM 504	MOLECULAR BIOLOGY	2+1
BIOCHEM 505*	BIOCHEMICAL TECHNIQUES	1+2
BIOCHEM 506	IMMUNO CHEMISTRY	2+1
BIOCHEM 507	PLANT BIOCHEMISTRY	3+0
BIOCHEM 508	ANIMAL BIOCHEMISTRY	3+0
BIOCHEM 509	FOOD AND NUTRITIONAL BIOCHEMISTRY	2+1
BIOCHEM 510	CARBON AND NITROGEN METABOLISM	2+1
BIOCHEM 591	MASTER'S SEMINAR	1+0
BIOCHEM 599	MASTER'S RESEARCH	20
BIOCHEM 601**	ADVANCED ENZYMOLOGY	2+0
BIOCHEM 602**	ADVANCED MOLECULAR BIOLOGY	3+0
BIOCHEM 603	BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESS	3+0
BIOCHEM 604**	CURRENT TOPICS IN BIOCHEMISTRY	1+0
BIOCHEM 605	FUNCTIONAL GENOMICS AND METABOLOMICS	3+0
BIOCHEM 606	BIOMEMBRANES	2+0
BIOCHEM 607**	ADVANCED TECHNIQUES IN BIOCHEMISTRY	0+2
BIOCHEM 691	DOCTORAL SEMINAR I	1+0
BIOCHEM 692	DOCTORAL SEMINAR II	1+0
BIOCHEM 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; ** Compulsory for Doctoral programme
^ Open for PG students of other discipline

BIOCHEMISTY
Course Contents

BIOCHEM 501 BASIC BIOCHEMISTRY 3+1

Objective

To provide elementary knowledge/overview of structure and functions and metabolism of biomolecules.

Theory

UNIT I

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II

Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids.

UNIT III

Structure and biological functions of vitamins, enzymes classification and mechanism of action; regulation, factors affecting enzyme action. Hormones animal plants and insects, Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

UNIT IV

Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology

Practical

Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids,Estimation of Proteins by Lowry's method,
Estimation of DNA and RNA by diphenylamine and orcinol methods
Estimation of Ascorbic acid, Separation of biomolecules by TLC and Paper chromatography.

Suggested Readings

Conn EE & Stumpf PK. 1987. *Outlines of Biochemistry*. John Wiley.
Metzler DE. 2006. *Biochemistry*. Vols. I, II. Wiley International.
Nelson DL & Cox MM. 2004. *Lehninger Principles of Biochemistry*. 4th Ed. MacMillan.
Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

BIOCHEM 502 INTERMEDIARY METABOLISM 3+0

Objective

To teach metabolic pathways, their regulation and engineering, and methods used in their elucidation.

Theory

UNIT I

The living cell a unique chemical system, Introduction to metabolism, methods of studying metabolism, transport mechanism, bioenergetics, biological oxidation, signal transduction.

UNIT II

Catabolic and anabolic pathways of carbohydrates, lipids, regulation and their metabolic disorders. Energy transduction and oxidative phosphorylation.

UNIT III

General reactions of amino acid metabolism, Degradative and biosynthetic pathways of amino acids and their metabolic disorders. Sulphur metabolism, Metabolic engineering concepts.

UNIT IV

Compartmentation of metabolic pathways, metabolic profiles of major organs and regulation of metabolic pathways.

Suggested Readings

Berg JM, Tymoczko JL, Stryer L & Clarke ND 2000. *Biochemistry*. 5th Ed. WH Freeman & Co.

Metzler DE. 2006. *Biochemistry*. Vols. I, II. John Wiley.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

Zubey GL. 1998. Biochemistry. 4th Ed. WCB London.

BIOCHEM 503 ENZYMOLOGY 2+1

Objective

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

Theory

UNIT I

Introduction and historic perspective, Enzyme nomenclature and classification, enzyme compartmentalization in cell organelles, isolation and purification of enzymes, measurement of enzyme activity. ribozymes, isozymes, abzymes,

UNIT II

Enzyme structure, enzyme specificity, active site, active site mapping, mechanism of enzyme catalysis. cofactors, coenzymes- their structure and role.

UNIT III

Enzyme kinetics, enzyme inhibition and activation, multienzyme complexes, allosteric enzymes and their kinetics, regulation of enzyme activity.

UNIT IV

Isolation and purification of enzymes, Applications of enzymes in chemical and food industry, enzyme immobilization, biosensors and clinical applications of enzymes.

Practical

Enzyme assay by taking any model enzyme like alpha-amylase or acid phosphatase,isolation and purification of any model enzyme like alpha-amylase or acid phosphatase,study of the effect of enzyme and substrate concentrations and determination of Km and Vmax,determination of pH

and temperature optima and effect of various inhibitors,determination of the pH and temperature stability of enzyme.

Suggested Readings

Bergmeyer HU. 1983. *Methods of Enzymatic Analysis*. Vol. II. Verlag Chemie, Academic Press.

Dixon M, Webb EC, Thorne CJR & Tipton KF. 1979. *Enzyme*s. 3rd Ed. Longman.

Maragoni AG. 2003. *Enzyme Kinetics - A Modern Approach*. John Wiley.

Palmer T. 2001. *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. 5th Ed. Horwood Publ.

Price NC & Stevens L. 2003. *Fundamentals of Enzymology*. Oxford Univ. Press.

Wilson K & Walker J. (Eds.). 2000. *Principles and Techniques of Practical Biochemistry*. 5th Ed. Cambridge Univ. Press.

BIOCHEM 504 MOLECULAR BIOLOGY 2+1

Objective

To provide knowledge regarding genes, their functions, expression, regulation and transfer in heterologous systems.

Theory

UNIT I

Historical development of molecular biology, nucleic acids as genetic material, chemistry and structure of DNA and RNA, Genome organization in prokaryotes and eukaryotes, chromatin structure and function.

UNIT II

DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, repetitive and non-repetitive DNA, satellite DNA; transcription process, RNA editing, RNA processing.

UNIT III

Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyl tRNA synthases' inhibitors of replication, transcription and translation; translation and Post translational modification; nucleases and restriction enzymes, regulation of gene expression in prokaryotes and eukaryotes, molecular mechanism of mutation.

UNIT IV

DNA sequencing, recombinant DNA technology, vectors, isolation of genes, recombinants vector, selection of recombinants, PCR; general features of replication, transcription, site directed mutagenesis and translation in eukaryotes.

Practical

Isolation and purification of DNA and RNA from different sources, check of purity of isolated DNA and RNA, restriction fragmentation and separation of oligos by agarose electrophoresis,RAPD analysis of DNA, cDNA synthesis using PCR, Southern and Northern blotting experiments

Suggested Readings

Adams RLP, Knowler JT & Leader DP. 1992. *The Biochemistry of the Nucleic Acids*. 11th Ed. Chapman & Hall.

Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD 2006. *Molecular Biology of the Cell*. 6th Ed. Garland Publ.

Blackburn GM & Gait MJ. 1996. *Nucleic Acids in Chemistry and Biology.* 2nd Ed. Oxford University Press.

Freifelder D & Malacinski GM. 1996. *Essentials of Molecular Biology*. 3rd Ed. Panima.

Glick BR & Pasternak JJ. 1994. *Molecular Biology: Principles and Applications of Recombinant DNA Technology*. ASM Press.

Lewin B. 2007. *Genes* IX. Oxford University Press.

Lodish H, Berk A, Zipursky SA, Matsudaira P, Baltimore D & Darnell J. 1999. *Molecular Cell Biology*. WH Freeman.

Old RW & Primrose SB. 1989. *Principles of Gene Manipulation*: *An Introduction to Genetic Engineering*. 4th Ed. Blackwell Scientific Publ.

Sambrook J & Russel DW. 2001. *Molecular Cloning: A Laboratory Manual*. Vols. I-III. Cold Spring Harbor.

BIOCHEM 505 TECHNIQUES IN BIOCHEMISTRY 1+2

Objective

To impart practical knowledge about various techniques used in purification and characterization and estimation of cellular constituents.

Theory

UNIT I

Chromatographic and electrophoretic methods of separation, Principles and applications of Paper, Thin layer & HPTLC, Gas, Gas-liquid, Liquid chromatography, HPLC and FPLC; Paper and gel electrophoresis, Different variants of polyacrylamide gel electrophoresis (PAGE) like native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

UNIT II

Spectrophotometry: Principles and applications UV-Visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

UNIT III

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

UNIT IV

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, principles and applications of phosphor imager.

Practical

Determination of absorption maxima of some important chemicals from their absorption spectra, estimation of biomolecule using spectrophotometer, Separation of carbohydrates and amino acids by paper chromatography, Separation of lipids by thin layer and column chromatography, Separation of proteins by ion exchange and gel filtration chromatography, Electrophoretic techniques to separate proteins and nucleic acids ,Centrifugation- Cell fractionation, Application of GLC,

HPLC, FPLC in separation of biomolecules,Use of radioisotopes in metabolic studies.

Suggested Readings

Clark JM. 1977. *Experimental Biochemistry*. 2nd Ed. WH Freeman.

Sawhney SK & Singh R. 2000. *Introductory Practical Biochemistry*. 2nd Ed. Narosa.

Willard M, Merritt LL & Dean JA.1981. *Instrumental Methods of Analysis*. 4th Ed. Van Nostrand.

William BL & Wilson K. 1975. *Principles and Techniques of Practical Biochemistry*. Edward Arnold.

Wilson K, Walker J & Walker JM. 2005. *Principles and Techniques of Practical Biochemistry.* Cambridge Univ. Press.

BIOCHEM 506 IMMUNOCHEMISTRY 2+1

Objective

To give an insight into the biochemical basis of immunity.

Theory

UNIT I

History and scope of immunology, antigens, adjuvants, immune system, organs, tissues and cells, immunoglobulins, molecular organization of Immunoglobulin.

UNIT II

Classes of antibodies, Antibody diversity, theories of generation of antibody diversity, Vaccine, Monoclonal antibodies, polyclonal antibodies, Hybridoma, Recombinant antibodies, complement system- classical and alternate.

UNIT III

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

UNIT IV

Immunoregulation, immunological tolerance, hypersensitivity, mechanisms of immunity, innate resistance and specific immunity. Current immunological techniques-ELISA, RIA

Practical

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, agglutination, direct and indirect haemagglutination, Immunoelectrophoresis, Complement fixation, Quantitation of immunoglobulins by zinc sulphate turbidity and single radial immunodiffusion.

Suggested Readings

Abbas AK & Lichtman AH. 2003. *Cellular and Molecular Immunology.* 5th Ed. WB Saunders.

Goldsby RA, Kindt TJ & Osborne BA. 2003. *Immunology*. 4th Ed. WH Freeman.

Harlow & Lane D. (Eds.) 1988. *Antibodies: A Laboratory Manual*. Cold Spring Harbor Laboratory.
Kuby J. 1996. *Immunology*. 3rd Ed. WH Freeman.
Male D, Brostoff J, Roth DB & Roitt I. 2006. *Immunology*. 7th Ed. Elsevier.

BIOCHEM 507 PLANT BIOCHEMISTRY 3+0

Objective

Detailed information about biochemical and molecular basis of various plant processes and plant growth regulatory substances.

Theory

UNIT I

Scope and importance of biochemistry in Agriculture, Plant cell organelles and their separation, structure and function of cell organelle. Photosynthetic pigments in relation to their functions, photosynthesis, C_3, C_4 and CAM pathways, photorespiration.

UNIT II

Sucrose-starch interconversion, biosynthesis of structural carbohydrates, storage proteins and lipids. Biochemistry of nitrogen fixation and nitrate assimilation, sulphate reduction and incorporation of sulphur in to amino acids.

UNIT III

Biochemistry of seed germination and development, Biochemistry of fruit ripening, phytohormones and their mode of action, signal transduction.

UNIT IV

Biochemistry and significance of secondary metabolites-cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids, plant defense system.

Suggested Readings

Buchanan BB, Gruissem W & Jones RL. 2000. *Biochemistry and Molecular Biology of Plants*. 2nd Ed. John Wiley.
Dey PM & Harborne JB. 1997. *Plant Biochemistry*. Academic Press.
Goodwin TW & Mercer EI. 1983. *Introduction to Plant Biochemistry*. Pergamon Press.
Heldt HS. 1997. *Plant Biochemistry and Molecular Biology*. Oxford Univ. Press.
Lea PJ & Leegood RC. 1993. *Plant Biochemistry and Molecular Biology*. 2nd Ed. John Wiley.

BIOCHEM 508 ANIMAL BIOCHEMISTRY 3+0

Objective

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

Theory

UNIT I

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

UNIT II

Water, electrolyte and acid-base balance, biochemistry of respiration, structure, function and mechanism of major trace elements.

UNIT III

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

UNIT IV

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.

Suggested Readings

Devlin TM. 2006. *Text Book of Biochemistry with Clinical Correlations.* 6th Ed. John Wiley.

Goldsby RA, Kindt TJ, Kuby J & Osborne BA. 2003. *Immunology*. 4th Ed. WH Freeman. & Co.

Harper H. A. 2000. *Physiological Chemistry*. MacMillan.

Buchanan BB, Gruissem W & Jones RL. 2000. *Biochemistry and Molecular Biology of Plants*. 2nd Ed. John Wiley.

BIOCHEM 509 FOOD AND NUTRITIONAL BIOCHEMISTRY 2+1

Objective

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

Theory

UNIT I

Fundamentals of humam 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.).

UNIT II

Biochemical and nutritional aspects of vitamins, minerals Nutraceuticals, antinutritional factors, biochemistry of post harvest storage.

UNIT III

Effect of cooking, processing and preservation of different food products on nutrients, biochemical aspects of food spoilage, role of lipase and lipoxygenase, oxidative rancidity and antioxidants.

UNIT IV

Enzymes in food industry, food additives (coloring agents, preservatives etc.), biogenesis of food flavours and aroma, nutritional quality of plant, dairy, poultry and marine products.

Practical

Estimation of starch, lipid/oil, phenols in plant tissue/sample, Estimation of carotenoids, Estimation of Trypsin and chymotrypsin inhibitor activities in

seeds, Estimation of Vitamin C in fruits,Reducing & non reducing sugar in fruits, Estimation of protein contents, Estimation of dietary fibre, Determination of limiting amino acids, Estimation of Phytate/Oxalate.

Suggested Readings

Alais C & Lindel G. 1995. *Food Biochemistry*. Amazon Springer.

DeMan JM. 1999. *Principles of Food Chemistry*. 3rd Ed. Springer.

Fennema OR. 1996. *Food Chemistry*. 3rd Ed. CRC Press.

Hulme AC. (Ed.). 1970. *Biochemistry of Fruits and Vegetables and their Products*. Vols. I, II. Academic Press.

