02 Lesson Plan for Pharmacokinetics, Pharmacodynamics, and Pharmacogenetics

OBJECTIVES

1. Differentiate the three phases of drug action.
2. Describe the four processes of pharmacokinetics.
3. Identify the four receptor families.
4. Describe the influence of protein binding on drug bioavailability.
5. Check drugs for half-life, percentage of protein binding, therapeutic index, and side effects in a drug reference book.
6. Anticipate potential unique responses to drugs based on biologic variations.
7. Differentiate the four types of drug interactions.
8. Explain the three mechanisms involved with drug–drug interactions.
9. Describe the effects of drug-nutrient interactions.
10. Explain the meaning of drug-induced photosensitivity.
11. Describe the nursing implications of pharmacokinetics and pharmacodynamics.

KEY TERMS

- absorption, p. 16
- active transport, p. 16
- additive effect, p. 25
- adverse drug reaction (ADRs), p. 22
- agonists, p. 21
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- bioavailability, p. 17
- biotransformation, p. 18
- blood-brain barrier (BBB), p. 18
- diffusion, p. 16
- distribution, p. 17
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- drug toxicity, p. 22
- duration of action, p. 20
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- excretion, p. 19
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- therapeutic index (TI), p. 19
- tolerance, p. 23
- trough drug level, p. 20

NURSING CURRICULUM STANDARDS

QSEN/NLN Competencies

- Patient-Centered Care/Human Flourishing
  - Nursing Process: Patient-Centered Collaborative Care, p. 27
- Teamwork and Collaboration/Professional Identity
  - Protein Binding, p. 17
  - Antagonistic Drug Effects, p. 26
  - Drug Interactions, p. 23
  - Nursing Process: Patient-Centered Collaborative Care, p. 27
- Evidence-Based Practice/Spirit of Inquiry
  - Biologic Variations, p. 23
- Safety/Nursing Judgment
  - Side Effects, Adverse Reactions, and Drug Toxicity, p. 22
  - Dose-Response Relationship, p. 19
  - Biologic Variations, p. 23
  - Therapeutic Drug Monitoring, p. 20
  - Figure 2.6. The Therapeutic Index, p. 19
- Informatics/Nursing Judgment
  - Drug-Laboratory Interactions, p. 26
  - Nursing Process: Patient-Centered Collaborative Care, p. 27

CONCEPTS

The following conceptual themes and specific concepts match those presented in Giddens J. R. (2017). *Concepts for nursing practice* (2nd ed.). St. Louis: Elsevier. The specific exemplars chosen and listed below for each concept have been tailored specifically to correspond to the McCuistion textbook.

A full *Concept-Based Curriculum Map* covering the entire book can be found in the "Download by Resource Type" folder on Evolve.

THEME: Personal Preferences

- Concept: Culture
  - Exemplar: Health Care Practices/Beliefs
    - Nursing Process: Patient-Centered Collaborative Care —Cultural and Pharmacogenetic Considerations, p. 27

THEME: Protection and Movement

- Concept: Immunity
  - Exemplar: Exaggerated Immune Response
    - Side Effects, Adverse Reactions, and Drug Toxicity, p. 22

THEME: Nursing Attributes and Roles

- Concept: Clinical Judgment
  - Exemplar: Urgent/Emergent Situations
    - Side Effects, Adverse Reactions, and Drug Toxicity, p. 22
- Concept: Patient Education
  - Exemplar: Illness Related

- Patient Teaching, p. 28

THEME: Care Competencies

- Concept: Collaboration
  - Exemplar: Interprofessional
    - Protein Binding, p. 17
    - Antagonistic Drug Effects, p. 26
    - Drug Interactions, p. 23
    - Nursing Process: Patient-Centered Collaborative Care, p. 27
- Concept: Safety
  - Exemplar: Point of Care
    - Side Effects, Adverse Reactions, and Drug Toxicity, p. 22
    - Dose-Response Relationship, p. 19
    - Biologic Variations, p. 23
    - Therapeutic Drug Monitoring, p. 20
    - Figure 2.6. The Therapeutic Index, p. 19
- Concept: Technology and Informatics
  - Exemplar: Clinical Informatics
    - Drug-Laboratory Interactions, p. 26
    - Nursing Process: Patient-Centered Collaborative Care, p. 27
- Concept: Evidence
  - Exemplar: Quantitative Research
    - Biologic Variations, p. 23

