

DEPARTMENT OF ZOOLOGY

Toxicology Programme
Ch. Charan Singh University
Meerut

Prescribed syllabus for M.Sc. degree in Toxicology w.e.f. July, 2009

Duration of the programme (2 years) : 4 Semesters

Number of proposed courses : 16

Courses to be taught in each semester : 4 + Practical

Ist Semester

1. Principles of toxicology
2. Environmental toxicology
3. Systemic toxicology
4. Cell and molecular biology

Practical exercises based on these courses

IIInd Semester

5. Molecular and immunotoxicology
6. Biochemical toxicology
7. Environmental and chemical carcinogenesis
8. Biochemistry

Practical exercises based on these courses

IIIrd Semester

9. Toxicology of heavy metals
10. Toxicology of pesticides and insecticides
11. Toxicology of organic solvents and dyes
12. Human physiology

Practical exercises based on these courses

IVth Semester

13. Analytical toxicology
14. Applied toxicology
15. Occupational and industrial toxicology
16. Biostatistics and Bioinformatics

Practical exercises based on these courses

PRACTICAL

Ist Semester – 50 + 50

IIInd Semester - 50 + 50

IIIrd Semester – 50 + 50

IVth Semester – 50 + 50

Summer/Industrial Training

Course 1:

PRINCIPLES OF TOXICOLOGY

- Unit I** : Definition, history, scope & sub-divisions of toxicology.
- Unit II** : Dose-effect and dose-response relationship- acute toxicity, chronic toxicity reversible & irreversible effects.
- Unit III** : Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins.
- Unit IV** : Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms.
- Unit V** : Absorption and distribution of toxicants-portals of entry-skin, gastro intestinal tract, gills and respiratory system.
- Unit VI** : Bio-distribution, biomagnification biotransformation of xenobiotics- brief introduction to Phase-I and Phase-II reactions.
- Unit VII** : Reactions of toxins with target molecules- Covalent binding, Non-covalent binding, Hydrogen abstraction, Electron transfer, Enzymatic reactions
- Unit VIII** : Elimination of toxicants-renal, hepatic, DMES, pulmonary systems, milk, egg and foetus.

Course 2:

ENVIRONMENTAL TOXICOLOGY

- Unit I** : Environmental pollution- Sources and types of pollution, Important pollution events, Priority pollutants
- Unit II** : Ecotoxicology- Examples of ecotoxicology, Scientific approach to ecotoxicology, Entry, movement, and fate of pollutants in ecosystems
- Unit III** : Air pollution- Classification and properties of air pollutants, Behaviour and fate of air pollutants, Photochemical smog, Acid Rain, health effects of air pollution
- Unit IV** : Water pollution- Origin of Wastewater, Domestic Water Pollution, Industrial water pollution, Agricultural water pollution, Toxic water pollutants and their health effects, Groundwater pollution, marine pollution
- Unit V** : Radioactive pollution- Sources of exposure to radiation, Biological effects of radiation, Famous accidents of radioactive pollution
- Unit VI** : Noise pollution- Sources of noise pollution, Industrial noise pollution, domestic noise pollution, traffic noise, other sources of noise pollution, Effects of noise pollution in man
- Unit VII** : Solid waste pollution- Sources and classification, Public health aspects
- Unit VIII** : Soil and land pollution- Heavy metal contamination, Industrial soil pollutants, agricultural soil pollution, petroleum products as soil pollutants

Course 3:
SYSTEMIC TOXICOLOGY (ORGAN TOXICITY)

- Unit I** : Basics of organ toxicity- Target organs, Organ selectivity and specificity
- Unit II** : Cutaneous toxicology- Structure of the skin, Functions of the skin, Dermatological effects of toxic agents, Allergic contact dermatitis, Cutaneous carcinogenesis
- Unit III** : Pulmonary toxicity- Structure of the lung, Lung injury, Systematic lung toxins, Lung pathology
- Unit IV** : Hepatic toxicity- Anatomy and physiology of the liver, Organization of the hepatic parenchyma, Other cell types of the liver, Actions of toxins on the liver, Chronic liver injury
- Unit V** : Renal toxicity- Renal structure and functions, susceptibility of kidney to toxic insult, chemically induced renal injury
- Unit VI** : Neurotoxicity- Cell types in the nervous system, Effect of toxic agents on neurons, axonopathy, myelinopathies, Ion channel neurotoxins, Convulsants, Lesions of specific neurons
- Unit VII** : Cardiotoxicity- Cardiac structure and function, Cardiac contraction, pathology of cardiac toxicity, mechanisms of cardiotoxicity
- Unit VIII** : Reproductive and endocrine toxicity – Teratogenicity, Reproductive organs, Chemicals affecting reproduction, General idea of endocrine glands, Toxicity to adrenal glands, Thyroid glands and Pancreas.

