SUPPLEMENTARY COURSE IN

DISPENSING

AND

RATIONAL PRESCRIBING

CHAPTER STUDY GUIDE: CLINICAL COMPONENTS OF DISPENSING

DISPOSITION – HOW THE BODY PROCESSES A DRUG

CLINICAL ASPECTS OF DRUG INTERACTIONS

DISPENSING IN PATIENTS WITH COMPROMISED ELIMINATION

HOW DRUGS WORK – PHARMACODYNAMICS

OVERVIEW OF DRUG DELIVERY SYSTEMS
CHAPTER 4: DISPOSITION – HOW THE BODY PROCESSES A DRUG

This Chapter is module 4 of the 7 Core Clinical Components of Dispensing. Study this section carefully to understand how the principles covered in this section apply to Chapter 3 (Dosing in problem patients), Chapter 5 (Drug Interactions), Chapter 6 (Adverse Reactions) and Chapter 7 (Practical Pharmacokinetics).

CHAPTER OVERVIEW:
This chapter provides the foundation necessary to understand and apply the clinical principles covered in Chapters 3 (Dosing in problem patients), 5 (Drug Interactions), 6 (Adverse Reactions) and 7 (Pharmacokinetics).

This section has been included in the Manual primarily to give nurse practitioners, who have generally not been exposed to the content of this chapter in their formal training, insight into the mechanisms of drug disposition.

Although medical officers and pharmacists will have encountered these topics in the course of their training, this section will serve a useful purpose to read through as a refresher.

This module deals with the disposition of drugs – how they are absorbed, distributed, metabolised and eliminated from the body. These processes are generally referred to by the acronym ‘R A D M E’ which describes the processes by which drugs are:

- Released from their dosage form
- Absorbed from their site of administration,
- Distributed to different body ‘compartments’
- Metabolised by different chemical reactions which are catalysed by enzyme systems and are then
- Eliminated (i.e. excreted) from the body.

These are the fundamental factors that control the action of drugs in the body because they govern the rate and extent of drug input (absorption) and output (elimination) from the body.

IMPORTANT STUDY POINTS:
It is suggested that you use the audiovisual lectures to gain an understanding of the material, followed by reading and review using the manual.

SECTION 1: INTRODUCTION TO THE LADME PROCESSES OF DRUG DISPOSITION
This section has been included in the course training material for the benefit of those practitioners who have not been exposed during the course of their formal training to the pharmacokinetic processes that are involved in the way the body handles an administered drug.

Collectively these pharmacokinetic processes are referred to as the processes of DISPOSITION. They describe how a medication is Released (or Liberated) from its dosage form and how it is subsequently Absorbed from its site of administration, Distributed around the body and, finally, how it is Metabolised and Excreted or eliminated.
Understanding the processes involved in disposition is important to ensure the safe and effective use of drugs. This is particularly important in patients where chronic illnesses have compromised one or more of the body's main drug disposition mechanisms. These are the processes that:

1. govern the duration and intensity of action of drugs in the body
2. underlie the mechanisms by which medications may give rise to adverse effects or drug interactions

**SECTION 2: PASSAGE OF DRUG MOLECULES ACROSS MEMBRANES**

Read through Section 2 of this chapter for background information on the mechanisms involved in the passage of drugs across membranes. Section 2(ii) gives an understanding of the mechanisms by which drug molecules are 'carried' across cell membranes by protein 'transporter' molecules embedded in the cell membrane. This information is important for two reasons: interference with carrier transport of molecules into cells explains the mechanism of a number of drug interactions and carrier transport of molecules out of cells by the 'P-glycoprotein Transporter' underlies the mechanism of drug resistance including multi drug resistant TB.

**SECTION 3: LIBERATION (OR RELEASE) OF MEDICATION FROM THE DOSAGE FORM**

Review the factors which affect the Liberation of Drugs from solid dosage forms because these factors can radically alter the bioavailability and the biological activity of a dosage form.

**SECTION 4: ABSORPTION OF MEDICATION FROM ITS ADMINISTRATION SITE**

Revise the factors affecting the Gastrointestinal Absorption of Drugs in sections 4(i), 4(ii) and 4(iii) and link this revision to section 3(i) of chapter 5 (Pharmacokinetic Interactions – Absorption Interactions).