BSN Essentials

- Essential I: Liberal Education for Baccalaureate Generalist Nursing Practice
  - Cultural Considerations, p. 28
  - Critical Thinking Case Study, p. 28
- Essential II: Basic Organizational and Systems Leadership for Quality Care and Patient Safety
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- Essential III: Scholarship for Evidence-Based Practice
  - Biologic Variations, p. 23
- Essential IV: Information Management and Application of Patient Care Technology
  - Drug-Laboratory Interactions, p. 26
  - Nursing Process: Patient-Centered Collaborative Care, p. 27
- Essential VI: Interprofessional Communication and Collaboration for Improving Patient Health Outcomes
  - Protein Binding, p. 17
  - Antagonistic Drug Effects, p. 26
  - Drug Interactions, p. 23
  - Nursing Process: Patient-Centered Collaborative Care, p. 27
- Essential VII: Clinical Prevention and Population Health
  - Assessment, p. 27
- Essential VIII: Professionalism and Professional Values

  - Biologic Variations, p. 23
- Essential IX: Baccalaureate Generalist Nursing Practice
  - Nursing Process: Patient-Centered Collaborative Care, p. 27

Interprofessional Collaborative Practice Core Competencies

- Domain 3: Interprofessional Communication
  - Protein Binding, p. 17
  - Antagonistic Drug Effects, p. 26
  - Drug Interactions, p. 23
  - Nursing Process: Patient-Centered Collaborative Care, p. 27

STUDENT CHAPTER RESOURCES	
Chap. 02	**READ – Textbook (pp. 15-29)** **REVIEW – Evolve Resources** • Content Updates • Downloadable Key Points • References **ANSWER – Evolve Resources** • Chapter 02 NCLEX Review Questions • Chapter 02 Critical Thinking Case Study

SG	**ANSWER – Study Guide**
	• Chapter 2, Pharmacokinetics, Pharmacodynamics, and Pharmacogenetics
	  ○ Study Questions 1-40
	  ○ Case Study Questions 1-2

EAQ	**ANSWER – Elsevier Adaptive Quizzing** • Chapter 2, Pharmacokinetics, Pharmacodynamics, and Pharmacogenetics

SHER	**REVIEW & APPLY – Sherpath**
	• Module 1: Basics of Pharmacology
	  ○ Orientation to Pharmacology
	  ○ Pharmacodynamics
	  ○ Pharmacokinetics

INSTRUCTOR CHAPTER RESOURCES	
TB	**Test Bank** • To access the **ExamView** format, go to the Downloads section.
PPT	**PowerPoint Presentations (Slides 1-35)**
IC	**Image Collection** • Figure 2.1 Passive and active transport. • Figure 2.2. Protein binding. • Figure 2.3. Drug movement across the blood-brain barrier. • Figure 2.4. Drug crossing the placenta. • Figure 2.5. Dose-response relationship. • Figure 2.6. The therapeutic index. The therapeutic index is the ratio between the toxic dose of a drug and the therapeutic dose of a drug. • Figure 2.7. Onset, peak, and duration of action. • Figure 2.8. Drug-receptor interactions are similar to the fit of the right key in a lock. • Figure 2.9. The four receptor families. The four receptor families are (1) cell membrane–embedded enzymes, (2) ligand-gated ion channels, (3) G protein–coupled receptor systems, and (4) transcription factors. • Figure 2.10. Cholinergic receptors are located in the bladder, heart, blood vessels, stomach, bronchi, and eyes. • Figure 2.11. Epinephrine affects three different receptors: alpha$_1$, beta$_1$, and beta$_2$

