

Appendix B: Additional Guidance on the Science Foundation for the Curriculum



1. Basic Biomedical Sciences

- 1.1. Anatomy and Physiology
- 1.2. Pathology/Pathophysiology
- 1.3. Microbiology
- 1.4. Immunology
- 1.5. Biochemistry/Biotechnology
- 1.6. Molecular Biology/Genetics
- 1.7. Biostatistics

2. Pharmaceutical Sciences

- 2.1. Medicinal Chemistry
- 2.2. Pharmacology
- 2.3. Pharmacognosy and Alternative and Complementary Treatments
- 2.4. Toxicology
- 2.5. Bioanalysis/Clinical Chemistry
- 2.6. Pharmaceutics/Biopharmaceutics
- 2.7. Pharmacokinetics/Clinical Pharmacokinetics
- 2.8. Pharmacogenomics/genetics
- 2.9. Extemporaneous Compounding/Parenteral/Enteral

3. Social/Behavioral/Administrative Pharmacy Sciences

- 3.1. Health Care Delivery Systems
- 3.2. Economics/Pharmacoeconomics
- 3.3. Practice Management
- 3.4. Pharmacoepidemiology
- 3.5. Pharmacy Law and Regulatory Affairs
- 3.6. History of Pharmacy
- 3.7. Ethics
- 3.8. Professional Communication
- 3.9. Social and Behavioral Aspects of Practice

4. Clinical Sciences

- 4.1. Pharmacy Practice and Pharmacist-Provided Care
- 4.2. Medication Dispensing and Distribution Systems
- 4.3. Pharmacotherapy
- 4.4. Pharmacist-Provided Care for Special Populations
- 4.5. Drug Information
- 4.6. Medication Safety
- 4.7. Literature Evaluation and Research Design
- 4.8. Patient Assessment Laboratory
- 4.9. Elective Courses

During the standards revision process from 2003 to 2006, ACPE stakeholders (faculty, practitioners, regulators, and others) identified elements of the science foundation that they believe essential to the development of pharmacists. Some of these areas may be addressed in pre-pharmacy courses, while the majority would be the purview of the curriculum of the professional degree program. The majority of the sections listed would reflect required course work, while some could be addressed in elective courses. Laboratory experiences and patient-care simulations should be incorporated as appropriate to the subject matter. Topic headings do not imply the need for separate courses but rather that the material be addressed adequately in the curriculum. Content may be delivered as individual or integrated courses involving multiple disciplines. It is expected that the listing below will change as a function of evolution of the profession, leading to future updates of this appendix.

Thus, the following information is provided as a basis for curricular evaluation and continuous quality improvement, driven by the mission and goals of the college or school.

Today's ever-changing health care environment requires a pharmacy practitioner to be knowledgeable and competent in the following areas critical to the foundation and delivery of effective patient care. The foundation in the sciences suggested by ACPE stakeholders follows:

1. Basic Biomedical Sciences

1.1. Anatomy and Physiology

- 1.1.1. structure and function of major body systems: integumentary, muscular skeletal, cardiovascular, lymphatic, respiratory, digestive, nervous, endocrine, urinary, reproductive, and body fluid and electrolytes
- 1.1.2. molecular aspects of cell biology
- 1.1.3. cell physiology and cellular structure and organization

1.2. Pathology/Pathophysiology

- 1.2.1. basic principles and mechanisms of disease, including:
 - 1.2.1.1. inflammation and repair
 - 1.2.1.2. degeneration
 - 1.2.1.3. disturbances on hemodynamics
 - 1.2.1.4. developmental defects
 - 1.2.1.5. neoplasia
- 1.2.2. pathophysiology of disease states amenable to pharmacist intervention

1.3. Microbiology

- 1.3.1. general principles of microbial concepts
- 1.3.2. principles of infectious disease
- 1.3.3. host-parasite relationships
- 1.3.4. pathogenic micro-organisms of man
- 1.3.5. inflammatory responses to infectious agents
- 1.3.6. clinical aspects of infection

1.4. Immunology

- 1.4.1. human immunity and immune response
- 1.4.2. principles of antigen-antibody relationships
- 1.4.3. molecular biology of immune response
- 1.4.4. genetic basis for antibody synthesis, development, function, and immunopathology

1.5. Biochemistry/Biotechnology

- 1.5.1.chemistry of biomacromolecules (proteins, lipids, carbohydrates, and DNA)
- 1.5.2.enzymology and co-enzymes and kinetics
- 1.5.3.metabolic pathways to energy utilization
- 1.5.4.nucleic acid metabolism, including DNA replication and repair, RNA, and protein synthesis
- 1.5.5.recombinant DNA technology

