

5.4 Equivalencies

The nurse performs a variety of calculations in the clinical setting including intake and output conversions, weight conversions, dosages, volumes, and rates. The metric system is typically used when documenting and performing calculations in the clinical setting. Dosages may be calculated and converted into micrograms (mcg), milligrams (mg), milliequivalents (mEq), and grams (gm); volumes may be calculated in cubic centimeters (cc), milliliters (mL), and liters (L); and rates may be calculated in drops per minute (gtt/min), milliliters per hour (mL/hr), or units per hour (units/hr). Each of these types of calculations will be described in the following sections. Let's begin by discussing equivalencies.

Equivalency is a mathematical term that refers to two values or quantities that are the same amount. For example, one cup is equivalent to eight ounces. Nurses must memorize common household and metric equivalents to perform drug calculations and convert quantities easily.

Household Equivalencies

The household system of measurement is familiar to patients and includes drops, teaspoons, tablespoons, ounces, cups, and pounds. See Table 5.4a for common household measurement conversions and abbreviations that must be memorized by nurses.

Table 5.4a Common Household Conversions

Measurement and Abbreviation	Common Conversions
drop (gtt)	10, 12, 15, or 20 gtt = 1 mL
microdrop (mcgtt)	60 mcgtt = 1 mL
teaspoon (tsp)	1 tsp = 5 mL
tablespoon (Tbsp or Tbs)	1 Tbsp = 3 tsp = 15 mL
ounce (oz)	1 oz = 30 mL
pound (lb)	1 lb = 16 oz
cup (C)	1 C = 8 oz = 240 mL
pint (pt)	1 pt = 2 C
quart (qt)	1 qt = 4 C
gallon (gal)	1 gal = 4 qt

Metric Equivalencies

The metric system is organized by units of 10. The basic units of measurement in the metric system include meter for length, liter for volume, and gram for weight. The decimal point is easily moved either to the right or left with multiplication or division in units of 10. For example, there are 1,000 mL in 1 liter, and 0.5 liters is the same as 500 mL. See Table 5.4b for a metric equivalency chart.

When converting to a smaller unit, the decimal moves to the right

→→→→→→→→→

When converting to a larger unit, the decimal moves to the left.

←←←←←←←←←←

Table 5.4b Common Metric Equivalencies in Health Care

Kilo-	Hecto-	Deca-	1	Deci-	Centi-	Milli-
1000 units	100 units	10 units	Unit	0.1 units	0.01 units	0.001 units

Nurses often need to convert household measurements to metric equivalents or vice versa. See Table 5.4c for common metric conversions that nurses must memorize.

Table 5.4c Common Metric Conversions in Health Care

Metric Measurement	Common Conversions
1 kilogram (kg)	1 kg = 2.2 pounds = 1000 grams
1 centimeter (cm)	1 in = 2.54 cm = 25.4 mm
37 degrees Celsius	98.6 degrees F
1 liter	1000 mL = 1000 cc
1 gram	1000 mg
1 mg	1000 mcg

Table 5.4 d Common Standard Conversions in Health Care

Standard Measurement	Common Conversions
1 tsp	5 mL
1 Tbsp	15 mL
1 ounce	30 mL

Review Videos for Metric Conversions:

🎥 Metric Table on YouTube¹



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2757#oembed-1>

🎥 Metric Conversions on YouTube²



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2757#oembed-2>

Other Measurements

The nurse encounters other miscellaneous measurements in practice, such as:

- **Units (U):** Units are used in insulin, heparin, and pitocin dosages.
- **International Units (IU):** International units are used for vitamins, such

1. RegisteredNurseRN. (2015, February 4). *What is the metric table for nursing calculations?* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/aGMLRnWGanM>
2. RegisteredNurseRN. (2015, February 5). *Metric conversions made easy | How solve in metric conversions w/ dimensional analysis (Vid 1)* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/ON6SmKVWZdI>

as Vitamin D 600 IU.

- **Milliequivalents (mEq):** Milliequivalents are used in electrolyte replacement, such as Potassium 40 mEq.
- **Percentages:** Percentages are used in intravenous (IV) fluids, such as 0.9% Normal Saline IV fluid, meaning 9 g of NaCl are diluted in 1000 mL water.
- **Ratios:** Ratios are used in medications such as Epinephrine 1:1000, meaning 1 gram of Epinephrine is diluted in 1000 mL of fluid (equivalent to 1 mg/mL).

Practice Problems: Household and Metric Equivalents

Practice converting household and metric equivalents using the following problems and referencing Tables 5.4a-c. *The answers are found in the Answer Key (Math Calculations Chapter section) at the end of the book.*

1. A prescription for a child is written as 1 teaspoon every 4 hours. How many milliliters (mL) will you draw up in an oral syringe?
2. A patient's prescription states to administer one ounce of medication. How many milliliters will you measure in the medication cup?
3. A patient's prescription states to administer 0.5 grams of medication. How many milligrams will you administer?
4. A baby weighs 3.636 kilograms. How many grams does this convert to?
5. A patient's pupils are 7 mm in size. How many centimeters does this convert to?

5.5 Rounding

Follow agency policy for rounding. When performing calculations, do not round until calculating the final answer. Dosages of oral liquid medications for adults are typically rounded to the tenth for doses over 1 mL, with 0.05 and above rounding up and 0.04 and lower rounding down. For example, 17.276 rounds to 17.3, and 17.248 rounds to 17.2. For doses less than 1 mL, the dosage is rounded to the hundredth. For example, 0.0467 rounds to 0.05.

For pediatric patients, it is important to be as precise as possible to avoid medication errors. Oral liquid medications less than 1 mL should be rounded to the hundredth. For example, 0.276 rounds to 0.28, and 0.243 rounds to 0.24.

When rounding, it is also important to use critical thinking to evaluate your final answer. For example, a drop cannot be administered as a fraction of a drop, so drops are rounded to the nearest whole number.

Avoiding Medication Errors with Decimals

There are two very important standards of practice for documenting decimals to avoid medication errors¹:

- Use leading zeros for decimals (i.e., use 0.6 mg)
- Do not use trailing zeros (i.e., do not use 6.0 mg)

Practice Problems: Rounding

Practice rounding using the following problems. *The answers are found in the Answer Key (Math Calculations Chapter) at the end of the book.*

1. Saljoughian, M. (2020). Avoiding medication errors. *U.S. Pharmacist*, 45(10).
<https://www.uspharmacist.com/article/avoiding-medication-errors>

1. Round the liquid dose for an adult that is calculated as 6.5349.
2. Round the liquid dose for a child that is calculated as 6.5349.
3. Round the liquid dose for an adult that is calculated as 5.479.
4. Round the liquid dose for a child that is calculated as 5.479.
5. Round the liquid dose for an adult that is calculated as 0.1947.
6. Round the liquid dose for a child that is calculated as 0.1947.
7. Round the liquid dose for an adult that is calculated as 0.1968.
8. Round the liquid dose for a child that is calculated as 0.1968.

5.6 Using Dimensional Analysis

A common method used to perform calculations with different units of measurement is called dimensional analysis. **Dimensional analysis** is a problem-solving technique where measurements are converted to equivalent units of measure by multiplying a given unit of measurement by a fractional form of 1 to obtain the desired unit of administration. This method is also referred to as creating proportions that state equivalent ratios. Equivalencies described in Section 5.7 are used to set up ratios with the fractional form of 1 to achieve the desired unit the problem is asking for. The units of measure that must be eliminated to solve the problem are set up on the diagonal so that they can be cancelled out. Lines are drawn during the problem-solving process to show that cancellation has occurred.¹

When setting up a dosage calculation using dimensional analysis, it is important to begin by identifying the goal unit to be solved. After the goal unit is set, the remainder of the equation is set up using fractional forms of 1 and equivalencies to cancel out units to achieve the goal unit. It is important to understand that when using this problem-solving method, the numerator and denominator are interchangeable because they are expressing a relationship.² Let's practice using dimensional analysis to solve simple conversion problems of ounces to milliliters in [Section 5.7 "Conversions"](#) to demonstrate the technique.

Review of Dimensional Analysis on

1. Esser, P. (2019). *Dimensional analysis in nursing*. Southwest Technical College.
<https://swtcmathscience.wixsite.com/swtcmath/dimensional-analysis-in-nursing>
2. Esser, P. (2019). *Dimensional analysis in nursing*. Southwest Technical College.
<https://swtcmathscience.wixsite.com/swtcmath/dimensional-analysis-in-nursing>



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2768#oembed-1>

3. RegisteredNurseRN. (2015, February 4). *Dimensional analysis for nursing & nursing students for dosage calculations nursing school* [Video]. YouTube. All rights reserved. Used with permission. <https://youtu.be/6dyM2puXbgc>

5.7 Conversions

Ounces to Milliliters

When caring for patients, nurses often need to convert between ounces and milliliters. Although these equivalencies are typically memorized, let's start with a simple problem of converting ounces to milliliters to demonstrate the technique of dimensional analysis.

Practice Problem #1: Ounces to Milliliters

A patient drank an 8 ounce can of juice. The nurse must document the intake in milliliters. How many milliliters of juice did the patient drink?

Here is an example of how to solve this conversion problem using dimensional analysis.

1. Identify the unit being solved for as the goal. In this example, we want to convert the patient's oral intake from ounces to milliliters, so we are solving for milliliters (mL):

$$mL = ?$$

2. Set up the numerator in the first fraction to match the desired unit to be solved. In this case, we want to know how many milliliters should be documented, so mL is placed in the numerator. To complete the fraction, we add information already known. In this example, we know that 30 mL is equivalent to 1 ounce, so 30 mL is added to the numerator and 1 ounce is added to the denominator:

$$mL = \frac{30 \text{ mL}}{1 \text{ ounce}}$$

3. Add the second fraction to the equation. When using dimensional analysis, fractions are set up so the same units are diagonal from each other so they cancel each other out, leaving the desired unit. For this

problem, the second fraction is set up to include ounces in the numerator so that it will cancel out ounces in the denominator of the first fraction. “8” is then added to the numerator because we know from the problem that the patient consumed 8 ounces. “1” is then added to the denominator because the purpose of the second fraction is to cancel out units:

$$ml = \frac{30 \text{ mL}}{1 \text{ ounce}} \times \frac{8 \text{ ounces}}{1}$$

4. Cancel out similar units that are diagonal to each other. After canceling out ounces, we are left with our desired units of mL:

$$mL = \frac{30 \text{ mL}}{1 \cancel{\text{ ounce}}} \times \frac{8 \cancel{\text{ ounces}}}{1}$$

5. Multiply across the numerators and then multiply across the denominators:

$$mL = \frac{30 \text{ mL}}{1 \cancel{\text{ ounce}}} \times \frac{8 \cancel{\text{ ounces}}}{1} = \frac{30 \text{ mL} \times 8}{1 \times 1 = 1} = 240 \text{ mL}$$

6. Divide the numerator by the denominator to get the final answer with the desired goal unit:

$$\frac{240 \text{ mL}}{1} = 240 \text{ mL}$$

Practice Problem #2: Ounces to Milliliters

In a similar manner, dimensional analysis can be used to calculate a patient’s total liquid intake on their meal tray. See Figure 5.6¹ for an example of a patient’s meal tray in a hospital setting.