TEACHING STRATEGIES		
CONTENT FOCUS	**CONTENT HIGHLIGHTS**	**LEARNING ACTIVITIES**
PHARMACOKINETICS **Drug Absorption** **Drug Distribution** **Drug Metabolism** **Drug Excretion**	Discuss the pharmacokinetic phase as the process of drug movement to achieve drug action. Explain pharmacokinetic interactions as changes that occur in the absorption, distribution, metabolism or biotransformation, and excretion of one or more drugs. Describe absorption as the movement of drug particles from the gastrointestinal (GI) tract to body fluids Review Figure 2.1 and passive absorption, active absorption, and pinocytosis. Review the effect of lipid solubility and drug absorption. Drugs that are lipid-soluble and nonionized are absorbed faster than water-soluble and ionized drugs. Explain that the process in which the drug passes to the liver first is called the first-pass effect, or hepatic first pass. Explain bioavailability as the percentage of the administered dose that reaches the systemic circulation. Discuss factors that alter bioavailability: 1. Drug form 2. Route of administration 3. GI mucosa and motility 4. Food and other drugs 5. Changes in liver metabolism Define *distribution* as the process by which the drug becomes available to body fluids and body tissues. Drug distribution is influenced by the rate of blood flow to the tissue, the drug's affinity to the tissue, and protein binding. Explain that when two highly protein-bound drugs are administered together, they compete for protein-binding sites, leading to an increase in free drug being released into the circulation. Describe the property that only free (unbound) drugs are active and can cause a pharmacologic response. Explain that when immediate drug response is desired, a large initial dose, known as the loading dose of the drug, is administered to achieve a rapid minimum effective concentration in plasma. Review the concept that low protein levels decrease the number of protein-binding sites and can cause an increase in the amount of free drug in the plasma, with drug overdose as a possible result. Discuss the blood-brain barrier and the placental barrier. Review Figures 2.2, 2.3, 2.4.	• **Discussion Topic:** Ask students why some drugs are not able to be administered by mouth. Give examples of drugs that cannot be administered by mouth. *Answer*: Protein-based drugs such as insulin and growth hormones are destroyed in the small intestine by digestive enzymes, so they are not administered by mouth. • **Discussion Topic:** Ask students to give examples of drugs that would increase or decrease gastric emptying time. *Answer*: Laxatives and metoclopramide (Reglan) increase gastric and intestinal motility and cause a decrease in drug absorption. Narcotics and anticholinergic drugs (atropine) decrease gastric emptying time and GI motility, thus causing an increase in absorption rate. • **Discussion Topic:** Ask students why tetracycline should not be administered with dairy products, multivitamins, and antacids. • *Answer*: Tetracycline and the heavy-metal ions found in antacids or iron may lead to the formation of a drug complex and thereby prevent the absorption of tetracycline. • **Discussion:** Ask students why lidocaine and some nitroglycerines are not administered orally. *Answer*: Lidocaine and some nitroglycerines have extensive first-pass metabolism; therefore, most of the dose would be destroyed if they were administered orally. • **Discussion:** Ask students why the dose of an oral medication is more than the dose of the same medication administered via the intravenous (IV) route. *Answer*: The percentage of bioavailability for the oral route is always less than 100%, but for the IV route it is usually 100% owing to the high first-pass hepatic metabolism of oral drugs. • **Small group activity:** Assign groups of students to look up nursing responsibilities of highly protein-bound drugs such as warfarin, various anticonvulsants, and nonsteroidal antiinflammatory drugs. Have students report their findings back to the group. • **Discussion topic:** Ask students if they have had experience working with patients with low

	Discuss metabolism or biotransformation. Explain that drugs can be metabolized in both the GI tract and liver; however, the liver is the primary site of metabolism. Explain half-life as the time it takes for half of the drug concentration to be eliminated from the body. Discuss dosage adjustments in the administration of digoxin to reach a therapeutic level in patients with normal renal function. Define and explain *steady state.* Review the excretion process of most drugs, which are filtered through the glomeruli and excreted in the urine. Remind students that with some drugs, excretion occurs in the bile, which passes into the intestinal tract. Describe factors that affect drug excretion: 1. Drugs that affect renal excretion 2. Drugs that decrease cardiac output 3. Use of diuretics 4. Competition of drugs that undergo the same route of excretion 5. Change of urine pH 6. Patients with decreased renal or hepatic function Inform students that the main route of drug elimination is through the kidneys. Other routes include hepatic metabolism, bile, feces, lungs, saliva, sweat, and breast milk. Explain that when the patient has decreased glomerular filtration rate (GFR) or decreased renal tubular secretion, drug excretion is slowed or impaired. Drug accumulation with possible severe adverse drug reactions can result. Review the concept that urine pH influences drug excretion. Acid urine promotes elimination of weak base drugs, and alkaline urine promotes elimination of weak acid drugs.	protein levels and how this may affect drug distribution. *Answer*: Examples of patients with low protein levels include those with liver or kidney disease, those who are malnourished, and those with advanced age. These patients are at risk for possible drug toxicity. To avoid possible drug toxicity, checking the protein-binding percentage of all drugs administered to a patient is important. • **Discussion:** Ask students what the effects are of administration of phenobarbital with antipsychotics. *Answer*: Phenobarbital increases the metabolism of most antipsychotics and theophylline, resulting in a decrease in drug action. • **Online Activity:** Ask students to find a video on the Internet that describes the blood-brain barrier. Have the students upload the link from that online video to the discussion forum or thread and ask each student to critique a video (two positives and two negatives). • **Discussion topic:** Ask students if they are aware of any factors affecting the creatinine clearance value. *Answer*: Creatinine clearance varies with age and gender. Lower values are expected in patients with decreased muscle mass, such as older adult patients and some female patients.
PHARMACODYNAMICS **Dose-Response Relationship** **Onset, Peak, and Duration of Action** **Therapeutic Drug Monitoring** **Receptor Theory** **Agonists and Antagonists** **Nonspecific and Nonselective Drug**	Define pharmacodynamics as the study of a drug's effect on the body. Describe the primary effect as desirable and the secondary effect as desirable or undesirable. Use diphenhydramine (Benadryl) as an example. Define dose response as the relationship between the minimal versus the maximal amount of drug dose needed to produce the desired drug response. Define potency and maximal efficacy, peak and duration of action. Contrast peak and trough drug levels. Define peak drug level as the highest plasma concentration of	• **Discussion:** Ask students what the pharmacodynamic phase is when they take acetaminophen (Tylenol) for a headache. *Answer*: They have relief of the headache because the acetaminophen (Tylenol) has caused a response in their bodies.

