

Contents

Foreword to First Edition (vii)

Preface to Second Edition (ix)

Preface to First Edition (xi)

Part - I

Pharmacognosy

CHAPTER 1

Pharmacognosy: Scope and History 3

Introduction 5

Scope 5

History 6

Alternative Systems of Medicine 7

Ayurveda System 7

Siddha System 8

Unani System 9

Homeopathy System 10

Chinese System 10

Kampo System 11

Aromatherapy System 12

Naturopathy 12

Yoga 12

Crude Drug: Classification 13

Alphabetical Classification 13

Morphological Classification (Organised and un-organised crude drugs) 13

Taxonomic Classification 14

Biological or Pharmacological Classification 14

Chemical Classification 14

Chemotaxonomic Classification 14

Serotaxonomical Classification 15

Sources of Crude Drug 16

CHAPTER 2

Plant Morphology and Anatomy 17

Plant Morphology 19

Roots 19

Stems 19

Leaves 19

Flower	22
Seed	23
Fruit	23
Bark	23
Wood	24
Plant Anatomy	25
Tissue systems in Plants	25
Anatomy of Plant Parts	29
Leaf Anatomy	30
Root Anatomy	31
Stem Anatomy	32
Fruit Anatomy	33
Seed Anatomy	33
Bark Anatomy	34
Wood Anatomy	34

CHAPTER 3

Basics in Microscopy 35

Microscope	37
Electron Microscope	40
Sample Preparation	41
Microscopical Aids	43
Camera Lucida	43
Micrometer	43
Microtome	44

CHAPTER 4

Cell: Organelles and Inclusions 49

Cell	51
Eukaryotic and prokaryotic cell	51
Plant cell and animal cell	52
Cell Contents	53
Cell Organelles and their Functions	53
Cell Inclusions	55
Starch Grains	55
Calcium Crystals	56
Pollen Grains	57
Aleurone Grains	58
Pigments	58
Gums and Mucilages	58

Amino Acids	58
Proteins	60
Enzymes	60
Vitamins	60
Nucleic Acids	60
Sugars	61
Lipids	61
Phenolic Compounds	61
Tannins	62
Resins	63
Alkaloids	63
Glycosides	63
Terpenoids	63
Phenylpropanoids	63
Iridoids	64
Lignans and Lignin	65
Naphthoquinones	65

CHAPTER 5

Plant Physiology and Biochemistry 67

Introduction	69
Photosynthesis - Calvin Cycle	69
Glycolysis	71
Kreb's Cycle	74
Oxidative Phosphorylation (Electron Transport Chain)	75
Other Physiological Processes	75
Biosynthesis	77
Role of Enzymes and Cofactors	78
Role of Vitamins	79
Shikimic Acid Pathway	80
Acetate Pathway	80
Isoprenoid Pathway/Mevalonate Pathway	82
Amino Acid Biosynthesis Pathway	85
Glycoside Biosynthesis	86
Cardioactive Sterol Biosynthesis	86
Anthraquinone Glycoside Biosynthesis	88
Alkaloid Biosynthesis	88
Tropane Alkaloid Pathway	88
Indole Alkaloid Pathway	88
Quinoline Alkaloids Pathway	88
Opium Alkaloid Pathway	93
Elucidation of Biosynthetic Pathway	93

CHAPTER 6

Plant Taxonomy 99

- Taxonomy 101
- Nomenclature 102
- Classification 102
- Types of Classification 105
 - Artificial 105
 - Natural 105
 - Phylogenetic (Phyletic) 106
 - Phenetic 106
 - Cladistic 106
 - Molecular 107
- Herbarium 107

CHAPTER 7

Chemotaxonomy 111

- Introduction 113
- History 113
- Principles of Chemotaxonomy 113
- Stages of Chemotaxonomic Investigations 114
- Applications of Chemotaxonomy 114
- Alkaloids 114
- Flavonoids 117

CHAPTER 8

Families 121

- Symbols used in this chapter 123
- Apocynaceae 123
- Compositae 124
- Convolvulaceae 125
- Leguminosae 125
- Labiatae 127
- Rubiaceae 128
- Rutaceae 128
- Scrophulariaceae 129
- Solanaceae 130
- Umbelliferae 130
- Liliaceae 131

