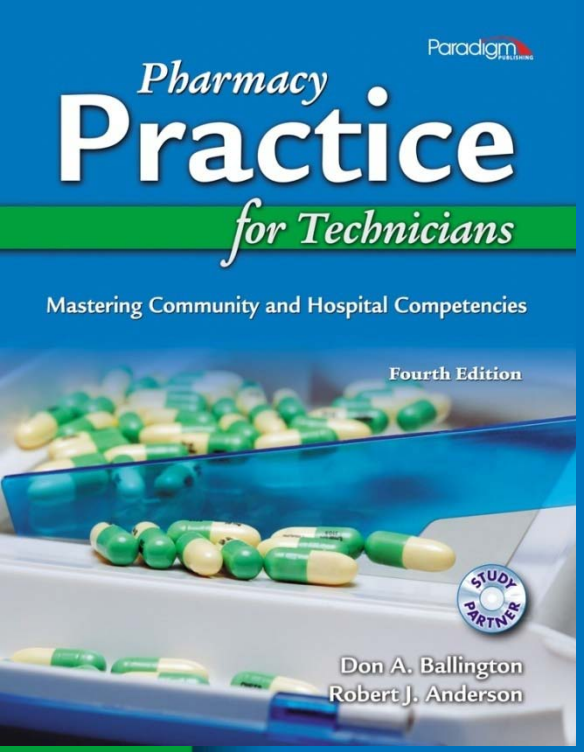


# Chapter 5

## Pharmaceutical Measurements and Calculations

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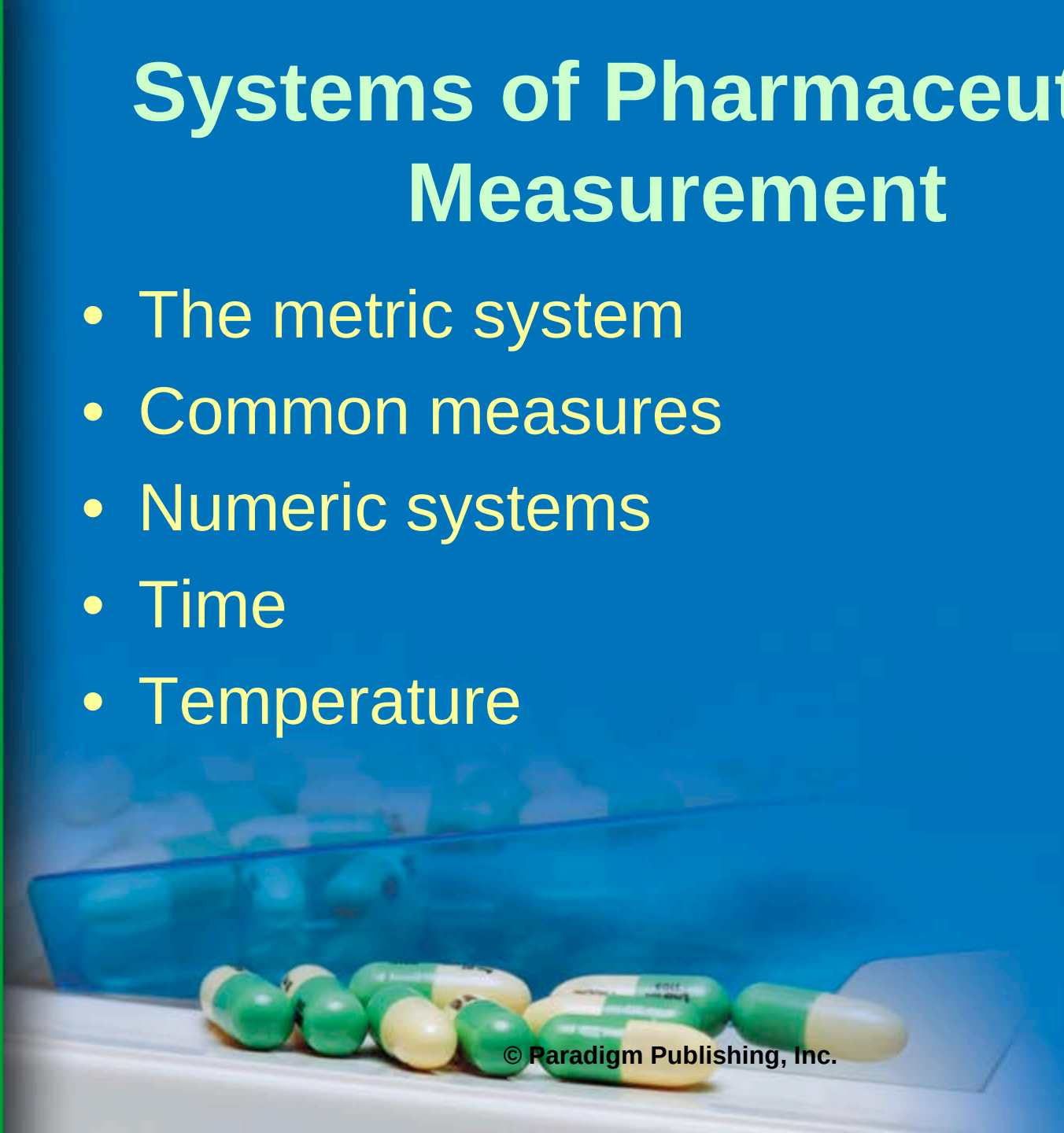
# Systems of Pharmaceutical Measurement

- The metric system
- Common measures
- Numeric systems
- Time
- Temperature



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# The Metric System

- Pharmacists and pharmacy techs must make precise measurements daily
- Most important measurements are
  - Temperature
  - Distance
  - Volume
  - Weight



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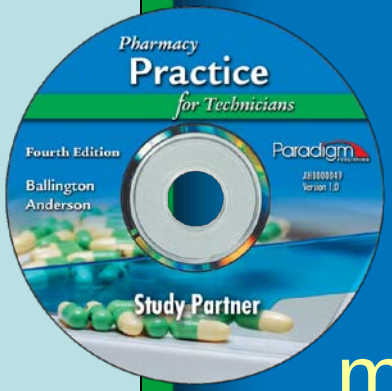


# Terms to Remember

## metric system

a measurement system based on subdivisions and multiples of 10; made up of three basic units: meter, gram, and liter

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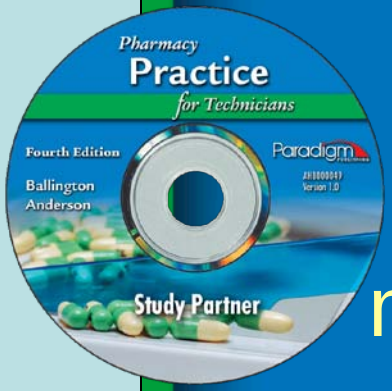


# Terms to Remember

**meter**

the metric system's base unit for measuring length

**gram**

the metric system's base unit for measuring weight

**liter**

the metric system's base unit for measuring volume

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# The Metric System

- Legal standard of measure for pharmaceutical measurements
- Developed in France in the 1700s
- Has several advantages
  - Based on decimal notation
  - Clear correlations among units of measurement
  - Used worldwide



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# The Metric System

- Uses standardized units of Systeme International (SI)
- Three basic units
  - Meter (distance, little use in pharmacy)
  - Gram (weight, used for solid form meds)
  - Liter (volume, used for liquid meds)
- Numbers expressed as decimals rather than fractions



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# The Metric System

Safety Note

An error of a single decimal place is an error of a factor of 10.



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# The Metric System

**TABLE 5.1 Système International Prefixes**

| Prefix | Symbol | Meaning |
|---|---|---|
| micro- | mc | one millionth (basic unit × $10^{-6}$, or unit × 0.000001) |
| milli- | m | one thousandth (basic unit × $10^{-3}$, or unit × 0.001) |
| centi- | c | one hundredth (basic unit × $10^{-2}$, or unit × 0.01) |
| deci- | d | one tenth (basic unit × $10^{-1}$, or unit × 0.1) |
| hecto- | h | one hundred times (basic unit × $10^{2}$, or unit × 100) |
| kilo- | k | one thousand times (basic unit × $10^{3}$, or unit × 1000) |



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# The Metric System

**TABLE 5.2 Common Metric Units**

| Measurement Unit | Equivalent |
|---|---|
| **Length: Meter** | |
| 1 meter (m) | 100 centimeters (cm) |
| 1 centimeter (cm) | 0.01 m; 10 millimeters (mm) |
| 1 millimeter (mm) | 0.001 m; 1000 micrometers, or microns (mcm) |
| **Volume: Liter** | |
| 1 liter (L) | 1000 milliliters (mL) |
| 1 milliliter (mL) | 0.001 L; 1000 microliters (mcL) |
| **Weight: Gram** | |
| 1 gram (g) | 1000 milligrams (mg) |
| 1 milligram (mg) | 1000 micrograms (mcg); one thousandth of a gram (g) |
| 1 kilogram (kg) | 1000 grams (g) |

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# Common Measures

- Common measures are approximate.
- Three types of common measures are used in the pharmacy:
  - Apothecary
  - Avoirdupois
  - Household



- Common measures are often converted to metric equivalents.