Effects **Mechanisms of Drug Action** **Side Effects, Adverse Drug Reactions, and Drug Toxicity**	drug at a specific time. Describe trough drug level as the lowest plasma concentration of a drug, which measures the rate at which the drug is eliminated. Review the therapeutic index (TI), which describes the relationship between the *therapeutic dose* of a drug (ED50) and the *toxic dose* of a drug (TD50). Discuss drugs with a low therapeutic index and a narrow margin of safety as well as drugs with a high therapeutic index and a wide margin of safety, which have less danger of producing toxic effects. Discuss the significance of onset, peak, and duration of action. Refer to Figures 2.7. Describe the four receptor families (Figures 2.8, 2.9): 1. Cell membrane–embedded enzymes 2. Ligand-gated ion channels 3. G protein–coupled receptor systems 4. Transcription factors Describe agonists as drugs that produce a response. Describe antagonists as drugs that block a response. Describe nonspecific drugs as drugs that affect various sites. Review Figures 2.10 and 2.11. Relate that drugs may act at different receptors. Drugs that affect various receptors are nonselective drugs or have properties of nonselectivity. Describe the seven categories of mechanisms of drug action: (1) stimulation, (2) depression, (3) irritation, (4) replacement, (5) cytotoxic action, (6) antimicrobial action, and (7) modification of immune status. Describe side effects as physiologic effects not related to desired drug effects. Adverse reactions are always undesirable. They are a range of untoward effects of drugs that cause mild to severe side effects, including anaphylaxis. Review that toxic effect or toxicity of a drug is identified by monitoring the plasma (serum) therapeutic range of the drug.	
PHARMACOGENETICS **Biologic Variations** **Tolerance and Tachyphylaxis** **Placebo Effect**	Define pharmacogenetics as the effect of a drug action that varies from a predicted drug response because of genetic factors or hereditary influence. Review Table 2-1. Describe tolerance as a decreased responsiveness over the course of therapy and tachyphylaxis as the rapid decrease in response to a drug. Explain a placebo effect as a psychologic benefit from a compound that may not have the chemical structure of a drug effect.	• **Discussion topic:** Ask students if they have ever worked with a patient who developed tolerance to a drug. • **Discussion topic:** Ask students their thoughts on the legal and ethical considerations of placebo therapy. • **Individual Interprofessional Activity:** Have students ask another type of health care worker how he or she uses pharmacokinetics, pharmacodynamics, and pharmacogenetics in