Ranganna S. (Ed.). 1986. *Handbook of Analysis and Quality for Fruits and Vegetable Products*. Tata McGraw Hill.

Robinson DS. 1987. *Food Biochemistry and Nutritional Value*. Longman.

BIOCHEM 510 CARBON AND NITROGEN METABOLISM 2+1

Objective

To impart knowledge of general carbon and nitrogen metabolism in plants with special reference to starch and cell wall polysaccharides and biological nitrogen fixation and assimilatory pathways.

Theory

UNIT I

Carbon metabolism: Synthesis of sucrose, Regulation of sucrose phosphate synthesis, Transport of sucrose, phloem loading and unloading, synthesis of starch in leaves and seeds, concept of transitory starch.

UNIT II

Synthesis of fructose, galactomannans raffinose series oligosaccharides and trehalose.

UNIT III

Nitrogen cycle- Biochemistry of nitrate assimilation and its regulation, GS/GOGAT and GDH pathway, ureides and amides as nitrogen transport compounds, chemoautotrophy in denitrifying bacteria.

UNIT IV

Biological nitrogen fixation; structure function and regulation of nitrogenase; nif genes and their regulation; biochemical basis of legume-Rhizobium symbiosis, genes involved in synthesis.

Practical

Estimation of nitrite content, Estimation of protein by Lowry's method, Estimation of starch, Estimation of nitrate content by hydrazine sulphate reduction method, i*n 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.

Suggested Readings

Beevers L. 1979. *Nitrogen Metabolism in Plants*. Gulab Vazirani for Arnold-Heinermann.

Bergersen FJ. (Ed.). 1980. *Methods for Evaluating Biological Nitrogen Fixation.* John Wiley & Sons.

Bray CM. 1983. *Nitrogen Metabolism in Plants*. Longman.
Buchanan BB, Gruissem W & James RL. (Eds.). 2000. *Biochemistry and Molecular Biology of Plants.* American Society of Plant Physiologists.
Mehta SL, Lodha ML & Sane PV. (Eds.). 1993. *Recent Advances in Plant Biochemistry*. ICAR.

BIOCHEM 601 ADVANCED ENZYMOLOGY 2+0

Objective

To provide advanced knowledge about the structure, mechanism, kinetics and regulation of enzymes and their use as biosensors.

Theory

UNIT I

Theory of enzymatic catalysis, specificity, concept of active site and enzyme substrate complex, active site mapping, acid-base and covalent catalysis, factors associated with catalytic efficiency, proximity and orientation, distortion and strain, induced fit hypothesis, Mechanism of enzyme reactions.

UNIT II

Effect of different factors affecting enzyme activity, transition state theory, Arrhenius equation, Determination of energy of activation, kinetics of pH and temperature and determination of pKa and ΔH of active site amino acids.

UNIT III

Kinetics of bisubstrate reactions, mechanism determination by radioisotope exchange, kinetics of mixed inhibitions, substrate and product inhibition.

UNIT IV

Role of enzymes in regulation of metabolism, allosteric enzymes and their kinetics, enzyme engineering, Bifunctional enzymes, enzyme engineering,

Suggested Readings

Dixon M & Web EC. 1979. *Enzymes*. 3rd Ed. Longmans Green.
Seigel IH. 1975. *Enzyme Kinetics.* John Wiley.
Selected reviews and articles from journals.

BIOCHEM 602 ADVANCED MOLECULAR BIOLOGY 3+0

Objective

To impart latest information on the molecular biochemistry of isolation, transfer and expression of genes in plants and biochemical approaches employed in gene therapy.

Theory

UNIT I

Organization of prokaryotic genome, nuclear and organelle genes, concept of genome mapping, molecular evolution, cell development and differentiation.

UNIT II

Prokaryotic and eukaryotic gene regulation, RNA editing, molecular biology of viruses.

UNIT III

Methods of gene isolation and transfer in plants and animals, molecular basis of male sterility, Application of genetic engineering in different fields.

UNIT IV

Site directed mutagenesis, gene targeting and gene therapy, bioethics and biosafety guidelines and IPR in recombinant DNA research.

Suggested Readings

Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD. 2006. *Molecular Biology of the Cell*. 6th Ed. Garland Publ.

Lewin B. 2007. *Gene IX*. 9th Ed. Pearson Publ.

Selected articles from journals.

BIOCHEM 603 BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES 3+0

Objective

To impart latest development about biochemistry of biotic and abiotic stresses in plants.

Theory

UNIT I

Plant-pathogen interaction and disease development; molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

UNIT II

Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance.

UNIT III

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

UNIT IV

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 V

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

Suggested Readings

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.

BIOCHEM 604 CURRENT TOPICS IN BIOCHEMISTRY 1+0

Objective

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.

Theory

UNIT I

Advanced topics related to Nutrition and metabolism.

UNIT II

Advanced topics related to enzymology and industrial biochemistry.

UNIT III

Advanced topics related to molecular biochemistry and immunology.

UNIT IV

Advanced topics related to metabolic engineering and bioprospecting.

Suggested Readings

Selected articles from journals.

BIOCHEM 605 GENOMICS, PROTEOMICS AND METABOLOMICS 3+0

Objective

To impart knowledge in the upcoming areas of biochemistry. and to acquaint the students with the recent developments of job opportunities in pharmaceutical and other industries.

Theory

UNIT I

Protein and nucleic acid sequencing: Various methods of sequencing including automated sequencing and microarrays, whole genome sequence analysis.

UNIT II

Comparative genomics, functional genomics, transcriptomics, gene identification, gene annotation, pairwise and multiple alignments, application of genomics, Quantitative PCR, SAGE, MPSS, microarray.

UNIT III

Proteome technology- 2D-PAGE, MSMS, MALDI-TOF, protein microarray, comparative proteomics and structural proteomics.

UNIT IV

Metabolic pathway engineering, vitamin A engineering in cereals, micro-array analysis, role of bioinformatics in functional genomics.

Suggested Readings

Baxevanis AD & Ouellette BFF. 2004. *Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins.* 3rd Ed. Wiley InterScience.

Dale JW & Schantz MV. 2002. *From Genes to Genomes*. John Wiley.

Lieber DC. 2002. *Introduction to Proteomics - Tools for the New Biology.* Humana Press.

Suhai S. 2002. *Genomics and Proteomics - Functional and Computational Aspects*. Kluwer.

BIOCHEM 606 BIOMEMBRANES 2+0

Objective

To teach structure and functions of biomembranes, structure-function relationships, membrane biogenesis.

Theory

UNIT I

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

UNIT II

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

UNIT III

Various membrane movements; transport across membrane and energy transduction.

UNIT IV

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

Suggested Readings

Lodish H, Berk A, Zipursky SA, Matsudaira P, Baltimore D & Darnel J. 1999. *Molecular Cell Biology*. WH Freeman.

Nelson DL & Cox MM. 2000. *Lehninger Principles of Biochemistry.* 3rd Ed. Printed in India by Replika Press Pvt. Ltd., New Delhi for Worth Publ., New York.

Smallwood M, Knox JP & Bowls BJ. 1996. *Membranes: Specialized Functions in Plants*. Bros. Scientific Publ.

BIOCHEM 607 ADVANCED TECHNIQUES IN BIOCHEMISTRY 0+2

Objective

To impart students a hands on training of techniques of biochemistry and molecular biology.

Theory

UNIT I

Isolation and purification of protein from microbial/plant/animal source. Electrophoretic separation of protein. Determination of molecular weight of protein using PAGE/ gel filtration method.

UNIT II

Experiments on DNA: Isolation, agarose gel electrophoresis and restriction analysis of DNA.

UNIT III

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

UNIT IV

Isolation and purification of enzymes, isozymic analysis and enzyme immobilization

Suggested Readings

Kolowick NP & Kaplan NP. *Methods in Enzymology*. Academic Press (Series).

Plummer DT. 1998. *An Introduction to Practical Biochemistry*. 3rd Ed. Tata McGraw Hill.

Rickwood D. (Ed.). 1984. *Practical Approaches in Biochemistry*. 2nd Ed. IRL Press, Washington DC.

Wilson K & Goulding KH. 1992. *A Biologist's Guide to Principles and Techniques of Practical Biochemistry*. 3rd Ed. Cambridge Univ. Press.

Wilson K & Walker J. 2000. *Principles and Techniques of Practical Biochemistry.* 5th Ed. Cambridge Univ. Press.

BIOCHEMISTRY

List of 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
- Biochim. Biophysic Acta
- Cell
- Current Science
- Federation of European Biochemical Society
- Indian Journal of Experimental Biology
- Journal of Biological Chemistry
- Journal of Immunology
- Journal of Molecular Modeling
- 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

e-Resources

- www.unixl.com/dir/molecular_sciences/biochemistry/biochemistry_jobs/
- www.unixl.com/dir/medical_sciences/
- http://www.ncbi.nlm.nih.gov/
- http://us.expasy.org
- http://us.expasy.org/spdbv/
- http://www.brenda.uni-koeln.de/
- http://www.worthington-biochem.com
- http://www.cefotaxime.net
- http://home.123india.com/nbsc/
- http://www.biochemist.org
- http://www.gwu.edu/~mpb

Suggested Broad Topics for Master's and Doctoral Research

- Immobilization of industrially important enzymes
- Manipulation of metabolic pathways for reserve biosynthesis and utilization.
- Biochemistry and molecular biology of biotic and abiotic stresses in plants.
- Biochemistry of fruits and vegetables during ripening and post ripening.
- Manipulation of metabolic pathways at molecular level to increase shelf life of fruits and to increase contents of alkaloids, flavones and isoflavones, PUFA etc.
- Use of molecular markers for identification and improvement of crop plants.
- Enzyme engineering and functional genomics/proteomics.
- Biochemical and molecular evaluation of varieties for quality improvement.
- Use of biomolecules as biosensors.
- Study of metabolome and elucidation of metabolic pathway of secondary metabolites.

CHEMISTRY
Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
CHEM 501	QUANTUM CHEMISTRY-STATISTICAL MECHANICS	3+0
CHEM 502*	THERMODYNAMICS	2+0
CHEM 503*	CHEMICAL KINETICS AND SURFACE CHEMISTRY	2+0
CHEM 504	SPECTROSCOPY	2+1
CHEM 505	EXPERIMENTS IN PHYSICAL CHEMISTRY	0+2
CHEM 506	GENERAL PHYSICAL AND COLLOIDAL CHEMISTRY	3+0
CHEM 507	CHEMISTRY OF POLYMERS	3+0
CHEM 508*	BASIC CONCEPTS OF INORGANIC CHEMISTRY	2+0
CHEM 509	CHEMISTRY OF TRANSITION METALS	2+1
CHEM 510*	COORDINATE CHEMISTRY REACTION MECHANISM & INORGANIC POLYMERS	2+1
CHEM 511	NUCLEAR CHEMISTRY	3+0
CHEM 512*	PHYSICAL ORGANIC CHEMISTRY	2+0
CHEM 513	REACTION, REAGENTS AND PHOTOCHEMISTRY	3+0
CHEM 514*	NATURAL PRODUCT CHEMISTRY	2+0
CHEM 515	DRUGS AND DYES	3+0
CHEM 516	BIOORGANIC CHEMISTRY	3+0
CHEM 517	SYNTHESIS AND CHARACTERIZATION OF ORGANIC COMPOUNDS	0+2
CHEM 518	CHEMISTRY OF PESTICIDES	2+1
CHEM 591	MASTER'S SEMINAR	1+0
CHEM 599	MASTER'S RESEARCH	20
CHEM 601**	TOPICS OF CURRENT INTEREST	3+0
CHEM 602**	ADVANCED PHYSICAL CHEMISTRY	3+0
OR		
CHEM 603**	ORGANO-METALLIC CHEMISTRY	3+0
CHEM 604**	BIOINORGANIC CHEMISTRY	3+0
OR		
CHEM 605**	ORGANIC SYNTHESIS	3+0
CHEM 606**	SPECTROSCOPY INORGANIC CHEMISTRY	3+0
CHEM 607**	CONSTITUTION OF INORGANIC COMPOUNDS & DYNAMICS OF INORGANIC REACTION	3+0
CHEM 608**	GREEN CHEMISTRY	2+0
CHEM 691	DOCTORAL SEMINAR I	1+0
CHEM 692	DOCTORAL SEMINAR II	1+0
CHEM 699	DOCTORAL RESEARCH	45

***** Compulsory for M.Sc. programme; ** Compulsory for Ph.D. programme
(Students have to take at least 3 courses of 600 series)
The courses other than marked as * / ** can be taken by the students of other departments

CHEMISTRY
Course Contents

CHEM 501 QUANTUM CHEMISTRY-STATISTICAL MECHANICS 3+0

Objective

To acquaint the students regarding the basic concept of quantum chemistry, atomic spectra, Boltzmann distribution function and Bose-Einstein statistics.

Theory

UNIT I

Historiocal background and the postulates of quantum mechanics; mathematical consideration and solution of hydrogen.

UNIT II

Atomic structure approximate methods and atomic spectra.

UNIT III

Boltzmann distribution function; general relationships translational, rotational and vibrational motions, equilibrium constants.

UNIT IV

Application of partition functions.

UNIT V

Bose-Einstein statistics and Fermi-Dirac statistics, application to radiation and electron gas in metals.

Suggested Readings

Atkin PW. 1996. *Elements of Physical Chemistry.* Oxford Univ. Press.
Glasstone S. 1968. *A Text Book of Physical Chemistry*. MacMillan Press.

CHEM 502 THERMODYNAMICS 2+0

Objective

This Course will impart knowledge to students about the concepts of thermodynamics, involvement of heat in different chemical and biological processes.

Theory

UNIT I

Brief resume of the concepts of free energy, entropy and laws of thermodynamics, partial molar properties; thermodynamics of ideal and real gases and gas mixtures.

UNIT II

Thermodynamics of ideal and non-ideal binary solutions; activities and activity coefficients of electrolytes.

UNIT III

Derivation of phase rule and its application to multi-component systems; non-equilibrium thermodynamis entropy.production in irreverssible process. Phenomenological equations.

UNIT IV

Membrane permeability, membrane transport involving biochemical reactions, phenomonological equation in non-linear regions.

UNIT V

Thermodynamics of living systems, metabolic and biosynthetic reactions, ATP production during biochemical process of various types, applications of irreversible thermodynamics in biological processes.

Suggested Readings

Atkin. PW. 1996. *Elements of Physical Chemistry.* Oxford Univ. Press.

Glasstone S. 1968. A *Text Book of Physical Chemistry*. The MacMillan Press.

CHEM 503 CHEMICAL KINETICS AND SURFACE CHEMISTRY 2+0

Objective

By learning chemical kinetics and surface chemistry, students will be able to learn the kinetics and mechanism of different types of reactions, distribution law, phase rule and partial molar volume etc.