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# Common Measures

**TABLE 5.5 Apothecary System**

| Measurement Unit | Equivalent within System | Metric Equivalent |
|---|---|---|
| **Volume** | | |
| 1 ♏ (minim) | – | 0.06 mL |
| 16.23 ♏ | – | 1 mL |
| 1 f℥ (fluidram) | 60 ♏ | 5 mL (3.75 mL)* |
| 1 f℥ (fluid ounce) | 6 f℥ | 30 mL (29.57 mL)† |
| 1 pt (pint) | 16 f℥ | 480 mL |
| 1 qt (quart) | 2 pt or 32 f℥ | 960 mL |
| 1 gal (gallon) | 4 qt or 8 pt | 3840 mL |
| **Weight** | | |
| 1 gr (grain) | – | 65 mg†† |
| 15.432 gr | – | 1 g |
| 1 ℈ (scruple) | 20 gr | 1.3 g |
| 1 ℥ (dram) | 3 ℈ or 60 gr | 3.9 g |
| 1 ℨ (ounce) | 8 ℥ or 480 gr | 30 g (31.1 g) |
| 1 # (pound) | 12 ℨ or 5760 gr | 373.2 g |

*In reality, 1 f℥ contains 3.75 mL; however, that number is usually rounded up to 5 mL or 1 tsp.
†In reality, 1 f ℨ contains 29.57 mL; however, that number is usually rounded up to 30 mL.
††Many manufacturers use 60 mg instead of 65 mg as the equivalent for 1 gr (grain).

# Common Measures

Safety Note

For safety reasons, the use of the apothecary system is discouraged. Use the metric system.



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# Common Measures

**TABLE 5.6 Avoirdupois System**

| Measurement Unit | Equivalent within System | Metric Equivalent |
|---|---|---|
| 1 gr (grain) | – | 65 mg |
| 1 oz (ounce) | 437.5 gr | 30 g (28.35 g)* |
| 1 lb (pound) | 16 oz or 7000 gr | 454 g |

*An avoirdupois ounce actually contains 28.34952 g; however, we often round up to 30 g. It is common practice to use 454 g as the equivalent for a pound (28.35 g × 16 oz/lb = 453.6 g/lb, rounded to 454 g/lb).



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# Common Measures

**TABLE 5.7 Household Measures**

| Measurement Unit | Equivalent within System | Metric Equivalent |
|---|---|---|
| **Volume** | | |
| 1 tsp (teaspoonful) | – | 5 mL |
| 1 tbsp (tablespoonful) | 3 tsp | 15 mL |
| 1 fl oz (fluid ounce) | 2 tbsp | 30 mL (29.57 mL)* |
| 1 cup | 8 fl oz | 240 mL |
| 1 pt (pint) | 2 cups | 480 mL† |
| 1 qt (quart) | 2 pt | 960 mL |
| 1 gal (gallon) | 4 qt | 3840 mL |
| **Weight** | | |
| 1 oz (ounce) | – | 30 g |
| 1 lb (pound) | – | 454 g |
| 2.2 lb | – | 1 kg |

*In reality, 1 fl oz (household measure) contains less than 30 mL; however, 30 mL is usually used.
†When packaging a pint, companies will typically present 473 mL, rather than the full 480 mL, thus saving money over time.

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# Common Measures

Safety Note

Always carefully check and double-check all calculations.



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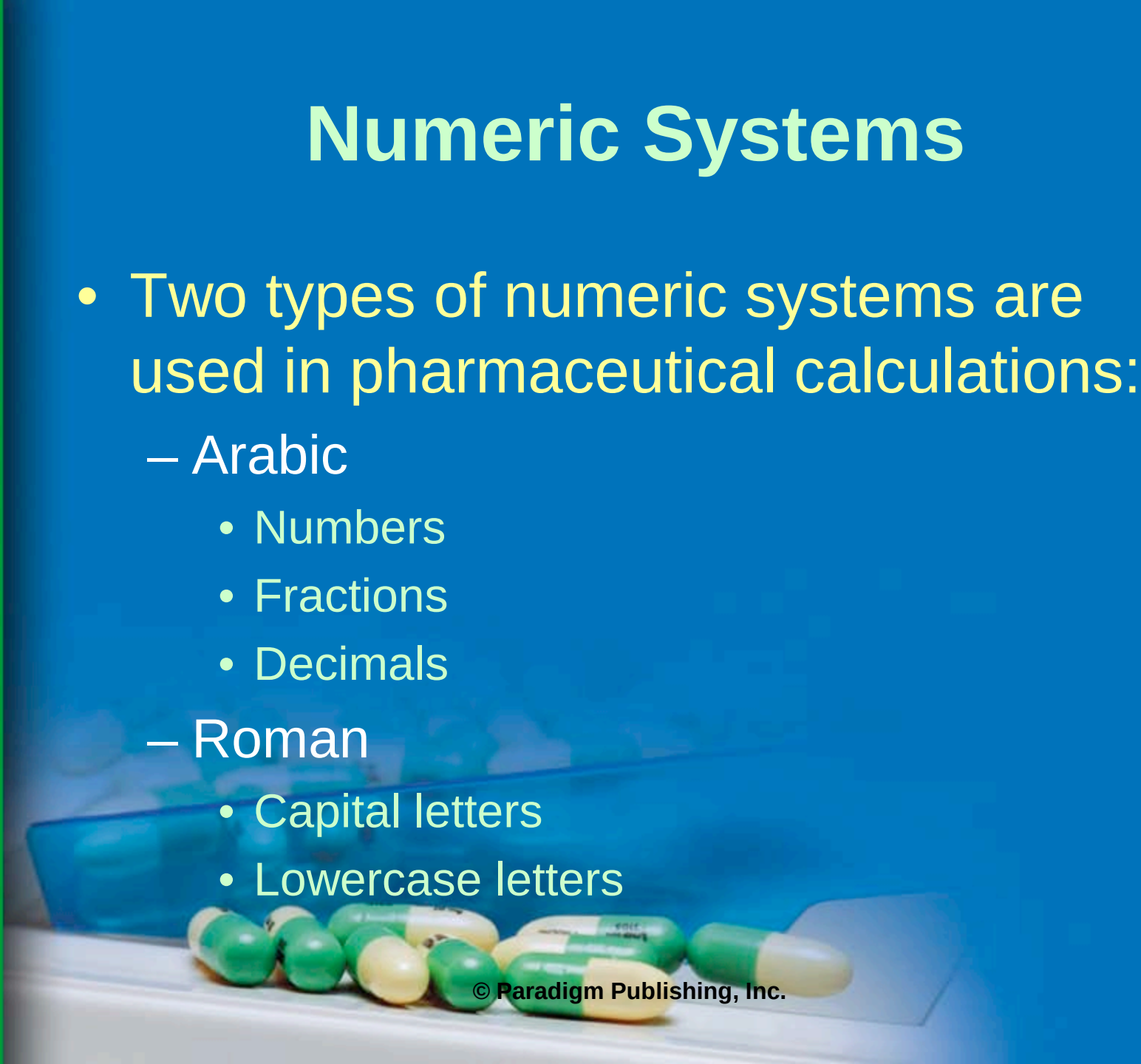
# Numeric Systems

- Two types of numeric systems are used in pharmaceutical calculations:
  - Arabic
    - Numbers
    - Fractions
    - Decimals
  - Roman
    - Capital letters
    - Lowercase letters



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# Numeric Systems

**TABLE 5.8 Comparison of Roman and Arabic Numerals**

| Roman | Arabic | Roman | Arabic |
|---|---|---|---|
| $\overline{ss}$ | 0.5 or ½ | L or l | 50 |
| I or i or i | 1 | C or c | 100 |
| V or v | 5 | D or d | 500 |
| X or x | 10 | M or m | 1000 |



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# Numeric Systems

Safety Note

New safety guidelines discourage the use of Roman numerals.



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# Time

- Military (or international) time often used in hospital settings
- Based on a 24 hour clock with no AM or PM, with midnight being 0000
- First two digits indicate hour, second two indicate minutes
- Thus 1800 = 6:00 PM



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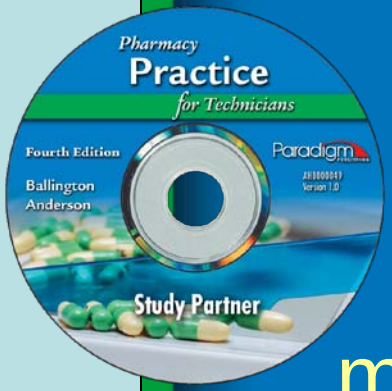


# Terms to Remember

## military time

a measure of time based on a 24 hour clock in which midnight is 0000, noon is 1200, and the minute before midnight is 2359; also referred to as international time

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# Time

Safety Note

The use of military time reduces errors.