**SECTION 5: DISTRIBUTION OF THE MEDICATION IN BODY COMPARTMENTS**

Revise the factors affecting the Distribution of medication into different Body Compartments in section 5. Section 5(i) - 'Ion Trapping' explains why some of medications are secreted into breast milk while others are not; section 5(ii) provides an important example of the distribution of metformin which gives rise to its gastrointestinal side effects because it concentrates in the organs of the gastrointestinal tract. Section 5(iii) is important because it discusses the binding of warfarin molecules to the plasma protein albumin. Link this revision to section 3(ii) of chapter 5 (Pharmacokinetic Interactions – distribution Interactions) where the clinical implication of the warfarin and aspirin interaction is discussed in more detail.

**SECTION 6: METABOLISM OF DRUGS**

READ THROUGH section 6 to get a basic understanding of the factors play a role in the metabolism of drugs. This section is divided into TWO PARTS: section 6(i) which discusses the General Mechanisms involved in drug metabolism and section 6(ii) which discusses the Cytochrome P450 Enzyme System.

**Section 6(i)**

Read through section 6(i) and make sure you understand the BROAD concepts of what is meant by a Phase 1 reaction section 6(i) (a), and a phase 2 reaction section 6(i) (b). Pay particular attention to the metabolism of aspirin in section 6(i) (c) to get a clear understanding of HOW the overall processes of phase 1 and phase 2 Metabolism are interlinked. Look closely at the metabolism of Paracetamol 6(i) (d) which explains how toxic metabolites are sometimes formed in the process of metabolism as outlined in the manual. Link this revision to section 3(iii) of chapter 5 (Pharmacokinetic Interactions – Metabolism Interactions).

**Section 6(ii)**

Read through section 6(ii) carefully and make sure you understand the Cytochrome P450 Enzyme System. Link this revision to section 3(iii) of chapter 5 (Pharmacokinetic Interactions – Metabolism Interactions)
Section 6(iii)

Read through section 6(iii) carefully and make sure you understand what is meant by the terms enzyme induction and enzyme inhibition. These two concepts are EXTREMELY IMPORTANT because they explain many of the side effects and adverse reactions that arise from drug interactions. Link this revision to sections 3 (iii) (a) to (f) - of chapter 5 (Pharmacokinetic Interactions – Metabolism Interactions). Pay particular attention to section 3 (iii) (f) of chapter 5 which underscores the importance of enzyme inhibition as it applies to mandatory dosing restrictions Simvastatin.

SECTION 7: ELIMINATION (EXCRETION) OF DRUGS

Read through Section 7 to get an overview of the processes involved in the elimination or excretion of drugs.

The most important aspect of this section is the part that deals with renal excretion of drugs because it describes the processes of Renal Glomerular Filtration, Tubular Secretion and Tubular Re-absorption of drugs. It is at these sites, and by these processes, that many important drug interactions occur.

Link this revision to section 3 (iv) of chapter 5 (Pharmacokinetic Interactions – Elimination Interactions)
CHAPTER 5: CLINICAL ASPECTS OF DRUG INTERACTIONS

This Chapter is module 5 of the 7 Core Clinical Components of Dispensing. Study this section carefully to understand how the principles covered in this section are applied in clinical practice when dealing with Drug Interactions. The contents of this section are incorporated in the course assessments in (1) a Practical Assessment in terms of completing a Portfolio Assignment (2) in the Practical OSDE (3) in the Formal Competency Assessment and (4) in the Written Assessment.

CHAPTER OVERVIEW:
This chapter has been incorporated into the dispensing course module to give practitioners insight and understanding about drug interactions that they identify when using their SAMF’s to identify potential problems in a patient's medication regimen.

The module has been compiled to provide an understanding of the underlying mechanisms of the different types of drug interactions. The objective is to enable the practitioner to be able to predict the possibility of a drug interaction occurring. The variation in onset time and severity of drug interactions that arise from their pharmacokinetic properties (which are covered in Chapter 7) is explained.

This module also reviews
- the principles of management of drug interactions
- assessment of drug interaction risk in patients
- categories of drug interactions and their clinical management
- classification and examples of the different mechanisms by which drug interactions occur.

IMPORTANT STUDY POINTS:
It is suggested that you use the audiovisual lectures to gain an understanding of the material, followed by reading and review using the manual.

SECTION 1: INTRODUCTION TO DRUG INTERACTIONS
Is important to realise that a drug interaction will affect the type of biological response to a drug as well as the intensity of the biological response and the duration of the biological response.