Theory

UNIT I

Theories of reaction rates, collisions theory, transition state theory, theory of unimolecular reactions-Lindemann`s mechanism; rate constants of fast reactions -relaxations, stop-flow and flash photolysis techniques.

UNIT II

Mechanism of free radical reactions, hydrogen-bromine reaction, photochemical decomposition, polymerisation, explosion, ionic reactions.

UNIT III

Complex reactions-electron transfer reactions, consecutive, opposing reactions; kinetics of catalytic reactions, acid base catalysis, effect of pH and salt effects.

UNIT IV

Enzyme, catalysis: adsorption-types of adsorption . Freundlich`s adsorption isotherm, Langmuirs adsorption isotherm and its limitations.

UNIT V

B.E.T adsorption isotherm; chemi sorption, kinetics of surface reaction and their mechanism.

Practical

Chemical kinetics-kinetics of catalytric reactions, Distribution law, Measurment of viscosity, Phase rule,Partial molal volume.

Suggested Readings

Atkin PW. 1996. *Elements of Physical Chemistry.* Oxford Univ. Press.

Gurtu JN. 1990 *Chemical Kinetics*. Pragati Prakashan, Meerut.

CHEM 504 SPECTROSCOPY 2+1

Objective

Spectroscopy is an important tool to determine the structures of molecules. This course will impart knowledge to the students about the NMR, Raman and laser spectroscopy.

Theory

UNIT I

Molecular structure-molecular orbital methods for H2+ and H2 molecule; the valence bonddescription of H2; electron spin functions; correlation diagram for diatomic moleculaes.

UNIT II

Huckel method for calculating resonance energy; rotation and vibration of molecules-linear and non-linear molecules, derivations of energy levels, selection rules.

UNIT III

Rotational vibrational spectroscopy-rotational and vibrational level corrections; electron spectroscopy.

UNIT IV

Raman Spectroscopy. Laser Raman spectroscopy

UNIT V

Nuclear Magnetic Resonance Spectroscopy; FTNMR.

Practical

Applications of spectroscopy for structural studies.

Suggested Readings

Dyre John R. 1984. *IR Spectroscopy.* Prentice Hall of India.

Jagmohan 2000. *Organic Spectroscopy.* Narosa.

William Camp 1987. *Organic Spectroscopy.* ELBS. Longman.

CHEM 505 EXPERIMENTS IN PHYSICAL CHEMISTRY 0+2

Objective

An exclusive practical course to teach the students about the different analytical techniques like potentiometry, refractometry, polarography, flame photometry and chromatography etc.

Practical

Conductivity; potentiometry; pH metry, polarography; amperometric titration, Spectrophotometry; flame-photometry; Refractometry; cryoscopic and ebulliosopic measurements; Chromatography.

Suggested Readings

Salzberg Morrow 1988. *Experiments in Physical Chemistry*. Academic Press.

Viswanathan R. 1993. *Practical Physical Chemistry*. Indian Book Co.

CHEM 506 GENERAL PHYSICAL AND COLLOIDAL CHEMISTRY 3+0

Objective

It is important to know the basic concepts of general physical chemistry and colloidal chemistry. This course will impart knowledge to students about physical and Colloidal Chemistry.

Theory

UNIT I

Thermochemistry: Heat changes at constant pressure and constant volume.Thermochemical laws, and Kirchoff`s equation.

UNIT II

Chemical Equilibrium: Introduction, chemical equilibrium constant, thermodynamic derivation of law of chemical equilibrium. Vant Hoff equation. Experimental methods. Catalysis.

UNIT III

Kinetics: First and second order reactions.Electrochemistry: phenomena of electrolysis, Faraday`s Laws of electrolysis, conductance of electrolytes.

UNIT IV

Theory of electrolytes, migration of ions, transport number. Simple treatment of e.m.f of cell. Pits measurement by indicatory and electrometric methods. Control and utility of pH in textile wet processing. Electrochemical theory of corrosion.

UNIT V

Colloid Chemistry: Theoretical properties of colloidal systems, intrerfacial phenomena, practice kinetics, electrical properties, viscosity. Lyophobic and lyophilic solutions, gels and emulsions developed from above properties.

Suggested Readings

Atkin PW. 1996. *Elements of Physical Chemistry*. Oxford Univ. Press.

Mahan BH. 1978. *University Chemistry*. Indian Book Co.

CHEM 507 CHEMISTRY OF POLYMERS 3+0

Objective

Objective of this course is to teach the students about the chemistry of some important polymer, techniques of polymerization and application of polymerization.

Theory

UNIT I

Classification of polymers, molecular weights, physical properties of polymers, mechanism of polymerization.

UNIT II

Chemistry of some industrially important polymers.

UNIT III

Epoxy and phenolic resins. Copolymerisation.

UNIT IV

Techniques of polymerisation. Appliction of polymers to textiles.

UNIT V

Essential properties of fibre forming polymers. Structure and degradation products of cellulose and their determination.

Suggested Readings

Heymour 1975. *Polymer Chemistry*. ELBS.

James E Marck 1989. *Inorganic Polymers*. John Wiley.

Kricheldorf H. *et al*. 2005. *Handbook of Polymer Synthesis*. 2nd Ed. CRC Press.

Ravve A. 2000. *Principles of Polymer Chemistry*. 2nd Ed. Kluwer.

Sandler & Karo W. 1991. *Polymer Syntheses*. 2nd Ed. Vol. I. Academic Press.

CHEM 508 BASIC CONCEPTS OF INORGANIC CHEMISTRY 2+0

Objective

Objective of this course is to teach the students about the basic concepts of inorganic chemistry, Wave function, s, p, d, f, VB, MO and VSEPR theories, inorganic free radicals.

Theory

UNIT I

Review of the atomic structure-wave mechanical approach, wave functions for hydrogen atom, radial distribution curves for s, p, d and f orbitals, angular wave functions for s, p, d and f orbitals-their significance and use.

UNIT II

Slater-type orbitals;effective nuclear charge; use of radial distribution curves to explain order of filing of orbitals in many electron system; review of chemical bond.

UNIT III

Application of VB,MO and VSEPR theories in explaining the structure of simple molecules.

UNIT IV

Rules for classification of molecules into point groups, group multiplication tables, degenerate and non-degenerate point groups, rules for fundamental vibrations.

UNIT V

Inorganic free radicals-their general reactions, preparation and uses; measurement of free radical concentration and decomposition rate.

Suggested Readings

Cotton FA & Wilkinson G. 1977. *Advanced Inorganic Chemistry*. John Wiley.

Puri BR & Sharma LR. 1985. *Principles of Inorganic Chemistry*. S. Nagin & Co.

CHEM 509 CHEMISTRY OF TRANSITION METALS 2+1

Objective

To acquaint the students regarding the different physical and chemical properties of transitional metal.

Theory

UNIT I

Transition elements-Hund's rule and spectroscopic energy states; magnetism in transition meta chemistry orgin and nature of paramagnetism, diamagnetism, erromagnetism and anti-ferro-magnetism.

UNIT II

Magnetic susceptibility and magnetic moment calculations, elements of 2nd and 3rd row transition series; chemistry of iso- and heteropolyacids and anions of Mo and W; the metal -metal bonds.

UNIT III

General remarks on different physical and chemical properties .compunds with two centered metal meta bonds; metal clusters, occurrence, electronic structure, oxidation states, stereo chemistry.

UNIT IV

Magnetic and spectral properties of lanthanide's and actinides; lanthanides contraction, separation of lanthanides and actinides.

UNIT V

Chemistry of rare elements francium, technitium, rehenium.

Practical

Potentimetric determination of formation constants of 3d-series transition metal ions.

Suggested Readings

Earshaw & Harrington 1990. *Chemistry of Transitional Elements*. John Wiley & Sons.

Puri BR & Sharma LR. 1985. *Principles of Inorganic Chemistry*. S. Nagin & Co.

CHEM 510 CO-ORDINATION CHEMISTRY, REACTION MECHANISM AND INORGANIC POLYMERS 2+1

Objective

This will impart knowledge to the students about the bonding in coordination compounds, their mechanisms and properties of inorganic polymers.

Theory

UNIT I

The theories of bonding in coordination compunds -valence bond theory, electroneutrality principle and back-bonding, crystal field theory and its application for understanding magnetic and spectral properties of metal complexes, structural effects of crystal field splitting (ionic radii, Jahn-Teller effect).

UNIT II

Thermodynamical effects of crystal field splitting (hydration, ligation and lattice energies). Limitations of crystal field theory; adjusted crystal field theory (ligand field theory); appplicion of molecular orbital theory of square planar, tetrahedral and octahedral complexes; stability of complexes-methods of determination.

UNIT III

Factors influencing stability; substitution reactions in octahedral complexes and associated stereochemical changes, redox reactions in coordination compounds and their mechanism.

UNIT IV

Transition metal complexes of pi acceptor ligands; inorganic polymers based upon homoatomic and heteroatomic structures.

UNIT V

Polymers containing boron and nitrogen, addition polymers of borazines, Polymeric phosphorus compounds and condensed phosphates.

Practical

Preparation of inorganic complexes like Co{Hg(SCN) 4], Hg[Co(SCN) 4], Co(NH3)5Cl]Cl2,[Cu(Gly)2], Preparation of [Co(NH3)5NO2]Cl2, [Co(acae)3],K4[Co2(C2O4)4(OH)2], K2[Cu(C2O4)2], [Co(NH3)4]SO4 and Na3 [Co(NO2)6], Determination of magnetic

characteristic of above complexes, Analysis of alloys using conventional physical and chemical techniques, Complexometric titrations.

Suggested Readings

James E Marck 1989. *Inorganic Polymers*. John Wiley.

Puri BR & Sharma LR. 1985. *Principles of Inorganic Chemistry.* S. Nagin & Co.

Wilson J. 1989. *New Methods of Analytical Chemistry.* Prentice Hall.

CHEM 511 NUCLEAR CHEMISTRY 3+0

Objective

This course will impart knowledge to the students regarding the nuclear particles, disintegration series, half life, radio isotopes-their production and application in industries, agriculture, medicines and research.

Theory

UNIT I

Nuclear particles-stable and unstable; nuclear binding energy and mass defect; nuclear forces and stability-shell and liquid drop models; natural and artificial radio-activity.

UNIT II

Disintegration series, disintegration rate and half life; types of nuclear reactions-nuclear fission and nuclear fusion.

UNIT III

Radio isotopes-their production and application in industry, agriculture, medicine and research.

UNIT IV

Principle of working of GM counters and scintillation counters; types of nuclear reactors; nuclear wastes and their disposal.

UNIT V

Boranes preparation, structure and bonding, borane anions and carboranes, metal complexes of carborane anions, boranes with hetero atoms other than carbon.

Suggested Readings

Harvey BG 1985. *Nuclear Chemistry.* Prentice Hall.

Karl Heinrich Lieser 2001. *Nuclear and Radiochemistry: Fundamentals and Applications.* Wiley VCH.

Lefort M. 1996. *Nuclear Chemistry*. D. Van Nostrad Co.

CHEM 512 PHYSICAL ORGANIC CHEMISTRY 2+0

Objective

To acquaint the students regarding the stereo chemistry of the molecule, cofuguration, conformation, reaction intermediates and tracer techniques etc.

Theory

UNIT I

Stereochemistry and conformation analysis-conformation and configuration, geometrical and optical isomers, methods of resolution, asymmetric synthesis.

UNIT II

ORD and CD; aromaticy; steric effects; reactive intermediates, carbocations, carbanions, free radicals, carbenes, arynes, nitrenes.

UNIT III

Organic reaction mechanism: substitution, addition, elimination and rearrangement reactions.

UNIT IV

Substituent isotope solvent and kinetic salt effects, tracer technique. Hamett equation, non-classical carbonium ions.

UNIT V

Neighbourning group participation; pericyclic reactions and molecular orbital symmetry.

Suggested Readings

Finar IL. 1969. *Organic Chemistry*. EBLS Longman.

Morrison RT & Boyd RN. 1969. *Organic Chemistry*. Prentice Hall.

CHEM 513 REACTIONS, REAGENTS AND PHOTOCHEMISTRY 3+0

Objective

To understand reactions, reagents and photochemistry, is very important. By learning this course students will learn regarding the reaction mechanism of different name reactions, reagents and about the reactions which proceed by light.

Theory

UNIT I

Backman, Claisen, Fries, Wagner-Meerwein rearrangement; Claisen condensation, Dieckmann, Reformatsky, Curtius, Friedel-crafts, Mannich, Michael, Pekin.

UNIT II

Kolbes, Reimer Tiemann, Hofmann, diels Alder, Arndt Eistert, Wittig reactions, Aldol condensation, Benzilic acid and Benzidine rearrangements, Acetoacetic, malonic ester and Grignard syntheses.

UNIT III

Reagents in organic syntheses- Cu, CuX, Zn, Mg, Li, ZnCl2 AlCl3 aluminum alkoxide, LiAlH4, Na, RONa, Ni, SeO2, BX3, NaBH4, CH2 N2, HIO4.

UNIT IV

Organiometallic compounds.

UNIT V

Photochemistry-Energy levels, quantum yield, photochemistry of simple organic molecules, Barton reaction.

Suggested Readings

Finar IL. 1969. *Organic Chemistry*. EBLS Longman.

Singh SP & Mukherjee M. 1992. *Organic Chemistry*. Wiley Eastern.

CHEM 514 NATURAL PRODUCT CHEMISTRY 2+0

Objective

Objective of this course is to impart the knowledge to the students about the isolation, structure determination and chemical properties of different type of natural products-like alkaloids, terpenea flavones coumarins etc.

Theory

UNIT I

Structures and syntheses of terpenes-geraneol, citral amyrins, a-terpeneol, a -pinene, camphor, squalene and abietic acid; isoprene rule; biogenesis of mono, di-and tri terpenoids.

UNIT II

Synthesis and biogenesis of ß-carotene, steroidscholesterol ergosterol, sex hormones, progesterone, testosterone, cortisone; plant hormones: auxin B and A, kinetin, abscisic acid, gibberllins.

UNIT III

Alkaloids- general structural determination, atropine, quinine, reserpine, morphine, nicotine, epherdrine, cocaine.

UNIT IV

Acetogenins-anthocyanins,flavones, flavonols, isoflavones, quinones, chalcones.

UNIT V

Coumarins, euxanthones, biogenesis of flavonoids; porphyrins, haemin, chlorophyll; structures of starch and cellulose.

Suggested Readings

Aggarwal OP. 1984. *Natural Product Chemistry*. Goel Publ. House.

Finar IL. 1969. *Organic Chemistry.* EBLS Longman.

Kalsi PS. 1983. *Chemistry of Natural Product*. Kalyani Publ.