Course 4:
CELL AND MOLECULAR BIOLOGY

- Unit I** : Introduction to the cell, cell theory, ultrastructure of the cell, prokaryotic vs eukaryotic cells, organization of eukaryotic cells, cell cycle
- Unit II** : Cell membrane- Theories on the structure of biomembrane, organization of lipids & proteins, specific membrane proteins, cyto skeleton of plasma membrane, functions of plasma membrane (transport, diffusion, active transport, pumps, uniports, symports and antiports).
- Unit III** : Cytoskeleton, structure and dynamics of microtubules, actin filaments (microfilaments), intermediate filaments, cilia & flagella, role of kinesin and dynein.
- Unit IV** : Cell organelles – Origin, structure and function of mitochondria, endoplasmic reticulum, Golgi complex, ribosomes, endosome, lysosomes, peroxysomes, centrosome
- Unit V** : The nucleus- Nuclear envelope, nucleolus, chromosomes, type, structure and chemical composition of chromosomes, organization of genes and noncoding DNA.
- Unit VI** : Cell communication- Cell-cell signaling, cell surface receptors, second messenger system, MDP kinase pathways, signaling from plasma membrane to nucleus.
- Unit VII** : Cell adhesion & cell junctions- cellular affinity, cell adhesion molecules (CAMs), Ca⁺⁺ dependent cell-cell adhesion, Ca⁺⁺ independent cell-cell adhesion, cadherins, selectins, integrins, cell junctions.
- Unit VIII** : Cell division- Mitotic & meiotic cell division, the central cell cycle control system, feedback signals, cyclin dependent kinases (Cdks) regulation of Cdks

Course 5:
MOLECULAR AND IMMUNOTOXICOLOGY

- Unit I** : A brief idea of cellular macromolecules, covalent adducts to macromolecules, cellular heterogeneity within the tissues, interrelationships in the synthesis of macromolecules.
- Unit II** : DNA synthesis, modification of DNA metabolism by toxicants, toxicological consequences of DNA alkylation, RNA synthesis, modification of RNA metabolism by toxicants.
- Unit III** : Proteins synthesis, modification and inactivation of proteins, modification of protein metabolism by toxicants.
- Unit IV** : Introduction to gene expression changes, toxicogenomics, toxicoproteomics and metabolonomics.
- Unit V** : Introduction to immunology: Basics of the immune system, structure and function of primary and secondary lymphoid organs, structure and function of immunoglobulins, MHC molecules, introduction to compliments.
- Unit VI** : Immunotoxicity: Mechanisms of immuno-toxicity, immuno-suppression, direct effects of xenobiotics, indirect effects of xenobiotics, immune mediated diseases, immunotoxicity of lead, immunotoxicity of TCDD.
- Unit VII** : Immunotoxicity in animals: Invertebrate, immunotoxicology, vertebrate immunotoxicology, mammalian immunotoxicology.
- Unit VIII** : Allergy and hyper sensitive reactions: Allergy to chemicals and proteins, respiratory allergy and occupational asthma, chemical allergy, food allergy, drug allergy (Penicillin and Halothane), idiosyncratic reactions and danger hypothesis.