1.6. Molecular Biology/Genetics

- 1.6.1.cell structure and components
- 1.6.2.ion channels and receptor physiology
- 1.6.3.mitosis and meiosis
- 1.6.4.chromosomes and DNA
- 1.6.5.gene transcription and translation processes
- 1.6.6.recombinant DNA technology

1.7. Biostatistics

- 1.7.1.understanding of commonly used statistical tests and their basis
- 1.7.2.management of data sets
- 1.7.3.evaluation of statistical results
- 1.7.4.understanding of statistical versus clinical significance

2. Pharmaceutical Sciences

2.1. Medicinal Chemistry

- 2.1.1.physico-chemical properties of drug molecules in relation to drug absorption, distribution, metabolism, and excretion (ADME)
- 2.1.2.chemical basis of pharmacology and therapeutics
- 2.1.3.fundamental pharmacophores for drugs used to treat disease
- 2.1.4.structure activity relationships in relation to drug-target interactions
- 2.1.5.chemical pathways of drug metabolism
- 2.1.6.application to making drug therapy decisions

2.2. Pharmacology

- 2.2.1.mechanism of action of drugs in various categories
- 2.2.2.role of pharmacology in drug choice and the treatment of disease
- 2.2.3.pharmacodynamics of drug action and absorption, distribution, metabolism, and elimination
- 2.2.4.adverse effects and side effects of drugs
- 2.2.5.drug-target interactions
- 2.2.6.drug-drug, drug-food, drug-lab test interactions
- 2.2.7.drug discovery and development

2.3. Pharmacognosy and Alternative and Complementary Treatments

- 2.3.1.concepts of crude drugs, semi-purified, and purified natural products
- 2.3.2.variability of occurrence of pharmacologically active substances in plants and impact on regulatory aspects of herbal products
- 2.3.3.overview of classes of pharmacologically active natural products
- 2.3.4.dietary supplements (vitamins, minerals, and herbals)
- 2.3.5.alternative medical treatments
- 2.3.6.evaluation of alternative and complementary medicine purity, bioavailability, safety, and efficacy
- 2.3.7.herbal-drug interactions

2.3.8. Dietary Health Supplement and Education Act and impact on regulation of dietary supplements and herbal products

2.4. Toxicology

2.4.1. mechanism of toxicity and toxicokinetics

2.4.2. acute and chronic toxic effect of xenobiotics on the body, including drug or chemical overdose and toxic signs of abuse

2.4.3. interpretation of drug screens

2.4.4. antidotes and approaches to toxic exposures

2.4.5. functions of poison control centers

2.4.6. bioterrorism and disaster preparedness and management

2.5. Bioanalysis/Clinical Chemistry

2.5.1. fundamentals of laboratory medicine and its importance to screening, diagnosis, and evaluation of patients

2.5.2. clinical data relevant to disease state management

2.6. Pharmaceutics/Biopharmaceutics

2.6.1. physical-chemical principles of dosage forms

2.6.2. biological principles of dosage forms

2.6.3. principles of drug delivery via dosage forms (e.g., liquid, solid, semi-solid, controlled release, patches, and implants)

2.6.4. principles of dosage form stability and drug degradation in dosage forms

2.6.5. materials and methods used in preparation and use of dosage forms

2.7. Pharmacokinetics/Clinical Pharmacokinetics

2.7.1. basic principles of in vivo drug kinetics (linear and nonlinear)

2.7.2. principles of bioavailability/bioequivalence

2.7.3. physiologic determinates of drug onset and duration

2.7.4. drug, disease, and dietary influences on absorption, distribution, metabolism, and excretion

2.7.5. clinical pharmacokinetics of commonly used and low-therapeutic-index drugs

2.7.6. the pharmacokinetic-pharmacodynamic interface

2.8. Pharmacogenomics/genetics

2.8.1. genetic basis for disease and drug action

2.8.2. genetic basis for alteration of drug metabolism

2.8.3. genome and proteomic principles in relation to disease and drug development

2.8.4. genetic basis for individualizing drug doses

2.9. Extemporaneous Compounding/Parenteral/Enteral

2.9.1. United States Pharmacopeia guidance on compounding and FDA Compliance Policy Guidelines

2.9.2. techniques and principles used to prepare and dispense individual extemporaneous prescriptions, including dating of compounded dosage forms