CHEM 515 DRUGS AND DYES 3+0

Objective

The objective of this course is to impart knowledge to the students regarding the principles of drug design and QSAR, Chemistry of antibiotics,antimalarials, CNS depressant, sedatives analgesic anticancer agents etc. and dyes.

Theory

UNIT I

Principles of drugs design and QSAR; chemistry of antibiotics, sulpha drugs, antimalarials, anthelmantics.

UNIT II

CNS depresants and stimulants, hypnotics, sedatives, tranquilisers, analeptics, hellucinogens, diuretics,.

UNIT III

CVS agents, antiallergic, analgesics, anti-inflammatory.

UNIT IV

Antifertility and anticancer agents, prostaglandins and vitamins.

UNIT V

Chemistry of some important classes of dyes; colour and chemical constitution.

Suggested Readings

Ashutosh Kar 1993. *Medicinal Chemistry*. Wiley Eastern.

Chatwal GR. 1984. *Synthetic Organic Chemistry*. Himalya Publ.

Foy D & Williams DA. 1995. *Principles of Medicinal Chemistry.* Lippincott Williams & Wilkins.

Thomas L Lemke, David A Williams & Victoria F Roche.2008. Foye's Principles of Medicinal Chemistry. Lippincott Williams & Wilkins.

CHEM 516 BIO ORGANIC CHEMISTRY 3+0

Objective

To acquaint the students about the structure and function of biomolecules like proteins and enzymes etc.

Theory

UNIT I

Structures and functions of biomolecules in living system. Elementary structure and function of proteins and nucleic acids.

UNIT II

Bioorganic chemistry of aminoacids and phosphates.

UNIT III

Mechanism of enzyme action, enzyme models, host-guest complexation chemistry, Enzyme inhibitory reactions.

UNIT IV

Enzyme design using steroid template and remote functionalisation.

UNIT V

Chemistry of lipids and membranes, transport phenomenon, ionophores. Structure and function of cell membrane.

Suggested Readings

Calvin M. 1984. *Bioorganic Chemistry.* WH Freeman.

Dugas H Penhes 1976. *Bio Organic Chemistry.* Springer Verlag.

CHEM 517 SYNTHESIS AND CHARACTERIZATION OF ORGANIC COMPOUNDS 0+2

Objective

By learning this course students will learn about the techniques used in separation and identification of organic compounds.

Practical

UNIT I

Separation and identification of the components of a binary organic mixture.

UNIT II

Synthetic preparations involving two steps.

UNIT III

Quantitative analysis of phenol, aniline.

UNIT IV

Quantitative analysis of sulphur, nitrogen.

UNIT V

Isolation experiments.

Suggested Readings

Clark HT. 1971. *Organic Analysis*. Orient Longman.

Vishnoi NK. 1985. *Advanced Practical Organic Chemistry.* Vani Educational Books, Delhi.
Vogel IL.1969. *A Text Book of Practical Organic Chemistry*. ELBS Longman.

CHEM 518 CHEMISTRY OF PESTICIDES 2+1

Objective

Objective of this course is to teach the students about the details of pesticides, testing of pesticidal formulations from point of view of their quality etc.

Theory

UNIT I

Classification of pesticides on the basis of function, mode of entry and mode of action; chemistry and structural activity relationship of different pesticidal compounds.

UNIT II

Insecticides-organochlorines, organo-phosphates, carbamates, pyrethrtoids, rotenones and stereochemistry of botanicals.

UNIT III

Fungicides-Inorganics, dithiocarbamates, phthalimides-organophosphates, diazoles and Exathions.

UNIT IV

Herbicides-phenoxy compounds, substituted ureas, sulfynyl ureas, triazenes, bipyridylium compounds and dinitroanilines.

UNIT V

Metabolic pathways of some important compounds of each chemical group.

Practical

Testing of pesticidal formulations from point of view of their quality; Estimation of active principles of pesticides employing different analytical techniques in different matrices, Determination of pesticide residues in different commodities by GLC.

Suggested Readings

György Matolcsy, Miklós Nádasy, Viktor 1988. *Pesticide Chemistry*. Elsevier.
Handa SK. 2000. *Principles of Pesticide Chemistry*. Agrobios.
Kenneth A Hassall 1982. *The Chemistry of Pesticides*. Verlag Chemie, Weinheim, F.R.G.
Matsmura.1980. *Text Book on Insecticides*. CRC Press.
Perry AS. *Insecticides in Agriculture, Environment and Perspective.* Springer Verlag.
Unger TA. 1996. *Pesticide Synthesis Handbook*. William Andrew.

CHEM 601 TOPICS OF CURRENT INTEREST 3+0

Objective

This course will impart knowledge to the students regarding the details of polymer chemistry, catalyst and solid state chemistry.

Theory

UNIT I

Chemicals that produce monomers, monomer polymerization, phase transfer in monomers, characterization.

UNIT II

Macromolecules: Polyacetal, polyaldehydes, polyalkylenes, polyamino and polycarbonates.

UNIT III

Catalysis: Polymerization catalysis, catalyst support, clay compounds, basic catalysts, autoexhaust catalysis and curing agents.

UNIT IV

Solid state chemistry: Crystallographic system, polymorphism , space-lattice and attraction and repulsion.

Suggested Readings

Charles E Carraher Jr. 2005. *Seymour/Carraher's Polymer Chemistry.* Marcel Decker.

Gurdeep Raj 1988. *Advanced Physical Chemistry*. Krishna Publ., Meerut.

Seymour RB.1978. *Polymer Chemistry*. Academic Press.

CHEM 602 ADVANCED PHYSICAL CHEMISTRY 3+0

Objective

After going through this course students will be able to learn the detail of the application of computer in chemistry, advanced quantum mechanics and spectroscopy.

Theory

UNIT I

Application of computers in Chemistry.

UNIT II

Advanced quantum mechanics.

UNIT III

Spectroscopy-II.

UNIT IV

Solid state chemistry.

Suggested Readings

Glasstone S. 1968. *Text Book of Phyical Chemistry*. The MacMillan Press.

Gurdeep Raj 1988. *Advanced Physical Chemistry*. Krishna Prakashan, Meerut.

William Camp 1987. *Organic Spectroscopy*. ELBS Longman.

Selected reviews and articles from Journals/Periodicals.

CHEM 603 ORGANOMETALLIC CHEMISTRY 3+0

Objective

The objective of this course is to acquaint the students regarding the Synthesis, structure and properties of organometallic compounds.

Theory

UNIT I

Introduction, synthesis and structure of metal alkyls, metal aryls, metal carbonyls, metal carbenes and metal carbines.

UNIT II

Complexes with chain *pi* donor ligands and cyclic *pi* donor ligands; reaction pathways-association reactions.

UNIT III

Substitution reactions, addition and elimination reactions, rearrangement reactions.

UNIT IV

Catalysis involving organometallic compounds-olefin hydrogenation, hydroformylation, the Wacker process.

UNIT V

Polymerization, the Fischer-Trospsch process, cyclo-oligomerisetion of olefins and acetylenes etc.

Suggested Readings

Chatwal G & Yadav HS. *Organometallic Chemistry.* Krishna Prakashan, Meerut.

Finar IL. 1969. *Organic Chemistry.* ELBS Longman.

CHEM 604 BIO-INORGANIC CHEMISTRY 3+0

Objective

This course will impart knowledge to the students about the inorganic elements in biological system, their importance and mechanism of electron transfer reaction.

Theory

UNIT I

Inorganic elements in biological systems; importance of alkali and alkaline earth metals, ions and ligands affecting the stability of complexes.

UNIT II

Coordinating sites in biologically important ligands such as purines, pyrimidines, nucleosides, nucleotides, amino-acids and peptides.

UNIT III

Metalloenzymes and metal activated enzyme, metal complexes as oxygen carriers-haemoglobin, myoglobin; nonporphyrin.

UNIT IV

Oxygen carriers-hemocyanin and hermarythrin; synthetic oxygen carriers non-redox metallo-enzymes.

UNIT V

Mechanism of electron transfer reactions in metal complexes as drugs and anticancer agents.

Suggested Readings

Gurdeep Raj 1988. *Advanced Physical Chemistry.* Krishna Prakashan.

Miessler GL. 1992. *Inorganic Chemistry*. Pearson Edu.

Puri BR & Sharma LR. 1985. *Principles of Inorganic Chemistry*. S. Nagin & Co.

CHEM 605 ORGANIC SYNTHESIS 3+0

Objective

By learning this course students will acquaint about the synthesis of different heterocyclic compounds and different types of polymerization reactions.

Theory

UNIT I

Synthesis and synthetic equivalents, formation of C-C, C-N and C-halogen bonds, Multi step synthetic strategy and catalysis, 3-7 membered heterocycles.

UNIT II

Synthesis and reactivity of furan, thiophene, pyrrole, pyridine, quinoline, isoquinoline and indole.

UNIT III

Skraup synthesis, Fisher indole synthesis.

UNIT IV

Natural and synthetic polymers.

UNIT V

Different types of polymerization reactions, rubber, nylon and polyester.

Suggested Readings

Finar IL. 1969. *Organic Chemistry*. ELBS Longman.

Ireland RE. 1988. *Organic Synthesis*. Prentice Hall.

CHEM 606 SPECTROSCOPY IN ORGANIC CHEMISTRY 3+0

Objective

The objective of this course is to impart knowledge to the students regarding the latest spectroscopic techniques like ^{13}CNMR, ^{15}NNMR, ^{19}FNMR, GCMS, FABMS, UV and IR.

Theory

UNIT I

UV-principle, solvents and their effects, chromophores, auxochromes, effect of conjugation, absorptions in polyenes , dienes, haloketones, enones, aldehydes, unsaturated acids, esters, benzenoid aromatics, heterocycles.

UNIT II

IR-absorption process, functional group and finger print regions, combination and overtone bands, Fermi resonance interpretation.

UNIT III

1H NMR-principle, resonance, chemical shifts, shielding and deshielding, equivalence of protons, splitting, n+1 rule, coupling constant, interpretations, shift reagents.

UNIT IV

Ideas of 13C NMR, 15N NMR,19F NMR , 31P NMR, MS-metastable ion, nitrogen rule, molecular mass determination, reaction pathways, fragmentation patterns, retro Diels Alder fission, McLafferty rearrangement, fragmentation in hydrocarbons, alcohols, phenols, ethers, aldehydes, isomer, ester, carboxylic acids, amines, nitro,amides, nitriles.

UNIT V

GCMS, CIMS, FABMS; Electron Spin Resonance(ESR).

Suggested Readings

Jag Mohan 2000. *Organic Spectroscopy*. Narosa Publ.

Silverstein S. 1977. *Spectroscopic Identification of Organic Compounds*. John Wiley & Sons.

William Camp 1987. *Organic Spectroscopy.* ELBS Longman.

CHEM 607 CONSTITUTION OF INORGANIC COMPOUNDS AND DYNAMICS OF INORGANIC REACTIONS 3+0

Objective

By learning this course the students will be able to understand the symmetry of crystals, classes, structure and X-ray differection.etc.

Theory

UNIT I

Symmetry of crystals, crystal system, classes of crystals, types of lattices, lattice energy, point group and space groups, symmetry parameters, defects in solids.

UNIT II

Structure of some typical binary and ternary compounds, structure of silicates, polyacids and their salts.

UNIT III

Introduction to determination of crystal structure by Xray diffraction, electron diffraction and neutron diffraction techniques.

UNIT IV

Thermodynamics.

UNIT V

Kinetics and spontaneity of reaction, Frost diagram and its relation to spontaneity and application in the prediction of chemical reactions.

Suggested Readings

Cotton & Wilkinson 1977. *Advanced Inorganic Chemistry*. John Wiley.
Glasstone S. 1968. *Text Book of Physical Chemistry*. The MacMillan Press.

CHEM 608 GREEN CHEMISTRY 2+0

Objective

The objective of this course is to impart knowledge to the students about the chemistry and chemical technology of different environmental issues.

Theory

UNIT I

Concept of green chemistry. Chemistry & Chemical Technology of Waste, pollution, effluent and other environmental issue which are caused by chemical manufacturing.

UNIT II

Novel synthetic techniques. Organic reactions involving reduction of raw material/solvent usage, milder operating conditions.

UNIT III

Use of catalyst towards green chemistry. Reactions that uses heterogeneous or homogeneous catalyst leading to green scenario. Use of Bio catalyst in reactions which make environment clean and friendly. Use of new reagents and solvents which are benign, environmentally friendly. Method of benign synthesis.

UNIT IV

Energy and renewable resources. Alternate energy sources. Use of renewable raw material includes ethanol & biodieset etc.

UNIT V

Inharent safly processes that are milder, use of less toxic solvents, do not product dangerous intermediate, side products, chemicals. Industrial examples.

Suggested Readings

Doble M & Kumar A. 2007. *Green Chemistry & Engineering.* Elsevier.

Gilberts M.M 1997. *Introduction to Environmental Engineering and Science.* Printice Hall.

