

## THIRD SEMESTER

### **PHAR 211 Organic Chemistry-II [60 hours]**

#### **Unit -1: Nucleophilic Aromatic Substitution (7 hours)**

Introduction to Nucleophilic Substitution in aromatic compound. Comparison of Nucleophilic aromatic substitution in aromatic & aliphatic substrate. Mechanism of nucleophilic aromatic substitution:-

Bimolecular aromatic Nucleophilic substitution (SN Ar mechanism) Reactivity & orientation in SN Ar rx<sup>n</sup> in aromatic substrate and Benzyne mechanism & its evidences.

#### **Unit -2: Unsaturated Carbonyl Compounds (4 hours)**

Introduction to unsaturated carbonyl compounds. Preparation of unsaturated carbonyl compounds by Aldol condensation, Perkin reaction, from  $\alpha$ - halo acids. (related to pharmaceutically active product) Reactions:-Electrophilic addition, Nucleophilic addition, Michael reaction and Diel's Alder reaction

#### **Unit -3: Conservation of Orbital Symmetry:- (10 hours)**

Concepts of molecular orbital with respect to same organic molecule. Concept to conservation of orbital symmetry. Introduction to pericyclic reaction and its types (Electro cyclic reaction. Cycloaddition reaction and Sigmatropic reaction).

#### **Unit -4: Neighboring Group Effect:- (3 hours)**

Effect of neighboring group in nucleophilic substitution. Stereochemistry of product. Explain anchimeric assistance with examples.

#### **Unit -5: Catalysis by Transition Metal Complexes:- (2 hours)**

Role of transition metal complex in organic reaction. Role of Wilkinson Catalyst in homogenous hydrogenation of alkenes & its stereochemistry. Role of octacarbonyldicobalt in oxo process.

#### **Unit -6: Stereo Selective & Stereo Specific Reaction:-(2 hours)**

Introduction to stereo selective & stereo specific reaction. Difference between stereo selective & stereo specific showing suitable examples.

#### **Unit -7: Heterocyclic Compounds (12 hours)**

Introduction to heterocyclic compounds. Preparation and properties of following heterocyclic compounds- Five membered ring: pyrrole, furan & thiophane. Six membered ring : pyridine (Basicity , Substitution rx<sup>n</sup>) Higher membered ring : Indole (2,3 - Benzopyrrole), Quinoline 2,3 – Benzopyridine and Isoquinoline.

### **Unit -8: Carbohydrate (8 hours)**

Classification of Carbohydrate. Glucose: Mutarotation, various structure. Classification, Sources & Structure of (Fructose, Sucrose, Maltose and starch). Amylose, Amylopectin, Cellulose. Chain lengthening reaction of aldoses : Killiani – fisher synthesis. Shortening of carbon chain of aldoses : Ruf degradation and Formation of osazone.

### **Unit -9: Lipids: (4 hours)**

Occurrence & composition of fats. Saponification of fats. Detergents. Hydrogenation of oils. Phosphoglycerite and Phospholipids.

### **Unit -10: Proteins & Nucleic acids (5 hours)**

Structure of Amino acids. Amino acid as dipolar ions. Isoelectric point of amino acid. Preparation & peptide linkage. Protein and its classification. Structure of protein. Denaturation of protein. Nucleic acid structure of DNA & RNA Watson & Crick model.

### **Unit -11: Uses and preparation of some new organic reagents used in drug synthesis: (3 hrs)**

Salicylic acid, cinnamic acid, quinoline, ethylacetoacetate, acetic anhydride, pyridine, benzaldehyde, acetophenone, dimethylaniline, tosyl chloride, diphenyl, succinic anhydride.

## **PHAR 211 Lab Pharmaceutical Organic Chemistry-II Practical**

Synthesis and test of the following compounds (Minimum 8 experiments)

m-dinitrobenzene from nitrobenzene, p-nitroacetanilide from Acetanilide, p-bromoacetanilide from Acetanilide, Oxazolone from Benzoylglycine, Acetanilide from Aniline, p- Benzanilide from benzophenone oxime (Beckmann's rearrangement), benzil from benzoin, fluorescein from phthalic anhydride, Eosin from fluorescein, O-chlorobenzoic acid from anthranilic acid (Sand mayer reaction), m-Dinitrobenzene from nitrobenzene, 2, 5-Dioxopiperazine from Glycine. Diazonium Coupling Reaction of p-Nitrobenzenediazonium sulfate and N,N -Dimethylaniline: Synthesis of p-(4-nitrobenzeneazo)-N,N-dimethylaniline.

Systematic analysis of organic binary mixtures (Determination of Acid value of fixed oils, Determination of Acid value of fixed oils, Determination of Saponification value of a fixed oil, Determination of Acetyl value of a fixed oil. Stereochemical Study of Organic Compounds via Models and R and S configuration of optical isomers.

### **Reference:**

1. Vogel's Textbook of Practical Organic Chemistry (5th Edition)
2. Modern Organic Synthesis: An introduction. George S. Zweifel and Michael H. Nantz
3. Problems in Organic Synthesis by Hasan Palandoken
4. Workbook for Organic Synthesis: Strategy and Control
5. Organic Synthesis, 3rd Edition by Professor Michael B. Smith

**Unit – 1: Evaluation of Herbal Drugs and Formulation (20 hours)**

- 1.1. Development of analytical techniques for the estimation of markers present in the Herbal and classical formulations.
- 1.2. Evaluation of Herbal drugs and formulations by Biological methods. General animal models for screening of Herbal drugs and formulations.
- 1.3. Toxicological evaluations of herbal drugs and formulations. Methods and materials for Acute, sub acute and chronic toxicity studies. Teratogenicity, mutagenicity and carcinogenicity studies. WHO and other regulatory requirements for toxicological evaluations.
- 1.4. WHO, Nepalese and Indian regulatory requirements of Clinical trials for herbal formulations.
- 1.5. Techniques in estimation of enzymes and endogenous substances in body fluids in physiological and pathological conditions.
- 1.6. Department of Drug Administration, (DDA) Nepal and Indian requirements (Schedule T) and other regulatory requirements for the manufacturing of Herbal and Ayurvedic products.
- 1.7. Comparative study of British herbal pharmacopeia Ayurvedic pharmacopeia of India, Chinese, Japanese herbal pharmacopoeias, European pharmacopoeia, US Formulary, W.H.O guidelines for herbal medicinal products.

**Unit – 2: Global Trading of Herbs and herbal constituents. (10 hours)**

Utilization and production of phytoconstituents such as Taxus resin, quinine, morphine, Reserpine, Sennosides, Digitalis glycosides, Diosgenin and Atropine. Herb collection centers around Nepal.