		daily care. Call on a few students to share the information they collected with the class.
DRUG INTERACTIONS **Pharmacokinetic Interactions** **Pharmacodynamic Interactions**	Define a drug interaction. Explain that drug–drug, drug–nutrient (e.g., food, supplements, alcohol), drug–disease, and drug–laboratory interactions (when a drug interferes with laboratory testing) are increasing problems. Because of possible numerous interactions, the nurse must be knowledgeable and closely monitor patient response to drug therapy. Discuss the effects of tobacco use, alcohol ingestion, and use of natural or herbal products on metabolism and biotransformation. Describe the process of many drug interactions of metabolism, which occur with the induction or inhibition of the hepatic microsomal system. Discuss the role of barbiturates, such as phenobarbital, as enzyme inducers. Review that pharmacokinetic interactions are changes that occur in the absorption, distribution, metabolism, and excretion of one or more drugs. Review Table 2-2. Explain that when a patient takes two drugs at the same time, the rate of absorption of one or both drugs can change by one of three ways: 1. By decreasing or increasing gastric emptying time 2. By changing the gastric pH 3. By forming drug complexes Pharmacodynamic interactions are those that result in additive, synergistic (potentiation), or antagonistic drug effects.	• **Discussion Topic:** What is the difference between additive drug effects and synergistic drug effects? *Answer:* **Additive** drug effect is the sum of the effects of two drugs that occurs when two drugs with similar action are administered. Describe an undesirable additive effect and describe how use of hydralazine (Apresoline) prescribed for hypertension and nitroglycerin prescribed for angina may have the possible result of a severe hypotensive episode. A **synergistic** drug effect or potentiation is use of two or more drugs administered together with one drug potentiating the other. Provide the example of meperidine (Demerol), a narcotic analgesic, and promethazine (Phenergan), an antihistamine. Less meperidine is required when it is combined with promethazine. • **Discussion Topic:** Ask students whether they have seen any combinations of drugs administered in the clinical setting, and, if so, what the purpose was. *Answer*: Aspirin and codeine are two analgesics that work by different mechanisms but can be given together for increased pain relief. Diuretics and beta blockers can be used for the treatment of hypertension.
DRUG–NUTRIENT INTERACTIONS	Explain that food may increase, decrease, or delay the body's pharmacokinetic response to drugs. Provide some examples of drug–food interactions: 1. Tetracycline and dairy products 2. Absorption of levothyroxine 3. Nitrofurantoin (Macrodantin) 4. Monoamine oxidase (MAO) inhibitors and tyramine-rich foods	• **Discussion Topic:** Ask students if they have ever had to alter their food intake because of medications they were taking. • **Small Group Activity:** Have students create a mock menu for a patient who is taking an MAO inhibitor. Ask students to purposefully insert one food into the menu with which the medication will interact. Have each student switch menus with a fellow student and ask the students to identify the food that will pose a problem for the patient.
DRUG–LABORATORY INTERACTIONS	Discuss that drugs often interfere with clinical laboratory testing by cross-reaction with antibodies, interference with enzyme reactions, or alteration of chemical reactions. Remind students that abnormal plasma or serum electrolyte concentrations can affect certain drug therapies.	• **Online Activity:** Have students look up a drug on RxList: http://www.rxlist.com/script/main/hp.asp, find any interactions with laboratory tests or nutrients, and report on them to the class. • **Discussion Topic:** Ask students to provide examples of laboratory–drug interactions. *Possible Answers:* Increased digitalis toxicity with decreased serum potassium and serum magnesium or an increased serum calcium. Use of hydrochlorothiazide (HydroDIURIL) can cause decreased serum potassium, magnesium, and sodium levels and can increase the serum

		calcium level.
DRUG-INDUCED PHOTOSENSITIVITY	Describe the differences between the two types of photosensitivity reactions, photoallergic and phototoxic. Review Table 2.3.	• **Discussion Topic:** Ask students what nursing interventions are associated with drug-induced photosensitivity. *Answer*: The nurse should provide appropriate patient teaching regarding use of sunscreen, avoiding excessive sunlight, and wearing protective clothing.
Nursing Process: Patient-Centered Collaborative Care	Discuss the nursing process with respect to pharmacokinetic, pharmacodynamic, and pharmacogenetic considerations.	• **Discussion Topic:** What nursing interventions apply to pharmacokinetic and pharmacodynamic considerations? • **Large Group Activity:** Ask an RN to speak to the class about how knowledge of pharmacokinetics and pharmacodynamics affects daily care. Have students prepare questions before the presentation. • **Collaborative Interprofessional Large Group Activity:** Ask a genetics researcher to speak to the class about clinically applicable pharmacogenetic information. Have students prepare questions before the presentation.

CHAPTER 02: ANSWER KEY TO TEXTBOOK CRITICAL THINKING CASE STUDY

1. What nursing diagnosis would be appropriate for this patient?

ANS: Ineffective protection related to drug therapy
Risk for injury
Knowledge deficit related to drug therapy

2. What information needs to be included in the interdisciplinary health and teaching plan for this patient?

ANS: Valproic acid may increase the patient's international normalized ratio (INR), increasing the risk for bleeding; therefore, the care plan needs to include a schedule for INR monitoring, and the patient needs to understand the rationale for frequent laboratory tests. The patient needs to be taught to take action to prevent bleeding (e.g., use a soft-bristled toothbrush, electric razor) and monitor for signs of bleeding (e.g., bleeding gums, dark or smoky-looking urine, blood in stool, easy bruising, or sudden onset of joint pain). The patient needs to know to report injury, even mild injury, and any signs of bleeding to the health care provider.

3. During a teaching session, the patient shares that he plans to start taking over-the-counter (OTC) products to boost his energy. What is the nurse's best response to the patient's comment? Explain your answer.

ANS: The patient should be instructed to clear any OTC medications or supplements with his health care provider because multiple drug interactions can occur with warfarin.