CHEMISTRY

List of Journals

- Accounts of Chemical Research
- ACS Chemical Biology
- Analytical Chemistry
- Bioconjugate Chemistry
- Bulletin of the Chemical Society of Japan (Chemical Society of Japan)
- Chemical and Engineering News
- Chemical Health and Safety
- Chemical Research in Toxicology
- Chemical Reviews
- Chemistry Letters
- Chemistry of Materials
- Chemical Innovation (formerly CHEMTECH) (ceased publ. December 2001)
- Crystal Growth and Design
- Energy and Fuels
- Environmental Science and Technology
- Industrial and Engineering Chemistry Research
- Inorganic Chemistry
- Journal of Agricultural and Food Chemistry
- Journal of the American Chemical Society
- Journal of Chemical and Engineering Data
- Journal of Chemical Education
- Journal of Chemical Information and Computer Science (now Journal of Chemical Information and Modeling and Journal of Chemical Theory and Computation)
- Journal of Chemical Information and Modeling
- Journal of Chemical Theory and Computation
- Journal of Combinatorial Chemistry
- Journal of Medicinal Chemistry
- Journal of Natural Products
- Journal of Organic Chemistry
- Journal of Physical Chemistry A
- Journal of Physical Chemistry B
- Journal of Physical Chemistry C
- Journal of Physical and Chemical Reference Data (Now distributed by the AIP)
- Langmuir
- Macromolecules
- Modern Drug Discovery
- Molecular Pharmaceutics
- Nano Letters
- Organic Letters
- Organic Process Research and Development
- Organometallics
- Today's Chemist at Work

e-Resources

- http://library.olivet.edu/pubserv/ins/chemistry/index.html
- http://www.chemistry.org/portal/Chemistry
- http://www.chemweb.com/

- http://www.iupac.org/dhtml_home.html
- http://www.atsdr.cdc.gov/
- http://chemfinder.cambridgesoft.com/
- http://www.cdc.gov/niosh/npg/npg.html
- http://ull.chemistry.uakron.edu/erd/
- http://physchem.ox.ac.uk/MSDS/
- http://www.energy.gov/
- http://www.pnl.gov/energyscience/
- http://www.epa..gov
- http://webbook.nist.gov/chemistry/
- http://physics.nist.gov/cuu
- http://physics.nist.gov/PhysRefData/Elements/cover.html
- http://www.chemsoc.org/viselements/
- http://www.webelements.com/
- http://www.americanelements.com/
- http://www.stanford.edu/~glassman/chem/index.htm
- http://www.shef.ac.uk/~chem/chemputer/
- http://antoine.frostburg.edu/chem/senese/101/index.shtml
- http://lrc-srvr.mps.ohio-state.edu/under/chemed/chemed.htm
- http://www.chem.purdue.edu/gchelp/vsepr/
- http://www.chemistry.ohio-state.edu/organic/flashcards/
- http://www.monomerchem.com/display4.html
- http://www.chemhelper.com/
- http://www.ilpi.com/organomet/index.html
- http://www.organicworldwide.net/tutorial.html
- http://www.cis.rit.edu/htbooks/nmr/bnmr.htm
- http://web.umr.edu/~jstoffer/Spectroscopy/protonNMR.html
- http://www.spectroscopynow.com/Spy/basehtml/SpyH/
- http://science.widener.edu/svb/molecule/molecule.html
- http://info.bio.cmu.edu/courses/biochemmols/bcmolecules.html
- http://www.umass.edu/microbio/rasmol/
- http://www.cnn.com/TECH/space/
- http://www.newscientist.com/
- http://www.sciencedaily.com/
- http://www.sciencemag.org/netwatch/
- http://www.sciencenews.org/
- http://dailynews.yahoo.com/h/sc
- http://www.akiti.ca/
- http://www.nobel.se/chemistry/
- http://www.chemistry.co.nz/stain_frame.htm
- http://www.twinkiesproject.com

Suggested Broad Research Areas for Master's and Doctoral Research

- Natural Products Chemistry
- Bioefficacy of chemical compounds
- Development of Agro chemicals
- Synthetic chemistry
- Environmental studies: chemical and physical aspect
- Synthesis of chemicals using microwaves

MICROBIOLOGY
Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
MICRO 501*	PRINCIPLES OF MICROBIOLOGY	3+1
MICRO 502*	MICROBIAL PHYSIOLOGY AND METABOLISM	3+1
MICRO 503*	MICROBIAL GENETICS	2+1
MICRO 504*#	SOIL MICROBIOLOGY	2+1
MICRO 505*@	MICROBIAL BIOTECHNOLOGY	2+1
MICRO 506*	FOOD AND DAIRY MICROBIOLOGY	2+1
MICRO 507	BACTERIOPHAGES	1+1
MICRO 508	ENVIRONMENTAL MICROBIOLOGY	2+1
MICRO 509**	PLANT-MICROBE INTERACTIONS	3+0
MICRO 510	INDUSTRIAL MICROBIOLOGY	2+1
MICRO 511	BIOFERTILIZER TECHNOLOGY	1+1
MICRO 512	CYANOBACTERIAL AND ALGAL BIOTECHNOLOGY	2+0
MICRO 591	MASTER'S SEMINAR	1+0
MICRO 599	MASTER'S RESEARCH	20
MICRO 601**	ADVANCES IN FERMENTATION	2+1
MICRO 602**	ADVANCED MICROBIAL PHYSIOLOGY	2+0
MICRO 603**	REGULATION OF MICROBIAL BIOSYNTHESIS	2+0
MICRO 604**	CURRENT TOPICS IN SOIL MICROBIOLOGY	2+0
MICRO 691	DOCTORAL SEMINAR I	1+0
MICRO 692	DOCTORAL SEMINAR II	1+0
MICRO 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; **Compulsory for Doctoral programme
#Can be cross-listed with Soil Science; @Can be cross-listed with Biotechnology

MICROBIOLOGY
Course Contents

MICRO 501 PRINCIPLES OF MICROBIOLOGY 3+1

Objective

To teach the students about basics in development of microbiology, differences in prokaryotes and eukaryotic cell and classification of prokaryotes.

Theory

UNIT I

Development of Microbiology in the 18th and 19th century. Morphology, structure and function of prokaryotic and eukaryotic cell. Archea. Classification of prokaryotes – Basic principles and techniques used in bacterial classification.

UNIT II

Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Use of DNA and r-RNA sequencing in classifications.

UNIT III

Study of major groups of bacteria belonging to Gracilicutes, Firmicutes, Tanericutes and Mendosicutes.

UNIT IV

Viruses – morphology, classification and replication of plant, animal and bacterial viruses. Cultivation methods of viruses. Immune response – specific and non-specific resistance. Normal microflora of human body; some common bacterial and viral diseases of humans and animals.

Practical

Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food). Enrichment culture technique – isolation of asymbiotic, symbiotic nitrogen fixing bacteria. Isolation of photosynthetic bacteria. Use of selective media, antibiotic resistance and isolation of antibiotic producing microorganisms. Morphological, physiological and biochemical characterization of bacteria.

Suggested Readings

Brock TD. 1961. *Milestones in Microbiology*. Infinity Books.

Pelczar MJ, Chan ECS & Kreig NR. 1997. *Microbiology: Concepts and Application*. Tata McGraw Hill.

Stainier RY, Ingraham JL, Wheelis ML & Painter PR. 2003. *General Microbiology*. MacMillan.

Tauro P, Kapoor KK & Yadav KS. 1996. *Introduction to Microbiology*. Wiley Eastern.

MICRO 502 MICROBIAL PHYSIOLOGY AND METABOLISM 3+1

(Pre-requisite Micro 401, Micro 501)

Objective

To teach students about cell cycle, growth and practical training on methods to determine microbial growth.

Theory

UNIT I

Structure, function, biosynthesis and assembly of various cellular components of prokaryotes. Archea and fungi. Transport of solutes across the membrane.

UNIT II

Microbial growth. Cell cycle and cell division. EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Biosynthesis of macromolecules. Regulation of microbial metabolism.

UNIT III

Effect of chemicals and other environmental factors on growth. Morphogenesis and cellular differentiation.

UNIT IV

Important metabolic patterns in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs.

Practical

Use of simple techniques in laboratory (Colorimetry, Centrifugation, Electrophoresis and GLC). Determination of viable and total number of cells. Measurement of cell size. Gross cellular composition of microbial cell. Growth – Factors affecting growth. Sporulation and spore germination in bacteria. Protoplasts formation. Induction and repression of enzymes.

Suggested Readings

Doelle HW. 1969. *Bacterial Metabolism*. Academic Press.
Gottschalk G. 1979. *Bacterial Metabolism.* Springer Verlag.
Moat AG. 1979. *Microbial Physiology*. John Wiley & Sons.
Sokatch JR. 1969. *Bacterial Physiology and Metabolism.* Academic Press.

MICRO 503 MICROBIAL GENETICS 2+1

(Pre-requisite Micro 401, Micro 501)

Objective

To acquaint the learners regarding molecular concepts of bacteria and viruses and impact of gene cloning on human welfare.

Theory

UNIT I

Prokaryotic, eukaryotic and viral genome. Replication of Eukaryotic, Prokaryotic and Viral DNA. Structure, classification and replication of plasmids.

UNIT II

Molecular basis of mutation. Biochemical genetics and gene mapping by recombination and complementation. Fine gene structure analysis. Fungal genetics.

UNIT III

Gene transfer in bacteria through transformation, conjugation and transduction; gene mapping by these processes. Transposable elements.

UNIT IV

Gene cloning and gene sequencing. Impact of gene cloning on human welfare. Regulation of gene expression. Recent advances in DNA repair and mutagenesis, Genetic basis of Cancer and cell death.

Practical

Inactivation of microorganisms by different mutagens. Production, isolation and characterization of mutants. Determination of mutation rate. Isolation, characterization and curing of plasmids. Transfer of plasmid by conjugation, electroporation. Tetrad and random spore analysis.

Suggested Readings

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

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

Lewin B.1999. *Gene*. Vols. VI-IX. John Wiley & Sons.

Maloy A & Friedfelder D. 1994. *Microbial Genetics*. Narosa.

Scaife J, Leach D & Galizzi A 1985. *Genetics of Bacteria*. Academic Press.

William Hayes 1981. *Genetics of Bacteria*. Academic Press.

MICRO 504 SOIL MICROBIOLOGY 2+1

Objective

Objective of this course is to teach students regarding basics of microbiology related to soil including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

UNIT I

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

UNIT II

Microbiology and biochemistry of root-soil interface; phyllosphere, Biofertilizers, soil enzyme activities and their importance.

UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials. Biochemical composition and biodegradation of soil organic matter and crop residues.

UNIT IV

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; Soil microbial biomass; Decomposition studies in soil, Soil enzymes; Measurement of important soil microbial processes such as ammonification, nitrification. N_2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients; Study of rhizosphere effect.

Suggested Readings

Martin Alexander 1977. *Soil Microbiology*. John Wiley.

Paul EA. 2007. *Soil Microbiology, Ecology and Biochemistry*. 3rd Ed. Academic Press.

Sylvia *et al.* 2005. *Principles and Applications of Soil Microbiology*. 2nd Ed. Pearson Edu.

van Elsas JD, Trevors JT & Wellington EMH. 1997. *Modern Soil Microbiology*. Marcel Dekker.

MICRO 505 MICROBIAL BIOTECHNOLOGY 2+1

(Pre-requisite Micro 401, Micro 402, Micro 501)

Objective

To teach students about industrially useful microorganisms and use of fermentor for the production of various primary and secondary metabolites.

Theory

UNIT I

Introduction, scope and historical development; Isolation, screening and genetic improvement of industrially important microorganisms.

UNIT II

Types of fermentation systems; production of various primary and secondary metabolities, e.g. amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, etc.

UNIT III

Process scale up steps: laboratory, pilot plant and industrial scales. Down stream processing; Over-production of metabolities; Bioreactor operations, process control.

UNIT IV

Fermented beverages; Production of single cell protein; Steroid transformation; Immobilization of cells/enzymes; Silage production; Waste water treatment.

UNIT V

Use of genetically-engineered microorganisms in biotechnology; Bioinsecticides, biofertilizers, etc. Microbiologically-produced food colours and flavours. Retting of flax.

Practical

Isolation of industrially important microorganisms, their maintenance and improvement. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery; Study of bio-reactors and their operation: Production of biofertilizers.

Suggested Readings

Cruger W & 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.

MICRO 506 FOOD AND DAIRY MICROBIOLOGY 2+1

(Pre-requisite Micro 401, Micro 403, Micro 501)

Objective

To familiarize the students with recent advances in food microbiology including fermented foods, dairy, food preservation, detection of food-borne diseases, their control measures.

Theory

UNIT I

Introduction and scope; Food Microbiology – A many faceted science; Interrelationship of food microbiology with other sciences; Perspectives on food safety and Food Biotechnology.

UNIT II

Factors of special significance in Food Microbiology – Principles influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria; Microbial spoilage of foods- meat, milk, fruits, vegetables and their products; Food poisoning and food-borne pathogenic bacteria.

UNIT III

Food fermentation; Fermented dairy, vegetable, meat products; Preservatives and preservation methods – physical methods, chemical preservatives and natural antimicrobial compounds. Bacteriocins and their applications; Biologically based preservation systems and probiotic bacteria.

UNIT IV

Advanced techniques in detecting food-borne pathogens and toxins. Hurdle technology and Hazard analysis. Critical control point systems in controlling microbiological hazards in foods.

Practical

Statutory, recommended and supplementary tests for microbiological analysis of various foods: Baby foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers and water.

Suggested Readings

Bibek Ray.1996. *Fundamentals of Food Microbiology*. CRC Press.

Frazier WC & Westhoff DC. 1991. *Food Microbiology*. 3rd Ed. Tata McGraw Hill.

George J Banwart. 1989. Basic Food Microbiology. AVI.

James M Jay. 1987. Modern Food Microbiology. CBS.

Peppler HJ & Perlman D.1979. *Microbial Technology*. 2nd Ed. Academic Press.

MICRO 507 BACTERIOPHAGES 1+1

Objective

To familiarize students about phages and phage- bacterial interactions.

Theory

UNIT I

Historical developments and classification of bacteriophages.

UNIT II

Physiology, biochemistry, enzymology and molecular biology of phage-bacterial interactions.

UNIT III

Structure, functions and life cycles of different DNA, RNA, lytic and lysogenic phages.

UNIT IV

Phages in the development of molecular biology and genetic engineering.

Practical

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 T_4 *rII* mutants etc.

Suggested Readings

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 & Trempy J. 2004. *Fundamental Bacterial Genetics*. Blackwell.
Stent SG. 1963. *Molecular Biology of Bacterial Viruses*. WH Freeman.
Winkler J, Ruger W & Wackernagel W. 1979. *Bacterial, Phage and Molecular Genetics - An Experimental Course.* Narosa.
Winkler U & Ruhr W. 1984. *Bacteria, Phage and Molecular Genetics*. ALA.

MICRO 508 ENVIRONMENTAL MICROBIOLOGY 2+1
(Pre-requisite Micro 502)

Objective

To teach and create awareness regarding environment, water, soil, air pollution and bioremediation.

Theory

UNIT I

Scope of environmental microbiology. An overview of microbial niches in global environment and microbial activities. Microbiology of air, outdoor and indoor environment in relation to human, animal and plant health and economic activities.

UNIT II

Microbiology of natural waters. Environmental pollution – Deleterious and beneficial role of microorganisms. Environmental microbiology in public health. Microorganism in extreme environments, Environmental determinants that govern extreme environment- Air water interface, extreme of pH, Temperature, Salinity, Hydrostatic pressure.

UNIT III

Microbial technology in pollution abatement, waste management and resource recovery in metal, petroleum and bioenergy fields. Biofuels. Global environmental problems

UNIT IV

Microbial upgradation of fossil fuels and coal gas. Microbial interaction in rumen and gastrointestinal tract. Biodeterioration and Bioremediation. Biodegradation and xenobiotic compounds

Practical

Analysis of natural waters, waste waters and organic waste in relation to water pollution assessment, pollution strength and resource quantification; Quality control tests, waste treatment and anaerobic digestion; Demonstration of waste water treatment processes such as activated sludge processes, biofilter and fluidized bed process.

Suggested Readings

Campbell R. 1983. *Microbial Ecology*. Blackwell.
Hawker LE & Linton AH. 1989. *Microorganisms Function, Form and Environment*. 2nd Ed. Edward Arnold.
Mitchell R. 1992. *Environmental Microbiology*. John Wiley & Sons.
Richards BN. 1987. *Microbes of Terrestrial Ecosystem*. Longman.