1. “Hospital Meal” by Michael Coghlin is licensed under [CC BY-SA 2.0](https://creativecommons.org/licenses/by-sa/2.0/)

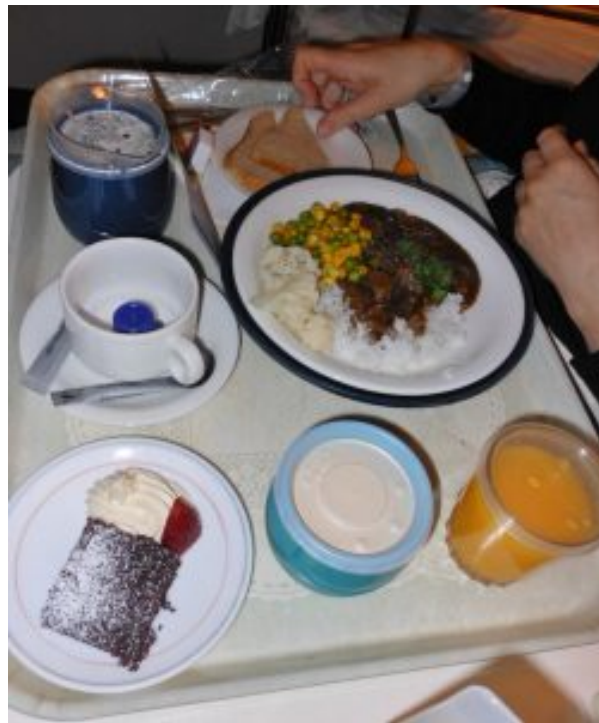


Figure 5.6 Meal Tray

Sample scenario: Your patient consumed 8 ounces of coffee, 4 ounces of orange juice, and 4 ounces of milk. How many milliliters of intake will you document?

Calculate using dimensional analysis.

1. Add up the total intake in ounces:

$$8 + 4 + 4 = 16 \text{ ounces}$$

2. Start by identifying mL as the goal unit for which you are solving. In this case, we want to know the number of milliliters:

$$mL = ?$$

3. Create the first fraction by matching milliliters in the numerator. Then, using known equivalency that 30 mL is equal to 1 ounce, place 30 in the numerator and 1 ounce in the denominator:

$$mL = \frac{30 \text{ mL}}{1 \text{ ounce}}$$

4. Create the second fraction to cross out units. You know you want to cross out ounces, so place ounces in the numerator. Then, add the known amount of ounces consumed, which was 16:

$$mL = \frac{30 \text{ mL}}{1 \text{ ounce}} \times \frac{16 \text{ ounces}}{1}$$

5. Multiply across the numerators and then the denominators. Divide the numerator by the denominator of 1 for the final answer in mL:

$$mL = \frac{30 \text{ mL}}{1 \text{ ounce}} \times \frac{16 \text{ ounces}}{1} = 30 \times 16 = 480 \text{ mL}$$



Review of Calculating Intake and Output² on YouTube



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2774#oembed-1>

Pounds to Kilograms

Converting pounds to kilograms is typically memorized as an equivalency, but let's practice using the technique of dimensional analysis.

2. RegisteredNurseRN. (2018, February 26). *Intake and output nursing calculation practice problems NCLEX review (CNA, LPN, RN) I and O* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/a6ovyZls9tg>

Sample problem: The patient entered their weight as 137 pounds on their intake form. Convert the patient's weight to kilograms to document it in the electronic medical record. Round your answer to the nearest tenth. Calculate using dimensional analysis.

1. Start by identifying kg as the goal unit for which you are solving. Then, set up the first fraction so that the numerator matches the goal unit of kg. For the denominator, add 2.2 lbs because the known equivalency is 1 kg is equivalent to 2.2 pounds. Set up the second fraction with pounds in the numerator so that pounds will cross out diagonally to eliminate this unit. Then, add the patient's known weight (137 lb) in the numerator, with 1 in the denominator because the function of this fraction is to cross out units. Multiply across the numerators and then the denominators. Finally, divide the final fraction to solve the problem.

$$kg = \frac{1 \text{ kg}}{2.2 \cancel{\text{ lb}}} \times \frac{137 \cancel{\text{ lb}}}{1} = \frac{137 \text{ kg}}{2.2} = 62.2727 = 62.3 \text{ kg}$$

- ▶ Review modules 1.0 to 1.4 within [*SWTC's Dimensional Analysis in Nursing*](#) page for more information about solving tablet problems.

5.8 Tablet Dosage

When tablets are prescribed for a patient, the dosage of the tablets supplied is often different from the prescription, and nurses must calculate the number of tablets to administer. Dimensional analysis can be used to calculate the number of tablets to administer. Let's practice using dimensional analysis using a practice problem.

Practice Problem: Tablet Dosage

Jane Doe recently had her prescription changed by her provider from Carvedilol 6.25 mg twice daily to Carvedilol 25 mg once daily. Jane shows you her prescription bottle (see Figure 5.7¹) and asks, "How many pills can I take every day so I can use up what I have before purchasing another refill?" How many 6.25 mg tablets will you instruct Jane to take based on the new prescribed dose of Carvedilol 25 mg once daily?

 ABC Pharmacy 620 W. Clairemont St, Anytown, US 12345 800-555-5555		
Rx# 2349509 Doe, Jane	Dr. John Smith	
TAKE 1 TABLET BY MOUTH TWICE DAILY.		
CARVEDILOL 6.25 MG TAB		
Refills Left: 1		
DR. M.SMITH	Qty: 60 TAB	
Date: 10/31/XX	RPh: TWD	
<i>Caution: Federal Law prohibits transfer of this drug to any other patient for whom prescribed</i>		

Figure 5.7 Prescription Bottle of Carvedilol

1. "Carvedilol Rx Bottle Label Fig. 5.PNG" by Jody Myhre-Oechsle, Chippewa Valley Technical College, Open RN is licensed under CC BY 4.0

Solve this question by using dimensional analysis.

1. Start by identifying the goal unit for which you are solving, which is a tablet (tab) in this scenario:

$$Tab =$$

2. Set up the first fraction with tab in the numerator to match the goal unit. From the prescription bottle, we know that one of the supplied tablets has a concentration of 6.25 mg, so place 1 in the numerator and 6.25 mg in the denominator:

$$Tab = \frac{1 \text{ tab}}{6.25 \text{ mg}}$$

3. Set up the second fraction with the intent to cross out mg, so place mg in the numerator. By reviewing the prescription, we know the new dosage prescribed is 25 mg, so place 25 in the numerator, and 1 in the denominator to cross off units:

$$Tab = \frac{1 \text{ tab}}{6.25 \text{ mg}} \times \frac{25 \text{ mg}}{1}$$

4. Cross out mg diagonally:

$$Tab = \frac{1 \text{ tab}}{6.25 \cancel{\text{mg}}} \times \frac{25 \cancel{\text{mg}}}{1}$$

5. Multiply across the numerators and denominators, and then divide the final fraction to solve the problem:

$$Tab = \frac{1 \text{ tab}}{6.25 \cancel{\text{mg}}} \times \frac{25 \cancel{\text{mg}}}{1} = 4 \text{ tabs}$$

- ▶ Review modules 1.5 to 1.7 on [SWTC's Dimensional Analysis in Nursing](#) page for more information about solving tablet problems.

View Supplementary YouTube Videos on Drug Calculations^{2,3,4,5:}



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2776#oembed-1>

2. Open RN Project. (2021, November 11). *Assessing blood pressure* [Video]. YouTube. Video licensed under CC-BY-4.0. [\[footnote\]Southwest Tech Math/Science Center. \(2018, April 25\). *Entry-level drug calculations for nursing students part 1 – Pharmacology, nursing math** \[Video\]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/HDmRmoi929U>](#)
3. Southwest Tech Math/Science Center. (2018, April 25). *Entry-level drug calculations for nursing students part 5 – Pharmacology, nursing math** [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/taMmPMVDzC0>
4. Southwest Tech Math/Science Center. (2018, April 25). *Entry-level drug calculations for nursing students part 6 – Pharmacology, nursing math** [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/vAY1xd2Y9kc>
5. Southwest Tech Math/Science Center. (2018, April 25). *Entry-level drug calculations for nursing students part 7 – Pharmacology, nursing math** [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/XN1Die8jTE>



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2776#oembed-2>



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2776#oembed-3>



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2776#oembed-4>

Practice tablet dosage calculations with the following interactive learning activity.



An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2776#h5p-77>

5.9 Liquid Concentrations

Medications can also be supplied in liquid instead of tablets or capsules. Liquid concentrations are typically provided in milligrams (mg) per a given number of milliliters (mL). The nurse must calculate how many milliliters (mL) to administer based on the prescribed dose in milligrams (mg). Let's practice using dimensional analysis to solve how much liquid medication to administer based on the prescription and the medication supplied.

Practice Problem: Liquid Concentrations

John Smith has been prescribed Phenergan as needed every 4-6 hours for nausea and vomiting. John is feeling nauseated and is requesting another dose of Phenergan. It has been 8 hours since the last dose was given. How many mL will you administer?

Prescription: Phenergan 12.5 mg IV PRN every 4 to 6 hours for nausea and vomiting.

Drug Supplied: See Figure 5.8¹ for an image of the label of the drug as it is supplied.