Worldwide trade in medicinal plants and derived products with special reference to diosgenin, taxol, digitalis, tropane alkaloids containing plants, papain, cinchona, ipecac, liquorice, ginseng, aloe, valerian, Rauwolfia and plants containing laxatives.

**Unit – 2: Study of traditional drugs (10 hours)**

Common Vernacular name, Biological sources, morphology, chemical nature of chief constituents, pharmacology, categories and common uses and toxicological activity of marketed formulations of following indigenous drugs: Amla, Kantkari, Satavari, Tylophora, Bhilwa, Kalijiri, Vach, Rasna Punarnava, Chitrak, Apamarg, Gokhru, Shankhpushpi, Brahmi, Methi, Lehsoun, Palash, Guggul, Gymnema, Shilajit, Tulsi, Nagarmotha, Majith, Malkanguni and Neem.

**Unit- 3: Alternative system of therapy. (5 hours)**

Introduction and principals of Ayurvedic, Unani, Sidha and Homeopathic system of medicine. Introduction to Ayurvedic dosages form: preparations and standardization of Ayurvedic preparations such as Aristas, Asvas, Gutika, Tailas, Churnas, Lehyas and Bhasmas.

## **PHAR 212 Lab Pharmacognosy III Practical**

Extraction and Isolation of some important phyto constituent mentioned in the theory.

2. Extractions of volatile oil and their chromatographic profile.
3. Chromatographic studies of some important phytoconstituent.

### **Books and other resources recommended**

1. Indian pharmacopoea, Indian Herbal Pharmacopoea.
2. Ayurvedic Formulary of India.
3. Screening methods of Pharmacology By Robert turner
4. WHO guide lines for the quality control of Herbal plant materials
5. The Practical evaluation of Phytopharmaceuticals by Brain and Turner.
6. Thin layer chromatography by Egon stahl.
7. Drug Discovery & Evaluation by H.Gerhard Vogel
8. British Herbal Pharmacopeia
9. Quality Standards of Indian Medicinal Plants Vol-I, ICMR, New Delhi
10. Scheuer, P.J., Marine Natural Products. Academic Press, London.
11. Swain, T. Chemical Plant Taxonomy Academic Press, London.
12. Reinert, J & Bajaj, Y.P.S. Applied and Fundamental aspects of plants cell, tissue and organ culture Berlin.
13. Atal C.K. and Kapoor, B.M. cultivation and utilization of medicinal plants. R.R.L. Jammu.
14. Barz, W., Reinhard, E. and Zerk, M.H. plant tissue culture and its Biotechnological application. Springer, Berlin.
15. Chadha, K.L. and Gupta, R. advance in horticulture vol. II medicinal and aromatic plants. Malhotra publishing house, New Delhi.
16. Export potential of selected medicinal plants; prepared by basic chemicals, pharmaceuticals and cosmetic export promotion council, Mumbai and other reports.
17. Trease, G.E. and Evasn W.C. Pharmacognosy. Baillier, Tindall, Eastbourne, U.K.
18. Kokate, C.K., Purohit, A.P. and Gokhale, Pharmacognosy, Nirali Prakashan, Pune.
19. Tyler, V.C., Brady, L.R., and Robers, Pharmacognosy, Lea and Febiger, Philadelphia.
20. Kalia, A.N. Textbook of Industrial Pharmacognosy, CBS Publishers and Distributors, New Delhi.
21. Vyas and Dixit, Biotechnology, CBS Publishers New Delhi
22. Dewick, P.M, (2002) Medicinal Natural Products (II edition), John Wiley and Sons, Chichester.

**Unit-1: Non-aqueous Titration (5 hrs)**

Principle of non-aqueous titration; aprotic, protogenic, protophilic and amphiprotic solvents; effect of temperature in non-aqueous titration; indicators in non-aqueous titration; end point detection by potentiometry, titration of alkali metal salts of organic acid, amines and amine salts of organic acid, halogen acid salts of bases and acidic substances, preparation & standardization of standard perchloric acid & methoxide solution, applications in assay of metronidazole, chloroquine phosphate, chlorpromazine HCl

**Unit-2: Complexometric Titration (7 hrs)**

Theory of complexometric titration; chelating and sequestering agents; effect of pH on complex formation; stability of complexes- stability constant, factors affecting stability constant, absolute & effective stability constant; types of complexometric titrations; end point detection using physical methods (spectrophotometric detection, potentiometric titration, amperometric titration, high frequency titration) and pM indicators; pM indicators, methods of increasing titrant selectivity-pH adjustment, use of selective indicators, use of selective precipitants & use of masking and demasking agents; disodium edetate titrations; application in determination of hardness of water, applications in assay of calcium gluconate.

**Unit-3: Miscellaneous Methods of Analysis (6 hrs)**

Diazotisation titrations, Kjeldahl method of nitrogen estimation, Karl-Fischer titration, Oxygen flask combustion, Gasometric analysis.

**Unit-4: Extraction procedures including separation of drugs from excipients (4 hrs)**

Nernst law, extraction efficiency & selectivity, factors influencing solvent extractions-effect of temperature, inert solutes, pH, ion pair formation & synergistic extraction, separation of drugs from excipients in pharmaceutical preparations- chloroquine phosphate tablets, codeine tablets.

**Unit-5: Chromatography (20 hrs)**

Introduction, classification of chromatographic techniques, modes of separation, distribution coefficient, retention volume, dead volume, retention time, dead time, selectivity factor, capacity factor, resolution, chromatographic theories- plate theory & rate theory, Sources of band broadening- eddy diffusion, longitudinal diffusion & non equilibrium mass transfer, van Deemter equation.

**Paper Chromatography**

Principle, Migration parameters-  $R_f$  &  $hR_f$ ,  $R_m$ ,  $R_x$ , types of paper chromatography- ascending, descending, ascending-descending, radial & two dimensional chromatography, choice of filter paper, developing solvent, detection method, applications of paper chromatography.

**TLC:** Principle, Advantages of TLC over paper chromatography; steps in TLC- selection of coating material, preparation of TLC plate, activation of plate, purification of plate, sample application, selection of mobile phase, development of plate, detection of components; Problems in TLC: Over-large Spots, Uneven Advance of Solvent Front and Streaking, applications of TLC.

**HPTLC:** Comparison of HPTLC & TLC; HPLC & HPTLC; Principle, Instrumentation- Sample applicator, Development Chamber, Scanner; Applications.