The 3 main categories of drug interactions are
1. pharmaceutical interactions
2. pharmacodynamic interactions and
3. pharmacokinetic interactions.

This chapter outlines the basic principles involved in the management of interactions and looks at how the risk of a drug interaction increases with an increase in (1) the number of drugs in a patient’s regimen (2) severely ill patients and in (3) elderly patients who are on multiple drugs regimens.
SECTION 2: IMPORTANT CLINICAL ASPECTS IN MANAGING DRUG INTERACTIONS
Section 2 discusses important clinical aspects that are involved in managing drug interactions. These include:

1. identifying drugs which are associated with a high risk of an interaction and patients whose underlying co-morbidities and pathology render them at high risk to experiencing a drug interaction (sections 2(i) and (ii))

2. predicting the number of possible interactions for any given number of drugs in a patients regimen (section 2 (iii))

3. predicting onset time of a drug interaction from the half-lives of the interacting drugs (section 2 (iv))

SECTION 3: ASSESSMENT OF DRUG INTERACTION RISK
Section 3 discusses how to assess the drug interaction risk in patients.

SECTION 4: PRACTICAL MANAGEMENT OF DRUG INTERACTIONS
Section 4 gives guidance on the practical management of drug interactions depending on which Category Type (Type 1, 2, 3, or 4) the Interaction may fall into.

Pay particular attention to what is meant by the CATEGORY of drug interaction. Drug interactions are categorised into different TYPES of interaction according to how they should be MANAGED.

1. TYPE 1 interactions are when the combination of two drugs are absolutely contraindicated

2. TYPE 2 interactions are preventable interactions in that the prescriber can take steps to circumvent the interaction.

3. TYPE 3 interactions require substituting with an alternative drug whereas

4. TYPE 4 drug interactions cannot be circumvented because both drugs are necessary. With this type of interaction that is necessary to monitor the patient

SECTION 5: CLASSIFICATION AND EXAMPLES OF INTERACTIONS
Section 5 of this chapter presents a schematic classification of drug interactions into three broad categories (pharmaceutical, pharmacodynamic and pharmacokinetic interactions).

Within these three broad categories there are sub categories into which interactions can be conveniently grouped according to the underlying mechanism involved in the interaction.

This schematic classification provides a convenient instrument to understand drug interactions and also to anticipate and prevent their occurrence and to manage their consequences.
Section 5 also lists important examples of interactions that fall into the various categories to give the reader insight as to how the classification works so that the readers will learn to do the same with the interactions that they identify in clinical practice.

Note that the section under which an interaction is classified gives an understanding of the underlying mechanism(s) of the interactions. One important point that you need to realize about this schematic classification of interactions is that a drug may be involved in more than one interaction pathway. For example, the absorption of drug A may be inhibited by one interaction pathway, its metabolism may be inhibited by a different interaction pathway, its interaction with receptors may be inhibited by a third interaction pathway and finally its renal elimination may be inhibited by a fourth interaction pathway.

Section 5.1 gives examples of Pharmaceutical Interactions.

Section 5.2 lists important Pharmacodynamic Interactions. These include, in section 5.2(i) interactions that occur when drugs interact at receptors (Agonist and Antagonistic Interactions), in section 5.2(ii) interactions on a Physiological System, in section 5.2(iii) interactions on Intracellular Transport Mechanisms and in section 5.2(iv) interactions involving Fluid and Electrolyte Balance. Read through these sections to get a perspective of what these interactions involve.
Section 5.3 lists important examples of Pharmacokinetic Interactions. These include, in section 5.3 (i) Absorption Interactions and in section 5.3 (ii) Distribution Interactions. Read through these sections to get a perspective of what these interactions involve.

Section 5.3 (iii) deals with the MOST IMPORTANT of all interactions - that is Metabolism Interactions. You need to study this section diligently and digest the information.

Section 5.3(iii) (a) discusses genetic variation within the CYP450 enzyme system. This is arguably the single most important factor affecting a patient’s response to drugs. Individual differences in genetic expression of these enzymes by different patient’s results in individual variations in drug metabolism that lead to differences in the intensity and duration of the clinical action of a drug between patients.