2.9.3. liquid (parenteral, enteral), solid, semi-solid, and topical preparations

2.9.4. dosage form preparation calculations

2.9.5. sterile admixture techniques

2.9.5.1. United States Pharmacopeia (USP) Chapter 997

2.9.5.2. stability and sterility testing and dating

2.9.5.3. clean room requirements

2.9.5.4. infusion devices and catheters

3. Social/Behavioral/Administrative Pharmacy Sciences

3.1. Health Care Delivery Systems

- 3.1.1.introduction to United States, state, and local health care delivery systems and their interfaces
- 3.1.2.social, political, and economic factors of the U.S. health care delivery system
- 3.1.3.principles that influence the distribution of pharmaceutical products and services
- 3.1.4.role of public and private insurers, pharmaceutical industry, and managed care on health care delivery in the United States
- 3.1.5.Medicare and Medicaid
- 3.1.6.Indigent care programs
- 3.1.7.incidence of and problems associated with drug overuse, underuse, and misuse in the U.S. health care system

3.2. Economics/Pharmacoeconomics

- 3.2.1.economic principles in relation to pharmacoeconomic analysis
- 3.2.2.concepts of pharmacoeconomics in relation to patient care
- 3.2.3.applications of economic theories and health-related quality-of-life concepts to improve allocation of limited health care resources

3.3. Practice Management

- 3.3.1.management principles (planning, organizing, directing, and controlling resources) applied to various pharmacy practice settings and patient outcomes
- 3.3.2.management of staff within the practice setting, including pharmacists, technicians, and other supportive personnel
- 3.3.3.principles of planning, organizing, directing, and controlling pharmacy resources.
- 3.3.4.tools, including informatics, needed to assess and address change, increase competitiveness, improve quality, and optimize patient services
- 3.3.5.management of medication use safety systems
- 3.3.6.strategies to improve continuity of patient care as patients move between health care settings
- 3.3.7.marketing principles
- 3.3.8.basic accounting principles
- 3.3.9.infection control
- 3.3.10. project management
- 3.3.11. managing and improving the medication-use process
- 3.3.12. third-party administration and managed care systems
- 3.3.13. health care improvement mechanisms at the micro- and macro-system levels

3.4. Pharmacoepidemiology

- 3.4.1.application of principles of epidemiology to the study of drug use and outcomes in large populations
- 3.4.2.studies that provide an estimate of the probability of beneficial effects in populations, or the probability of adverse effects in populations, and other parameters relating to drug use benefit
- 3.4.3.methods for continual monitoring for unwanted effects and other safety-related aspects of drugs

3.5. Pharmacy Law and Regulatory Affairs

- 3.5.1.legal basis of pharmacy practice
- 3.5.2.pharmacist's responsibilities and limits under the law

- 3.5.3.pharmacist's role in reducing liability by reducing drug-related misadventure
- 3.5.4.civil versus criminal liability
- 3.5.5.business contract law

3.6. History of Pharmacy

- 3.6.1.overview of the evolution of pharmacy as a distinct profession
- 3.6.2.moving from focus on the drug to focus on the patient and the drug, including clinical pharmaceutical care and other aspects of patient-provided pharmacist care
- 3.6.3.major milestones and contributors in the evolution of pharmacy

3.7. Ethics

- 3.7.1.principles of professional behavior
- 3.7.2.ethical issues related to the development, promotion, sales, prescription, and use of drugs
- 3.7.3.dealing with ethical dilemmas
- 3.7.4.conflict of interest
- 3.7.5.ethical issues in delivery of patient-centered care and clinical research
- 3.7.6.principles of end-of-life care
- 3.7.7.ethical issues in teamwork

3.8. Professional Communication

- 3.8.1.effective verbal and written interpersonal communication
- 3.8.2.health literacy
- 3.8.3.communicating with diverse patients, families, pharmacists, and other health professionals in a variety of settings, both individually and as a member of a team
- 3.8.4.interviewing techniques
- 3.8.5.active listening and empathy
- 3.8.6.assertiveness and problem-solving techniques
- 3.8.7.cultural influences on communication of health information
- 3.8.8.group presentation skills
- 3.8.9.strategies for handling difficult situations
- 3.8.10. documentation of pharmacist recommendations and consultations
- 3.8.11. principles of behavior modification

3.9. Social and Behavioral Aspects of Practice

- 3.9.1.pharmacy as a patient-centered profession
- 3.9.2.patient and other health care provider perceptions of pharmacists' capabilities
- 3.9.3.role of the pharmacist related to patient care
- 3.9.4.role of the pharmacist related to interaction with other health care professionals
- 3.9.5.development of leadership skills
- 3.9.6.importance of involvement in pharmacy organizational, regulatory, state, and federal issues