**HPLC** : Principle, Instrumentation: Solvent reservoir & degassing system, Solvent programming, Pumps- reciprocating pump, syringe pump, constant pressure pumps, Sample injection system, Columns, Bonded phase, Column switching, Detectors- bulk & solute property detectors, Photometric detectors, fluorescence detectors, refractive index detectors, electrochemical detectors; Elution methods: Gradient, Isocratic & Stepwise elution; Internal Standard; Peak asymmetry, peak tailing & peak fronting; Ghost peaks, System suitability test, Pharmaceutical applications of HPLC.

**GC:** Principle, Instrumentation-carrier gas supply & flow regulators, sample injection system, detectors (ECD, FID, DTC, thermionic emission detector); Temperature programming, Headspace analysis, pharmaceutical applications of GC; limitations of GC.

**Column Chromatography:** Principle, Applications, Ion Exchange Chromatography, Principle, Cation exchanger, Anion exchanger, Ion exchange capacity; Suppressor column, Pharmaceutical applications of IEC, Size Exclusion Chromatography, Principle; Gel Permeation & Gel Filtration chromatography; Packing Material for column and Solvent; Detector, Applications of SEC.

#### **Unit-6: Potentiometry (5 hrs)**

Reference electrodes (SHE, SCE, Silver- silver chloride electrode) and indicator electrodes (metal electrodes-first, second, third & inert electrodes; membrane indicator electrodes-glass electrode including its advantages & disadvantages); potentiometric titrations-advantages, apparatus & methods of end point detection -graphical, differential and Gran's plot; applications.

#### **Unit-7: Conductometry (3 hrs)**

Ohm's law, specific, molar & equivalent conductance, measurement of conductivity, cell constant, conductometric titrations: acid-base titrations (SA vs.SB, SA vs. WB, WA vs.SB, WA vs.WB, mixture of acids with strong base), applications of conductometry in precipitation titrations, redox titration, complexometric titration; advantages of conductometric titrations.

#### **Unit-8: Coulometry (2 hrs)**

Current efficiency, principle of coulometry, types of coulometric titration, coulometric titrations, advantages & application of coulometric titration including application in Karl Fischer titration.

#### **Unit-9: Polarography (5 hrs)**

Principle, instrumentation, residual current, migration current, diffusion current, limiting current, equation of polarographic waves, Ilkovic equation, DME- advantages & limitations; polarographic maxima, polarographic methods of analysis-direct comparison method, use of calibration curves, internal standard or pilot ion method, quasi-absolute method & standard addition method; pharmaceutical applications of polarography-metronidazole & diazepam.

#### **Unit-10: Amperometry (3 hrs)**

Principle, Amperometric titration curves, Rotating platinum electrodes & its advantages, Dead stop end point technique, Advantages of amperometry & Pharmaceutical applications of amperometry.

### **PHAR 213 Lab Pharmaceutical Analysis– II Practical**

Minimum 8 experiments in topics covered in theory.

#### **Books and other resources recommended**

1. Principles of Instrumental Analysis by Skoog, Holler, Nieman, 5th Ed..Saunders College Publishing
2. A Text book of Pharmaceutical Analysis by Kenneth A. Connors, 3rd Ed. John Wiley & Sons
3. Instrumental Methods of Chemical Analysis by Galin W. Ewing, 5th Edition, N.C. Graw-hill International Edition
4. Instrumental Methods of Analysis by Willard, Merritt, Dean, Settle, CBS Publishers, 7th Edition
5. Spectrometric Identification of Organic Compounds by Silverstein, Dassler, Morrill, 5th Ed. John Willey & Sons inc.
6. Pharmaceutical Analysis: Modern Methods by James Monson, Marcel Dekker inc.
7. Practical Pharmaceutical Chemistry-I & II by A. H. Backett & Jacket Stanlake, 4th Ed.. CBS Publishers
8. Indian, British & United State Pharmacopoeia.
9. P D Sethi Quantitative Analysis of Drugs in Pharmaceutical formulations.
10. Bochmman & Hassan, Pharmaceutical Analysis, edited by: Higuchi.

# **PHAR 214 Pharmaceutical Engineering I [45 hours]**

## **Unit- 1: Introduction to Unit operation, (2 hours)**

Law of conservation of matter, Law of conservation of energy, introduction to Gas Laws, Dalton's law of partial pressure.

## **Unit- 2: Fluid Flow(10 hours)**

Fluid Flow: Properties of fluid, Viscosity, Compressibility and Surface tension, static and dynamic flow, fluid in motion, Bernoulli's theorem, Flow measurement and flow meters, Laminar and Turbulent flow, Liquids in flow pipe, Significance of Reynolds' flow, Reynolds's experiment and Reynolds number, flow of fluid through packed bed, pumps, positive displacement pumps, centrifugal impeller pump, . Measurement of rate of flow of liquids-measuring devices (Manometer, Orifice meter, venturimeter, Rota meter). Liquid handling (transportation of fluids)- valves, pumps and pump impeller..Flow of purified water in pharmaceutical manufacturing unit.

## **Unit- 3: Handling of solids (2 hours)**

Sliding and flow of powder, Method for free flowing powder and granules, methods for cohesive powders Bins, Vacuum and conveyor.

## **Unit- 4: Handling of steam and gas – Cylinder, steam traps, valves and pipes and pipe handling system. (2 hours)**

## **Unit- 5: Filtration and clarification (6 hours)**

Mechanism (straining, impingement, entanglement, attractive force) , types of filtration , difference between surface and depth filtration and Theory of filtration (Poiseuille's equation, Darcy's equation, Kozeny's-Carman Equation), factors influencing filtration, filter media including materials (rigid media, flexible media) and filter aids, handling of filter aids, and filtration equipments (Gravity filters, Vacuum filters, Pressure filters and the centrifuge filters)

## **Unit- 6: Centrifugation (3 hours)**

Theory and application, classification of centrifuge (sedimentation, filtration) and equipment (perforated basket centrifuge, non-perforated basket centrifuge, short cycle batch centrifuge, continuous horizontal centrifuge, Super centrifuge, conical disc centrifuge).

## **Unit- 7: Crystallization (5 hours)**

Theory and application, characteristics of crystals (geometry, habit, crystal lattice, crystal systems), pharmaceutical solids (crystalline, amorphous), polymorphs and isomorphs, crystal hydrate and caking of crystals. Crystal hydrates and crystal solvates, Production of very fine crystals, Production of large crystals. Crystallizers (Agitated batch crystallizers, Swenson Walker Crystallizer, Krystal Crystallizer, vacuum crystallizer).