CHAPTER 9

Cultivation 133

- Introduction 135
 - Biodynamic Agriculture (Organic Farming) 135
- Cultivation and Collection Practice 136
 - Method of Propagation 137
 - Harvesting and Collection 137
 - Drying 137
 - Garbling 138
 - Packaging 138
 - Storage 138
- Factors Affecting Cultivation 138
- Exogenous/Extrinsic Factors 138
 - Climate 138
 - Soil and Soil Fertility 139
 - Altitude and Latitude 140
 - Age of Plant / Stage of Development 141
 - Fertilizers 141
 - Pests and Pest Control 141
 - Allelopathy 142
- Endogenous/ Intrinsic Factors 142
 - Selection 142
 - Mutation 143
 - Polyploidy 143
 - Hybridization 144
 - Chemical Races/Chemo Demes 144
 - Plant Growth Regulators 145
 - Plant Diseases 152
- Pest and Pest Control 156
- Natural Pesticides 161

CHAPTER 10

Good Agricultural and Collection Practices [GACP] 163

- Section 1: General Introduction and Glossary 165
- Section 2: Good Agricultural Practices for Medicinal Plants [GAP] 165
 - Identification/Authentication of Cultivated Medicinal Plants 165
 - Seeds and Other Propagation Materials 166
 - Site selection 166
 - Personnel 166

Ecological Environment and Social Impact	166
Soil	166
Climate	166
Irrigation and Drainage	166
Cultivation	166
Plant Maintenance and Protection	166
Harvest	166
Section 3: Good Collection Practices for Medicinal Plants	167
Permission to Collect	167
Technical Planning	167
Selection of Medicinal Plants for Collection	167
Collection	167
Personnel	167
Section 4: Common Technical Aspects of GACP	167
Post-harvest Processing	167
(a) Inspection and Sorting	167
(b) Primary Processing	167
(c) Drying	168
(d) Specific Processing	168
(e) Processing Facilities	168
Bulk Packaging and Labelling	168
Storage and Transportation	168
Equipment	168
Quality Assurance	168
Documentation	168
Personnel (growers, collectors, producers, handlers, processors)	168
Section 5: Other Relevant Issues	168
Ethical and Legal Considerations	168
Intellectual Property Rights and Benefits Sharing	168
Threatened and Endangered Species	169
Research Needs	169

CHAPTER 11

Quality Control of Crude Drugs 171

Evaluation of Crude Drugs	173
Adulteration	173
Types of Adulteration on the basis of Reasons	173
Terminologies Related to Adulteration	174
Adulterants of Various Crude Drugs	174

Standardization of Crude Drugs	178
Important Terminologies Related to Herbal Drug Standardisation	178
Role of Markers in Standardization of Herbal Products	180
Need of Standardization	181
WHO Guidelines	181
Preliminary Evaluation	183
Morphological Evaluation	183
Microscopical Evaluation	185
Powder Microscopical Evaluation	193
Physical Evaluation	194
Qualitative Physical Evaluation	194
Quantitative Physical Evaluation or Physicochemical Evaluation	195
Chemical Evaluation	199
WHO Specific Parameters	200
Determination of Swelling Index	200
Determination of Foaming Index	200
Determination of Haemolytic Activity	200
Bitterness Value Determination	201
Total Tannin Value Determination	202
Toxicological Evaluation	203
Microbial Contamination	203
Aflatoxin Determination	203
Radioactive Contamination	204
Pesticide Residue Determination	204
Heavy Metal Determination	204
Pharmacological Evaluation	205
Antimicrobial Activity	205
Advanced Analytical Evaluation	206
Chromatography	206
Spectroscopy	216

CHAPTER 12

WHO Guidelines for Safety and Toxicity of Herbal Drugs 221

Background	223
Goals	223
Objectives	223
Ethical Considerations	223
Non-clinical Studies	223