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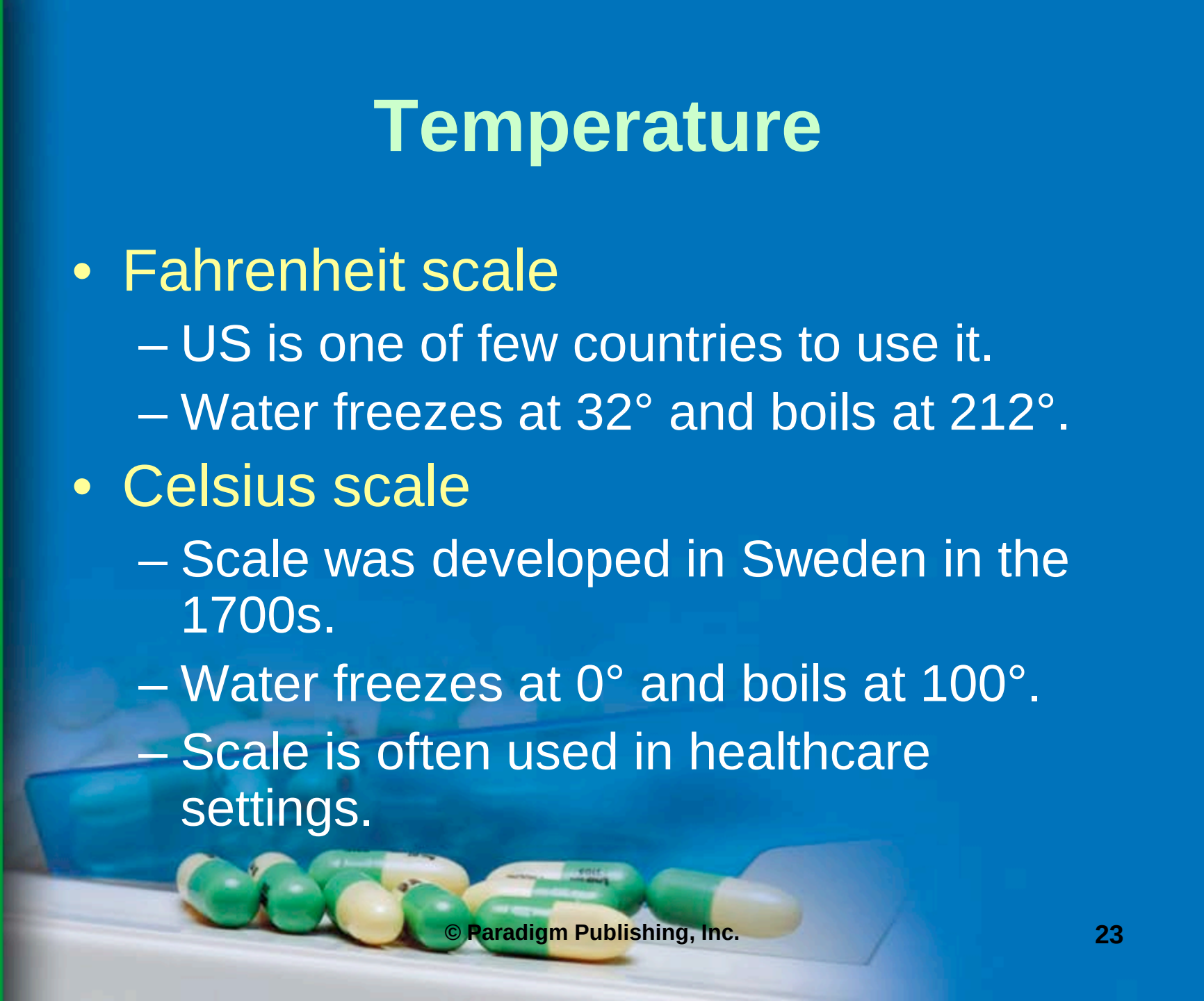
# Temperature

- Fahrenheit scale
  - US is one of few countries to use it.
  - Water freezes at 32° and boils at 212°.
- Celsius scale
  - Scale was developed in Sweden in the 1700s.
  - Water freezes at 0° and boils at 100°.
  - Scale is often used in healthcare settings.



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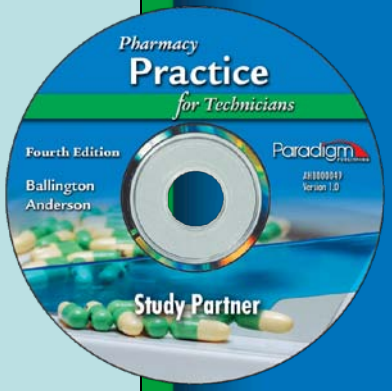


# Terms to Remember

## Fahrenheit temperature scale

the temperature scale that uses 32 °F as the temperature at which water freezes at sea level and 212 °F as the temperature at which it boils

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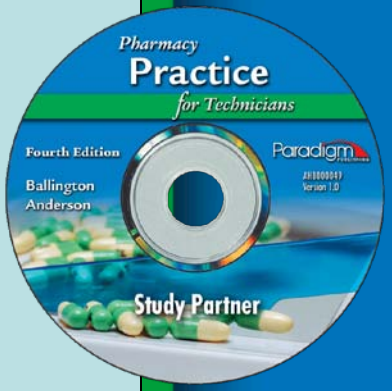


# Terms to Remember

## Celsius temperature scale

the temperature scale that uses zero degrees (i.e., 0 °C) as the temperature at which water freezes at sea level and 100 °C as the temperature at which it boils

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# Temperature

- Conversions

  °F = (1.8 x °C) + 32°

  °C = (°F - 32°) ÷ 1.8

**TABLE 5.9** Temperature Equivalencies between Celsius and Fahrenheit

| Celsius | Fahrenheit |
|---|---|
| 0 °C | 32 °F |
| 5 °C | 41 °F |
| 10 °C | 50 °F |
| 15 °C | 59 °F |
| 20 °C | 68 °F |

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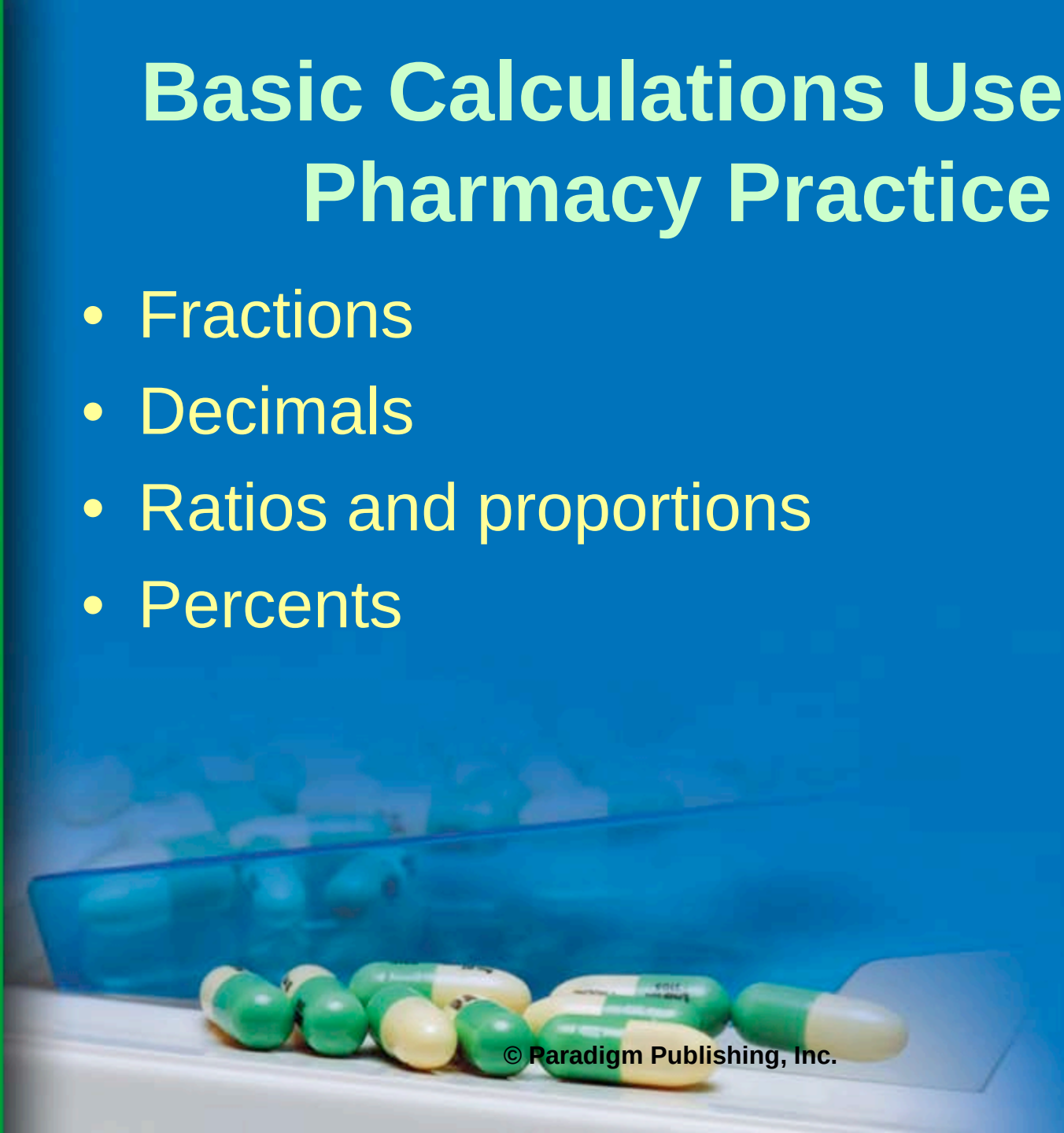
# Basic Calculations Used in Pharmacy Practice

- Fractions
- Decimals
- Ratios and proportions
- Percents



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# Fractions

- Fractions are parts of a whole.
- Simple fractions consist of two numbers:
  - Numerator (top number)
  - Denominator (bottom number)
- The value of a fraction equals the numerator divided by the denominator.