## **Unit- 8: Heating, Ventilation and Air conditioning (HVAC) (8 hours)**

Definition of Humidity, Absolute humidity, Relative humidity, specific humidity, humidity chart and its utility, dry bulb and wet bulb thermometers. Dew point, methods of dehumidification, Types of dehumidifiers, Approaches to dehumidification, heat exchangers. HVAC terms, Application of HVAC in pharmaceutical unit – Air handling units (AHU), Factors that contribute



to quality of pharmaceutical products. The manufacturing environment is critical for product quality, Role of AHU for the reduction of cross contamination, laminar and turbulent air flow. Refrigeration: Principle, Refrigeration cycle and condensers.

### **Unit- 9: Material of construction**

(4 hours)

Factors affecting selection of material of construction( physical, chemical and economical); Ferrous metal (including stainless steel – 202,304,316 and 316L), Alloys, nonferrous metal (aluminum, aluminum alloy, copper lead, Tin ), Non-metals (inorganic- glass – Types: soda lime, borosilicate glass, Pyrex, quartz, neutral, fiber glass with special reference to glass for pharmaceutical use.) organic (rubber natural and synthetic(silicon rubber) special reference to pharmaceutical use) and plastic (polymers)- Type of plastic: Cellulose based plastic, Polystyrene and PVC, Nylon, Rubber, and their uses in Pharmacy. Common plastic and special purpose plastic.

### **Unit- 10: Industrial Hazards and safety precautions (3 hours)**

Hazards (mechanical, chemical, electrical, environmental, fire, noise abatement), dust explosion personal protective equipments (masks, gloves, respirators, spectacles, suits). Biological Hazard Protection, manmade hazards and Technological hazards; Fire and types of fire extinguisher.

## **PHAR 214 Lab Pharmaceutical Engineering I Practical**

1. Determination of water flow by a water pump.
2. Study of factors affecting filtration using filter media and/or aids.
3. Demonstration of centrifugation.
4. Study of crystallization behavior of Ibuprofen, Salicylic acid and sodium carbonate.
5. Observation of HVAC.
6. Determination of humidity using dry and wet bulb thermometer. Learning the skill of using thermometers and psychometric charts.
7. Observation of different construction materials focus to utensils, equipments and machines.
8. Demonstration of different personal safety equipments.

### **Books and other resources Suggested**

1. Pharmaceutical Engineering –principles and practices by CVS Subrahmanyam, J T Setty, S Suresh and V K Devi. Vallabh Prakashan Delhi.
2. Pharmaceutical Engineering by K Sambamurthy – New age international publisher.
3. Theory and Practice of industrial Pharmacy by Lacman and Lieberman.
4. Unit Operation by Anthony J Hiki
5. Pharmaceutical Process scale-up: by Michel Levin- Marcel Dekker.
6. Pharmaceutical production facilities; design and application by Cole G- 2nd edition Taylor Francis, 1998.
7. Pharmaceutical Process Engineering - Anthony J Hickey, Marcel Dekker 2001.

## **PHAR 215 Anatomy & Physiology II**

**[45 hours]**

### **Unit-1: Respiratory System (8 hours)**

Anatomy of respiratory organs & its functions, respiration, mechanism and regulation of respiration, respiratory volumes and vital capacity. Acid base balance and brief description of respiratory system. Bronchopulmonary segments, nervous control of respiration, Basic concept about hypoxia, anoxia, hyperventilation.

### **Unit-2: Central Nervous System (8 hours)**

Functions of different parts of brain and spinal cord. Neurohumoral transmission in the central nervous system, reflex action, specialized functions of the brain, Cranial nerves and their functions. C.S.F and it's route of transmission; Pyramidal tracts.

### **Unit-3: Autonomic Nervous System (6 hours)**

Physiology and functions of the autonomic nervous system. Mechanism of neurohumoral transmission in the A.N.S.

### **Unit-4: Urinary System (5 hours)**

Various parts, structures and functions of the kidney and urinary tract. Physiology of urine formation and acid-base balance.

### **Unit-5: Reproductive System (4 hours)**

Male and female reproductive systems and their hormones, physiology of menstruation, spermatogenesis & oogenesis. Pregnancy its maintenance and parturition.

### **Unit-6: Endocrine System (5 hours)**

Basic anatomy and physiology of Pituitary, Thyroid, Parathyroid. Adrenals, Pancreas, Testes and ovary, their hormones and functions.

### **Unit-7: Sense Organs (5 hours)**

Basic anatomy and physiology of the eye (vision), ear (hearing), taste buds, nose (smell) and skin (superficial receptors).

### **Unit-8: Body Temperature Regulation (4 hours)**

Structure and function of skin, heat production and dissipation, nervous factors involved in body temperature regulation.

## **PHAR 215 Lab Anatomy & Physiology II    Practical**

1. Study of different systems with the help of charts and models.
2. Microscopic studies of different tissues.
3. Simple experiments involved in the analysis of normal and abnormal urine: Collection of specimen, appearance, and determination of pH, Sugars, proteins, urea and creatinine.
4. Physiological experiments on nerve-muscle preparations.
5. Determination of vital capacity, experiments on spirometry.

### **Books and Other resources Recommended**

1. Sujit K. Chaudhuri: Concise Medical Physiology.
2. C.C. Chatterjee: Human Physiology.
3. Kathleen J.W. Wilson Ross and Wilson: Anatomy and Physiology in Health and Illness
4. T.W.A. Glenister and Jean R.W. Ross: Anatomy and Physiology for Nurses
5. Arthur C. Guyton: Textbook of Medical Physiology.
6. Cyril A. Keele, Erie Neil, Norman Joels and Samson Wrights: Applied Physiology

## FORTH SEMESTER

**PHAR 221**

**Biochemistry**

**[ 45 hours]**

**Unit -1:** Biochemical organization of the cell and transport process across cell membrane. **(1 hr)**

**Unit -2:** The concept of free energy, bioenergetics, production of ATP and its biological significance. **(2 hrs)**

**Unit -3: Enzymes:** Nomenclature, enzyme kinetics and its mechanism of action, mechanism of inhibition, enzymes and iso-enzymes in clinical diagnosis. **(4 hrs)**

**Unit -4: Carbohydrate Metabolism:** Conversion of polysaccharide to glucose-1- phosphate, Glycolysis and fermentation and their regulation, gluconeogenesis and glycogenolysis, Metabolism of galactose and galactosemia, role of sugar nucleotides in biosynthesis, and Pentosephosphate pathway. **(6 hrs)**