The concept of genetic polymorphism is discussed in this section and it is important that you are aware of the 4 different Metabolic Phenotypes

1. Extensive metabolizers
2. Intermediate metabolizers
3. Poor metabolizers
4. Ultra (Rapid) metabolizers

Section 5.3(iii) (b) (c) and (d) discuss drug interactions that occur because of either Enzyme Inhibition or Enzyme Induction (these two concepts were introduced previously in Chapter 4; Drug Disposition), and list important examples of each. At the end of the discussion on these interactions, a SUMMARY TABLE of Important Substrates, Inducers and Inhibitors of the major drug-metabolizing CYP-450 enzymes (CYP1, CYP2 and CYP3) that give rise to clinically important drug interactions is presented in section 5.3 (iii) (e).
Study this table carefully and learn how to apply it because it can be used to identify potential interacting drug combinations that may result in clinical problems when patients are on multidrug regimens.

The importance of this aspect is underlined in Section 5.3(iii) (f) which lists the limitations placed on Simvastatin doses by the FDA in 2008 and 2011 when it is prescribed in conjunction with certain enzyme inhibiting drugs.

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<th>CYP 2C19 (±8%)</th>
<th>CYP 2C9 (±16%)</th>
<th>CYP 2D6 (±19%)</th>
<th>CYP 2E1 (±4%)</th>
<th>CYP 3A (±50% of drugs)</th>
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Note: (Bold Type = Strong Inhibitor > 5-fold ↑ AUC or > 80% ↓ Clearance) (Underline = Moderate Inhibitor > 2-fold ↑ AUC or 50 - 80% ↓ Clearance)
CHAPTER 3: DISPENSING IN PATIENTS WITH COMPROMISED ELIMINATION

This Chapter is a module of the 7 Core Clinical Components of Dispensing. Study this section carefully to understand how the principles covered are applied in clinical practice when dose adjustments are necessary in the patients described below. The contents of this section are incorporated in the course assessments in (1) a Practical Assessment in terms of completing a Portfolio Assignment (2) in the Practical OSDE and (3) in the Formal Competency Assessment and (4) in the Written Assessment.

CHAPTER OVERVIEW:
This chapter is EXTREMELY IMPORTANT because it deals with drug dosing in patients who have impaired drug disposition and elimination mechanisms that often require adjusting drug doses.

Patients in this category are patients with impaired renal and hepatic function. This includes:

a. elderly patients where there is a physiological decline in drug metabolism and excretion with age:

b. children, where drug metabolism and elimination pathways have not yet reached maturity and

c. patients where illness (e.g. heart failure, renal failure) or drugs (e.g. chronic alcoholism, cytotoxic drugs) have compromised the body’s ability to metabolise and excrete drugs.

IMPORTANT STUDY POINTS:
It is suggested that you use the audiovisual lectures to gain an understanding of the material, followed by reading and review using the manual.

SECTION 1: DRUG THERAPY IN PATIENTS WITH IMPAIRED RENAL FUNCTION
Section 1 of this chapter is VERY IMPORTANT and you need to study it very carefully and make sure that you understand the concepts of dosing in renal failure and that you can apply them with confidence in practical situations.

Section 1 (i) explains the relationship between Serum Creatinine and renal function and how the measurement of Serum Creatinine can be used to estimate renal function by assessing Glomerular Filtration Rate (GFR). Know how to apply the Cockcroft-Gault equation (below) that is used to estimate renal function from a given Serum Creatinine value.

\[
\text{GFR} = \frac{\text{F} \times (140 - \text{age}) \times \text{body mass (kg)}}{\text{Sr Creatinine (mcmol/litre)}}
\]

(For Males F = 1.23; For females F = 1.04)

It is important to mention two factors in connection with the Cockcroft-Gault equation:

- The first is the fact that this equation overestimates renal function in obese patients (because body mass is used in the numerator of the equation).

- The second is the fact that this equation also overestimates renal function in elderly patients who may have a GFR in the range of 50 mL/min that is not reflected by an increase in Serum Creatinine.

In these cases the MDRD (Modification of Diet in Renal Disease) formula is advised by the NKF for estimating GFR. The MDRD Formula for estimating GFR in White Male Patients is given by:
Women have a lower muscle mass than males – therefore the result of the equation above is multiplied by a factor of 0.742 in female patients. Conversely black persons have greater muscle mass than whites – therefore the result of the equation above is multiplied by a factor of 1.21 in black patients.

Use of the Cockcroft-Gault equation is advised by the National Kidney Foundation (NKF) in the US to calculate GFR when adjustment of drug doses is necessary for patients with renal failure. This formula differs slightly from the formula given by the SAMF to estimate GFR but both formulas yield essentially the same results. Where the above equation introduces a Factor for Males and Females, the SAMF formula compensates for GFR in females by dividing the GFR obtained by 0.87.