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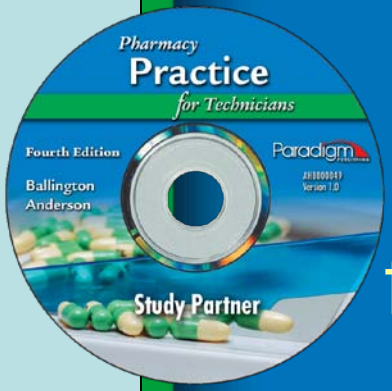


# Terms to Remember

**fraction**

a portion of a whole that is represented as a ratio

**numerator**

the number on the upper part of a fraction that represents the part of the whole

**denominator**

the number on the bottom part of a fraction that represents the whole

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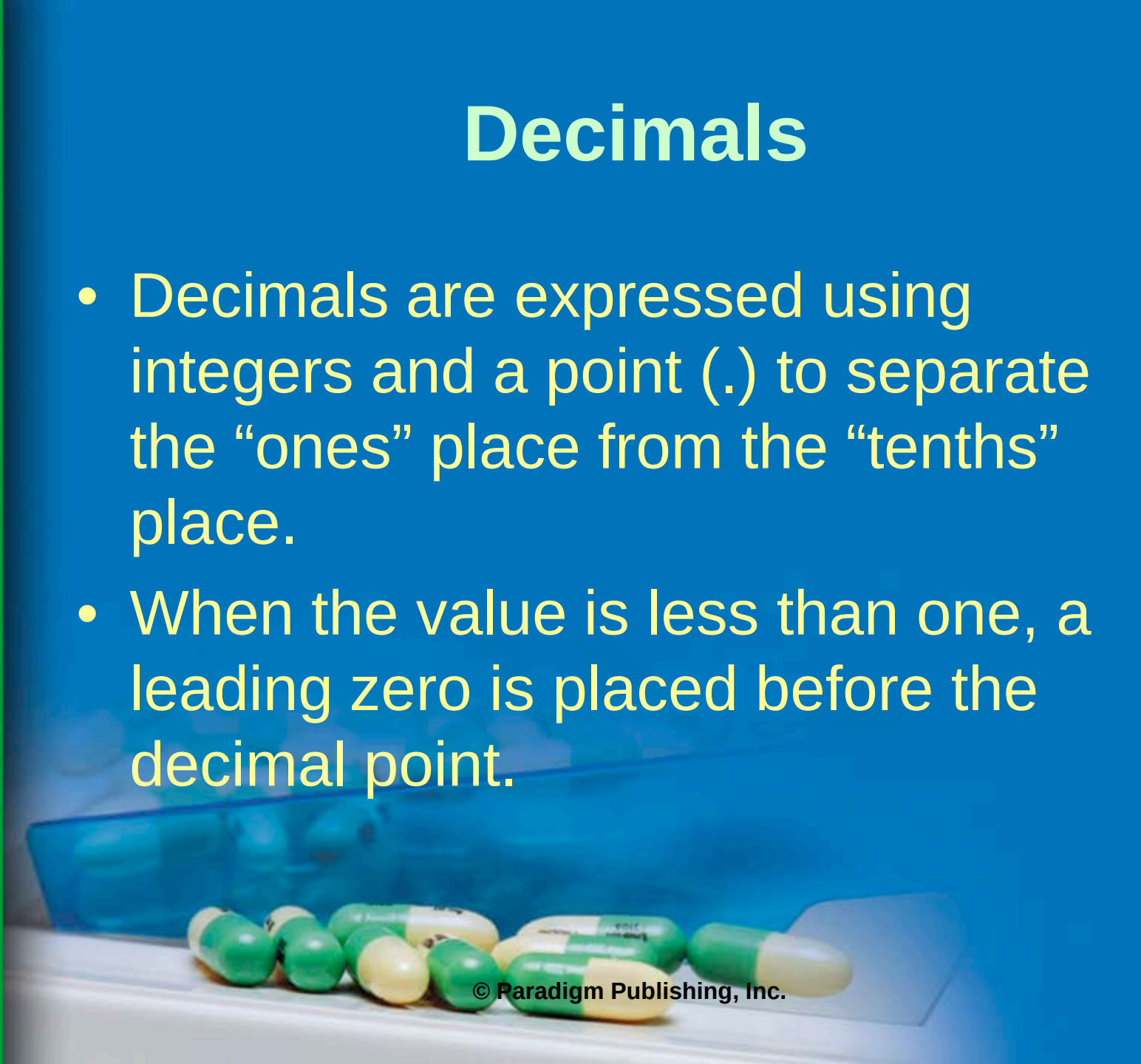
# Decimals

- Decimals are expressed using integers and a point (.) to separate the “ones” place from the “tenths” place.
- When the value is less than one, a leading zero is placed before the decimal point.



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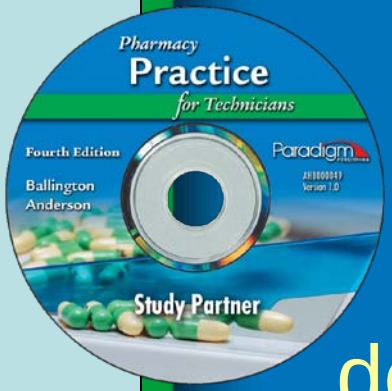


# Terms to Remember

## decimal

any number that can be written in decimal notation using the integers 0 through 9 and a point (.) to divide the "ones" place from the "tenths" place (e.g., 10.25 is equal to 10¼)

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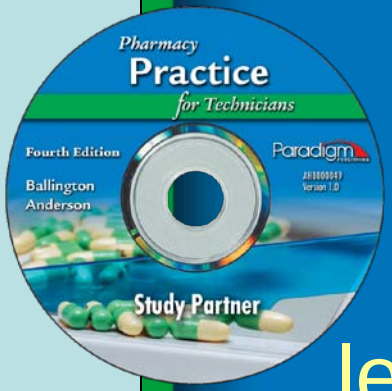


# Terms to Remember

## leading zero

a zero that is placed in the ones place in a number less than zero that is being represented by a decimal value

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# Decimals

Safety Note

For a decimal value less than 1, use a leading zero to prevent errors.



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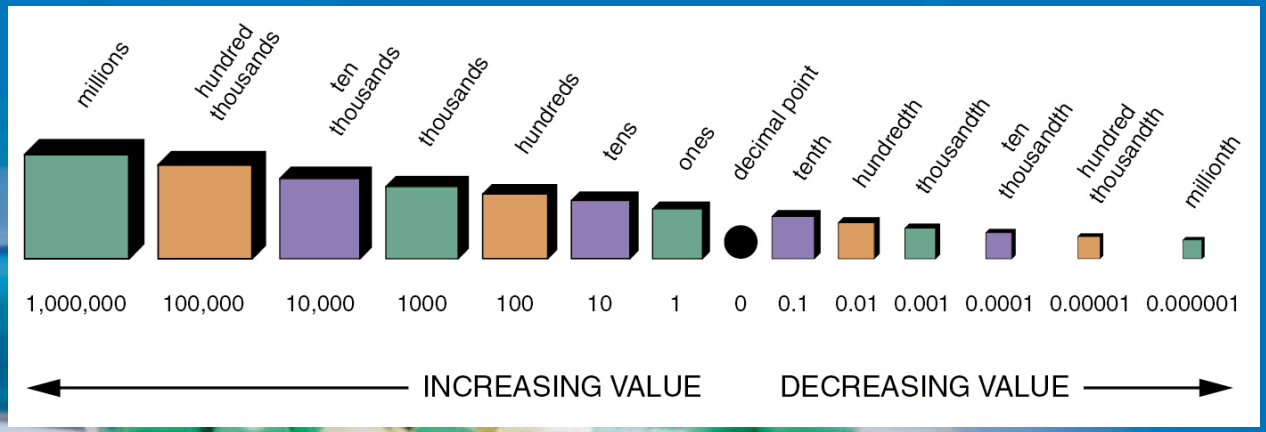
# Decimals

Decimals can be converted to fractions:

- The numerator is the decimal number without the point (1.33 → 133).
- The denominator is a power of 10 equal to the number of decimal places (1.33 → 100).