1. "Phenergan Label Fig. 8.PNG" by Jody Myhre-Oechsle, [Chippewa Valley Technical College](#), [Open RN](#) is licensed under [CC BY 4.0](#)

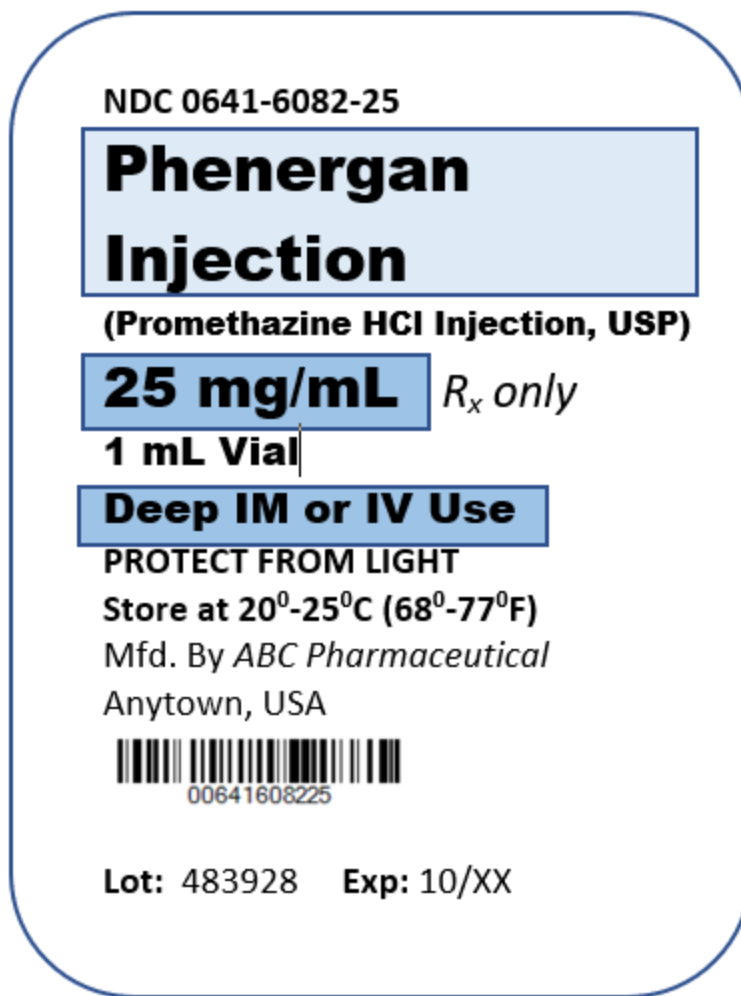


Figure 5.8 Phenergan Medication Label

Solve this question by using dimensional analysis.

1. Start by identifying mL as the goal unit for which you are solving because you need to know how many mL of medication to administer:

$$mL =$$

2. Set up the first fraction with mL in the numerator to match the goal unit. In this problem, we know from the drug label that 1 mL contains 25 mg of medication, so plug in 1 in numerator and 25 mg in the denominator:

$$mL = \frac{1 \text{ mL}}{25 \text{ mg}}$$

3. Set up the second fraction to cross out mg, so place mg in the numerator. We know from the order that the new dosage prescribed is 12.5 mg, so plug in 12.5 next to mg in the numerator and 1 in the denominator to cross off units:

$$mL = \frac{1 \text{ mL}}{25 \text{ mg}} \times \frac{12.5 \text{ mg}}{1}$$

4. Cross out mg diagonally:

$$mL = \frac{1 \text{ mL}}{25 \cancel{\text{mg}}} \times \frac{12.5 \cancel{\text{mg}}}{1}$$

5. Multiply across the numerators and denominators, and then divide the final fraction to solve the problem:

$$mL = \frac{1 \text{ mL}}{25 \cancel{\text{mg}}} \times \frac{12.5 \cancel{\text{mg}}}{1} = \frac{12.5 \text{ mL}}{25} = 0.5 \text{ mL}$$

View supplementary YouTube videos on How to Use Dimensional Analysis to Calculate Oral Medication Dosages^{2,3,4,5:}



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2779#oembed-1>



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2779#oembed-2>

2. Southwest Tech Math/Science Center. (2018, April 25). *Entry-level drug calculations for nursing students part 2 – Pharmacology, nursing math** [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/VHHpGeu9sNw>
3. Southwest Tech Math/Science Center. (2018, April 25). *Entry-level drug calculations for nursing students part 4 – Pharmacology, nursing math** [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/f6bpA3usjkl>
4. RegisteredNurseRN. (2015, February 21). *Dosage calculations | Nursing drug calculations | Oral medications problems nursing school (Video 3)* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/zZ3M747ChrQ>
5. RegisteredNurseRN. (2018, April 25). *Weight-based calculations | Drug medication calculations by weight nursing students (Video 6)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/E_LfMcRT8aY



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2779#oembed-3>



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2779#oembed-4>

- ▶ Review modules 1.8 and 1.9 within [SWTC's Dimensional Analysis in Nursing](#) page for more information about solving liquid problems.

Practice liquid dosing calculations with the following interactive learning activity:



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/nursingskills/?p=2779#h5p-87>

5.10 Reconstituted Medication

In the previous section, we calculated medication doses that were provided in a liquid form in a given concentration. Medications are also commonly supplied in dry form, such as powders or crystals, that must be reconstituted with fluid before they are administered parenterally by injection. **Reconstitution** is the process of adding a liquid diluent to a dry ingredient to make a specific concentration of liquid. See Figure 5.9¹ for an example of a vial of medication that requires reconstitution. When reconstituting medications, it is important to follow the reconstitution instructions carefully so the medication is prepared in the correct concentration. When calculating the dosage of reconstituted medication to administer to the patient, the amount of fluid used to dilute the medication must also be considered. Let's practice using dimensional analysis to determine how much of a reconstituted medication should be administered.

1. "[Zevtera IVial UK\(3\)\(1\) \(29608654394\).jpg](#)" by [Mohamd Ghani](#) is licensed under [CC BY-SA 2.0](#)



Figure 5.9 Dry Medication Requiring Reconstitution

Practice Problem: Reconstituted Medication

Patient Information:

Name: Liam Vang, DOB: 04/04/20xx, Age 8, Allergies: NKDA, Weight: 60 kg

Provider Order: Cefazolin 500 mg IM every 8 hours

Medication Supplied: See Figure 5.10² for the drug label of the medication as it is supplied.

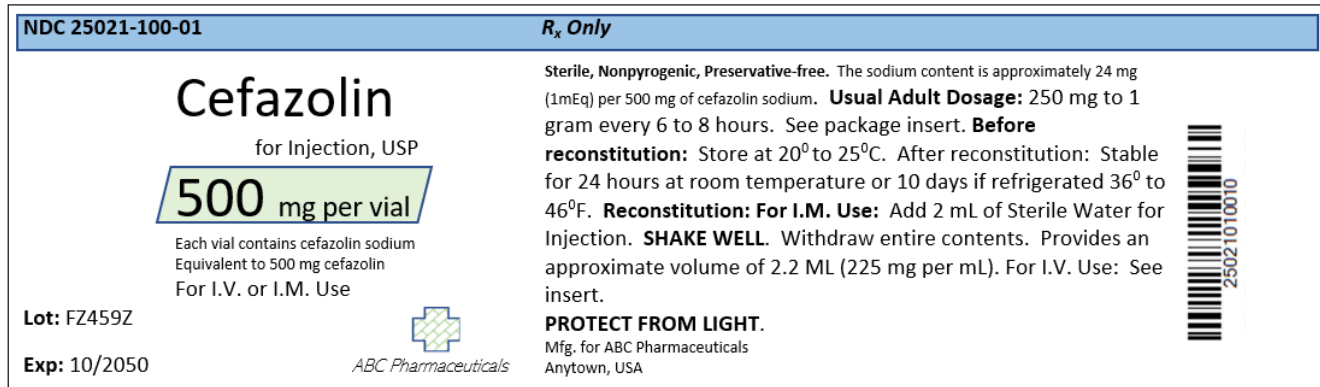


Figure 5.10 Drug Label of Cefazolin

1. Start by reading the order and the drug label. Liam has an order to receive 500 mg of Cefazolin. The vial of medication in powder form states there are 500 mg per vial. The powder must be reconstituted before it can be administered. The reconstitution instructions on the label state to add 2 mL of sterile water to the vial to reconstitute the powder into a liquid form for injection. The label states that after the powder is reconstituted with the 2 mL of diluent, the concentration of fluid will be 225 mg/mL. See a close-up image of reconstitution instructions in Figure 5.11.³

2. "Cefazolin Label Fig. 9.PNG" by Jody Myhre-Oechsle, [Chippewa Valley Technical College](#), [Open RN](#) is licensed under [CC BY 4.0](#)
3. "Reconstitution Instructions.png" by Jody Myhre-Oechsle, [Chippewa Valley Technical College](#), [Open RN](#) is licensed under [CC BY 4.0](#)

Before reconstitution: Store at 20° to 25°C. After reconstitution: Stable for 24 hours at room temperature or 10 days if refrigerated 36° to 46°F.
Reconstitution: For I.M. Use: Add 2 mL of Sterile Water for Injection. **SHAKE WELL.** Withdraw entire contents. Provides an approximate volume of 2.2 mL (225 mg per mL). For I.V. Use: See insert.

Figure 5.11 Reconstitution Instructions

When setting up the problem, we need to identify the correct information to include in the equation. There are several numbers we may be tempted to try to incorporate into our equation, such as 500 mg per vial, 2 mL diluent, and approximate volume of 2.2 mL. These are numbers specific to the reconstitution process. However, keep in mind that our final goal is to calculate the number of mL of fluid to administer after the medication is reconstituted, so this will be the goal unit. The other piece of important information that the drug label states is that the reconstituted medication will provide a concentration of 225 mg/mL.