Pharmacodynamic Studies	224
Pharmacological Studies	224
Toxicological Studies	224
Methods	224
Systemic Toxicity Tests	224
Acute Toxicity Tests	224
Sub Acute Toxicity Tests	226
Chronic [Long-term Toxicity]	226
Local Toxicity Tests	228
Skin Irritation/Corrosion Test	228
Skin Sensitization	228
Eye Irritation Test	228
Special Toxicity Tests	228
Mutagenicity Tests	228
Test for Gene Mutations in Bacteria-Ames Test	228
Reproductive Toxicity Study	229
Teratogenic Toxicity Study	229
Alternatives to Animal Testing	229
Types	230
Computer Simulation	230

Part - II

Phytochemistry

CHAPTER 13

Natural Product Chemistry 233

Introduction, Occurrence and Distribution, Biosynthesis, Function, Classification, Chemistry, Method of Analysis, Extraction, Estimation, Chromatographic Analysis of following Phytochemical Classes:	
Carbohydrates	235
Lipids	245
Amino Acids	254
Proteins	258
Nucleic Acids	263
Enzymes	264
Glycosides	279
Essential Oils and other Terpenoids	318
Alkaloids	341
Tannins	358

Resins	362
Minerals	365
Suture	367
Fibers	368
Surgical Dressings	371

CHAPTER 14

Pharmacognostic Account of Crude Drugs 373

Carbohydrates	377
Lipids	387
Glycosides	393
Alkaloids	456
Resins	499
Tannins	510

CHAPTER 15

Extraction, Isolation and Purification of Phytoconstituents 517

Introduction	519
Factors Affecting Extraction of Crude Drugs	519
Methods of Extraction (Maceration, Percolation, Soxhlet, Infusion, Decoction, Distillation, Expression, Microwave Assisted, Sonication, Sublimation, Counter Current Extraction (CCE), Supercritical Fluid Extraction (SCF))	519-522
Methods of Purification (Chromatography, Droplet Counter-Current Chromatography, Distillation, Water, Steam, Evaporation, Sublimation, Crystallisation, Precipitation, Hydrolysis, Salt Formation, Acetylation, Electrophoresis)	522-524
Isolation of	
Andrographolide	525
Artemisinin	526
Asiaticosides/Madecassosides	527
Atropine	528
Berberine	528
Caffeine	529
Citral	529
Curcumin	530
Digoxin	531
Diosgenin	532
Emetine	533
Ephedrine	533
Ergometrine (Ergonovine)	534

Ergotamine	535
Eugenol	535
Forskolin	536
Gymnemic Acid	536
Guggulosterone	537
Ginsenosides	538
Glycyrrhetic Acid	539
Hesperidin	540
Menthol	541
Pectin	541
Piperine	541
Podophyllotoxin	542
Quinine and Quinidine	542
Reserpine (Raudixin, Serpalan Serpasil)	543
Rutin	544
Sennosides	545
Solanine	546
Solasodine	546
Tannic Acid	547
Taxol	548
Vinblastine and Vincristine (Vinca Alkaloids)	549
Withanolides	550
Manufacturing Kattha/Khair/Catechu	551
Physical Properties of Phytochemicals	552

Part - III

Phytopharmacognosy

CHAPTER 16

Screening Methods for Plant Drugs 557

Introduction	559
Anti-inflammatory Activity	561
Hypoglycemic Activity	562
Anti-diabetic Activity	563
Antiulcer Activity	563
Hepatoprotective Activity	565
Diuretic Activity	566
Psychopharmacological Activity	566
Antidepressant Activity	566
Anticonvulsant Activity	567
Anti Alzheimer's Activity	567

Immunomodulatory Activity	570
Antimicrobial Activity	572
Antiviral Activity	575
Antioxidant Activity	578
Anti Fertility Activity	581
Anticancer Activity	582
Cardiotonic Activity	583

CHAPTER 17

Phytopharmacology 585

Introduction	587
Plants Acting on CNS	587
Anti-inflammatory Plants	591
Hepatoprotective Plants	595
Antidiabetic Plants	598
Anti HIV Plants	600
Anticancer Plants	604
Classification	604
Nomenclature	604
Plants Acting on CVS	608
Hypolipidemic Plants	608
Antihypertensive Plants	608
Cardiotonic Plants	608
Immunomodulating / Adaptogenic / Antistress Plants	618
Antiviral Plants	624
Antiobesity Plants	627
Antipyretic Plants	631
Antimicrobial Plants	633