**Unit -5: The Citric Acid Cycle:** Significance, reactions and energetic of the cycle, Amphibolic role of the cycle. **(4 hrs)**

**Unit -6: Lipids Metabolism:** Oxidation of fatty acids,  $\beta$ -oxidation & energetic,  $\alpha$ -oxidation,  $\omega$ -oxidation, Biosynthesis of ketone bodies and their utilization, Biosynthesis of saturated and unsaturated fatty acids, Control of lipid **(6 hrs)**

**Unit -7: Biological Oxidation:** Enzymes and co-enzymes involved in oxidation, reduction & its control, respiratory chain, its role in energy capture and its control, Inhibitors of respiratory chain and oxidative phosphorylation, Mechanism of oxidative phosphorylation. **(6 hrs)**

**Unit -8: Metabolism of Ammonia and Nitrogen Containing Monomers:** Nitrogen balance, Biosynthesis of amino acids, Catabolism of amino acids, Conversion of amino acids. Formation of bile pigments, hyperbilirubinemia, Purine biosynthesis, Purine nucleotide interconversion. **(6 hrs)**

**Unit -9: Biosynthesis of Nucleic Acids:** Brief introduction of genetic organization of the mammalian genome, alteration and rearrangements of genetic material, Biosynthesis of DNA and RNA. **(4 hrs)**

**Unit -10: Genetic Code and Protein Synthesis:** Genetic code, Components of protein synthesis, and Inhibition of protein, synthesis. Brief account of genetic engineering and polymerase chain reactions. Regulation of gene expression. **(6 hrs)**

### **PHAR 221 Lab Biochemistry Practical**

Proposed topics for practical

1. Preparation of standard buffers (citrate, phosphate and carbonate) and measurement of pH.
2. Titration curve for amino acids.
3. Separation of amino acids by two dimensional paper chromatography and gel electrophoresis.
4. Separation of lipids by TLC.
5. Separation of serum proteins by electrophoresis on cellulose acetate.
6. Quantitative estimation of amino acids.
7. Quantitative estimation of proteins.
8. Determination of glucose by means of the enzyme glucose oxidase.
9. Enzymatic hydrolysis of glycogen by alpha- and beta- amylases.
10. Isolation and determination of RNA and DNA.
11. Effect of temperature on the activity of alpha-amylase.
12. Estimation of SGOT, SGPT, Alkaline phosphotase and Bilirubin in the serum.

## **Books and other resources recommended**

1. Conn, E.E. and Stump, P.K. Outlines of Biochemistry. John Wiley & Sons, New York.
2. Jayaraman, J. Laboratory Manual in Biochemistry. Wiley Eastern Ltd., New Delhi
3. Lehninger, A.L. Biochemistry, Worth Publisher, Inc.
4. Plumer, D.T. An Introduction to Practical Biochemistry. Tata McGraw Hill, New Delhi.
5. Harper's Biochemistry, Lange Publishing Group.
6. Harrow, B and Mazur, A. Textbook of Biochemistry. W.B. Saunders Co., Philadelphia.
7. Lehninger, A.L. Principles of Biochemistry. CBS Publishers.
8. Martin, D.W., Mayos, P.A. and Redwell, V.M. Harper's Biochemistry. Lange Medical Publications.
9. Mussay, R.K., Granner, D.K., Mayos, P.A. and Redwell, V.M. Harper's Biochemistry. Prentice-Hall International.
10. Ramarao Textbook of Biochemistry UBSPD.
11. Stryer, L. Biochemistry. W.H. Freeman & Co., San Fransisco.

## **PHAR 222 Chemistry of Natural Products [45 hours]**

### **Unit-1: Introduction (6 hrs)**

Introduction to natural product chemistry, primary & secondary metabolites & fundamental metabolic pathways—the acetate, shikimate, mevalonate, and deoxyxylulose phosphate pathways.

### **Unit-2: Application of chromatographic & spectroscopic techniques. (4 hrs)**

### **Unit-3: Terpenoids(8 hrs)**

Chemistry and pharmacological activity of medicinally important monoterpenes (limonene, menthol), sesquiterpenes (zingiberene), diterpenes (taxol, forskolin, phorbol, steviol) and triterpenoids (fusidic acid), biogenetic relationship among monoterpenes.

### **Unit-4: Carotenoids (4 hrs)**

Chemistry & pharmacological activity of alpha-carotene, beta-carotene, Vitamin A & medicinally important xanthophylls-capsorubin & capsanthin.

### **Unit-5: Glycoside (6 hrs)**

Chemistry, biosynthesis (those marked with \* only) & pharmacological activity of digitoxin\*, digoxin\*, hecogenin, sennosides, diosgenin\* and sarsapogenin.

### **Unit-6: Alkaloids (10 hrs)**

Chemistry, biogenesis (those marked with \* only) and pharmacological activity of atropine\* and hyoscine\*, quinine\*, reserpine\*, morphine\*, papaverine\*, ephedrine\*, ergot, and vinca alkaloids.

### **Unit-7: Lignans (7 hrs)**

Chemistry and pharmacological activity of medicinally important lignans (lignans of *Podophyllum* spps, *Piper cubeba* & *Linum usitatissimum*); flavanoids (flavanoids of *Ginkgo biloba*-Kaempferol, Quercetin, Myricetin ; *Liquorice*-Liquirtin, Liquirtigenin) and quassanoids (Quassia wood).

## **PHAR 222 Lab Chemistry of Natural Products Practical**

1. Laboratory experiments on isolation, separation, and purification of various groups of chemical constituents of pharmaceutical significance.
2. Exercises on paper and thin layer chromatographic evaluations of herbal drug constituents.

## **Books recommended**

1. Paul M Dewick Medicinal Natural Products-A Biosynthetic Approach 3rd Edition.
2. Trieber, Quantitative TLC & industrial Application.
3. Vepoorte Swendson – Chromatography of alkaloids.
4. V K Srivastava – Introduction to Chromatography – Theory and Practice.
5. Harbone – Phytochemical Methods of Chemical Analysis.
6. Ara Dermarderosia – The Review of Natural Products.
7. H F Liskens and J F Jacksons- Modern Method of Plant Analysis- HPLC in Plant Science.