MICRO 509 PLANT-MICROBE INTERACTIONS 3+0

(Open for: Microbiology, Biotechnology & Molecular Biology, Genetics, Pl. Physiology, Biochemistry, Plant Breeding & Plant Pathology students; Pre-requisite Micro503/Equiv., Micro 504)

Objective

To familiarize the students with the biochemical and biophysical mechanisms, genetics, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces of beneficial and pathogenic plant microbe interactions. 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.

Theory

UNIT I

Different interfaces of interactions - Plant-microbe, microbe-microbe, soil-microbe, soil-plant-microbe interactions leading to symbiotic (rhizobial and mycorrhizal), associative, endophytic and pathogenic interactions. 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.

UNIT II

Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized.

UNIT III

Methodology/resources to study plant-microbe interaction, recombinant inbred lines, biosensors, transcriptome profiling, metabolic profiling, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces.

UNIT IV

Plant and microbial gene expression and signal exchange, global and specific regulators for different interactions. Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants.

Suggested Readings

Kosuge T & Nester EW. 1989. *Plant-Microbe Interactions: Molecular and Genetic Perspectives*. Vols I-IV. McGraw Hill.

Verma DPS & Kohn TH. 1984. *Genes Involved in Microbe-Plant Interactions*. Springer Verlag.

Molecular Plant-Microbe Interactions. Journal Published by APS.

MICRO 510 INDUSTRIAL MICROBIOLOGY 2+1

(Open for: Microbiology, Biotechnology, Biochemistry, Soil Science, Agronomy, Plant Pathology, Horticulture students; pre-requisite Micro 504, Micro 506)

Objective

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.

Theory

UNIT I

Biofermentor; Production of wine, beer, lactic acid, acetic acid (vinegar), citric acid, antibiotics, enzymes, vitamins and single cell proteins. Biofuels: Production of ethanol, biogas and hydrogen production.

UNIT II

Brief introduction to bacterial, fungal and insect diseases, Types of chemicals/pesticides used for disease control. Vaccines. Bioagents and Biopesticides Biocontrol agents and their scope in control of plant diseases, nematodes and insect pests. Introduction to phytopathogens, symptoms, pathogenesis molecular aspects of plant pathogens, host-pathogens interactions, host defense mechanisms, disease forecasting and assesment of losses, prevention of epidemics, and disease control. Detailed study of the representative examples of plant diseases casuad by fungi and bacteria

UNIT III

Bioplastics and biopolymers: Microorganisms involved in synthesis of biodegradable plastics, other pigments, Biosensors: Development of biosensors to detect food contamination and environment pollution, Biodiversity: Structural, biochemical and molecular systematics, Numerical taxonomy. Magnitude and distribution of biodiversity.

UNIT IV

Biofertilizers, Genetic engineering of microbes for enhanced pesticide degradation 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.

Practical

Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Detection of food-borne pathogens, pesticide degradation. Demonstration of biogas production. Production of biocontrol agents.

Suggested Readings

Alexander M. 1977. *Soil Microbiology*. John Wiley.

Hawker LE & Linton AH. 1989. *Microorganisms Function, Form and Environment*. 2nd Ed. Edward Arnold.

James M Jaq 1987. *Modern Food Microbiology*. CBS.

Paul EA. 2007. *Soil Microbiology, Ecology and Biochemistry*. 3rd Ed Academic Press.

Stanbury PF & Whitaker A. 1987. *Principles of Fermentation Technology.* Pergamon Press.

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

MICRO 511 BIOFERTILIZER TECHNOLOGY 1+1

Objective

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.

Theory

UNIT I

Different agriculturally important beneficial microorganisms – free living, symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers including cyanobacteria, taxonomic classification, nodule formation, competitiveness and quantification of N_2 fixed.

UNIT II

Different agriculturally important beneficial microorganisms – phosphate solubilizing bacteria and fungi, including mycorrhiza.

UNIT III

Different agriculturally important beneficial microorganisms – plant growth promoting rhizobacteria.

UNIT IV

Different agriculturally important beneficial microorganisms – Biocontrol microbial inoculants.

UNIT V

Different agriculturally important beneficial microorganisms for recycling of organic waste and compositing, bioremediators and other related microbes.

UNIT VI

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.

Practical

Isolations of symbiotic, asymbiotic, associative nitrogen fixating bacteria. 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

Suggested Readings

Alexander M. 1977. *Soil Microbiology*. John Wiley.

Bergerson FJ. 1980. *Methods for Evaluating Biological Nitrogen Fixation.* John Wiley & Sons.

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

van Elsas JD, Trevors JT & Wellington EMH. 1997. *Modern Soil Microbiology*. CRC Press.

MICRO 512 CYANOBACTERIAL AND ALGAL BIOTECHNOLOGY 2+0

Objective

To teach students about this upcoming fascinating field of microbes develoed at a faster pace, mainly due to photoautotrophic nature of Cyanobacteria, their ability to survive under a variety of habitats and wide diversity of thallus structure and functions. Their importance for mankind is enormous including their role as biofertilizers, nutraceuticals,

experimental models, dyes, biofuels and a variety of biochemicals. regarding structure, molecular evolution and properties of cyanobacteria and algae

Theory

UNIT I

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.

UNIT II

Algal pigments, storage products, carbon metabolism, photosynthesis. Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photobioreactors, algal density and growth, seaweed cultivation.

UNIT III

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 IV

Algae in pollution - as pollution indicators, eutrophication agents and role in Bioremediation.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 Readings

Ahluwalia AS. 2003. *Phycology: Principles, Processes and Applications*. Daya Publ.

Barsanti L & Gualtieri P. 2006. *Algae: Anatomy, Biochemistry and Biotechnology*. Taylor & Francis, CRC Press.

Carr NG & Whitton BA. 1982. *The Biology of Cyanobacteria*. Blackwell.

Herrero A & 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 W Wilcox. 2000. *Algae*. Prentice Hall.

Robert A Andersen. 2005. *Algal Culturing Techniques.* Academic Press.

Venkataraman LV & Becker EW. 1985. *Biotechnology and Utilization of Algae: the Indian Experience*. DST.

MICRO 601 ADVANCES IN FERMENTATION 2+1

Objective

To teach students regarding fermentation industry using industrially useful microorganisms including yeast technology.

Theory

UNIT I

An overview of fermentation - current status of fermentation industry. Fermentor design, high performance bioreactors, mass and energy transfer

in bioreactors. Instrumentation and control in fermentors – on line measurements systems, computer application.

UNIT II

Media for microbial fermentation; Criteria in media formulation. An overview of downstream processing.

UNIT III

New strategies for isolation of industrially important microbes and their genetic manipulations; Microbial production of health care products. Antibiotic fermentation research; steroid transformation.

UNIT IV

Recent developments on production of primary and secondary metabolites, Treatment of biological wastes, microbial inoculants and enzymes for waste treatment.

UNIT V

Yeast technology – classification, genetics, strain improvement for brewing, baking and distilleries and topics of current interest in fermentations.

Practical

Industrially important microbes and their genetic manipulations, Fermentation by improved strains of yeast for production of alcohol and beer, Microbial production of important antibiotics, enzymes and organic acids, Bioremediation of industrial effluents

Suggested Readings

Peppler HJ & Perlman D. 1979. *Microbial Technology*. 2nd Ed. Academic Press.

Reed G. 1987. *Presscott & Dunn's Industrial Microbiology.* 4th Ed. CBS.

Stanbury PF & Whitaker A. 1987. *Principles of Fermentation Technology*. Pergamon Press.

Wiseman A. 1983. *Principles of Biotechnology.* Chapman & Hall.

MICRO 602 ADVANCED MICROBIAL PHYSIOLOGY 2+0

(Pre-requisite Micro 502)

Objective

To acquaint students with current topics in molecular microbiology

Theory

UNIT I

Origin, evolution, structure, function and molecular aspects of various cell components.

UNIT II

Differentiation in bacteria, slime molds, yeasts.

UNIT III

Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria.

UNIT IV

Topics of current interest in molecular microbiology.

Suggested Readings

Selected articles from journals.

MICRO 603 REGULATION OF MICROBIAL BIOSYNTHESIS 2+0
(Pre-requisite Micro 502, Micro 503)

Objective

Course imparts thorough knowledge about the synthesis of biomolecules in microorganisms by various pathways and their regulation.

Theory

UNIT I

Regulation of initiation, termination and anti-termination of transcription. Global regulation and differentiation by sigma factor. Regulatory controls in bacteria - inducible and biosynthetic pathways.

UNIT II

Ribosomal RNA and ribosomal proteins regulation under stress condition. Specific regulatory systems; SOS regulatory control; Antisense RNA regulation of gene expression.

UNIT III

Oxidative stress control. Fermentative and respiratory regulatory pathways. Regulation of cell cycle. Lytic and lysogenic cascade.

UNIT IV

Global nitrogen control and regulation of nitrogen fixation and other recent topics of regulatory systems of current interest.

Suggested Readings

Selected articles from journals**.**

MICRO 604 CURRENT TOPICS IN SOIL MICROBIOLOGY 2+0
(Pre-requisite Micro 504)

Objective

To make students learn the latest trends in soil microbiology like diversity, biological control and bioremediation.

Theory

UNIT I

Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms.

UNIT II

Microbial successions and transformation of organic matter; Role of microorganisms in soil fertility.

UNIT III

Bioremediation of polluted soils; Biological control.

UNIT IV

Other topics of current interest.

Suggested Readings

Selected articles from journals.

MICROBIOLOGY

List of 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

e-Resources

Books

- http://www.aw-bc.com/microplace/
- http://www.personal.psu.edu/jel5/micro/index.htm
- http://microbiology.ucsc.edu/

Details of sites related to Microbiology

- 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/

Latest in microbiology- Microbiology News

- http://microbiologybytes.wordpress.com/
- http://www.topix.net/science/microbiolog

Suggested Broad Topics for Master's and Doctoral Research

Molecular Microbiology

- Microbial diversity
- Meta genomics
- Improvement of beneficial microorganisms
  (Nitrogen fixers, Phosphate solubilizers etc.)

Environmental Microbiology

- Biocontrol
- PGPR, Termite control, Pathogenic fungi control

Biofuels

- Biogas, alcohol production

Bioremediation

- Waste management, Bioremediation of industrial effluents and agrochemicals
- Composting

Microbial Biotechnology

- Biofertilizers
  (Nitrogen fixers, Phosphate solubilizers, PGPR, BGA, composting etc)
- Secondary metabolites including industrially important enzymes, amino acids
- Citric acid and lactic acid fermentations

Food Microbiology

- Improvenment and industrial exploitation of microorganisms
- Fermented foods

PLANT PHYSIOLOGY

Course Structure –at a Glance

CODE	COURSE TITLE	CREDITS
PP 501*	PRINCIPLES OF PLANT PHYSIOLOGY	3+1
PP 502*	PLANT DEVELOPMENTAL BIOLOGY – PHYSIOLOGICAL AND MOLECULAR BASIS	2+0
PP 503*	PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES	2+1
PP 504*	HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT	2+1
PP 506*	PHYSIOLOGY OF GROWTH AND YIELD AND MODELING	1+1
PP 507	GENOME ORGANIZATION IN HIGHER PLANTS	2+1
PP 508*	MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION	2+1
PP 509	PHYSIOLOGY OF CROP PLANTS –SPECIFIC CASE STUDIES	2+0
PP 510	PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS- CARBON AND NITROGEN ASSIMILATION	2+1
PP 511	MINERAL NUTRITION	2+1
PP 591	MASTER'S SEMINAR	1+0
PP 599	MASTER'S RESEARCH	20
PP 601**	FUNCTIONAL GENOMICS AND GENES ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES	2+0
PP602**	SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES	2+0
PP 603**	MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS	2+1
PP 604	TECHNIQUES IN PLANT PHYSIOLOGY	1+2
PP 605	CLIMATE CHANGE AND CROP GROWTH	2+0
PP 606	POST HARVEST PHYSIOLOGY	2+0
PP 607	WEED PHYSIOLOGY AND HERBICIDE ACTION	1+1
PP 608	SEED PHYSIOLOGY	2+1
PP 691	DOCTORAL SEMINAR I	1+0
PP 692	DOCTORAL SEMINAR II	1+0
PP 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; ** Compulsory for Ph. D. programme

PLANT PHYSIOLOGY
Course Contents

PP 501 PRINCIPLES OF PLANT PHYSIOLOGY 3+1

Objective

To acquaint the students with the basic concepts of plant physiology and their application in agriculture.

Theory

UNIT I

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.

UNIT II

Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells.

UNIT III

Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants – Mycorhizal association on water uptake.

UNIT IV

Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration transpiration –Driving force for transpiration, plant factors influencing transpiration rate.

UNIT V

Stomata structure and function – mechanism of stomatal movement, antitranspirants.

UNIT VI

Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

UNIT VII

The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants.

UNIT VIII

Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants.

UNIT IX

Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

UNIT X

Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO_2 reduction in Calvin cycle, supplementary pathway of C fixation in C4 and CAM plants and its significance.

UNIT XI

Photorespiration and its relevance. Photosynthesis as a diffusive process-effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth.

UNIT XII

Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.

UNIT XIII

Nitrogen metabolism: Inorganic nitrogen species (N_2, NO_3 and NH_3) and their reduction to aminoacids, protein synthesis and nucleic acids.

Unit XIV

Lipid metabolism- Storage, protective and structural lipids. Biosynthesis of fattyacids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defence mechanism.

UNIT XV

Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role synthetic growth regulators, growth retardants., Apical dominanace, senescence, fruit growth, abscission.

UNIT XVI

Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering- Photoperiodism and Vernalisation.

Practical

Measurement of soil water status: Theory and principle of pressure plate apparatus, neutron probe, Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test. Theory and principle of pressure bomb, psychrometer and osmometer, Measurement of transpiration rate. Measurement of vapour pressure deficits, theory and principle of porometry, diffusion prometer and Steady state porometer, Stomatal physiology, influence of ABA on stomatal closing. Mineral nutrients: Demonstration of energy requirement for ion uptake. Deficiency symptoms of nutrients, Radiant energy measurements, separation and quantification of chlorophylls, O_2 evolution during photosynthesis, Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration, Respiration rates, Estimation of reducing sugars, starch. Estimation of NO_3, free aminoacids in the xylem exudates, quantification of soluble proteins. Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene. Demonstration of photoperiodic response of plants in terms of flowering.

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PP 502 PLANT DEVELOPMENTAL BIOLOGY – PHYSIOLOGICAL AND MOLECULAR BASIS 2+0

Objective

To explain about basic physiological and molecular processes concerning various facets of growth and development of plants.