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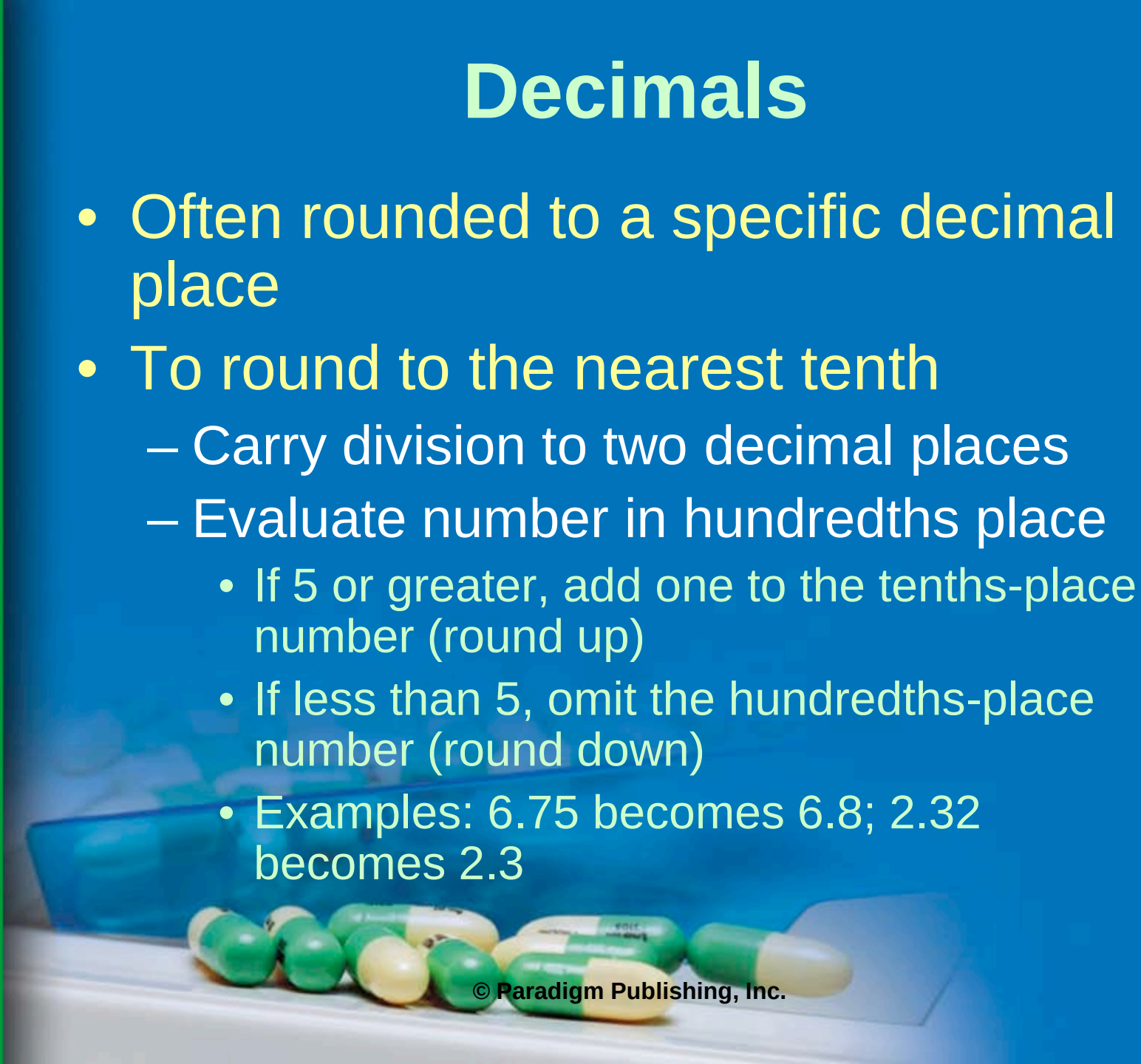
# Decimals

- Often rounded to a specific decimal place
- To round to the nearest tenth
  - Carry division to two decimal places
  - Evaluate number in hundredths place
    - If 5 or greater, add one to the tenths-place number (round up)
    - If less than 5, omit the hundredths-place number (round down)
    - Examples: 6.75 becomes 6.8; 2.32 becomes 2.3



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# Decimals

Safety Note

When rounding calculations of IV fluid drops per minute (gtt/min), round partial drops down. If a calculation indicates 28.6 gtt/min, the answer is rounded down to 28 gtt/min, not 29 gtt/min.

Calculations involving drops are discussed in Chapter 11.



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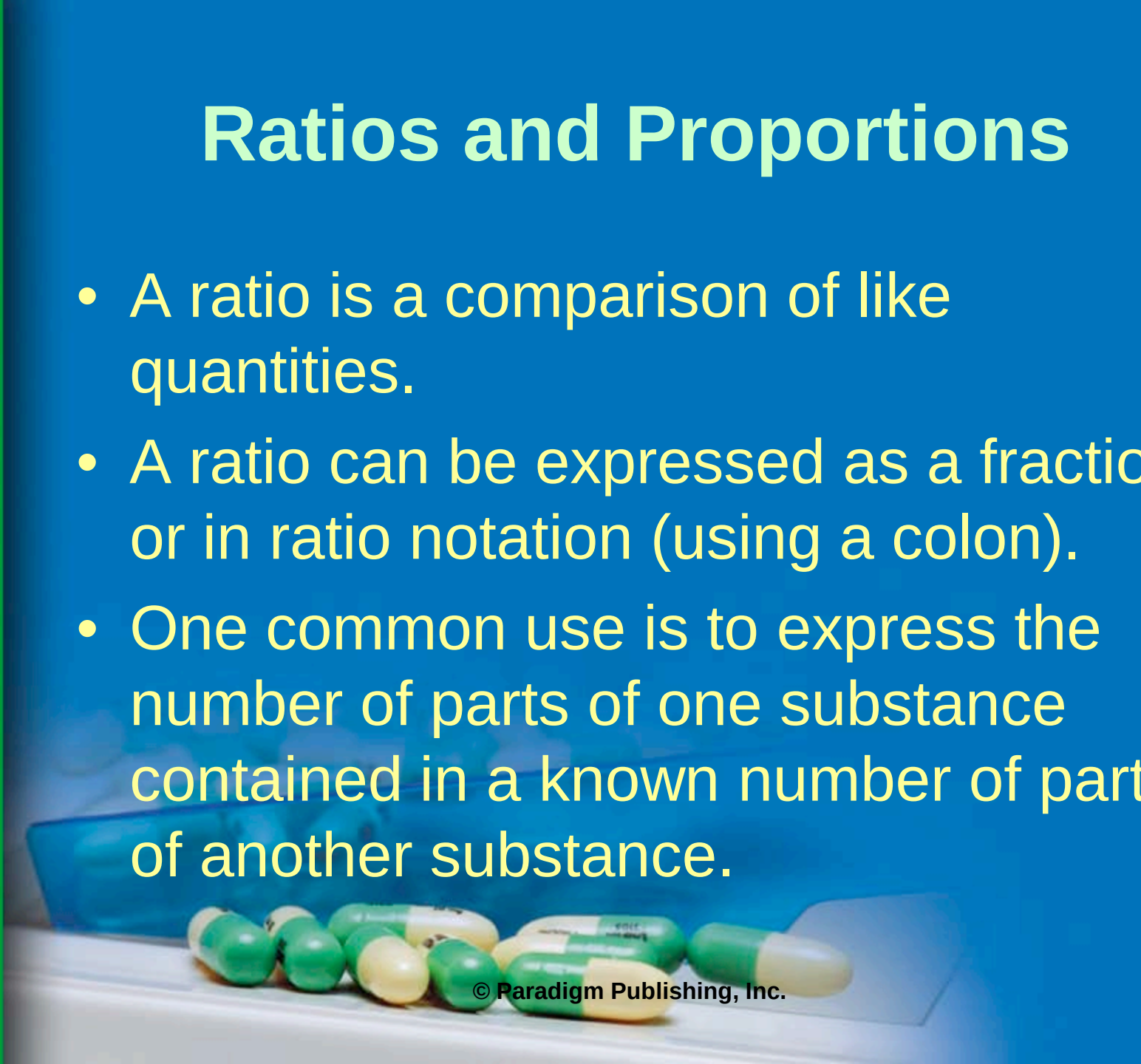
# Ratios and Proportions

- A ratio is a comparison of like quantities.
- A ratio can be expressed as a fraction or in ratio notation (using a colon).
- One common use is to express the number of parts of one substance contained in a known number of parts of another substance.



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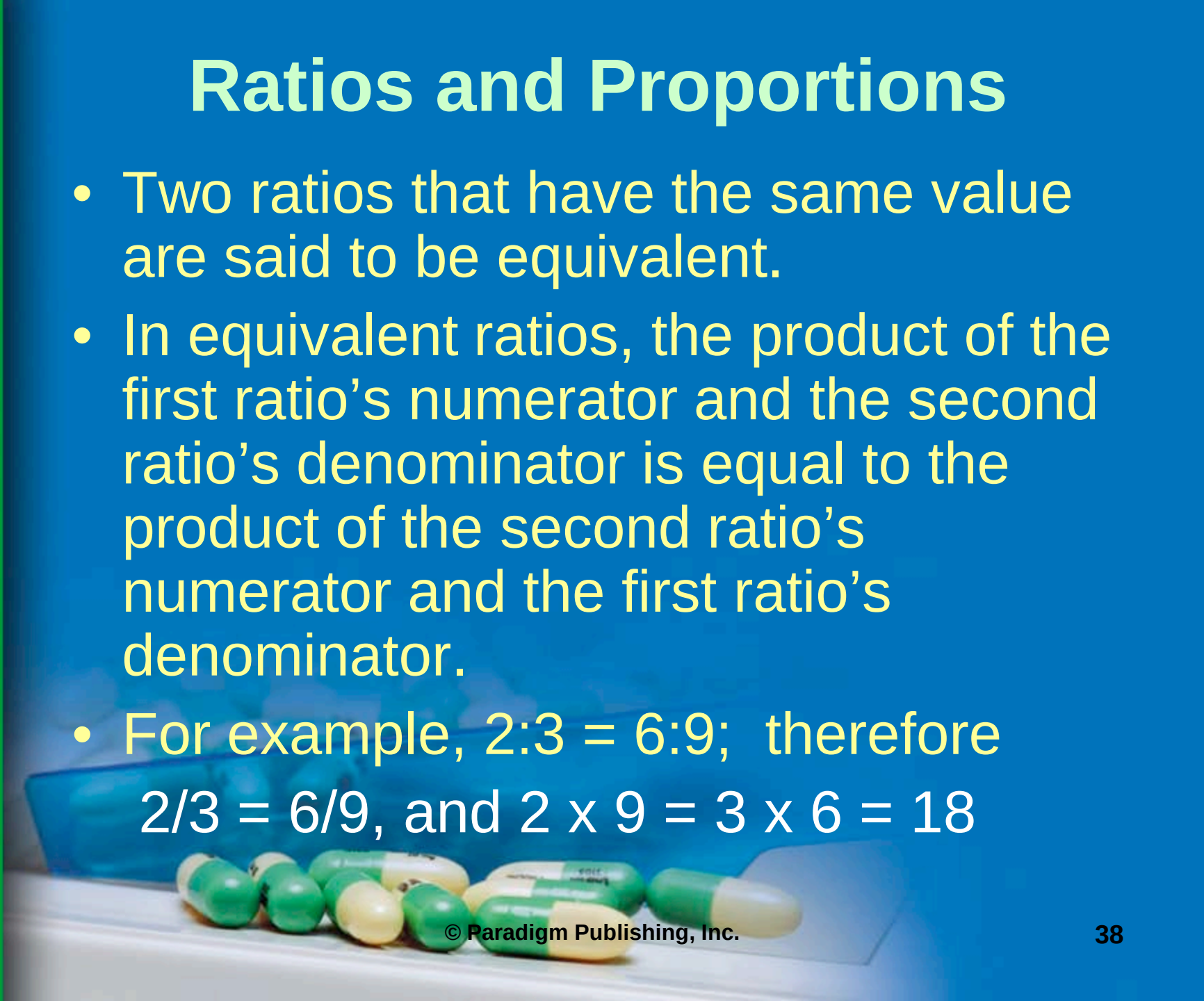
# Ratios and Proportions