**Unit 1: Heat Transfer:** Sources of heat (steam and electricity, Mechanism of heat transfer (conduction, convection and radiation), Conduction: Fourier's law, Conduction through Single Metal Wall, Compound resistances in series, heat flow through a cylinder; Convection: Temperature gradient in forced circulation; Radiation: Black body, Grey Body Fourier Law (heat flow through a metal wall and through a cylinder); equipments (heat exchangers and interchangers); Heat exchangers: tubular heater, multi pass heater; Heat interchangers: Baffles, liquid to liquid interchanger, double pipe heat interchanger, Numerical on heat transfer [6 hours ]

**Unit 2: Evaporation:** Introduction, factors affecting evaporation, evaporators:- tube evaporators (horizontal and vertical), film evaporators (Rising film and falling film), Forced Circulation Evaporator, multiple effect evaporators. [4 hr]

**Unit 3: Drying:** Definition, pharmaceutical application of drying, theory of drying (drying equation), terms used in drying process (bound water, unbound water, equilibrium moisture content, measurement of EMC, free moisture content, loss on drying, percentage moisture content, drying rate), behaviours of solids during drying (drying rate curves) , Classification and types of dryers, dryers used in pharmaceutical industries:- Tray Dryer, Spray Dryer, Fluidised Bed Dryer, Vacuum Dryer, Freeze Dryer and drum dryer, Numerical on drying [6 hrs]

**Unit 4: Distillation:** Definition, application, theory of distillation (Raoult's law, Dalton's law, phase diagrams, volatility), general equipments for distillation ( still, condenser, receiver), Distillation methods( simple distillation, flash distillation, fractional distillation, principle of working of fractionating column, packed column & plate column (bubble cap plates), azeotropic and Extractive distillation, steam distillation, distillation under reduced pressure, rectification), molecular distillation, destructive distillation, compression distillation, calculation of theoretical plates (Mc. Cabe-thiele method), Equipments, production of WFI in pharmaceutical industries. [6 hours]

**Unit 5: Size Reduction and size separation:** Definition, pharmaceutical application of size reduction, factors affecting size reduction/selection of size reduction equipments, laws of size reduction (Rittinger's Law, Kick's Law and Bond theory), mechanism of size reduction (cutting, compression, impact and attrition), Size reduction equipments (cutter mill, roller mill, hammer mill, edge and end runner mill, ball mill, fluid energy mill and colloid mill) [5 hours]

**Size Separation:** Introduction, Official standards for powders (powder grades according to IP/BP), sieve analysis using sieve shaker (Sieve size BSS standards), equipments for size separation (Sieving and Screening equipments:- shaking screens, cyclone separator, air separator and bag filter) [3 hours]

**Unit 6: Mixing:** Theory of mixing, applications, mechanism of **mixing in solids**, degree of mixing (Perfect mixing, Alternative to mixing (Random & ordered Mixing)) and statistical evaluation, factors influencing mixing, equipments for solid mixing ( double cone blender, Ribbon blender, sigma blade blender, planetary mixer, barrel type continuous mixer, zigzag continuous blender); **Mixing of liquids:-** mechanism, mixing vessels( baffles) and devices ( propeller, turbines, paddles), flow pattern during mixing, vortex formation and its prevention, equipments for continuous mixing ( air jet mixers and jet mixer ) ; **Mixing of immiscible**



**liquids**- emulsification (equipments: -Silverson Mixer, colloid mill and ultrasonic emulsifier).  
Mixing of semi-solids (equipments:- Triple roller mill). [6 hours]

**Unit 7: Automated Process Control Systems** - definition, history, advantage and disadvantage, Automation tools, automated manufacturing, introduction to PID controller, control panel and PLC. CAM- introduction, origin, advantage and disadvantage, Introduction and list of Computer added techniques and devices, five basic Technologies that adopted for CAM, introduce Computer Integrated Manufacturing Open System Architecture and Manufacturing process management [5 hours]

**Unit 8: Reactors and fundamentals of reactors design for chemical reactions:** Chemical reactors- introduction and type, important process variables of chemical reactors, aspects of the CSTR, Plug Flow Reactor, Semi-batch reactor, Catalytic reactor, microreactor and Upflow Anaerobic Sludge Blanket (UASB) Reactors. [4 hours]

## **PHAR 223 Lab Pharmaceutical Engineering II Practical.**

1. Determination of overall heat transfer coefficient
2. Determination of rate of evaporation.
3. Two experiments on distillation.
4. Determination of drying rate and verification of drying curve.
5. Experiments on milling of solid
6. Experiments on sieve analysis.
7. Demonstration of mixing of solids
8. Demonstration of mixing of miscible liquids and study of vortex formation during liquid mixing.
9. Demonstration of mixing of immiscible liquids
10. Demonstration of APCS.

## **Books and Other Resouces Suggested**

1. Pharmaceutical Engineering –principles and practices by CVS Subrahmanyam, J T Setty, S Suresh and V K Devi. Vallabh Prakashan Delhi.
2. Pharmaceutical Engineering by K Sambamurthy – new age international publisher.

### Reference Books

1. Theory and Practice of industrial Pharmacy by Lachman and Lieberman.
2. Unit Operation by Anthony J Hiki
3. Pharmaceutical Process scale-up: by Michel Levin- Marcel Dekker.
4. Pharmaceutical production facilities; design and application by Cole G- 2<sup>nd</sup> edition Taylor Francis, 1998.

## **PHAR 224 Pharmaceutical Microbiology**

**[45 hours]**

### **Unit -1: Introduction (2 hours)**

History, branches of microbiology and importance of pharmaceutical microbiology. Contribution of Antony Van Leeuwenhoek, Robert Koch, Louis Pasteur and Alexander Fleming.

### **Unit -2: Structure of bacterial cell. (8 hours)**

Microscopy– Principle and description of light microscopes and electron microscope. Structure of prokaryotic and eukaryotic cells and their comparison. Theory of staining, simple, Gram's, acid fast, negative, flagella and spore staining methods. Classification of microbes and their taxonomy. Actinomycetes, bacteria, rickettsiae, spirochetes and viruses. Nutrition, culture media, cultivation, isolation of bacteria, actinomycetes, fungi, viruses. Microbial genetics and mutation.

### **Unit -3: Control of Microbial Growth (2 hours)**

Disinfection, factors influencing disinfectants, dynamics of disinfection, disinfectants and antiseptics and their evaluation. Sterilization, different methods of sterilization, validation of sterilization methods & equipments. Introduction to microbiology of water. Bacteriological examination for assessment of the quality of water. Microbial limit tests for E. coli and Pseudomonas.

### **Unit -4: Sterility testing of all pharmaceutical products (8 hours)**

General methodology, Method of membrane filtration, Method of direct transfer, Negative product control test, Media for use in sterility testing, diluents, solvents and wash solution for use in sterility testing. Sterility testing environment. Limulus amoebocyte lysate (LAL) Test, introduction to aseptic technique.