Course 6:
BIOCHEMICAL TOXICOLOGY

- Unit I** : Mechanisms of toxicity-I – Delivery, Absorption, Distribution and Excretion of xenobiotics
- Unit II** : Mechanisms of toxicity-II – Reaction of toxicants with target molecules, Cellular dysrepair and repair mechanisms
- Unit III** : Lipid peroxidation – Introduction to the process of lipid peroxidation, ROS & RNS, Mechanism of reactive oxygen species production, The key role of super oxide anion radical, Hydrogen peroxide and hydroxyl radicals in toxicity of xenobiotics
- Unit IV** : Oxidative stress – Definition of oxidative stress, Toxicological consequences of oxidative stress, Oxidative stress and protein damage, Oxidative stress and DNA damage, Oxidative stress and lipid damage
- Unit V** : Antioxidative defence mechanisms – Enzymatic and Non enzymatic antioxidants, Role of glutathione, Superoxide dismutase, Metallothionein and α -tocopherol as antioxidants
- Unit VI** : Disturbances in calcium homeostasis – Xenobiotic-induced alterations in intracellular calcium distribution, Toxicological consequences of increased intracellular calcium concentrations
- Unit VII** : Disruption of cellular energy production – Microcondrial targets, Protonophoretic and uncoupling activity of xenobiotics, Inhibition of NADH production, Inhibition of electron transport change, Change in microcondrial membrane permeability
- Unit VIII** : Necrotic and apoptotic cell death – Mechanisms of necrosis, Mechanisms of Apoptosis

Course 7:

ENVIRONMENTAL AND CHEMICAL CARCINOGENESIS

- Unit I** : Historical background- Environmental pollution and carcinogens, General characteristics of carcinogens
- Unit II** : Types of Carcinogens- Direct acting carcinogens, Pro carcinogens and co carcinogens, Epigenetic carcinogens
- Unit III** : Genotoxicity- DNA interaction, DNA adducts & mutations, DNA repair, oncogene & tumor suppressor genes, telomerase
- Unit IV** : Mechanism of chemical carcinogenesis- Role of somatic mutation, Initiation and Promotion, Proliferation, The Miller and Miller theory
- Unit V** : Human inorganic carcinogens- Arsenic, asbestos and chromium mechanism of their actions
- Unit VI** : Organic carcinogenesis- Polycyclic hydrocarbons, Polycyclic aromatic hydrocarbons, Alkalyting carcinogens, N-nitroso compounds mechanism of their actions
- Unit VII** : Oncogenes- Viral and cellular oncogenes, Mechanisms of Oncogene activation by retroviruses, Oncogene activation by Leukemia viruses, Target Oncogenes in Chemical carcinogenesis
- Unit VIII** : Persistence of DNA, damage in relation to carcinogenesis, Assay of chemical carcinogens in mammalian systems, transgenic animal models in carcinogenesis, AMES test

Course 8:

BIOCHEMISTRY

- Unit I** : Thermodynamics principles and steady-state conditions of living organisms, storage and utilization of biological energy, energy metabolism-redox potentials, mitochondrial electron transport chain, oxidative phosphorylation, glycolysis & citric acid cycle
- Unit II** : Biochemistry of the cell- Macromolecules- carbohydrates, fatty acids, amino acids, nucleotides & lipids; Micromolecules-nucleic acids, proteins & polysaccharides
- Unit III** : Proteins- Biosynthesis of proteins, primary, secondary, tertiary and quaternary structure of proteins, globular and fibrous proteins. Protein folding and thermodynamics, Amino acids & peptides
- Unit IV** : Protein-ligand, protein-protein, nucleic acid protein, and nucleic acid-ligand interactions, extracellular matrix proteins
- Unit V** : Nucleic acid- Structure-I. Duplex stability, hybridization, RNA structure, hairpin and pseudoknot structures of RNA
- Unit VI** : Nucleic acid- Structure-II. DNA & RNA helical geometries (A-Z), bending, deformation, triplexes, quadruplexes, interaction of nucleic acids with small molecules transaction & translation, metabolism of nucleotides
- Unit VII** : Lipids- Classification, structure and function, synthesis of fats & fatty acids, synthesis of prostaglandin & leukotrenes, regulation of lipid metabolism
- Unit VIII** : Carbohydrates- classification-structure & function of carbohydrates, synthesis of glucose of glycogen, regulation of carbohydrate metabolism.