Theory

UNIT I

Plant Biodiversity, Concept of evolution in plants.

UNIT II

General Aspects – Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth.

UNIT III

Seed Germination and Seedling Growth – Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth.

UNIT IV

Shoot, Leaf and Root Development – Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages.

UNIT V

Floral Induction and Development – Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination.

UNIT VI

Seed Development and Dormancy – Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy.

UNIT VII

Senescence and Programmed Cell Death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

UNIT VIII

Light Control of Plant Development – Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants

UNIT IX

Embryonic Pattern Formation – Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants.

UNIT X

Regeneration and totipotency; Organ differentiation and development; Cell lineages and developmental control genes in maize.

UNIT XI

Special Aspects of Plant Development and Differentiation – Pollen germination and pollen tube guidance; Phloem differentiation; Sex determination in plants;

UNIT XII

Self-incompatibility and its genetic control; Heterosis and apomixis.

Suggested Readings

Kabita Datta 2007. *Plant Physiology*. Mittal Publ.

Srivastava L.M. 2002. *Plant Growth and Development: Hormones and Environment.* Academic Press.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.
Wareing PF & Phillips IDJ. 1981. *Growth and Differentiation in Plants*. 3rd Ed. Pergamon Press.
Wilkins MB. 1969. *Physiology of Plant Growth and Development.* Tata McGraw-Hill.

PP 503 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES 2+1

Objective

To apprise the students regarding abiotic stress to plant and its molecular basis.

Theory

UNIT I

Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses.

UNIT II

Drought-characteristic features, Water potential in the soil-Plant air continuum. Development of water deficits, energy balance concept.

UNIT III

Transpiration and its regulation – stomatal functions.

UNIT IV

Physiological processes affected by drought. Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait.

UNIT V

Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products.

UNIT VI

Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.).

UNIT VII

High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's.

UNIT VIII

Chilling stress: Effects on physiological processes. Crucial role of membrane lipids.

UNIT IX

Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in – Glycophytes and halophytes, Breeding for salt resistance.

UNIT X

Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

Practical

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression, Determination of soil water potential and content by psychrometry and other systems. Stress imposition and quantification, Stress –stomatal conductance. Canopy temperature as a reflection of transpiration and root activity,Water use – efficiency, Determination at whole plant and single leaf level,Root- shoot signals-ABA and cytokinin effect on stomatal behavior, Heat tolerance and membrane integrity. Sullivans heat tolerance test, chilling tolerance-Galactolipase and free fatty acid levels as biochemical markers for chilling damage, Cold induced inactivation of O_2 evolution of chloroplasts- as a screening technique for chilling tolerance.

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PP 504 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT 2+1

Objective

To apprise the students about structure function of plant growth regulator on growth and development of plant.

Theory

UNIT I

Definition and classifiacation of palnt growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. tricontanol, Phenols – polyamines, jasmonates, concept of death hormone.

UNIT II

Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberlins, cytokinins, Abscisic acid and Ethylene Brassinosteroids.

UNIT III

Hormone mutants and transgenic plants in understanding role of hormones.

UNIT IV

Signal perception.transduction, and effect at functional gene level of different hormones- Auxins- cell elongation, Gibberellins -, germination of dormant seeds, cytokinins- cell division. Retardation of senescence of plant parts, Abscisic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening.

UNIT V

Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings-Flowering. Apical dominance, molecular aspects of control of reproductive growth and development.

UNIT VI

Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

Practical

Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue. Auxins- bioassays- auxins effect onrooting of cuttings, abscission, apical dominance, Gibberellins- bioassays-GA effect on germination of dormant seeds, cytokinin- bioassays- estimation using immunoassay technique cytokinin effect on apical dormance and senescence, ABA bioassays- estimation using immunoassay technique. ABA effect on somatal movement, Ethylene bioassays, estimation using physico chemical techniques- effect on breaking dormancy in sunflower and groundnut.

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C. 1992.*Plant Physiology.* 4th Ed. Wadsworth Publ.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PP 506 PHYSIOLOGY OF GROWTH AND YIELD AND MODELING 1+1

Objective

To impart knowledge regarding crop growth analysis and different yield prediction models.

Theory

UNIT I

Crop growth analysis, key growth parameters. Analysis of factors limiting crop growth and productivity- the concept of rate limitation

UNIT II

Phenology- Growth stages, internal and external factors influencing flowering. Photoperiodic and thermo-periodic responses and the concept of Degree days and crop growth duration.

UNIT III

Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI.

UNIT IV

Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning efficiency and harvest index.

UNIT V

Plant growth analysis techniques, yield structure analysis, theoretical and actual yields.

UNIT VI

Plant ideotypes,

UNIT VII

Simple physiological yield models- Duncan's. Monteith's, and Passioura's

UNIT VIII

Crop growth models-empirical models testing and yield prediction.

Practical

Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency HI, Measurement of light interception, light extinction

coefficient, energy utilization efficiency based energy intercepted, and realized, Computer applications in plant physiology, crop productivity and modeling.

Suggested Readings

Gardner FP, Pearce RB & Mitchell RL. 1988. *Physiology of Crop Plants*. Scientific Publ.

Goudriaan J & Van Laar HH. 1995. *Modelling Potential Crop Growth Processes.* (Textbook with Exercises) Series: *Current Issues in Production Ecology.* Vol. II. Kluwer.

Hunt R. *Plant Growth Curve - The Fundamental Approach to Plant Growth Analysis*. Edward Arnold.

John H, Thornley M & Johnson IR. *Plant and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology*. Blackburn Press.

Vos J, Marcelis LFM, Visser PHBD, Struik PC & Evers JB. (Eds.). 2007. *Functional-Structural Plant Modelling in Crop Production.* Vol. XXII. Springer.

PP 507 GENOME ORGANIZATION IN HIGHER PLANTS 2+1

Objective

To impart basic concept on genome organization in prokaryotic and eukaryotic system.

Theory

UNIT I

Introduction: Basic discoveries in molecular genetics; basic concepts on genome organization and its replication in prokaryotic systems including cyanobacteria; genome organization in diploids, tetraploids, autoptetraploids and polyploids.

UNIT II

Gene & gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokayotes; Promoters and terminators; Positive and negative control of transcription; Repression and activation-operon concept.

UNIT III

Mitochondrial and chloroplastic genome organization and regulation of gene expression.

UNIT IV

Eukaryotic genome structure: Organization and replication; control of gene expression-transcription and post-transcriptional; promoter analysis; concept of cis elements; transcription factors, function and role of RNA polymerases.

UNIT V

Genetic code and translation-deciphering the genetic code; Codon bias; tRNAs, ribosomes; Initiation and termination of translation; Translational and post-translational controls; Attenuation ; Suppressor tRNAs.

UNIT IV

Mobile genetic elements; Structure and function of transposable elements; Mechanism of transposition; Special features of retroptransposans; Repair and recombination.

Practical

Culturing and transformation of bacteria; genomic DNA and plasmid DNA isolation from bacteria, restriction enzyme digestion and analysis by agarose gel electrophoresis, isolation of genomic DNA and RNA from plants and quantification; Culture of bactriophage; studis on lytic and lysogenic phages.

Suggested Readings

Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts & Peter Walter. *Molecular Biology of the Cell*. 3rd Ed. Garland Science.

PP 508 MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION 2+1

Objective

To impart knowledge about cellular basic of growth and morphogenesis in plants.

Theory

UNIT I

Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation.

UNIT II

The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency.

UNIT III

Introduction to in vitro methods : Terms and definitions, Use of growth regulators, Beginning of in vitro cultures in our country (ovary and ovule culture , in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids.

UNIT IV

Introduction to the processes of embryogenesis and organogenesis and their practical applications : Clonal Multiplication of elite species (micropropagation) – axillary bud, shoot – tip and meristem culture. Haploids and their applications. Somaclonal variations and applications (treasure your exceptions).

UNIT V

Introduction to protoplast isolation : Principles and applications . Testing of viability of isolated protoplast . Various steps in the regeneration of protoplast . Somatic hybridization – an introduction, Various methods for fusing protoplast, chemical and electrical . Use of makers for selection of hybrid cells. Practical applications of somatic hybridization (hybrids vs cybrids)

UNIT VI

Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introdiuction to *A. tumefaciens*. Tumour formation on plants using *A. tumefaciens* (Monocots vs Dicots), Root – formation using *A.rhizogenes*

Practical

In vitro culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes; Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethlyne on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

Suggested Readings

Bajaj YPS. (Ed.). 1991. *Biotechnology in Agriculture and Forestry*. Vol. XIV. Springer-Verlag.

Rajdan MK. 1993. *Plant Tissue Culture*. Oxford & IBH.

PP 509 PHYSIOLOGY OF CROP PLANTS – SPECIFIC CASE STUDIES 2+0

Objective

To impart knowledge of physiological aspects of different crop plants.

Theory

UNIT I

Crop physiological aspects of rice, wheat, maize, sorghum, millets, sugarcane, pulses, oil seeds, cotton and potato Crops. Six to Eight Species could be chosen based on local importance.

UNIT II

Crop specific topics.

UNIT III

Seed dormancy, photoperiodic and thermoperiodic responses.

UNIT IV

Source-sink relationship, Yield structure and factors influencing yield, Nutrients and other resource requirements and crop specific features.

Suggested Readings

Gardner FP, Pearce RB & Mitchell RL. 1988. *Physiology of Crop Plants*. Scientific Publ.

Pessarakli M. *Handbook of Plant and Crop Physiology*. CRC Press.

Selected reviews and articles from Periodicals and Journals.

PP 510 PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS-CARBON AND NITROGEN ASSIMILATION 2+1

Objective

To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation.

Theory

UNIT I

Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere.

UNIT II

Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield.

UNIT III

Photosynthetic carbon reduction cycle and its regulation. CO_2 Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic macrophages (SAM), C_4, CAM and single celled C_4 organisms, C_3-C_4 intermediates. Ecological significance of CCM.

UNIT IV

Rubisco structure, assembly and kinetics, photorespiration and its significance.

UNIT V

Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of r_a, r_s and r_m. Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc.

UNIT VI

Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity – transgenics. Conceptual approaches of expressing C_4 photosynthesis genes in C_3 species.

UNIT VII

Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and no-photochemical quenching of chlorophyll fluorescence. Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept.

UNIT VIII

Prospects of improving photo synthetic rate and productivity – potential traits of photosynthesis- biotechnological approaches.

UNIT IX

Nitrogen assimilation in photosynthesizing cells – NO_3^-, NO_2^- reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its re-assimilation and NUE.

Practical

Extraction and separation of plant pigments, Isolation of chloroplasts ETC reactions- O_2 evolution, Determination of rubisco content (western and ELISA), activity and activation state, Enzymatic determination of starch and sucrose, Determination of photosynthetic rates –gas exchange. A, g_s, C_i, A/g_s, C/g_s- intrinsic WUE by gas exchange rates. Light, CO_2, VPD response curves, Determination of photorespiration by gas exchange- (TPS-APS). Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception, Determination of NH_4^+, reduction of inorganic nitrogen species.

Suggested Readings

Edwin Oxlade & Graham Lawler (year). *Plant Physiology: The Structure of Plants Explained.* John Wiley & Sons.

Hopkins WG & Huner NPA.2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C.1992. *Plant Physiology.* 4th Ed. Wadsworth Publ.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PP 511 MINERAL NUTRITION 2+1

Objective

To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation

Theory

UNIT I

Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system.

UNIT II

Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity.

UNIT III

Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation.

UNIT IV

Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels.

UNIT V

Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Iron and Zinc efficient crop varieties.

UNIT VI

Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

Practical

Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities.

Suggested Readings

Barker AB & Pilbeam DJ. 2007. *Handbook of Plant Nutrition*. CRC Press.

Epstein E. 2007. *Mineral Nutrition of Plants*. John Wiley & Sons.

Marschner H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press.

PP 601 FUNCTIONAL GENOMICS AND GENES ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES 2+0

Objective

To impart knowledge about physiological process of plant at molecular level.

Theory

UNIT I

Gene discovery: Finding Genes in Complex Plant System, Constructing Gene-Enriched Plant Genomic Libraries, In Silico Prediction of plant Gene Function, Quantitative Trait Locus Analysis as a Gene Discovery Tool.

UNIT II

Genetic tools for plant development- Understanding the importance of mutants in unraveling the physiological processes – T-DNA insertion mutants, Gain in function, Transposon mutagens, Transposition, Physical and Chemical mutagenesis, Gene and Enhancer Traps for Gene Discovery, High-Throughput TAIL-PCR as a Tool to identify DNA Flanking insertions, High-Throughput TILLING for functional Genomics.

UNIT III

Gene knock out approaches: Antisense technology, Virus induced gene silencing (VIGS), Custom Knock-outs with Haripin RNA-mediated Gene Silencing and other silencing tools, Complementation studies, DNA micro arrays.

UNIT IV

Gene Over expression approaches: Vector Construction for Gene Overexpression as a Tool to Elucidate Gene Function; Transient expression, Transgenics.

UNIT VI

Proteomics: Networking of Biotechnology for interpreting gene functions. Yeast two hybrid systems to study protein –protein interaction to study gene functions, Proteomics as a Functional Genomics Tool, Crystallographic and NMR approaches to determine protein structures.

UNIT VII

Functional characterization of genes associated with important cellular processes influencing crop growth and development.

UNIT VIII

Case studies of genes controlling photosynthesis, respiration, photorespiration, fatty acid biosynthesis, nutrient uptake, flowering, seed protein quality and quantity.

Suggested Readings

Selected articles from various journals

PP 602 SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES 2+0

Objective

To impart the knowledge about signal ling of hormones and regulation of physiological processes.

Theory

UNIT I

General aspects: Introduction to signaling-Long range (Diffusible) signaling and short range (contact) signaling. Components of signaling-Upstream components: receptor and ligands concept-types of ligands and its relevance-receptor kinases-Two component sensing system. Down stream components: G. proteins-second messengers-Cyclic AMP, adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-Kinases-Effector molecules (transcription factor).

UNIT II

Hormone signaling: Hormone binding receptors-Transduction process. Effector molecules and gene expression.

UNIT III

Specific signaling pathways of Auxins, Cytokinisn, Gibberllins, Ethylene, ABA, Brassinosteroids which leads to formative effects. The cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

UNIT IV

Light signaling: Perception of light-pigments involved-activation of phytochrome/cryptochrome (study of mutants). Light signal transduction-Multiple signaling cascades-identification of signaling components through mutant analysis-changes in gene expression.

UNIT V

Abiotic stress signaling: Sensing of environmental factors (Temperature-Osmoticum-Ionic stress) Activation of specific molecules and secondary messengers-Activation of Down stream components-leading to stress gene expression. Case studies with different abiotic stresses.

UNIT VI

Cross talk between signaling pathways.