Part - IV

Herbal Drug Technology

CHAPTER 18

Herbs as Raw Material: Processing of Herbal Raw Materials and Dosage Forms 637

Introduction	639
Important Definitions (Herbs, Herbal Medicines, Medicinal Herbal Products, Herbal Preparations, Medicinal Plants, Processed Plant Materials, Raw Plant Materials)	639 - 640
Processing of Herbal Raw Material	640
Collection	640

Harvesting	640
Drying	640
Classification of Drying Process	641
Garbling	642
Packing	643
Storage of Herbal Raw Drug	643
Pulverisation	643
Extraction and Drying of Herbal Extracts	644
Herbal or Natural Excipients (Sources, classification, regulation, roles, examples)	645-648
Processing of Herbal Dosage Forms	648
Manufacturing Process Development	648
Control of Critical Steps and Intermediates	648
Characterization of Active Constituents and Impurities	648
Quality Control	649
Validation of Analytical Procedures	649
Container Closure System	649
Stability Studies	650
Herbal Solid Dosage Forms	650
Herbal Tablets	650
Herbal Capsules	651
Herbal Semisolid Dosage Forms	652
Ointments	652
Creams	653
Gels	654
Herbal Liquids	654
Syrups	654
Elixirs	655
Aromatic Waters	656
Emulsion	656
Suspensions	657
Novel Dosage Forms	658
Liposomes (Phytosome, Niosomes, Ethosom, Transferosome)	658-659
Micro-emulsion	659
Nano-emulsion	660
Preparation Methods	660
Mucoadhesive Drug Delivery	661

CHAPTER 19

Good Manufacturing Practices for Herbal Medicines 663

Introduction	665
Elements of cGMPs	666

Organization and Personnel	666
Buildings and Facilities	667
Equipments	668
Control of Components, Containers and Closures	668
Production and Control Procedures	669
Master Formula Records	670
Packaging and Labeling Control	671
Laboratory Controls	672
Stability Controls	673
Holding and Distribution Records	673
Complaint Files	673
Returned and Salvaged Drug Products	674

CHAPTER 20

Traditional Drugs and Derived Formulation 675

Ayurvedic Dosage Forms	677
Bhasma	677
Preparation	677
Asava and Arishta	678
Leha (Avaleha/Paka)	679
Churna	679
Taila	680
Gutika/Vati	680
Common Ayurvedic Drugs	681
Unani Dosage Forms	686
Sufoof (Powder)	686
Habb (Pills)	686
Qurs (Tablet)	687
Kushta (Calx)	687
Shiyaf (Suppositories)	687
Marham (Ointment)	687
Laooq (Linctus)	687
Majun (Confection)	688
Homeopathic Dosage Forms	688
Medicated Pellet or Globule	688
Triturate Tablets	688
Compressed Tablets	689
Medicated Tablets	689
Oral Liquid Dosage Forms	689

CHAPTER 21

Herbal Cosmetics 691

- Introduction 693
- Classification 694
 - Skin Cosmetics 694
 - Antioxidants in Skin Cosmetics 698
 - Skin Whitening (Bleaching) Agents 699
 - Hair Cosmetics 701
 - Dental Cosmetics (Oral Hygiene Products) 703
 - Shaving Cosmetics 704
 - Lip Cosmetics 704
 - Eye Cosmetics 704
 - Nail Cosmetics 705
- Different Chemical Classes of Cosmetic Raw Material 705
- Volatile Oils /Perfumes 706
- Colorants 706
- Quality Control / Evaluation of Cosmetics 708
 - All Cosmetics Products 708
 - Powder Cosmetics 708
 - Lipstick 709
 - Roughes 709
 - Sunscreen Preparations 709
 - Skin Cosmetics 710
 - Shampoo 711
 - Shaving Praparation 711
 - Hair Removers 711
 - Mouth Washes 711
 - Nail Polish 712
 - Plants used in Cosmetic Formulations 714