You also need to be aware of the conditions that can affect Serum Creatinine levels (see the box on page 50 of the Volume 2 Course Manual).

Section 1 (ii) is important because it defines the different stages of Chronic Kidney Disease (CKD) that have been defined the National Kidney Foundation of the United States. Make sure that you know the GFR’s that constitute:

1. Mild Renal Impairment
2. Moderate Renal Impairment,
3. Severe Renal Impairment and
4. Renal Failure.

SECTION 2: DRUG THERAPY IN PATIENTS WITH IMPAIRED HEPATIC FUNCTION

Section 2 of this chapter deals with drug therapy in patients with impaired hepatic function.

SECTION 3: DRUG THERAPY IN PATIENTS WITH IMPAIRED RENAL FUNCTION

Section 3 deals with the factors that operate in elderly patients. These are important factors that all practitioners dealing with the elderly patients need to be aware of. These include:

1. changes in renal excretion that occur in the elderly 3(i)
2. changes in drug Metabolism mechanisms that occur in the elderly 3(ii) and
3. changes in drug Pharmacodynamic mechanisms that occur in the elderly 3(iii)

SECTION 4: DRUG THERAPY IN CHILDREN

Section 4 of this chapter deals with drug therapy in children.

It is an important section in that children manifest quite different drug responses to adults.

This section presents 4 different methods that have been used to estimate drug doses in children. The first three methods listed include:

1. dose estimate is based on child’s body mass Clarks method (4(i))
2. dose estimate based on age (Young's method 4(ii)) and

3. dose estimate based on age (Webster's method 4(ii))

These first 3 methods are included for information purposes only and should not be used to estimate drug doses for children because they yield widely variable and unreliable results.

The fourth method, 4(iii), which basis paediatric dosage estimates on Body Surface Area (BSA) is the most reliable method.

The BSA method provides realistic dose estimates which generally fall well within paediatric dose ranges published in medical literature.

Historically, the first 3 methods listed in this section were used when manufacturers’ did not routinely study or publish information about paediatric doses. However this is no longer generally the case because most manufacturers provide dosing information for paediatric patients.

Thus the golden rule in dosing paediatric patients is to check for doses published in the medical references. However there are circumstances where this information is not available and the clinician is faced with the situation of estimating an appropriate dose for a paediatric patient.
CHAPTER 8: HOW DRUGS WORK – PHARMACODYNAMICS

CHAPTER OVERVIEW:
Pharmacodynamics is the science which studies the
1. biochemical and physiological effects of drugs on the body and the
2. mechanisms of drug action and
3. the relationship between drug concentration and effect

This section has been included in the Manual primarily to give nurse practitioners, who have generally not been exposed to the content of this chapter in their formal training, insight into the mechanisms of drug action.

Although medical officers and pharmacists will have encountered these topics in the course of their training, this section will serve a useful purpose to read through as a refresher.

The chapter also discusses the changes in receptor function that are associated with ageing and disease.

This chapter provides the foundation necessary to understand and apply the clinical principles covered in Chapters 3 (Dosing in problem patients), 5 (Drug Interactions), 6 (Adverse Reactions) and 7 (Pharmacokinetics).

IMPORTANT STUDY POINTS:
It is suggested that you use the audiovisual lectures to gain an understanding of the material, followed by reading and review using the manual.

SECTION 1: INTRODUCTION TO PHARMACODYNAMICS
This chapter provides a concise overview of how drugs work i.e. it explains the mechanisms of their biological action.

The purpose is to provide an understanding of the
1. clinical use of drugs
2. drug-receptor interactions
3. the different types of receptors – their nature and biological functions
4. the function of receptors
5. how the bodies chemical transmitters and drug molecules react with receptors.
These factors in turn explain the relationship between the dose of an administered drug and the therapeutic response it produces in the patient.  

However, it is important to realise that the clinical response to a drug in an individual patient is controlled by both the pharmacokinetic as well as the pharmacodynamic properties of a drug that 

This is illustrated by the diagram on the right which shows the interrelationship between the pharmacokinetic and the pharmacodynamic properties of a drug. 

Besides problems with compliance, dosing and medication errors, the pharmacokinetic action of a medication in a prescribed regimen is affected by: 

1. individual differences in tissue and body fluid mass and volume 
2. drug interactions which result from the factors that control disposition (absorption, distribution, metabolism, and elimination). 