2. Start by identifying the goal unit for which you are solving, which is mL to administer as an injection:

$$mL = ?$$

3. Set up the first fraction by matching the numerator to the goal unit of mL. In this problem, we know from the drug label that the known concentration of the reconstituted medication is 225 mg per mL, so add 1 mL to the numerator and 225 mg to the denominator:

$$mL = \frac{1 \text{ mL}}{225 \text{ mg}}$$

4. Set up the second fraction with mg in the numerator with the intent to cross off mg diagonally. Look at the given information to determine how it relates to mg. The order tells us to give Liam 500 mg of the medication. Place 500 in the numerator of the second fraction with one in the denominator so that mg will cross off diagonally:

$$mL = \frac{1 \text{ mL}}{225 \text{ mg}} \times \frac{500 \text{ mg}}{1}$$

5. Cross off units diagonally. Multiply across the numerators and the denominators, and then divide the final fraction for the answer in mL:

$$mL = \frac{1 \text{ mL}}{225 \cancel{\text{mg}}} \times \frac{500 \cancel{\text{mg}}}{1} = \frac{500 \text{ mL}}{225} = 2.2222 \text{ mL}$$

6. Because the patient is a child, round to hundredth for the final answer:
2.22 mL

View supplementary YouTube videos for Using Dimensional Analysis to Calculate Reconstitution^{4,5}:



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2782#oembed-1>



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2782#oembed-2>

Practice medication reconstitution calculations with this interactive learning activity.

4. Southwest Tech Math/Science Center. (2018, April 25). *Entry-level drug calculations for nursing students part 3 – Pharmacology, nursing math** [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/g9nqo-aZuHE>
5. RegisteredNurseRN. (2015, October 7). *Dosage calculations made easy | Reconstitution calculation medication problems nursing students (10)* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/TK3ZAaMuhYk>



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/nursingskills/?p=2782#h5p-79>

5.11 Weight-Based Calculations

Liquid medications are often prescribed based on the patient's weight. Dimensional analysis can be used to determine the amount of liquid medication the patient will receive based on their weight, the provider order, and the concentration of medication supplied.

Practice Problem: Weight-Based Calculations

Patient Information:

Name: Aidan Smith, DOB: 5/09/20xx, Age 4, Allergies: NKDA, Weight: 22 pounds

Prescription: Tylenol 15mg/kg PO every 4-6 hours for pain or fever

Medication Supplied: See Figure 5.12¹ for the drug label of the medication supplied.

1. This work is a derivative of [tylenol-01.jpg](#), courtesy of the [U.S. National Library of Medicine](#). This image is included on the basis of Fair Use.

NDC 50580-612-01

Children's TYLENOL®

Acetaminophen (160 mg per 5 mL)

Oral Suspension

Pain Reliever-Fever Reducer

Pain + Fever
Ages 2-11 Years

Alcohol Free
Ibuprofen Free
Aspirin Free
No Parabens



4 fl oz (120 mL)
160 mg per 5 mL

Grape
Flavor

Drug Facts

Active ingredient (in each 5 mL)

Acetaminophen 160 mg.....Pain reliever/fever reducer

Purpose

Uses temporarily:

- reduces fever
- relieves minor aches and pains due to:
 - the common cold ■ flu ■ headache
 - sore throat ■ toothache

Warnings

Liver warning: This product contains acetaminophen. Severe liver damage may occur if your child takes
■ more than 5 doses in 24 hours, which is the maximum daily amount

■ with other drugs containing acetaminophen

Allergy alert: acetaminophen may cause severe skin reactions. Symptoms may include:

- skin reddening ■ blisters ■ rash

If a skin reaction occurs, stop use and seek medical help right away.

Sore throat warning: If sore throat is severe, persists for more than 2 days, is accompanied or followed by fever, headache, rash, nausea, or vomiting, consult a doctor promptly.

Do not use

- with any other drug containing acetaminophen (prescription or nonprescription). If you are not sure whether a drug contains acetaminophen, ask a doctor or pharmacist.
- if your child is allergic to acetaminophen or any of the inactive ingredients in this product

Ask a doctor before use if your child has liver disease

Ask a doctor or pharmacist before use if your child is taking the blood thinning drug warfarin

When using this product do not exceed recommended dose (see overdose warning)

Stop use and ask a doctor if

- pain gets worse or lasts more than 5 days
- fever gets worse or lasts more than 3 days
- new symptoms occur
- redness or swelling is present

These could be signs of a serious condition.

Keep out of reach of children.

Overdose warning: In case of overdose, get medical help or contact a Poison Control Center right away.

(1-800-222-1222) Quick medical attention is critical for adults as well as for children even if you do not notice any signs or symptoms



Figure 5.12 Acetaminophen

Aidan had his last dose of Tylenol eight hours ago and now has a fever of 38 degrees Celsius. Calculate the amount of Tylenol you will prepare and administer to Aidan using dimensional analysis.

1. Review the medication label. We see that acetaminophen (Tylenol) is supplied in a concentration of 160 mg in 5 mL.
2. Set up the equation by starting with the goal unit for which we are solving, which, in this case, is milliliters of liquid medication to administer:

$$mL = ?$$

3. Set up the first fraction by matching the numerator to mL. Place in the known amount of mL from the drug label, which is 5. Add 160 mg to the denominator because the medication supplied has a known concentration amount of 160 mg in 5 mL:

$$mL = \frac{5 \text{ mL}}{160 \text{ mg}}$$

4. Create the second fraction with the intent to cross out units by placing mg in the numerator. Look for other important information in the problem related to mg. The prescription is for 15 mg of acetaminophen (Tylenol) for each kg of weight. Add 15 the numerator and 1 kg in the denominator because 15 mg of Tylenol are ordered for every 1 kg of patient weight:

$$mL = \frac{5 \text{ mL}}{160 \text{ mg}} \times \frac{15 \text{ mg}}{1 \text{ kg}}$$

5. Create the third fraction with the intent to cross out kg, so place kg in the numerator. Look for important information in the problem related to kg. The patient's chart tells us their weight is 22 pounds. Add 1 kg to the numerator and then place 2.2 lb (based on a known equivalency) in the denominator:

$$mL = \frac{5 \text{ mL}}{160 \cancel{\text{ mg}}} \times \frac{15 \cancel{\text{ mg}}}{1 \text{ kg}} \times \frac{1 \text{ kg}}{2.2 \text{ lb}}$$

6. Place lb in the numerator of the fourth fraction with the intent to cross out pounds. Look at the information provided and see that the patient weighs 22 pounds. Add 22 pounds in the numerator and 1 in the denominator with the intent to cross off units:

$$mL = \frac{5 \text{ mL}}{160 \cancel{\text{ mg}}} \times \frac{15 \cancel{\text{ mg}}}{1 \text{ kg}} \times \frac{1 \cancel{\text{ kg}}}{2.2 \cancel{\text{ lb}}} \times \frac{22 \text{ lb}}{1} =$$

7. Cancel out units diagonally:

$$mL = \frac{5 \text{ mL}}{160 \cancel{\text{ mg}}} \times \frac{15 \cancel{\text{ mg}}}{1 \text{ kg}} \times \frac{1 \cancel{\text{ kg}}}{2.2 \cancel{\text{ lb}}} \times \frac{22 \cancel{\text{ lb}}}{1} =$$

8. After canceling out similar units, we are left with mL, our goal unit, so we can complete the calculation. Multiply across the numerators and the denominators, and then divide the final fraction for the answer:

$$mL = \frac{5 \text{ mL} \times 15 \times 1 \times 22}{160 \times 1 \times 2.2 \times 1} = \frac{1650 \text{ mL}}{352} = \frac{1650 \text{ mL}}{352} = 4.6875 \text{ mL}$$

9. Round your final answer. Because the patient is a child, round the final answer to the hundredth, so the final answer is 4.69 mL.

► Review module 1.12 within [*SWTC's Dimensional Analysis in Nursing Page*](#) for more information about solving weight-based problems.

Practice weight-based calculations with the interactive learning activity below.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/nursingskills/?p=2785#h5p-88>

5.12 Safe Dosage Range

When administering calculated liquid medication, it is important to double-check that the dosage administered is within a safe range. Safe ranges of dosages are provided in drug reference materials. Medication errors often occur in children, who have smaller ranges of safe dosage than adults due to their smaller weight.

When verifying that a dosage is within a safe range based on a patient's weight, begin by completing the dosage calculation. Then, calculate the low and high ends of the safe dosage range. Finally, verify that the calculated dose is within this range.

Practice Problem: Safe Dosage Range

Declan is an 8-month-old infant who weighs 7 kg. He has been prescribed acetaminophen 100 mg every 4-6 hours PO for a fever. The recommended dosage range for infants is 10-15 mg/kg/dose. Calculate the acceptable dosage range for Declan and determine if the prescribed dose is safe.

1. Calculate the low end of the safe dosage. Start by identifying the goal unit. For this problem we want to know the dose in milligrams:

$$mg = ?$$

2. To set up the problem, match the numerator in the first fraction to the desired unit to be solved, which in this case is mg. Based on information known from the problem, we know that the recommended low dose is 10 mg per kg, so add 1 kg to the denominator:

$$mg = \frac{10 \text{ mg}}{1 \text{ kg}}$$

3. Create the second fraction with the intent to cross out units. Place kg in the numerator. Look to the problem for information related to kg. We

know that Declan weighs 7 kg, so place 7 in the numerator and 1 in the denominator with the intent to cross off units:

$$mg = \frac{10 \text{ mg}}{1 \text{ kg}} \times \frac{7 \text{ kg}}{1}$$

4. Cross off units. Multiply across the numerators and then the denominators, and then divide the final fraction for the final low dose answer in mg:

$$mg = \frac{10 \text{ mg}}{1 \cancel{\text{ kg}}} \times \frac{7 \cancel{\text{ kg}}}{1} = \frac{70}{1} = 70 \text{ mg (low dose)}$$

5. Calculate the high dose. Set up a similar equation, but this time using the high dose information of 15 mg per kg:

$$mg = \frac{15 \text{ mg}}{1 \cancel{\text{ kg}}} \times \frac{7 \cancel{\text{ kg}}}{1} = \frac{105}{1} = 105 \text{ mg (high dose)}$$

6. Based on the calculations, the safe dosage range for Declan is 70 mg – 105 mg. Compare the prescribed dose to the low- and high-dose range calculations to determine if it is safe. Declan was prescribed 100 mg. It falls within the calculated safe dosage range of 70 – 105 mg, so, yes, this is a safe dose for Declan.



View a supplementary YouTube video on Safe Pediatric Dosage Calculations:¹



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2787#oembed-1>

Practice dosage range calculations with the interactive activity below.