Part - V

Pharmaceutical Biotechnology

CHAPTER 22

Pharmaceutical Biotechnology 721

- Introduction to Biotechnology 723
- Plant Tissue Culture (PTC) 723
 - Introduction 723
 - Historical Development 723

Basics of Plant Tissue Culture	725
Totipotency	725
Explant	725
Callus	725
Dedifferentiation	725
Redifferentiation	725
Plant Regeneration	725
Factors Affecting Vascular Differentiation	726
Plant Growth Regulators	726
Cyclic AMP	726
Chemical Factor	726
Physical Factor	726
Elicitors	726
Precursors	727
Plant Tissue Culture Establishment	728
Plant Tissue Culture Lab	728
Media	728
Media Preparation	730
Explant Selection and Surface Sterilization	731
Callus Culture/Solid Medium Culture	731
Suspension Culture/Liquid Medium Culture	731
Growth Profile for PTC	733
Culture Growth Measurement: Fresh and Dry Weight Measurement, Cell Counts, Packed Cell Volume, Cell Viability Test, Protein Content, Mitotic Index, Plating of Cell Suspension	733-734
Types of Culture: Meristem Culture, Root Culture, Shoot Tip Culture, Anther or Pollen Culture, Ovary Culture, Seed Culture, Embryo Culture, Protoplasts Culture, Hairy Root Culture	734-735
Plant Tissue Culture Applications	737
To Study Respiration and Metabolism	737
To Study Proliferation and Organ Function	738
Single Cell Culture of Higher Plant Cells	738
Genetic Transformation	738
Production of Disease Free and Disease Resistant Plant	738
Germplasm Storage	738
Embryo Rescue	739
Somaclonal Modification	739
Production of Haploids	739
Production of Artificial Seeds	739
Clonal Propagation	739

Micro Propagation	739
Mutant Selection	739
Somatic Hybridization	740
Cloning	740
Production of Secondary Metabolites	740
Taxol Secondary Metabolite Production	741
Shikonin Secondary Metabolite Production	743
Biotransformation	744
Transgenic Plants and Gene Transfer	746
Mechanical: Gene gun method/Electroporator method, Microinjection	747-749
Biological: Agrobacterium mediated gene transfer, leaf disc infection method	749-751
Chemical: Cellular targeting and compartment	751
Edible vaccines	751
Production	751
Challenges	753

Part - VI

Selected Topics in Pharmacology

CHAPTER 23

Recent Trends in Pharmacognosy 757

Problems and Prospects of Discovering New Drugs from Higher Plants	759
Prospects	759
Bioavailability and Herbal Drugs	760
Phytoequivalence and Herbal Drugs	763
Pharmacovigilance and Herbal Drugs	764
Herb-Drug or Herb-Food Interaction	766
Stability Studies of Herbal Products	769
High-Throughput Screening (HTS)	772
High Content Screening (HCS)	773
Ethnopharmacognosy	773
Ethnobotany	774
Conservation of Medicinal Plants	775
Herbal Drug Regulatory Affairs or regulations of ASU (Ayurveda, Siddha, Unani) Drugs	778
CDSCO/DTAB/DCC	778
Regulatory Issues of ASU Drugs	781
ASU-DTAB/ASU-DCC	781
ASU Pharmacopoeias	781

CHAPTER 24

Photosensitizing Plants, Plant Allergens, Fungal Toxins, Poisonous Plants, Hallucinogenic Plants, Teratogenic Plants 785

Photosensitizing Plants	787
Introduction	787
Photosensitizing Reaction	787
Clinical Findings	787
Classification of Photosensitizers	787
Photosensitizing Plants as Therapeutic Agents	788
Plant Allergens	791
Process of Allergy	791
Types of Reactions	791
Plant Allergens	792
Plant Allergens as Therapeutic Agents	794
Fungal Toxins	794
Properties	794
Types	794
Toxins and associated Fungi	795
Poisonous Plants of India	796
Classification	796
Alkaloid	796
Proteins	799
Essential Oils	800
Calcium Oxalate Crystals	800
Fixed Oils	801
Glycosides	801
Hallucinogenic Plants	803
Teratogenic Plants	804