UNIT VII

Signal perception and transduction in plant defense responses: Role of salicylic acid and active oxygen species.

UNIT VIII

Signaling cascade during leaf senescence, abscission, flowering and tuberisation

UNIT IX

Transcription factor as signaling regulatory tools for improving growth processes-Case studies: Tbi- lateral branch development, Shi 4- grain shattering, GA1- Dwarfing.MADS, KNOX- flowering development, HAT 4- Shade development, AP2-EREBP- biotic/abiotic stresses.

Suggested Readings

Selected articles from various journals.

PP 603 MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS 2+1

Objective

To impart knowledge to improve the physiological traits using molecular approaches.

Theory

UNIT I

Importance of Molecular Breeding for complex multi-gene controlled physiological traits and its relevance in augmenting trait based breeding. Physiological traits with relevance to growth, development, abiotic stress tolerance, nutrient acquisition, Approaches for accurate phenotyping of large germplasm accessions and/or mapping populations.

UNIT II

The advantages of “Trait based” breeding approaches. Concept of segregation, independent assortment and linkage. The concept of molecular markers, various types of Dominant and Co-dominant marker systems.

UNIT III

Relevance and development of mapping populations and genetic analysis using marker systems. Advantages of association mapping and the concept of linkage, LD decay and population structure.

UNIT IV

Statistical analysis to assess the variance in phenotypic traits and molecular data. Assessment of genetic parameters such as heritability, genetic advance etc.

UNIT V

Strategies for QTL introgression and Marker Assisted Selection (MAS). Map based cloning of novel genes and alleles. Allele mining

UNIT VI

Transgenic approach in improving physiological processes- Introduction to GMOs and application in crop improvement; gene mining, sequence structure & function analysis using bioinformatics tools, identification of candidate genes for various physiological process associated with specific traits (such as stress tolerance) and their potential benefits in transgenic crops.

UNIT VII

Cloning full-length candidate genes, stress inducible promoters, strategies to clone and characterize and make constructs for specific crops, gene stacking strategies, tissue specific expression and functional validation of genes.

UNIT VIII

Transformation of crop plants-*Agrobacterium* and use of other organisms for transformation-particle gun transformation and other methods.

UNIT IX

Selection of transformants- molecular analysis on the basis of qRT-PCR, Southern, Northern analysis and immunoassays; estimation of copy number. Concept of desirable number of independent events.

UNIT X

Evaluation of transgenics on basis of empirical/physiological/biochemical process under specific conditions on the basis of gene function. Generation of T1 populations, event characterization and generation of molecular data as per the regulatory requirements.

UNIT XI

Issues related to Biosafety and Registration of Transgenic Agricultural Organisms, methods to detect GMOs from agricultural products.

Practical

Phenotyping approaches for the different physiological traits. Genotyping options using gene-scan systems. Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping using a DNA sequencing machine, scoring of gels and assessment of polymorphism, Statistical approaches to assess genetic variability, heritability and other parameters, Phylogenic analysis, Principal component analysis and construction of dendrograms. Construction of Linkage map, QTL maps, population structure, LD decay etc leading to identification of QTLs, Bioinformatics – sequence analysis, structure analysis, Molecular biology - genomic/plasmid DNA isolation, RNA

isolation. Full-length gene cloning, vector construction with specific promoter, gene stacking & transient assays. Transformation in model system,Crop transformation - *Agrobacterium* mediated transformation (in-planta & invitro), particle-gun transformation, Evaluation of transgenics – semiquantitative & quantitative RT-PCR, southern blot, northern blot, western blot and ELISA, biochemical/physiological assay based on the function of gene & testing LOD.

Suggested Readings

Selected articles from various journals.

PP 604 TECHNIQUES IN PLANT PHYSIOLOGY 1+2

Objective

To impart recent practical training to study various physiological processes in plants.

Theory

UNIT I

Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO2 response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements.

UNIT II

Estimation of water use efficiency at whole plant and single leaf level. Use of stable isotopes to understand physiological processes.

UNIT III

Radio isotopes in plant biology.

UNIT IV

Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants, such as (a) DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays; (b) techniques for defined physiological processes.

UNIT V

Methods to phenotype germplasm for specific physiological traits.

UNIT VI

Quantification of mineral nutrients using advanced instruments like AAS, & ICP.

UNIT VII

Techniques in plant transformation & analysis of transgenic plants

UNIT VIII

Molecular markers- genetic distance and mapping population concept of linkage maps and identification of QTLS.

UNIT IX

Instrumentation: Acquaintance of the operation of specific instruments important in physiological research like Mass spec., phosphor-imager, DNA sequencer, spectro-fluorometer, oxygen electrode, etc.

Practical

Photosynthetic gas exchange measurements, light and CO2 response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements. Estimation of water use efficiency at whole

plant and single leaf level. Use of stable and radioactive isotopes to understand physiological processes. DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays; techniques for defined physiological processes, Quantification of mineral nutrients using advanced instruments like AAS.

Suggested Readings

Dhopte MA & Manuael Livera M. 1986. *Useful Techniques for Plant Scientists*. Forum for Plant Physiologists, R. D. G., Aloka.

PP 605 CLIMATE CHANGE AND CROP GROWTH 2+0

Objective

To impart knowledge about climate change and its implication to crop growth.

Theory

UNIT I

History and evidences of climate change and its implications. Effect of climate change on monsoons, hydrological cycle and water availability.

UNIT II

Natural and anthropogenic activities and agricultural practices on GHG production, Monitoring of greenhouse gases and their influence on global warming and climate change, Ozone depletion leading to increased ionizing radiations and its implications on crop growth.

UNIT III

Long-term and short-term projections of climate change effects on natural vegetations and ecosystems, crop-pest interaction, area shift, food production and supply.

UNIT IV

Approaches to mitigate climate change through studies on plant responses.

UNIT V

Direct and indirect effects of climate change on plant processes – phenology, net carbon assimilation, water relations, grain development and quality, nutrient acquisition and yield.

UNIT VI

Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of "Genome wide mutants" to identify genes/processes for improved adaptation to changing environments

UNIT VII

International conventions and global initiatives on Carbon sequestration, carbon trading.

Suggested Readings

Abrol YP & Gadgil S. (Eds.). 1999. *Rice in a Changing Climate*.

Reddy KR & Hodges HF. 2000. *Climate Change and Global Crop Productivity*. CABI.

Watson RT, Zinyowera MC & Moss RH. 1998. *The Regional Impacts of Climate Change - an Assessment of Vulnerability*. Cambridge Univ. Press.

PP 606 POST HARVEST PHYSIOLOGY 2+0

Objective

To impart knowledge about physiological changes during senescence and ripening.

Theory

UNIT I

Environmental factors influencing senescence, ripening and post harvest life of flowers, vegetables and seeds.

UNIT II

Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening.

UNIT III

Senescence associated genes and gene products.

UNIT IV

Functional and ultrastructural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening.

UNIT V

Regulatory role of ethylene in senescence and ripening, ethylene biosynthesis, perception and molecular mechanism of action.

UNIT VI

Post harvest changes in seed and tubers biochemical constituent's quality parameters. Effect of environmental factors on post harvest changes in seed and tubers.

UNIT VII

Biotechnological approaches to manipulate ethylene biosynthesis and action.

UNIT VIII

Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life of flowers and fruits.

UNIT IX

Uses of GM crops and ecological risk assessment.

Practical

Physiological and biochemical changes during senescence and ripening, Estimation of ethylene during senescence and ripening, determination of Reactive Oxygen Species and scavenging enzymes, Measurement of dark and alternate respiration rates during senescence and ripening. Estimation of ripening related enzyme activity, Cellulases pectin methyl esterases, polygalacturonase etc.

Suggested Readings

Jeffrey K Brecht & Weichmann J. 2003**.** *Post Harvest Physiology and Pathology of Vegetables.* CRC Press.

PP 607 WEED PHYSIOLOGY AND HERBICIDE ACTION 1+1

Objective

To apprise students regarding weed and crop competition, and physiological and molecular aspects of herbicides.

Theory

UNIT I

Weed biology, ecology and physiology. Weed and crop competition, allelo-chemicals, their nature and impact. Weed-seed physiology.

UNIT II

Classification of herbicides and selectivity. Recent concepts on entry, uptake, translocation and metabolism of soil and foliar applied herbicides.Environmental and plant factors influencing entry, uptake and translocation of herbicides.

UNIT III

Classification and chemistry of common herbicides. Physiological, biochemical and molecular mechanism of action of different groups of herbicides; ACC synthase inhibitors, ALS inhibitors, Mitotic inhibitors, Cellulose biosynthesis inhibitors, Inhibitors of fatty acid biosynthesis, inhibitors of Photosynthesis, Auxinic Herbicides, New herbicides,

UNIT IV

Metabolic pathway of herbicide degradation in plants and soil. Herbicide adjuvants and their classification.

UNIT V

Molecular mechanism of action of herbicide synergists and antagonists.

UNIT VI

Physiological and molecular mechanism of herbicide selectivity.

UNIT VII

Herbicide resistant crops; transgenic & tissue culture approaches to develop herbicide tolerant varieties

Practical

Adjuvants and their effect on spray droplets, chemical entry and transport. Determination of physiological and biochemical processes like photosynthesis, respiration, cell division, Protein & fatty acid synthesis, membrane permeability as affected by herbicides. Quantification of pigment levels in leaves, specific enzyme activities affected by herbicides. Demonstration of translocating type of herbicides by radio labeling studies.

Suggested Readings

Devine MD, Duke SO & Fedtake C. 1993. *Physiology of Herbicide Action*. Prentice Hall.

Monaco TJ, Weller SC & Ashton FM. 2002. *Weed Science - Principles and Practices*. Wiley.com Publ.

PP 608 SEED PHYSIOLOGY 2+1

Objective

To apprise students regarding seed germination, dormancy and physiological processes involved in regulation of seed development

Theory

UNIT I

Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development.

UNIT II

Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion.

UNIT III

Structure of seeds and their storage resources, seed developmental patterns and source of assimilates for seed development.

UNIT IV

Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats in seeds and their biosynthesis.

UNIT V

Seed respiration, mitochondrial activity, Seed ageing, Mobilization of stored resource in seeds, Chemistry of oxidation of starch, proteins and fats, Utilization of breakdown products by embryonic axis.

UNIT VI

Control processes in mobilization of stored resources, Role of embryonic axes, Gibberllin and a-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins.

UNIT VII

Seed viability, Physiology of and means to prolong seed viability, Seed vigour: concept, importance, measurement; invigoration: methods and physiological basis of it, Seed dormancy, types and regulation, Means to overcome seed dormancy.

Practical

Determination of seed storage proteins, Sink drawing ability of ovules, empty ovule technique, Alpha-amylase activity in germinating seeds, Role of GA in inducing amylase activity, Role of embryo in GA induced a-amylase activity, Protease and lipase activity in germinating seeds, Seed viability test and accelerated ageing test. Seed hardening/osmotic priming of seeds, Seed respiration rates, Seed viability losses through membrane leakage studies.

Suggested Readings

Bewley JD & Black M. 1985. *Seed Physiology of Development and Germination*. Plenum Publ.

Copeland LO & McDonald MB**.** *Principles of Seed Sciences and Technology*. Burgers Publ. Co.

Srivastav L M. Plant Growth and Development - Hormones and Environment, Academic Press.

PLANT PHYSIOLOGY
List of Journals

- American Journal of Botany
- Annals of Arid Zone
- Annual Review of Plant Physiology and Plant Molecular Biology
- Australian Journal of Agricultural Research
- Australian Journal of Biological Sciences
- Australian Journal of Botany
- Australian Journal of Plant Physiology
- Biochemie und Physiologie der Pflanzen
- Biologia Plantarum
- Botanical Gazette
- Botanical Review
- Canadian Journal of Agricultural Research
- Canadian Journal of Botany
- Canadian Journal of Plant Science
- Communications in Soil Science and Plant Analysis
- Current Science
- Environmental and Experimental Botany
- Euphytica
- Experimental Agriculture
- Experimental Cell Biology
- Functional Plant Biology
- Indian Journal of Agriculture
- Indian Journal of Experimental Biology
- Indian Journal of Plant Physiology
- International Journal of Botany
- Japanese Journal of Crop Science
- Journal of Agricultural and Scientific Research
- Journal of Agricultural Science
- Journal of Arid Environment
- Journal of Experimental Botany
- Journal of Plant Biology
- Journal of Plant Nutrition
- Nature
- New Physiologist
- Physiologia Plantarum
- Physiology and Molecular Biology of Plants
- Plant and Cell Physiology
- Plant and Soils
- Plant Cell, Tissue and Organ Culture
- Plant Growth Regulator abstracts
- Plant Physiology and Biochemistry
- Plant Science
- Plant Science (India)

- Science Journal
- Seed Science and Technology
- Seed Science Research
- Soil Science and Plant Nutrition
- Soviet Plant Physiology
- Trends in Plant Science
- Tropical Agriculture

e-Resources

- www.Bioone Online Journals The Arabiopsis Book.
- www. Botany on line:
- www.Ingenta Connect Physiologia Plantarum
- www.new.phytologist.org.
- www.plant physiol.org.
- www.mpiz-Kolen.mpg.de.
- www.Science Direct.
- www.Scientia Agricolo.
- www.wiley interscience.

Suggested Broad Topics for Master's and Doctoral Research

- Environmental stress physiology- Salt, Drought, Heat, Freezing, and Heavy Metal
- Nodulation and nitrogen fixation in leguminous plants
- Physiology of senescence and abscission in crop plants especially in cotton
- Phytoremediation, especially with reference to salt and heavy metal stress
- Ecophysiology of tree species to evaluate bio-drainage potential of plants under waterlogged saline area
- Growth and development of crop plants
- Mineral nutrition in crop plant
- Application of plant growth regulators to improve crop productivity
- Photosynthesis, respiration and related processes for crop improvement

COMPULSORY NON-CREDIT COURSES

(Compulsory for Master's programme in all disciplines; Optional for Ph.D. scholars)

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	0+1
PGS 503 (e-Course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-Course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-Course)	DISASTER MANAGEMENT	1+0

Course Contents

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.

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.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively*. MacMillan India.

Richard WS. 1969. *Technical Writing*. Barnes & Noble.

Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.

Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.

Wren PC & Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

PGS 503 (e-Course) **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 bio-diversity 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.

Suggested Readings

Erbisch FH & Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.

Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

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

Suggested Readings

Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.

Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

PGS 505 (e-Course) **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, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS & Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.

Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.

Singh K.. 1998. *Rural Development - Principles, Policies and Management.* Sage Publ.

PGS 506 (e-Course) **DISASTER MANAGEMENT** **1+0**

Objectives

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

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 wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters 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.

Suggested Readings

Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.

Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.