An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2787#h5p-89>

1. RegisteredNurseRN. (2016, September 13). *Safe dose dosage range pediatric calculations nursing drug math (Video 7)* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/QRdIVGaQf7Q>

5.13 Intravenous Infusions

So far in this chapter, we have practiced using dimensional analysis to determine dosage calculations for medications given orally and parenterally (by injection). Medications can also be administered intravenously (IV). There are two methods for administering intravenous medications: infusion pump or gravity using IV drip tubing.

In the United States, intravenous medications are most commonly administered via an infusion pump for patient safety. When an infusion pump is used to administer IV medications, it is typically programmed by the nurse in milliliters per hour (mL/hour). However, situations may occur when an infusion pump is not available, so the nurse must also know how to calculate drip rates using IV drip tubing to administer a medication by gravity. There are different types of IV drip tubing, and each type provides a specific number of drops of medication per milliliter.

As we perform math calculations related to IV medication administration, we are ultimately ensuring that our patients are receiving the correct dose over the correct period of time to avoid adverse effects from too-rapid or too-slow intravenous administration. Specific math calculations for IV infusion by gravity and IV infusion by pump are further described in the following sections.

5.14 IV Infusion by Gravity

IV drip tubing comes in a variety of sizes called drop factors. The **drop factor** is the number of drops in one mL of solution using gravity IV tubing. The drop factor is printed on the IV tubing package. **Macro drip tubing** includes tubing with drop factors of 10, 12, 15, or 20 drops per milliliter and is typically used to deliver general IV solutions to adults. **Microdrip tubing** includes tubing with a drop factor of 60 drops per milliliter. It is typically used to deliver precise amounts of medication in small drops to children and infants. See Figure 5.13¹ for an image of microdrip and macrodrip tubing.



Figure 5.13 Microdrip and Macro drip IV Tubing

1. “Microdrip Tubing” and “Macro drip Tubing” by Deanna Hoyord, [Chippewa Valley Technical College](#) HPS Lab is licensed under [CC BY 4.0](#)



View a supplementary YouTube video² about Micro Tubing Drip Chamber



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2791#oembed-1>

In the sample problems below, you will be calculating the number of drops needed per minute to achieve the quantity of fluid to be infused per hour in the provider order.

Practice Problem: IV Infusion (Example 1)

Let's practice calculating the rate of IV infusion by gravity using macrodrip tubing.

Patient Information:

Name: Elaina Dimas, DOB: 12/09/20xx, Age 6, Allergies: NKDA, Weight: 15 kg

Diagnosis: Dehydration

Prescription: 0.9% Sodium Chloride 500 mL IV bolus over four hours

2. [Open RN Project](#). (2020, December 9). *Micro tubing drip chamber video* [Video]. YouTube. Licensed under [CC BY 3.0](#). <https://youtu.be/reH50eHpmsQ>

See Figure 5.14³ for the IV fluid supplied.

See Figure 5.15⁴ for IV tubing supplied.



Figure 5.14 0.9% Sodium Chloride in 500 mL

3. "0.9% Sodium Chloride 500 ml" by Deanna Hoyord, Chippewa Valley Technical College HPS Lab is licensed under [CC BY 4.0](#)

4. "Microdrip Tubing" by Deanna Hoyord, Chippewa Valley Technical College is licensed under [CC BY 4.0](#)



Figure 5.15 Micro drip Tubing

Solve using dimensional analysis.

1. To set up the problem, begin by identifying the goal unit(s) for which we are solving. When calculating infusion rates by gravity, we need to calculate how many drops (gtts) of the solution will be infused each minute. This will allow us to count the actual drops dripping from the tubing and regulate the rate, so the volume of infusion is delivered in the time ordered. Set up the problem by identifying the goal unit to solve, but instead of solving for one unit, we will be solving for two units: drops (gtts) and minutes:

$$\frac{gtts}{min} = ?$$

2. Set up the first fraction by matching drops (gtts) in the numerator to the goal unit. Review the tubing provided to determine how many drops per minute are administered with this type of tubing. In this example, the tubing is labelled as 60 gtts/mL. Place 60 in the numerator for how many drops are administered by the tubing in 1 mL, and then add 1 mL to the denominator:

$$\frac{gtts}{min} = \frac{60 gtts}{1 mL}$$

3. Set up the second fraction with the intent to cross off mL, so place mL in the numerator. Look for information provided in the problem related to mL. The prescription is for 500 mL of solution over four hours. Place 500 into the numerator, and place 4 hours in the denominator, and then cross off the mL units:

$$\frac{gtts}{min} = \frac{60 gtts}{1 mL} \times \frac{500 mL}{4 hours}$$

4. Calculate the minutes to achieve our goal unit of drops per minute. Create the third fraction with hour in the numerator with the intent to cross off hour units. Using equivalencies, we know that 1 hour is equivalent to 60 minutes, so plug in 60 minutes in the denominator. Cancel out hours. Evaluate if we have reached our goal units. This equation now matches the goal of units/min and can be solved:

$$\frac{gtts}{min} = \frac{60 gtts}{1 mL} \times \frac{500 mL}{4 hours} \times \frac{1 hour}{60 min}$$

5. Multiply across the numerators and denominators, and then divide the final fraction.

$$\frac{gtts}{min} = \frac{60 gtts}{1 mL} \times \frac{500 mL}{4 hours} \times \frac{1 hour}{60 min} = \frac{60 gtts \times 500 \times 1}{1 \times 4 \times 60 min} = 125 gtts/min$$

6. The final answer is 125 drops/minute.

Practice Problem: IV Infusion (Example 2)

Let's practice a second problem using different types of IV drip tubing and a different time to be infused.

Patient Information:

Tubing Supplied: See Figure 5.17⁶ for the tubing available.





Figure 5.17 Macro drip Tubing

Solve using dimensional analysis:

$$\frac{gtts}{min} = \frac{10 \text{ gtts}}{1 \text{ mL}} \times \frac{250 \text{ mL}}{2 \text{ hour}} \times \frac{1 \text{ hour}}{60 \text{ min}} = \frac{10 \text{ gtts} \times 250 \times 1}{1 \times 2 \times 60 \text{ min}} = 20.83 \text{ gtts/min}$$

Round drops to the nearest whole number for a final answer of 21 drops/minute.

View a supplementary YouTube video about Solving IV Drip Factor Rate Calculations⁷



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2791#oembed-2>

- ▶ Review module 1.11 within *SWTC's Dimensional Analysis in Nursing* page for more information about solving drop rates.

Practice flow rate calculations with this interactive activity.



An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2791#h5p-85>

7. RegisteredNurseRN. (2015, September 28). *Dosage calculations for nursing students on IV drip rate factors made easy (Video 4)*. [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/W5Vlc6f0fBA>

5.15 IV Infusion by Pump

Intravenous (IV) infusion pumps are the second method used to administer intravenous medications and fluids. See Figure 5.18¹ for an image of an IV pump. Infusion pumps provide an additional safeguard by using a pump to provide an exact amount of fluid per hour to prevent medications from being inadvertently administered too slowly or too quickly. While IV pumps are intended to improve patient safety, the nurse is still responsible for safely setting up the pump. The flow rate using IV pumps is typically calculated in mL/hour. There are many different types of infusion pumps, so the nurse should become familiar with the pumps used at the clinical agency and seek assistance when working with unfamiliar equipment. For additional information about IV infusions, see the [“IV Therapy Management” chapter](#).

1. “DSC_0738-e1443533768679-678x1024.jpg” by [British Columbia Institute of Technology](#) is licensed under CC BY 4.0. Access for free at <https://opentextbc.ca/clinicalskills/chapter/8-2-types-of-iv-therapy/>



Figure 5.18 IV Infusion Pump

Practice Problem: Infusion by Pump (Example 1)

Let's use the same information from the problem for the patient named Amber Gomez in the "IV Infusion by Gravity" subsection, but instead we will calculate the rate of infusion using an IV infusion pump.

Name: Amber Gomez, DOB: 08/26/xxxx, Age 26, Allergies: NKDA, Weight: 50 kg

Prescription: Lactated Ringers 200 mL IV bolus over 2 hours

1. Start by identifying the goal units for which you are solving, which is mL per hour:

$$\frac{mL}{hour} = ?$$

2. Set up the first fraction by matching mL in the numerator. Look at the known information in the problem related to mL. The prescription is to administer 200 mL IV bolus over 2 hours, so put 200 mL in the numerator and 2 hours in the denominator:

$$\frac{mL}{hour} = \frac{200 \text{ mL}}{2 \text{ hours}}$$

3. Because the units match the goal unit of mL/hour, divide the numerator by the denominator for the final answer:

$$\frac{mL}{hour} = \frac{200 \text{ mL}}{2 \text{ hours}} = 100 \text{ mL/hr}$$

Practice Problem: Infusion by Pump (Example 2)

Let's practice another problem calculating flow rate via IV infusion pump, but this time the prescription states the rate in minutes instead of hours.

Patient Information:

Name: Ashley Hanson, DOB: 09/29/20xx, Age 21, Allergies: NKDA

Diagnosis: Dehydration

Prescription: Lactated Ringers 100 mL IV bolus over 30 minutes

1. Start by setting the goal units being solved. In this case, the pump will still be set for mL per hour:

$$\frac{mL}{hour} = ?$$

2. Set up the first fraction by matching the numerator to mL. Look for additional information in the problem related to mL. The order states that 100 mL should be administered over 30 minutes. Place 100 mL in the numerator and 30 minutes in the denominator:

$$\frac{mL}{Hr} = \frac{100 \text{ mL}}{30 \text{ minutes}}$$

3. Because the pump will be set in mL/hour, convert minutes to hours. Add a second fraction with the intent of crossing off minutes. Place minutes in the numerator so the units will cross out diagonally. Using the known equivalency of 60 minutes in an hour, plug in 60 minutes in the numerator and 1 hour in the denominator. Cross off units diagonally. Multiple across the numerators and the denominators, and then divide for the final answer in mL/hr:

$$\frac{mL}{Hr} = \frac{100 \text{ mL}}{30 \text{ minutes}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = \frac{100 \text{ mL} \times 60}{30 \times 1 \text{ hour}} = \frac{6000 \text{ mL}}{30 \text{ hour}} = 200 \text{ mL/hr}$$

View supplementary YouTube videos on calculating IV infusion rates:

IV Infusion Flow Rate Calculations²



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2794#oembed-1>

IV Bolus Calculations³



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2794#oembed-2>

▶ Review module 1.10 within [SWTC's Dimensional Analysis in](#)

2. RegisteredNurseRN. (2015, September 30). *Dosage calculations for nursing students made easy on IV infusion rate calculations (Video 5)* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/rRN3DifaMWo>
3. RegisteredNurseRN. (2015, February 9). *Dosage calculations / Nursing drug calculations / IV medications problems nursing school (Vid 2)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/N9gZVo_Sc60

► [Nursing](#) page for more information about solving weight-based problems.