- Two ratios that have the same value are said to be equivalent.
- In equivalent ratios, the product of the first ratio's numerator and the second ratio's denominator is equal to the product of the second ratio's numerator and the first ratio's denominator.
- For example, 2:3 = 6:9; therefore

  2/3 = 6/9, and 2 x 9 = 3 x 6 = 18



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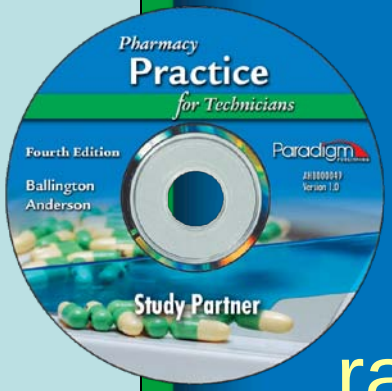


# Terms to Remember

**ratio**

a comparison of numeric values

**proportion**

a comparison of equal ratios; the product of the means equals the product of the extremes

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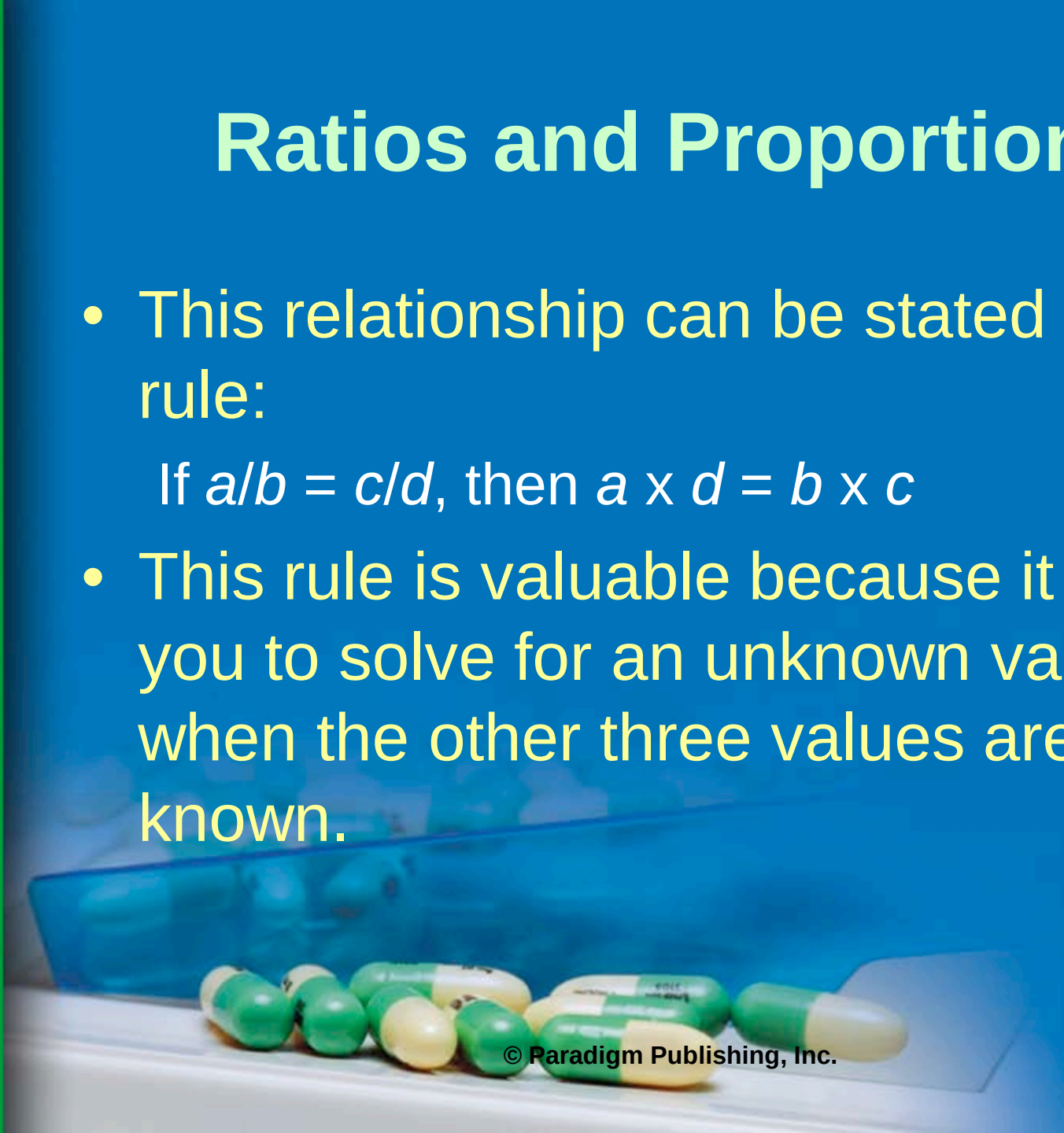
# Ratios and Proportions

- This relationship can be stated as a rule:

  If $a/b = c/d$, then $a \times d = b \times c$

- This rule is valuable because it allows you to solve for an unknown value when the other three values are known.



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# Ratios and Proportions

Safety Note

Always double-check the units in a proportion, and always double-check your calculations.



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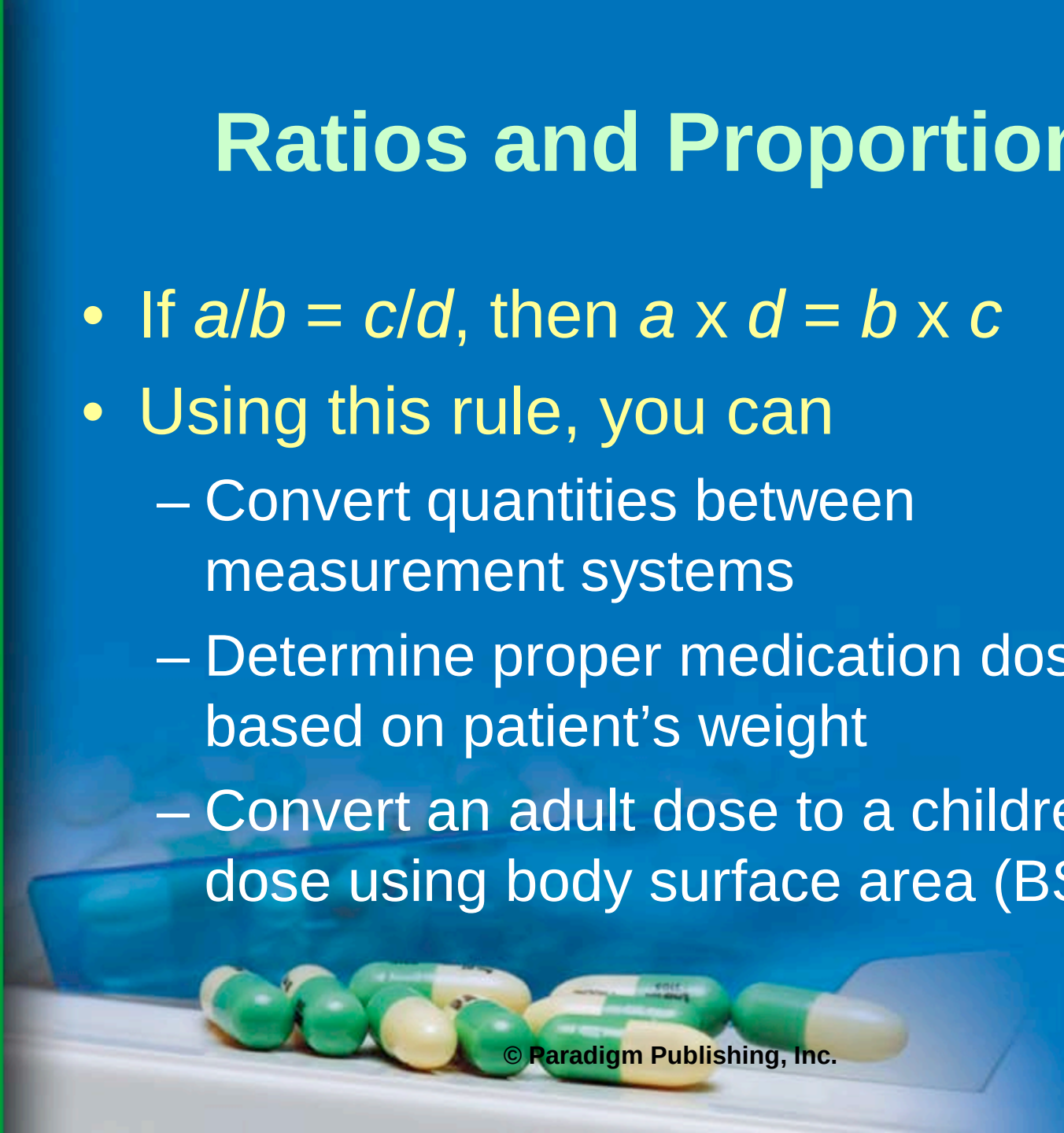
# Ratios and Proportions