4. **Clinical Sciences**

4.1. Pharmacy Practice and Pharmacist-Provided Care

- 4.1.1.overview of the pharmacy profession
- 4.1.2.issues of contemporary practice
- 4.1.3.emerging and unique roles for the pharmacist on the health care team
- 4.1.4.concepts of pharmacist-provided patient care and medication therapy management services
- 4.1.5.principles of pharmacist-managed, patient-centered pharmacy services
- 4.1.6.methods of outcome monitoring and assessment techniques

- 4.1.7.problem identification (e.g., duplication, dosage, drug interactions, adverse drug reactions and interactions, frequency, dosage form, indication mismatches) and resolution
- 4.1.8.role of pharmacy care plans in patient care
- 4.1.9.monitoring for positive and negative drug therapy outcomes
- 4.1.10. evidence-based practice and decisions
- 4.1.11. principles of clinical management of drug toxicity and overdosage
- 4.1.12. home diagnostic devices
- 4.2. Medication Dispensing and Distribution Systems
 - 4.2.1.preparation and dispensing of prescriptions
 - 4.2.2.development and maintenance of patient medication profiles
 - 4.2.3.identification and prevention of medication errors
 - 4.2.4.identification and prevention of drug toxicity
 - 4.2.5.issues of distribution systems associated with all types of practice settings
 - 4.2.6.role of automation and technology in workload efficiency and patient safety
 - 4.2.7.assurance of safety in the medication-use process
 - 4.2.8.medication error reduction programs
 - 4.2.9.continuous quality improvement programs
- 4.3. Pharmacotherapy
 - 4.3.1.principles of clinical practice guidelines for various disease states and their interpretation in the clinical setting
 - 4.3.2.integration of core scientific and systems-based knowledge in patient care decisions
 - 4.3.3.reinforcement of basic science principles relative to drug treatment protocols and clinical practice guidelines
 - 4.3.4.evaluation of clinical trials that validate treatment usefulness
 - 4.3.5.application of evidence-based decision making to patient care
 - 4.3.6.drug monitoring for positive and negative outcomes
 - 4.3.7.diagnostic tests in the diagnosis, staging, and monitoring of various disease states
 - 4.3.8.concepts of pain management and palliative care
 - 4.3.9.promotion of wellness and nonpharmacologic therapies
 - 4.3.10. disease prevention and monitoring
 - 4.3.11. nonprescription drug therapies
 - 4.3.12. dietary supplements
 - 4.3.13. design of patient-centered, culturally relevant treatment plans
 - 4.3.14. drug-induced disease
- 4.4. Pharmacist-Provided Care for Special Populations
 - 4.4.1.pathophysiologic and pharmacotherapy alterations specific for special population patients (e.g., pediatric, geriatric, pregnant, cystic fibrosis, sickle cell anemia, celiac disease, genetic disorders, and others) for prescription and nonprescription medications
 - 4.4.2.dosage calculation and adjustments in special-population patients
 - 4.4.3.drug monitoring for positive/negative outcomes in special-population patients
- 4.5. Drug Information
 - 4.5.1.fundamentals of the practice of drug information
 - 4.5.2.application of drug information skills for delivery of pharmaceutical care
 - 4.5.3.technology of drug information retrieval for quality assurance
 - 4.5.4.the ability to judge the reliability of various sources of information

4.6. Medication Safety

- 4.6.1.causes of medication errors/systems approaches
- 4.6.2.human factors in errors
- 4.6.3.strategies for reducing errors
- 4.6.4.pharmacy leadership in medication safety

4.7. Literature Evaluation and Research Design

- 4.7.1.fundamentals of research design and methodology
- 4.7.2.principles of evaluation of the primary literature
- 4.7.3.practical implications of the primary literature
- 4.7.4.principles of research design and analysis in practicing evidence-based pharmacy

4.8. Patient Assessment Laboratory

- 4.8.1.obtaining a comprehensive patient history
- 4.8.2.familiarity with basic assessment techniques (inspection, palpation, percussion, auscultation), terminology, and the modifications caused by common disease states and drug therapy
- 4.8.3.triage and referral skills
- 4.8.4.knowledge of therapeutic drug concentrations and their interpretation
- 4.8.5.knowledge of the basis for common clinical laboratory values and diagnostic tests and the influences of common disease states
- 4.8.6.false positive and false negative results
- 4.8.7.OTC point-of-care testing devices (e.g., glucometers, pregnancy tests, home testing for HbA1c, drug screening)
- 4.8.8.principles of electrocardiography and common EKG abnormalities
- 4.8.9.advanced cardiac life support

4.9. Elective Courses

- 4.9.1.Multiple opportunities should be provided throughout the curriculum for students to take course work designed to develop areas of personal interest, to expand their understanding of professional opportunities, and to achieve the outcomes of the curriculum.