Practice calculating flow rates by infusion pumps using this interactive activity.



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/nursingskills/?p=2794#h5p-84>

5.16 IV Completion Time

In addition to calculating IV flow rates, nurses also commonly calculate when an infusion will be completed so they will know when to discontinue the infusion or hang another IV bag. Let's practice calculating how long it will take an IV infusion to complete.

Practice Problem: IV Completion Time (Example 1)

Patient Information:

Name: Amanda Parks, DOB: 09/29/xxxx, Allergies: NKDA, Weight: 70 kg

Prescription: 0.9% Sodium Chloride IV at 75 mL/hr

Fluid Supplied: See Figure 5.19¹ for the IV fluid bag supplied.

1. "0.9% Sodium Chloride in 500 ml" by Deanna Hoyord, [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)



Figure 5.19 0.9% Normal Saline in 500 mL

1. Begin by setting up the goal unit being solved for, which is an hour:

$$Hour = ?$$

2. Set up the first fraction by matching the numerator to hour. Look at the information in the problem related to hours. The order states the IV should be administered at 75 mL per hour, so add 75 mL to the denominator:

$$Hour = \frac{1 \text{ hour}}{75 \text{ mL}}$$

3. Set up the second fraction with the intent to cancel out mL, so add mL to the numerator of the second fraction. Look at the information in the problem related to mL. By looking at the bag, we know there are 500 mL to infuse, so place 500 in the numerator and place 1 in the denominator with the intent to cross out units:

$$Hour = \frac{1 \text{ hour}}{75 \text{ mL}} \times \frac{500 \text{ mL}}{1}$$

4. Cross off units then multiply across the numerators and denominators. Divide the final fraction for the final answer:

$$Hour = \frac{1 \text{ hour}}{75 \text{ mL}} \times \frac{500 \text{ mL}}{1} = \frac{1 \text{ hour} \times 500}{75 \times 1} = \frac{500 \text{ hour}}{75} = 6.666667 \text{ hours}$$

5. When performing calculations related to time, it is important to remember that anything after the decimal is a portion of an hour and needs to be converted to minutes. To finish the answer, multiply 60 minutes X 0.6667 = 40.02 minutes. The final answer is the infusion will be completed in 6 hours and 40 minutes.

Practice Problem: IV Completion Time (Example 2)

Now let's add a start time to the above problem and calculate what time the infusion will end. We determined that the IV infusion will take 6.6667 hours to infuse 500 mL at 75 mL/hr.

Let's assume the infusion started at 0800.

1. Add the total infusion time to the start time of the infusion, so add 6 hours to the start time of 0800. Use military time and put a "0" before the six for 6 hours:

$$0800 + 0600 = 1400$$

2. Add the minutes to the time:

$$1400 + 40 = 1440$$

3. Answer: Our infusion will be complete at 1440.



View a supplementary YouTube video on Calculating IV Infusion Times²:



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2801#oembed-1>

Practice calculating IV completion rates in this interactive learning activity.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://wtcs.pressbooks.pub/nursingskills/?p=2801#h5p-86>

2. RegisteredNurseRN. (2015, February 21). *IV infusion time calculations nursing / Dosage calculations practice for nursing student (Vid 9)* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/QPAeGgVkyBY>

5.17 Multi-Step Calculations

Sometimes multi-step calculations are required, especially for medications used in critical care. There are many different ways to solve multi-step calculations, so it is important to select a method that works for you that is consistently accurate. Let's practice a multi-step calculation for a medication supplied in mg/mL but is prescribed based on micrograms (mcg) per kilogram (kg) per minute, and the patient's weight is provided in pounds.

Practice Problem: Multi-Step Calculations

Patient Information:

Name: Ideen Hanson, DOB: 09/29/19xx, Allergies: NKDA, Weight: 180 lbs

Diagnosis: Hypertension

Prescription: Begin initial infusion of Nipride at 0.5 mcg/kg/min

Medication Supplied: See Figure 5.20¹ for the drug label of the medication supplied.

1. "Nipride Label" by Jody Myhre-Oechsle, [Chippewa Valley Technical College](#), [Open RN](#) is licensed under [CC BY 4.0](#)

NIPRIDE 50 mg
in D5W 250 mL
(sodium nitroprusside)

Lot: AA102220



00409302401

INJECTION

EXP 10/31/XX

Figure 5.20 Nipride Label

Problem: What rate (in mL/hr) should the nurse set the pump to begin the infusion?

1. Set up the goal units to solve for, which is mL/hr.

$$\frac{mL}{hr} =$$

2. Review the problem. The prescription is based on mcg/kg/min. Having three elements can create confusion when setting up the equation using dimensional analysis, so it can be easier to eliminate one element by doing some preliminary steps. First, convert the patient weight to kilograms (kg) by dividing 180 pounds/2.2= 81.8181 kg. Now multiply the micrograms (mcg) ordered by weight in kg to determine the amount of medication to administer per minute: 81.8181 x 0.5 mcg = 40.9090 mcg/minute. Use this information as you set up your problem.

3. Start by identifying the unit you are solving for, which is mL/hour. Then set up the first fraction. Match the numerator to mL. Look to the problem for information related to mL. On the drug label, we see that 50 mg of Nipride is supplied in 250 mL of D5W. Place 250 in the numerator, and then 50 mg in the denominator:

$$\frac{mL}{Hr} = \frac{250 \text{ mL}}{50 \text{ mg}}$$

4. Set up the second fraction with the intent to cross off mg by placing 1 mg in the numerator. Based on the known equivalency that 1000 mcg are equal to 1 mg, place 1000 mcg in the denominator:

$$\frac{mL}{Hr} = \frac{250 \text{ mL}}{50 \text{ mg}} \times \frac{1 \text{ mg}}{1000 \text{ mcg}}$$

5. Cross off mg diagonally. Set up the third equation with the intent to cross off mcg by placing it in the numerator. Place the information previously calculated, which was 40.9090 mcg/minute:

$$\frac{mL}{Hr} = \frac{250 \text{ mL}}{50 \text{ mg}} \times \frac{1 \text{ mg}}{1000 \text{ mcg}} \times \frac{40.9090 \text{ mcg}}{1 \text{ min}}$$

6. Cross off mcg diagonally. Set up the fourth fraction with the intent to cross off minutes. Based on the known equivalency of 60 minutes in 1 hour, place 60 in the numerator and 1 hour in the denominator:

$$\frac{mL}{Hr} = \frac{250 \text{ mL}}{50 \text{ mg}} \times \frac{1 \text{ mg}}{1000 \text{ mcg}} \times \frac{40.9090 \text{ mcg}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hour}} = 12.2727$$

7. Cross off min diagonally. Review the equation to ensure the goal unit has been met. It has been met, so multiply across the numerators and the denominators, and then divide the final fraction:

$$\frac{mL}{Hr} = \frac{250 \text{ mL}}{50 \text{ mg}} \times \frac{1 \text{ mg}}{1000 \text{ mcg}} \times \frac{40.9090 \text{ mcg}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hour}} = 12.2727$$

8. Depending on the agency policy and available pump settings, round to 12.27 mL/hour.

View supplementary YouTube Videos on Multiple-Step Calculations That Commonly Occur With Heparin and Dopamine Drips:

Heparin Drip Calculations²



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2803#oembed-1>

Dopamine Drip Calculations³



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=2803#oembed-2>

2. RegisteredNurseRN. (2018, July 26). *Heparin drip calculation practice problems for nurses / Dosage calculations nursing* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/10y4gRdnCy8>
3. RegisteredNurseRN. (2019, February 8). *Dopamine IV drip calculation & nursing considerations pharmacology implications* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/R2XMro13dD0>

5.18 Learning Activities



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/nursingskills/?p=3156#h5p-123>



- ▶ Test your clinical judgment with an NCLEX Next Generation-style question: [Chapter 5, Assignment 1](#).

V Glossary

Dimensional analysis: Dimensional analysis is a problem-solving technique where measurements are converted to a different (but equivalent) unit of measure by multiplying with a fractional form of 1 to obtain a desired unit of administration.

Drop factor: The number of drops in one mL of solution when fluids or medications are administered using gravity IV tubing.

Equivalency: Two values or quantities that are the same amount. For example, one cup is equivalent to eight ounces.

Macrodrop tubing: Gravity IV tubing with drop factors of 10, 15, or 20 drops per milliliter that are typically used to deliver general IV solutions for adults.

Medication cup: A small plastic or paper cup used to dispense oral medications. Some plastic medication cups have calibration marks for measuring medication amounts.

Microdrop tubing: Gravity IV tubing with a drop factor of 60 drops per milliliter.

Military time: A method of measuring the time based on the full 24 hours of the day rather than two groups of 12 hours indicated by AM and PM.

Oral syringe: A specific type of syringe used to measure and/or administer medications via the oral route.

Reconstitution: The process of adding a liquid diluent to a dry ingredient to make a liquid in a specific concentration.

Syringe: A medical device used to administer parenteral medication into tissue or into the bloodstream. Syringes can also be used to withdraw blood or fluid.

6.1 Neurological Assessment Introduction

Learning Objectives

- Perform a neurological assessment, including mental status, cranial nerves, sensory function, motor strength, cerebellar function, and reflexes
- Modify assessment techniques to reflect variations across the life span
- Document actions and observations
- Recognize and report significant deviations from norms

The neurological system is a complex and intricate system that affects all body functions. A neurological assessment includes collecting subjective and objective data through an interview and detailed physical examination of the central nervous system and the peripheral nervous system. Let's begin by reviewing the anatomy of the neurological system.