- If $a/b = c/d$, then $a \times d = b \times c$
- Using this rule, you can
  - Convert quantities between measurement systems
  - Determine proper medication doses based on patient's weight
  - Convert an adult dose to a children's dose using body surface area (BSA)



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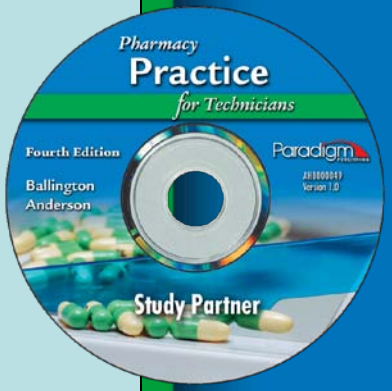


# Terms to Remember

## body surface area (BSA)

a measurement related to a patient's weight and height, expressed in meters squared ($m^2$), and used to calculate patient-specific dosages of medications

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# Percents

Percents can be expressed in many ways:

- An actual percent (47%)
- A fraction with 100 as denominator (47/100)
- A ratio (47:100)
- A decimal (0.47)



A pharmacy technician will need to be able to describe the piece of tablet as a ratio (1:2), a fraction (½), and a percentage (50%).

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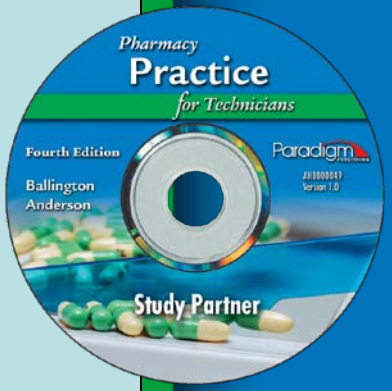


# Terms to Remember

**percent**

the number or ratio per 100

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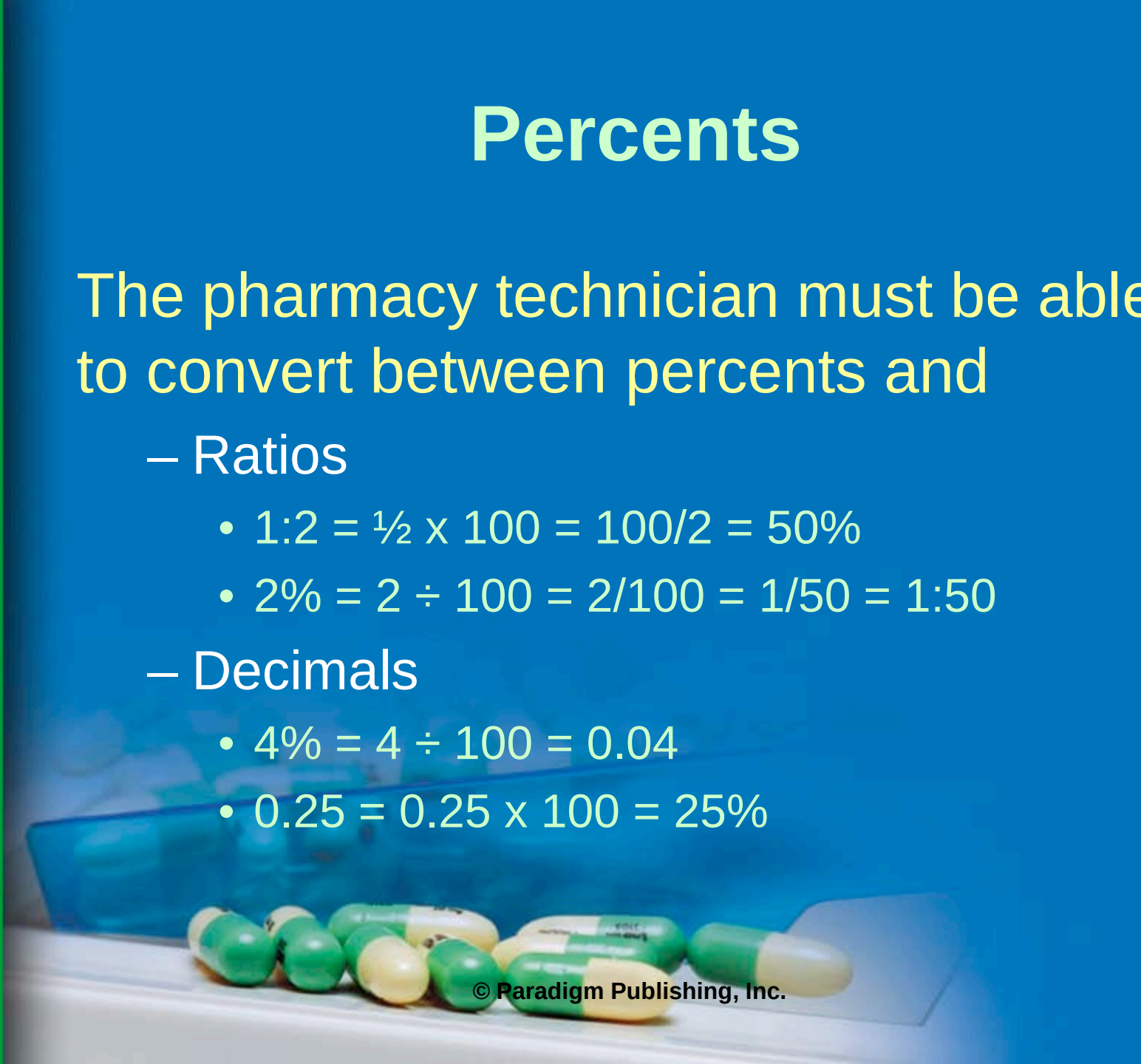
# Percents

The pharmacy technician must be able to convert between percents and

- Ratios
  - 1:2 = ½ x 100 = 100/2 = 50%
  - 2% = 2 ÷ 100 = 2/100 = 1/50 = 1:50
- Decimals
  - 4% = 4 ÷ 100 = 0.04
  - 0.25 = 0.25 x 100 = 25%



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# Advanced Calculations Used in Pharmacy Practice

- Preparing solutions using powders
- Working with dilutions
- Using alligation to prepare compounded products
- Calculating specific gravity



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# Preparing Solutions Using Powders

- Dry pharmaceuticals are described in terms of the space they occupy – the powder volume (pv).
- Powder volume is equal to the final volume (fv) minus the diluent volume (dv).

  pv = fv – dv
- When pv and fv are known, the equation can be used to determine the amount of diluent needed (dv) for reconstitution.



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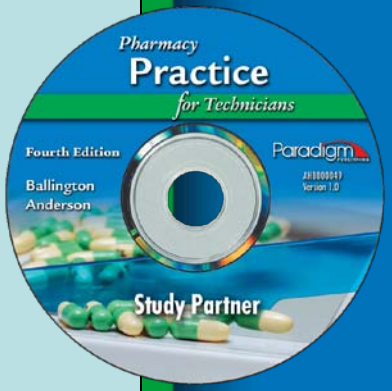


# Terms to Remember

powder volume (pv)

the amount of space occupied by a freeze-dried medication in a sterile vial, used for reconstitution; equal to the difference between the final volume (fv) and the volume of the diluting ingredient, or the diluent volume (dv)