Course 9:

TOXICOLOGY OF HEAVY METALS

- Unit I** : Introduction to Bioinorganic Chemistry, Definition of trace element, Nutritionally required trace elements, Non-nutritive trace elements as environmental contaminants
- Unit II** : Mechanisms of heavy metal toxicity- Induction of metallothionein, heat shock proteins, cyto skeletal effects, heme porphyrin metabolism, lipid peroxidation
- Unit III** : Toxicity of trace elements- Iodine, iron, zinc, copper, manganese, selenium, molybdenum, and cobalt
- Unit IV** : Cyto-toxicity of heavy metals- Cadmium, mercury, arsenic, chromium and lead
- Unit V** : Ecotoxicology of heavy metals- Case studies of arsenic, mercury and cadmium
- Unit VI** : Carcinogenicity and genotoxicity of heavy metals, arsenic & chromium
- Unit VII** : Metal- Ligand interactions in biological fluids, metal ion interactions with macromolecules
- Unit VIII** : Metal protein interaction, metal nucleic acid interactions

Course 10:

TOXICOLOGY OF PESTICIDES AND INSECTICIDES

- Unit I** : Introduction to pesticides, general classification of pesticides, herbicides fungicides, insecticides, pesticides in the environment, bio-magnification of pesticides
- Unit II** : Fundamentals of pesticide toxicity- Reproductive & developmental effects, carcinogenicity, immunological effects
- Unit III** : Environmental problems by organochlorine pesticides- Case studies of DDT, endosulphan, benzene hexachloride (Lindane)
- Unit IV** : Environmental problems by organophosphate pesticides- Case studies of parathion, and malathion
- Unit V** : Neurotoxicity of pesticides- Neuropathy
- Unit VI** : Toxicity of pesticides in fish, birds and poultry
- Unit VII** : Toxicity of pesticides in wild animals, bioindicators of pesticide exposure
- Unit VIII** : Toxicity of pesticides in man- Case studies, Handigodu syndrome, BHC poisoning in Turkey, and endosulphan toxicity in Kerala

Course 11:
TOXICOLOGY OF ORGANIC SOLVENTS AND DYES

- Unit I** : General principles of solvent toxicity- Nature of toxic effects, neuro toxic effects, Hepato toxic effects, Reno toxic effects
- Unit II** : Metabolism of organic solvents- Enzyme induction and metabolic interactions
- Unit III** : Toxicity of aliphatic solvents- Carbon tetrachloride, chloroform, trichloroethylene, tetrachloroethylene
- Unit IV** : Toxicity of aromatic hydro carbons- Benzene, Toluene, Xylene, Styrene
- Unit V** : Toxicity of alcohols- Ethyl alcohol, Methyl alcohol, Isopropyl alcohol
- Unit VI** : Toxicity of food additives- Polycyclic hydrocarbons, Hydrocyclic amines, Nitrosoamines, Natural contaminants, Synthetic carcinogens
- Unit VII** : Toxicity of dyes- Azo dyes, Fluorescent dyes, Natural colours
- Unit VIII** : Biological monitoring, toxicity of solvent mixtures, haematotoxicity

Course 12:
HUMAN PHYSIOLOGY

- Unit I** : Introduction, aims and scope of physiology, general physiological principles & functions, pH, pK, acids, bases, buffers, osmosis, diffusion.
- Unit II** : Blood & lymph- Erythropoiesis, types of blood cells, blood groups, blood coagulation & blood pigments, anemia, polycythemia
- Unit III** : Circulation- blood circulatory system, the heart, arterial & venous systems, factors affecting blood flow, cardiac cycle, cardiac failure, the lymphatic system
- Unit IV** : Respiration- Pulmonary ventilation, pulmonary circulation physical exchange of gases, regulation of respiration, respiratory insufficiency
- Unit V** : Digestion- Gastro intestinal system, secretory function, digestion & absorption in the gastrointestinal tract, gastrointestinal disorders
- Unit VI** : Excretion & osmoregulation- structure of kidney, glomerular filtration, urine formation, acid-base balance, ornithine cycle, renal diseases
- Unit VII** : Muscular system- types of muscles ultra structure of muscles, contraction of skeletal muscle, contraction & excitation of smooth muscle
- Unit VIII** : Nervous system- Organization of nervous system, sensory receptors, synapse, physiology of nerve impulse transmission