6.2 Basic Neurological Concepts

When completing a neurological assessment, it is important to understand the functions performed by different parts of the nervous system while analyzing findings. For example, damage to specific areas of the brain, such as that caused by a head injury or cerebrovascular accidents (i.e., strokes), can cause specific deficits in speech, facial movements, or use of the extremities. Damage to the spinal cord, such as that caused by a motor vehicle accident or diving accident, will cause specific motor and sensory deficits according to the level where the spinal cord was damaged.

The nervous system is divided into two parts, the central nervous system and the peripheral nervous system. See Figure 6.1¹ for an image of the entire nervous system. The **central nervous system (CNS)** includes the brain and the spinal cord. The brain can be described as the interpretation center, and the spinal cord can be described as the transmission pathway. The peripheral nervous system (PNS) consists of the neurological system outside of the brain and spinal cord, including the cranial nerves that branch out from the brain and the spinal nerves that branch out from the spinal cord. The **peripheral nervous system** can be described as the communication network between the brain and the body parts. Both parts of the nervous system must work correctly for healthy body functioning.

1. "Nervous system diagram.png" by unknown is licensed under [CC BY-NC-SA 3.0](https://creativecommons.org/licenses/by-nc-sa/3.0/). Access for free at [https://med.libretexts.org/Bookshelves/Nursing/Book%3A_Clinical_Procedures_for_Safer_Patient_Care_\(Doyle_and_McCutcheon\)/02%3A_Patient_Assessment/2.07%3A_Focused_Assessments](https://med.libretexts.org/Bookshelves/Nursing/Book%3A_Clinical_Procedures_for_Safer_Patient_Care_(Doyle_and_McCutcheon)/02%3A_Patient_Assessment/2.07%3A_Focused_Assessments)

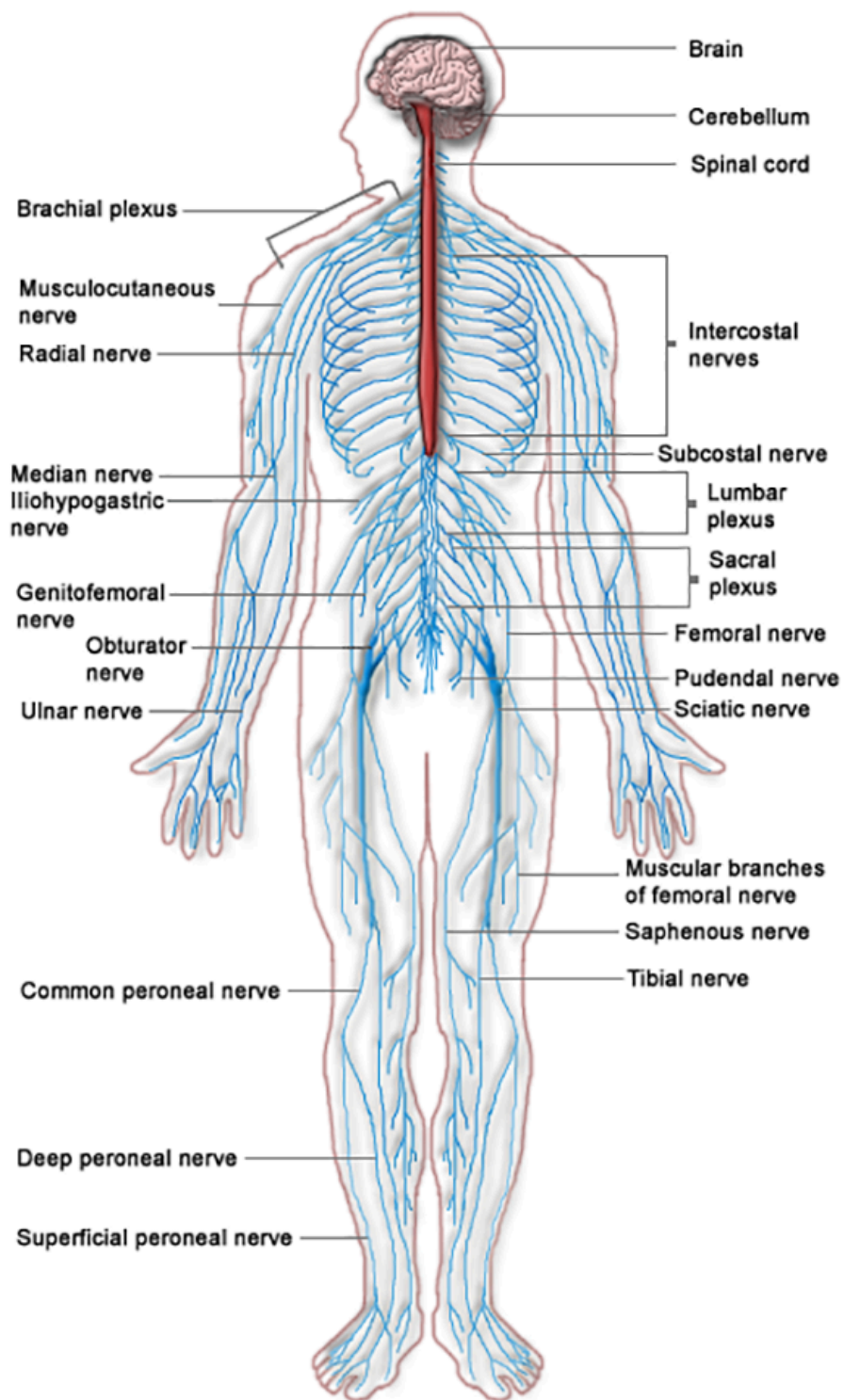


Figure 6.1 Central and Peripheral Nervous Systems

Central Nervous System

The major regions of the brain are the cerebrum and cerebral cortex, the

diencephalon, the brain stem, and the cerebellum. See Figure 6.2² for an illustration of the cerebellum and the lobes of the cerebrum.

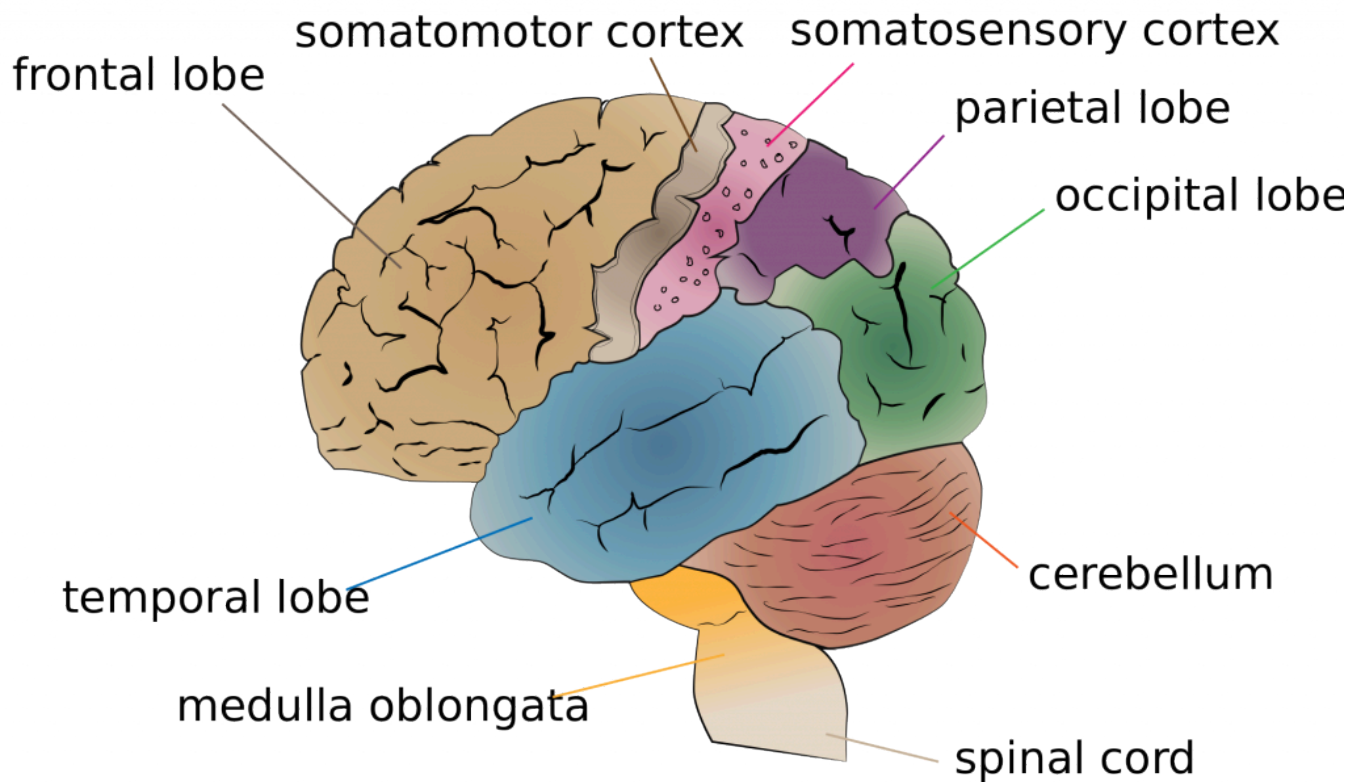


Figure 6.2 Regions of the Brain

Cerebrum and Cerebral Cortex

The largest portion of our brain is the cerebrum. The cerebrum is covered by a wrinkled outer layer of gray matter called the cerebral cortex. See Figure 6.3³ for an image of the cerebral cortex. The cerebral cortex is responsible for the higher functions of the nervous system such as memory, emotion, and consciousness. The corpus callosum is the major pathway of communication between the right and left hemispheres of the

2. "Cerebrum lobes.svg" by Jkwchui is licensed under CC BY-SA 3.0

3. "1305 CerebrumN.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/13-2-the-central-nervous-system>

cerebral cortex. The **cerebral cortex** is further divided into four lobes named the frontal, parietal, occipital, and temporal lobes.⁴ Each lobe has specific functions.