CHAPTER 25

Marine Drugs 805

Introduction	807
Common Marine Bioactive Molecules	808
Examples of Marine Pharmaceuticals	809
Anti-malarial	811
Anti-diabetic	813
Immuno-modulatory	813
Anti-nociceptive, anti-inflammatory and analgesic	814
Neuro-protective	814

Cardiovascular System	815
Anticancer	817
Anti-inflammatory	820
Antimicrobial	821
Antibiotic	822
Anthelmintic	823
Toxins	824

CHAPTER 26

Plant Sweeteners and Bitters 827

Introduction	829
Plant Sweeteners	829
Classification	829
Examples: Glycyrrhizin, Neohesperidin dihydrocalone (NHDC), Stevioside and Rebaudioside, Thaumatin, Monellins, Phyllodulcin, Abrusoside, Miscellaneous	830-834
Plant Bitters	834
Classification of Plant Bitters	835

CHAPTER 27

Nutraceuticals 839

Introduction	841
Why Nutraceuticals?	841
Market Scenario of Nutraceuticals	841
Types of Nutraceuticals Products available in Market	842
Regulatory Concepts	842
Classification	843
Important pure phytochemicals, their sources and potential health benefits	846
Future Scope	849
Nutraceutically Valuable Plants	849

CHAPTER 28

Medicinal and Aromatic Plants: National Economy, Industry and Institutes Involved in Research 853

Herbal Drugs Industry: Present Scope and Future Prospects	855
Medicinal Plants	855
National and International Trade of Medicinal Plants	856

Aromatic Plants	857
National and International Trade of Aromatic Plants	857-858
Herbal Cosmetics	858
Prospectus of Herbal Medicines and Cosmetics	859
Institutes Involved in Herbal Research	859
Major Research Funding Bodies	863
Industries Involved in Herbal Research (Herbal Medicines, Nutraceutical Companies)	864-868

CHAPTER 29

Natural Product Drug Delivery 869

Introduction	871
Methods of Drug Discovery	871
Traditional Drug Design	871
Rational Drug Design	871
Role of Natural Products in Drug Discovery	872
Natural Chemicals as Lead Molecules from Different Sources	872
Natural Chemicals as Raw Material for Semi Synthesis	878

CHAPTER 30

Herbal Medicines and Intellectual Property Rights 883

Intellectual Property Rights (IPR)	885
History	885
Types of IPs	885
Patent	885
Copyright	886
Industrial Design	886
Trademark	886
Trade Secret	886
Geographical Indication	886
Patent	886
Types of Patent	888
Preparation of Patent Proposal	889
Indian Patent Act, 1970	890
Traditional Knowledge (TK) of Medicines	892
Existing IPR Loop Holes for Traditional Medicines	893
Bio-prospecting and Bio-piracy with examples	893
Unauthorized or Inappropriate Use by Third Parties	894

Biodiversity	894
Geographical Indication	894
New IPR Solutions for Traditional Medicines	894
Defensive Protection	895
Equitable Benefit-sharing with Examples	895
Unfair Competition and Trade Practices Laws	895
The Law of Confidentiality and Trade Secrets	895
Sui Generis Laws	895
Convention on Biological Diversity (CBD) Law	896
Prior Informed Consent (PIC)	896
Unfair Competition Law	896
Customary Laws and Practices	896
Other Solutions	896
Protection of Plant Variety and Farmers Right Act, 2001 (PPVFR Act)	896
Salient Features of PPVFR Act	897
Plant breeders' rights (PBR) OR plant variety rights (PVR)	898
Traditional Knowledge Digital Library (TKDL)	899
What is Next?	899

ANNEXURE 1

Pharmacological Classification of Crude Drugs	901
---	-----

ANNEXURE 2

Cultivation Technology of Selected Medicinal and Aromatic Plants	921
---	-----

ANNEXURE 3

Multiple Choice Questions	957
---------------------------	-----

ANNEXURE 4

Question Bank	1001
---------------	------

References	1011
------------	------

Index	1029
-------	------