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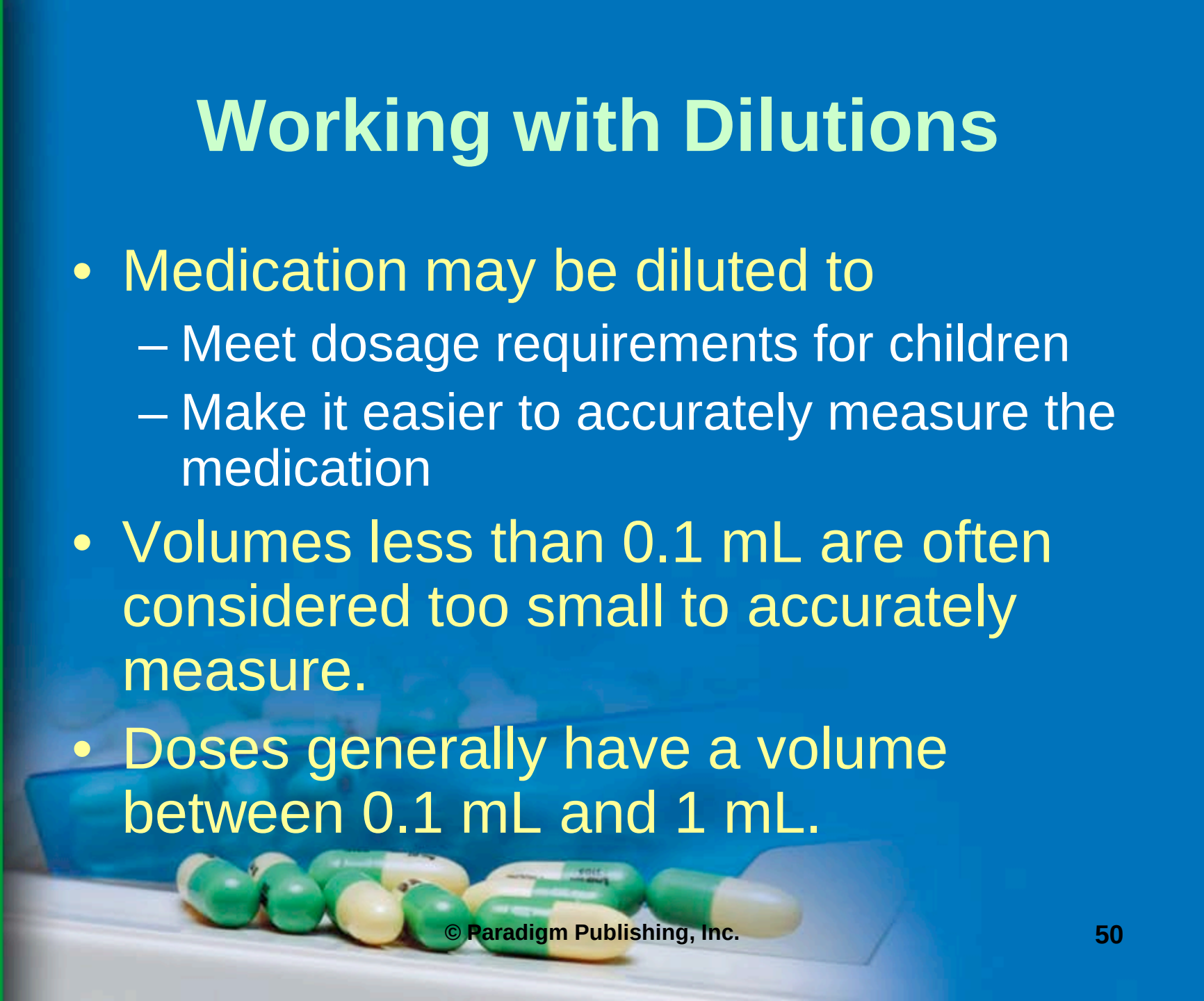
# Working with Dilutions

- Medication may be diluted to
  - Meet dosage requirements for children
  - Make it easier to accurately measure the medication
- Volumes less than 0.1 mL are often considered too small to accurately measure.
- Doses generally have a volume between 0.1 mL and 1 mL.



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# Working with Dilutions

To solve a dilution problem

- Determine the volume of the final product
- Determine the amount of diluent needed to reach the total volume



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# Using Alligation to Prepare Compounded Products

- Physicians often prescribe drugs that must be compounded at the pharmacy.
- To achieve the prescribed concentration, it may be necessary to combine two solutions with the same active ingredient, but in differing strengths.
- This process is called alligation.



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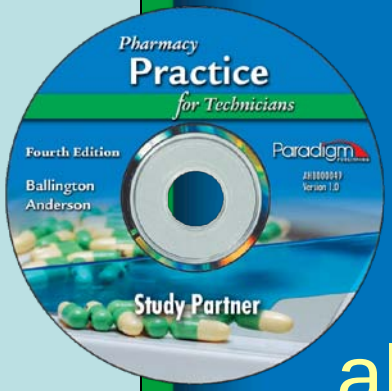


# Terms to Remember

**alligation**

the compounding of two or more products to obtain a desired concentration

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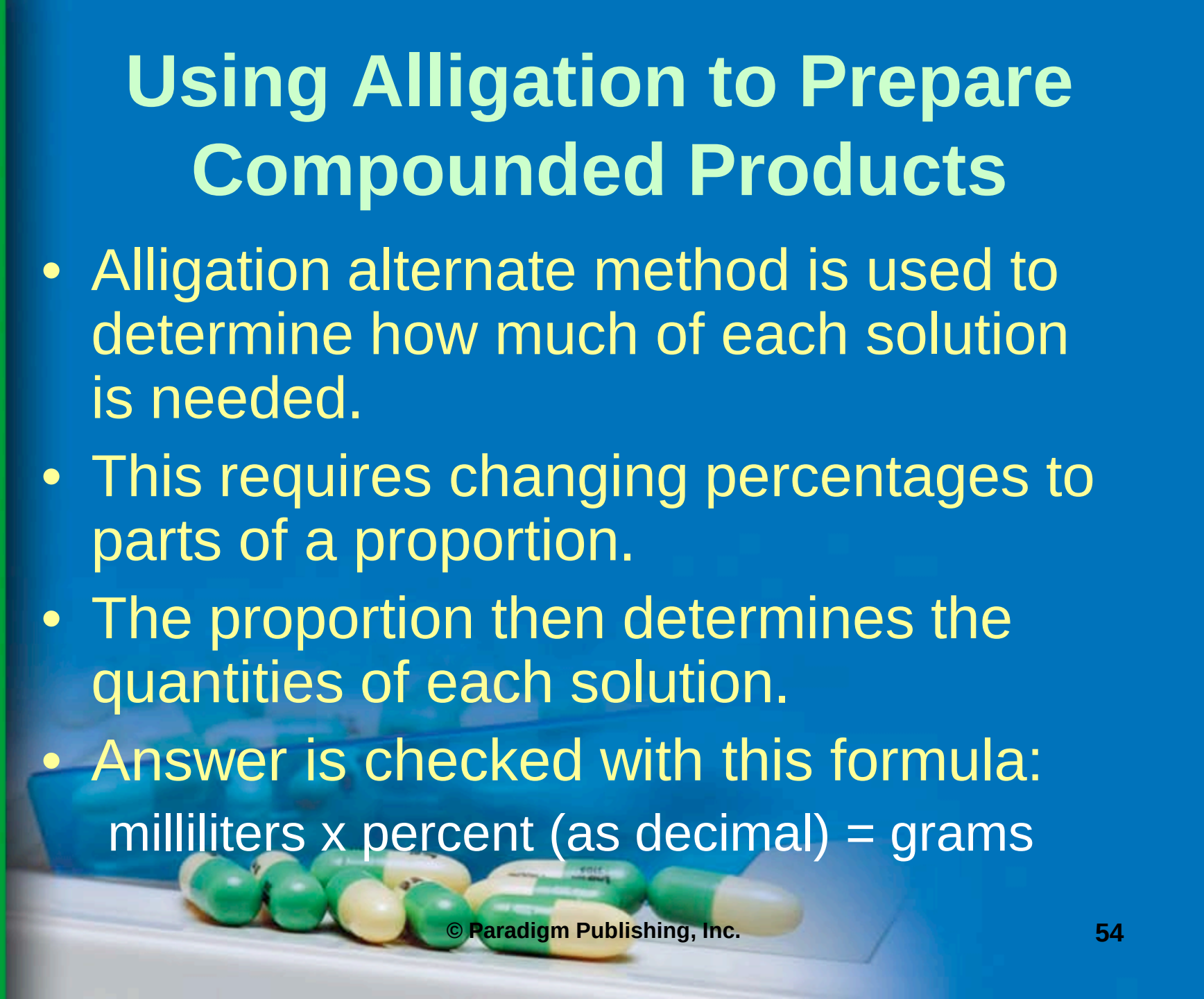
# Using Alligation to Prepare Compounded Products

- Alligation alternate method is used to determine how much of each solution is needed.
- This requires changing percentages to parts of a proportion.
- The proportion then determines the quantities of each solution.
- Answer is checked with this formula:

milliliters x percent (as decimal) = grams



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# Using Alligation to Prepare Compounded Products

See examples 19 & 20 (pages 140–142)



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# Calculating Specific Gravity

- Specific gravity is the ratio of the weight of a substance to the weight of an equal volume of water.
- Water is the standard (1 mL = 1 g).
- Calculating specific volume is a ratio and proportion application.
- Specific gravity is expressed without units.



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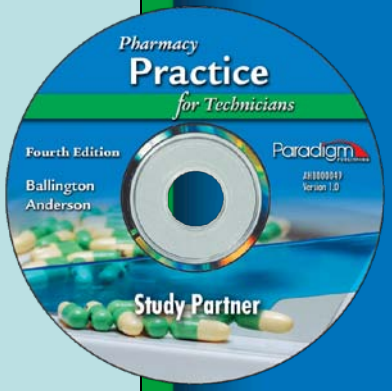


# Terms to Remember

specific gravity

the ratio of the weight of a substance compared to an equal volume of water when both have the same temperature

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# Calculating Specific Gravity

Safety Note

Usually numbers are not written without units, but no units exist for specific gravity.



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# Calculating Specific Gravity

- Specific gravity equals the weight of a substance divided by the weight of an equal volume of water.
- Specific gravities higher than 1 are heavier than water (thick, viscous solutions).
- Specific gravities lower than 1 are lighter than water (volatile solutions such as alcohol).



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