### **Unit -5: Immunity (8 hours)**

Immunity: Definition of antigen and antibody, types of antigens and antibodies, classification of immunoglobulin, types of immunity.

Antigen-antibody reactions (agglutination, precipitation, neutralization and complement fixation). Types of Hypersensitivity reactions.

Definition of infection, non-specific defense mechanisms, bacterial toxins, virulence and virulence factors and attenuation.

### **Unit -6: Microbial assays of antibiotics, vitamins & amino acids. (10 hours)**

Principles and Methods involved in Assay of Antibiotics, Vitamins, Amino acids & Bio-Sensors in Analysis.

## **PHAR 224 Lab Pharmaceutical Microbiology Practical**

Experiments devised to prepare various types of culture media, sub culturing of common aerobic and anaerobic bacteria, fungus and yeast, various staining methods, various methods of isolation and identification of microbes, sterilization techniques and their validation, evaluation of antiseptics and disinfectants, testing the sterility of pharmaceutical products as per pharmacopoeial requirements, microbial assay of antibiotics and vitamins.

### **Proposed List of experiments:**

1. Preparation of nutrient broth; 2. Preparation of nutrient agar; 3. Inoculation of bacteria;
4. Isolation of pure cultures; 5. Simple staining; 6. Gram's staining; 7. Motility of bacteria; 8. Spore staining; 9. Oligodynamic action of copper; 10. Liquefaction of gelatin; 11. Starch hydrolysis; 12. Nitrate reduction; 13. H<sub>2</sub>S production 14. Phenol coefficient; 15. Chick Martin coefficient; 16. Viable count; 17. Fermentation of carbohydrates; 18. Microbiology of water;
19. Microbiology of milk; 20. Antibiotic sensitivity test; 21. Morphology of yeast, fungi and actinomycetes. 21. Sterility testing

### **Books and other resources Recommended**

1. Microbiology by Pelczar, M.J. Reid, R.D. and Chan, E.S. Tata McGraw Hill Publishing Co. Ltd.;
2. Medical microbiology edited by Robert Cruick Shank. ELBS edition;
3. Pharmaceutical microbiology by Harrish M. Baillere, Tindal and Co., London;
4. Pharmaceutical microbiology edited by Hugo and Russel, P.g. publishing company Ltd., New Delhi.
5. 1 Heritage, J Introductory Microbiology.
6. Nester, Anderson, Roberts, Pearsall, Microbiology, McGraw-Hill.
7. Hugo, W B Pharmaceutical Microbiology.
8. Tortora, Gerard Text Book of Microbiology.
9. E.A Rawlins, Betley's Text Book of Pharmaceutics, Latest edition.
10. Garg, F C Experimental Microbiology
11. Gaud, R.S Practical Microbiology
12. Recommendations for Sterility Testing- <http://www.picscheme.org>
13. USP Sterility Testing USP <71>
14. TGA guidelines for sterility testing of therapeutic goods.
15. Denyer SP et al. : Filtration Sterilization : In Principles and Practice of Disinfection, Preservation and Sterilization (ed. Russell AD et al.) Blackwell Scientific Publications, Oxford (UK), Latest edition.
16. Hugo WB and Russell AD : Pharmaceutical Microbiology, PG Publishing Pvt. Ltd., Singapore, 3rd edn, Latest edition.
17. Indian Pharmacopoeia: Published by the Controller of Publications, Delhi, Vol. II, 1996 and 2007.
18. Remington: The Science and Practice of Pharmacy, Lippincott Williams & Wilkins, New York, Vol.-1, 21st. edn, 2006.
19. 20. Interference with the LAL Test and How to Address It, LAL Update, October 2005.

# **PHAR 225 - Pharmacology I**

**[60 Hours]**

## **Part -1: General Pharmacology**

### **Unit-1: Introduction to Pharmacology:**

Terms used in Pharmacology, Drug nomenclature **(0.5 Hr.)**

### **Unit-2: Sources of drugs:**

Plant, Animal, Microorganism, Mineral, Inorganic, Synthetic and laboratory (genetic) source with examples from each source.

**Dosage forms:** Classification of different dosage forms with examples. **(1 Hr.)**

### **Unit-3: Route of drug administration:**

Factors governing choice of route of drug administration, Classification (Local and systemic), Advantages and disadvantages of various routes of drug administration, Characteristics of Topical and Systemic routes (Oral and Parenteral) **(1.5 Hr.)**

### **Unit-4: Pharmacokinetics: **(8 Hrs.)****

#### **Absorption:**

Introduction to biological membranes, Drug transport processes, (including Passive diffusion, Filtration, Specialized transport, Facilitated diffusion and Pinocytosis).

Factors affecting absorption, Bioavailability (Chemical equivalent and Biological equivalent),

#### **Distribution:**

Apparent volume of distribution (Vd), Significance of high and low Vd, Conditions altering Vd, Redistribution, penetration into brain and cerebrospinal fluid, Passage across placenta, Plasma protein binding and its significance, examples of few clinically important displacement interactions.

#### **Metabolism (Biotransformation):**

Definition of first pass metabolism, sites and consequences of drug metabolism, Types with examples (Phase I and Phase II reaction), enzyme inhibition and its consequence (in brief) and use, First pass metabolism and its attributes.

#### **Excretion:**

Routes (renal and non-renal) of excretion of drugs with few examples. Plasma half-life and its importance, Clearance Loading dose and Maintenance dose, Therapeutic Drug Monitoring and its indications, Fixed dose Combination (Advantage and Disadvantage)

### **Unit-5: Pharmacodynamics: **(9 hrs)****

Introduction, Principles of drug action, Mechanism of drug action, Action through enzymes (Enzyme inhibition and its type using suitable examples).

Action through receptors, Terms used in describing drug-receptor interaction, Receptor occupation theory, Two-state receptor model, nature of receptors, Receptor sub-types, Action-effect sequence.

Transducer mechanisms (G-protein coupled receptors, Receptors with intrinsic ion channels, Enzyme linked receptors, receptors regulating gene expression), regulation of receptors, Functions of receptors,

Dose-response relationship (dose response curve), therapeutic index, Drug potency and efficacy, Selectivity, Risk-benefit ratio, combined effects of drugs.

### **Tolerance and dependence:**

Definition of tolerance and its types (Natural and Acquired), Mechanism of development of tolerance (Pharmacokinetic Tolerance, Pharmacodynamic Tolerance, Cross tolerance, Tachyphylaxis), Drug dependence and its types, Drug abuse, addiction and habituation, Drug withdrawal reactions. (2 hrs)

### **Pharmacogenetics:**

Definition and introduction. Explanation using suitable examples (0.5 hr)

### **Basic and clinical pharmacokinetics:**

Order of reaction (equation only, **NO** derivation required), Concept and graph for one and two compartment model.