On the other hand the pharmacodynamic action of a drug is controlled by factors that include: 

1. Drug–Receptor Interaction 
2. Receptor synthesis and turnover 
3. Changes in receptor function (up-regulation or down-regulation of receptors) 
4. Genetic Factors 
5. Drug Interactions 

SECTION 2: HOW DO DRUGS WORK? 

Section 2 describes the two broad categories of drug action. The actions of drugs can be classified into: 

1. Non specific drugs (2) (i) which do not act via receptors and 
2. Specific drugs (2) (ii) which do act via receptors. 

For most drugs, the concentration at the receptor site determines the intensity of a drug’s effect. However, other factors affect drug response as well. These include:
1. Density of receptors on the cell surface
2. the mechanism by which a signal is transmitted into the cell by second messengers (substances within the cell),
3. regulatory factors that control translation of the genes that carry the code for the production of receptor proteins

This multilevel regulation results in variation of sensitivity to drug effect from one individual to another and also determines enhancement of or tolerance to drug effects.

SECTION 3: DRUG, NEUROTRANSMITTER AND HORMONE INTERACTION WITH RECEPTORS

Section 3 (i) describes how drugs as well as the body's neurotransmitter molecules and hormones interact with receptors.

Section 3 (ii) describes the Key-Lock principle of drug action while Section 3 (iii) explains the forces by which chemical molecules bind to receptors

Section 3 (iv) explains what is meant by the 'Affinity' of a drug molecule for a receptor. Affinity is a measure of the attraction of a drug molecule to a receptor.

Section 3 (v) explains the differences between the terms ‘Specificity’ and ‘Selectivity’ with respect to drug action on a receptor

Section 3 (vi) describes what an Agonist is and how it reacts with a receptor to produce a response

Section 3 (vii) explains what is meant by an Antagonist and how antagonists act by preventing agonists from activating their receptors

SECTION 4: RECEPTORS – THEIR NATURE AND BIOLOGICAL FUNCTIONS

Section 4 explains the nature and biological functions of receptors.

Section 4 (i) describes how receptors are found on for broad groups of protein target sites within the body which include receptors found on:

1. ion channels
2. carrier molecules
3. enzymes
4. cell membranes

Section 4 (ii) gives a concise description of the 4 ‘Families’ that receptors are grouped into:

1. ion channel receptors (benzodiazepines act on the chloride ion channel)
2. receptors linked to G-proteins (where neurotransmitters like noradrenaline, dopamine as well as for the cardiovascular drugs work),

![Diagram of G-protein coupled receptors](image1)

3. receptors linked to tyrosine kinase (where insulin works)

![Diagram of insulin receptor](image2)

4. receptors found on the DNA molecule of the cell nucleus (where the steroid hormones work)

![Diagram of steroid receptor](image3)

**SECTION 5: CHANGES IN RECEPTOR FUNCTION ASSOCIATED WITH ILLNESS**

Finally Section 5 discusses the changes in receptor function that are associated with illness.
CHAPTER 9: OVERVIEW OF DRUG DELIVERY SYSTEMS

This Chapter is included for general information to give practitioners, who have not been exposed to this material previously, a brief overview on Drug Delivery Systems. As such – there is no formal assessment on the contents of this section.

CHAPTER OVERVIEW:
This chapter provides a concise summary of the properties and applications of the various drug-delivery systems that are commonly dispensed.

IMPORTANT STUDY POINTS:
It is suggested that you use the audiovisual lectures to gain an understanding of the material, followed by reading and review using the manual.

The summary of dosage forms reviewed in this chapter include

1. Oral drug delivery systems that can be subdivided into
   a. Buccal and sublingual dosage forms,
   b. Lozenge dosage forms
   c. Tablet and capsule dosage forms
   d. Liquid dosage forms (syrups, elixirs, suspensions and had emulsions

2. Parenteral drug delivery systems

3. Topical drug delivery systems are that are subdivided into topical drug delivery systems for this can include lotions, ointments and creams

4. Topical drug delivery systems for eye, ear and nose that include
   a. Ophthalmic preparations,
   b. Otic preparations and
   c. Nasal preparations
   d. Rectal and Vaginal drug delivery systems
   e. Inhalation drug delivery systems that include Inhalations, Insufflations and Aerosols