Course 13:
ANALYTICAL TOXICOLOGY

- Unit I** : Laboratory animals- Animal environment, Animal husbandry, Animal care & maintenance accreditation, CPCSEA
- Unit II** : Histopathology- Fixation, dehydration, clearing, embedding, microtomy and staining
- Unit III** : Microscopy- Light microscopy, Interference microscopy, Polarization microscopy, Electron microscopy, Confocal microscopy
- Unit IV** : Centrifugation- Principles of centrifugation, Types of centrifuges, ultracentrifugation, Applications of centrifugation
- Unit V** : Spectrophotometry- Beer-Lambert relationship, Instrumentation, Applications of spectrophotometry, Atomic absorption spectrophotometry
- Unit VI** : Chromatography- Adsorption chromatography, thin layer chromatography, Paper chromatography, High performance liquid chromatography (HPLC), Gas- liquid chromatography their applications
- Unit VII** : Electrophoresis- Introduction to electrophoresis, Instrumentation, Electrophoresis of proteins, Electrophoresis of enzymes, Isoelectric focusing, Isotachophoresis, Southern, northern & western blotting
- Unit VIII** : Radiological techniques- Radioimmuno assay (RIA), ELISA- competitive ELISA, indirect ELISA, sandwich ELISA, applications of ELISA

Course 14:

APPLIED TOXICOLOGY

- Unit I** : Regulatory toxicology, Regulatory agencies, Regulation of Industrial chemicals in USA and EU, Regulation of pesticides, regulation of pharmaceuticals, regulation of food additives
- Unit II** : Cosmetic toxicology- Toxicity of shampoos, conditioners, bleachers, dyes, allergic and respiratory disorders.
- Unit III** : Wildlife toxicology- Susceptibility of wildlife to chemicals, Acute ecological hazards, Toxicology of chemicals in birds and mammals, Integrated approach to wildlife toxicology
- Unit IV** : Medical toxicology- Mission of medical toxicology, Comparative toxicology, Human risk assessment, Toxicological database
- Unit V** : Forensic toxicology- Specimen sample collection, types of testing, detection of poisons, applications of forensic toxicology
- Unit VI** : Toxicology of chemical warfare agents- Chemical weapons, classification of chemical warfare agents, mustard gas, lewisite, nerve agents, hydrogen cyanide, management of chemical warfare agents
- Unit VII** : Veterinary toxicology- Common toxicity in dogs, cats, horses and poultry, by herbicides, house hold chemicals, heavy metals, mycotoxins, blue green algae and toxic plants
- Unit VIII** : Preventive toxicology- Bioremediation, Toxic site reclamation, prevention of occupational diseases

Course 15:

OCCUPATIONAL AND INDUSTRIAL TOXICOLOGY

- Unit I** : Occupational hazards- Physical hazards, Chemical hazards, Biological hazards, Mechanical hazards, Psychosocial hazards
- Unit II** : Occupational diseases- Pneumoconiosis, silicosis, asbestosis, anthracosis, byssinosis, bagassosis, Farmers' lung
- Unit III** : Occupational Cancer- Skin cancer, Lung cancer, Bladder cancer, Leukaemia
- Unit IV** : Prevention of occupational diseases- Medical measures, Engineering measures, Legislative measures, Occupational health in India
- Unit V** : Industrial toxicology- History and basic features, Industrial hygiene
- Unit VI** : Risk assessment – Risk assessment for industrial chemicals in EU, OECD and USA, Risk management of industrial chemicals
- Unit VII** : Industrial hygiene- Concepts of Industrial hygiene, TLV, MAK, OES, ACGIH, OSHA etc.
- Unit VIII** : Biological monitoring of industrial solvents and metals, pesticides

Course 16:

BIostatISTICS AND BIOinformatics

- Unit I** : General principles of biostatistics- Bias and Chance hypotheses testing, improbability, multiple comparisons
- Unit II** : Sample size, Experimental designing, control v/s treatment results, robustness and significance
- Unit III** : Statistical calculations of acute toxicity, chronic toxicity, mortality, body weight, organ weight and histopathological findings
- Unit IV** : Statistical analysis- Statistical methods, SD, SE, *t*-test, One way ANOVA, Two way ANOVA
- Unit V** : Brief introduction to Computers- Computer education, e-mail and internet based learning
- Unit VI** : Databases in toxicology, Databanks, the internet and organizational resources in toxicology
- Unit VII** : Introduction to bioinformatics- Applications of bioinformatics, Molecular biology and bioinformatics, Toxicology and bioinformatics
- Unit VIII** : Genome analysis, gene mapping and toxico-genomics, Introduction to proteomics, metabolonomics and drug discovery