Evaluation of Pharmacokinetic parameters ( $V_d$ , Cl and  $T_{1/2}$ ). (1 hr)

### **Adverse drug reaction and treatment of poisoning:**

Definition and types of ADR, Predisposing factors, Mechanism of ADR types (in brief), Hypersensitivity and its types, Route of exposure and general method of treatment of poisoning.

(2 hrs)

### **Unit-6: Bioassay of drug and Biological standardization:**

Concept and purpose of bioassay, type and techniques of bioassay assessment. (2 hrs)

### **Unit-7: Discovery and development of new drugs:**

Various phases of clinical trials (1 hr)

## **Part -2: Pharmacology of Peripheral Nervous System (15 hours)**

### **Unit-8: Neurohumoral transmission**

Classification, Mechanism of action, Side-effects, Contraindications, Precautions and doses of commonly used drugs:

Differences between Sympathetic, Parasympathetic Nervous system. Steps Involved in Neurotransmission. Cholinergic Transmission. Muscarinic and Nicotinic Receptors.

Adrenergic Transmission. Adrenergic Receptors. Prejunctional Regulation of Norepinephrine Release.

### **Unit-9: Parasympathomimetics and Parasympatholytics:**

Classification, Mechanism of action, Side-effects, Contraindications, Precautions and doses of:

Acetylcholine, Carbachol, Pilocarpine, Physostigmine, Neostigmine, Organophosphate, Pralidoxime, Atropine, Scopolamine, Hyoscine.

#### **Unit-10: Sympathomimetics and Sympatholytics:**

Adrenaline, Epinephrine, Norepinephrine, Isoprenaline, Dopamine, Dobutamine, Clonidine, Salbutamol (Albuterol), Salmeterol, Formoterol, Terbutaline and Amphetamine, Prazosin, Terazosin, Tamsulosin, Propranolol, Methyldopa, Timolol, Atenolol and Metoprolol.

**Ganglionic stimulant:** Pilocarpine

**Ganglionic blocker:** Hexamethonium, Mecamylamine, Trimethaphan, Nicotine

#### **Unit-11: Neuromuscular blocker and Local anaesthetic:**

Tubocurarine, Pancuronium, Succinylcholine (depolarizing), Tizanidine. Procaine, lidocaine, Bupivacaine, Topical anesthesia (surface), Infiltration, Plexus block, Epidural (extradural) block and Spinal anesthesia (subarachnoid block).

### **Part 3: Pharmacology of the Central Nervous System (16 hours)**

#### **Neurohumoral transmission in the CNS:**

Classification, Mechanism of action, Side-effects, Contraindications, Precautions and doses of commonly used drugs. Steps in neurohumoral transmission.

#### **Unit-12: General anesthetics:**

##### **Stages of General Anesthesia, Types and ideal characteristics**

Mechanism of action, indication, ADRs, C/I, Doses of commonly used GAs ( Halothane, Isoflurane, Nitrous oxide, Ketamine, Thiopental)

**CNS Stimulants:** Methylxantines, Doxapram, Amphetamine.

#### **Unit-13: Alcohol and Disulfiram**

Effect of alcohol in CNS, kidney and Liver. Use of Disulfiram for alcohol withdrawal, Recommended dose, Precautions, Side-effects, Potential interaction.

#### **Unit-14: Anxiolytics, Sedative and hypnotics:**

BZDs: Alprazolam, Diazepam, lorazepam, chlordiazepoxide. Phenobarbital: Phenobarbitons.

#### **Unit-15: Drugs used as:**

**Anti-psychotics:** Haloperidol, Clozapine.

**Anti-depressants:** Fluoxetine, Duloxetine, Bupropion, Amitriptyline, Imipramine, Nortriptyline,

**Mood Stabilizers:** Valproate semi-sodium, Lithium salts.

**Anti-epileptic drugs:** Phenytoin, Carbamazepine, Oxcarbazepine, and Topiramide . .

**Anti-Parkinsonian drugs:** Levodopa, Carbidopa, Selegiline.

## **. PHAR 225 Lab Pharmacology –I Practical**

1. Introduction to experimental pharmacology.
2. Preparation of different solutions for experiments.
3. Drug dilution, use of molar and W/V solutions in experimental pharmacology.
4. Common laboratory animals and anesthetics used in animal studies.
5. Commonly used instruments in experimental pharmacology.
6. Some common and standard techniques. Bleeding and intravenous injection, intragastric administration procedure for rendering animal's unconscious, stunning or redents, pithing of frogs, chemical anesthesia.
7. Experiments on intact preparation :
8. Study of different route of administration of drugs in mice/rats.
9. To study the effect of hepatic microsomal enzyme inhibitors and introduction of the Pentobarbitone sleeping time in mice.
10. Evaluation of local anesthetics.
11. To study the effect of autonomic drugs on rabbit eye.
12. To study the effect of various agonists and antagonists and their characterization using isolated preparation like frogs rectus abdominus muscle and isolated ileum preparation of rat, guinea pig

### **Books Recommended:**

1. C.R.Craig and R.E.Stitzel: Modern Pharmacology
2. Theodore W.Rall, Alan S.Nies and Palmer Taylor: Goodman Gilman's : The Pharmacological Basis of Therapeutics by Alfred Goodman Gilman.
3. D.R.Laurence and P.N.Bennett: Clinical Pharmacology.
4. K.D.Tripathi: Essentials of Medical Pharmacology.
5. R.S.Satoskar and S.D.Bhandarkar: Pharmacology and Pharmacotherapeutics.
6. F.S.K. Barar: Essentials of Pharmacotherapeutics.
7. H.P.Rang and M.M.Dale: Pharmacology.
8. James Crossland: Lewis's Pharmacology, revised.
9. Pharmacological experiments on isolated preparations by Edinburgh University Pharmacology Staff, 1968.
10. Robert A.Turner and Peter Hebbom: Screening methods in Pharmacology, Vol.1 edited
11. S.K.Kulkarni: Handbook of experimental Pharmacology
12. M.N.Ghosh: Fundamentals of experimental pharmacology
13. Ian Kitchen: Text book of invitro Pharmacology
14. U.K.Sheth, N.K.Dadkar, Usha G.Kamat: Selected topics in Experimental Pharmacology
7. K. K. Pillai: Experimental Pharmacology, CBS, Delhi.