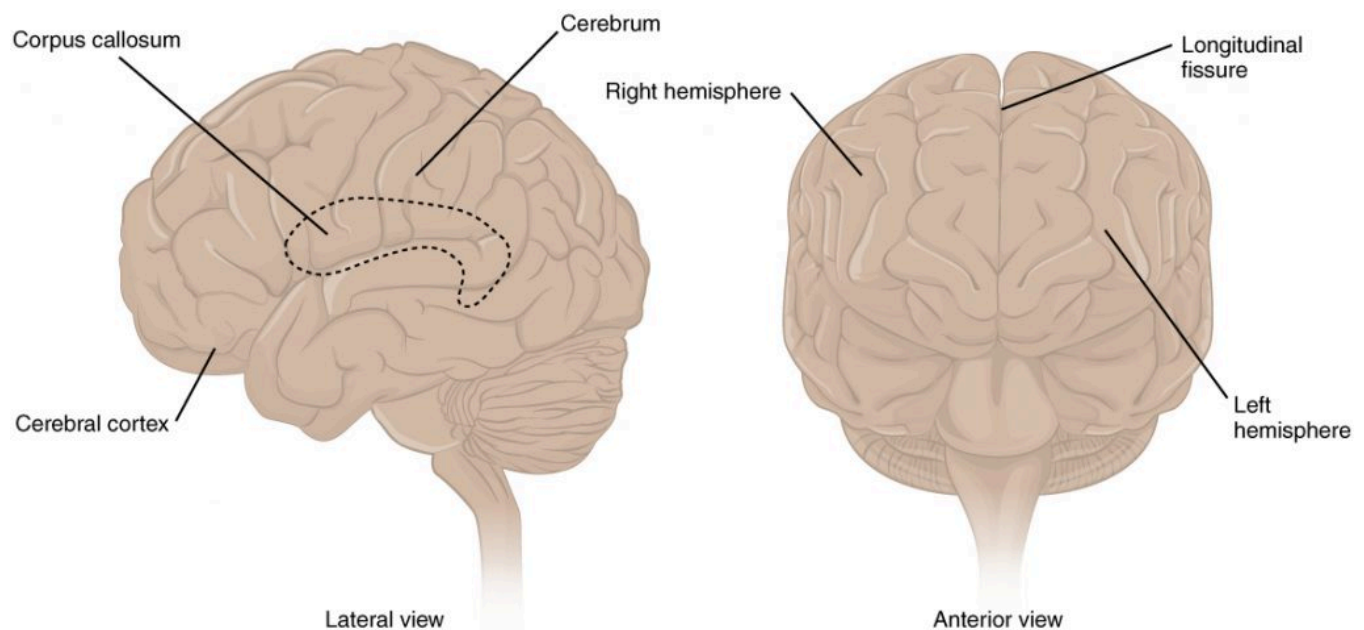


Figure 6.3 Cerebral Cortex

FRONTAL LOBE

The frontal lobe is associated with movement because it contains neurons that instruct cells in the spinal cord to move skeletal muscles. The anterior portion of the frontal lobe is called the prefrontal lobe, and it provides cognitive functions such as planning and problem-solving that are the basis of our personality, short-term memory, and consciousness. **Broca's area** is also located in the frontal lobe and is responsible for the production of language and controlling movements responsible for speech.⁵

4. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

5. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

PARIETAL LOBE

The parietal lobe processes general sensations from the body. All of the tactile senses are processed in this area, including touch, pressure, tickle, pain, itch, and vibration, as well as general senses of the body, such as **proprioception** (the sense of body position) and **kinesthesia** (the sense of movement).⁶

TEMPORAL LOBE

The temporal lobe processes auditory information and is involved with language comprehension and production. Wernicke's area and Broca's area are located in the temporal lobe. Wernicke's area is involved in the comprehension of written and spoken language, and Broca's area is involved in the production of language. Because regions of the temporal lobe are part of the limbic system, memory is also an important function associated with the temporal lobe.⁷ The limbic system is involved with our behavioral and emotional responses needed for survival, such as feeding, reproduction, and the fight – or – flight responses.

OCCIPITAL LOBE

The occipital lobe primarily processes visual information.⁸

Diencephalon

Information from the rest of the central and peripheral nervous system is sent to the cerebrum through the diencephalon, with the exception of the

6. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

7. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

8. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

olfactory nerve that connects directly to the cerebrum.⁹ See Figure 6.4¹⁰ for an illustration of the diencephalon deep within the cerebrum. The diencephalon contains the hypothalamus and the thalamus.

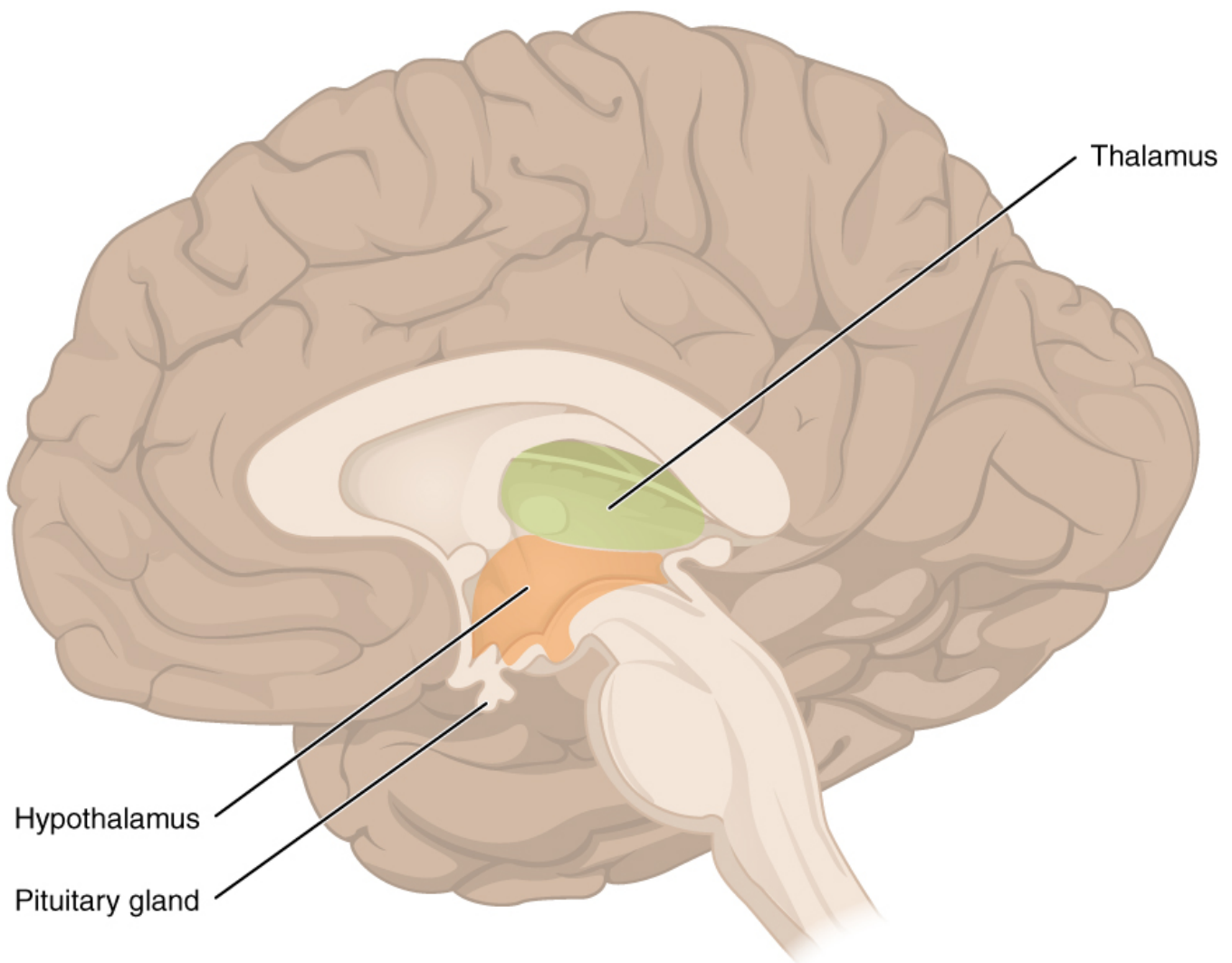


Figure 6.4 The Diencephalon Containing the Hypothalamus and the Thalamus.

The **hypothalamus** helps regulate homeostasis such as body temperature,

9. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

10. "1310 Diencephalon.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/13-2-the-central-nervous-system>

thirst, hunger, and sleep. The hypothalamus is also the executive region in charge of the autonomic nervous system and the endocrine system through its regulation of the anterior pituitary gland. Other parts of the hypothalamus are involved in memory and emotion as part of the limbic system.¹¹

The **thalamus** relays sensory information and motor information in collaboration with the cerebellum. The thalamus does not just pass the information on, but it also processes and prioritizes that information. For example, the portion of the thalamus that receives visual information will influence what visual stimuli are considered important enough to receive further attention from the brain.¹²

Brain Stem

The brain stem is composed of the pons and the medulla. The pons and the medulla regulate several crucial autonomic functions in the body, including involuntary functions in the cardiovascular and respiratory systems, vasodilation, and reflexes like vomiting, coughing, sneezing, and swallowing. Cranial nerves also connect to the brain through the brain stem and provide sensory input and motor output.¹³

► For more information about the functions of the autonomic nervous system, visit the “[Autonomic Nervous System](#)” chapter in the Open RN *Nursing Pharmacology* textbook.

11. This work is a derivative of [Anatomy & Physiology](#) by OpenStax and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

12. This work is a derivative of [Anatomy & Physiology](#) by OpenStax and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

13. This work is a derivative of [Anatomy & Physiology](#) by OpenStax and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

Cerebellum

The **cerebellum** is located in the posterior part of the brain behind the brain stem and is responsible for fine motor movements and coordination. For example, when the motor neurons in the frontal lobe of the cerebral cortex send a command down the spinal cord to initiate walking, a copy of that instruction is also sent to the cerebellum. Sensory feedback from the muscles and joints, proprioceptive information about the movements of walking, and sensations of balance are sent back to the cerebellum. If the person becomes unbalanced while walking because the ground is uneven, the cerebellum sends out a corrective command to compensate for the difference between the original cerebral cortex command and the sensory feedback.¹⁴

Spinal Cord

The spinal cord is a continuation of the brain stem that transmits sensory and motor impulses. The length of the spinal cord is divided into regions that correspond to the level at which spinal nerves pass through the vertebrae. Immediately adjacent to the brain stem is the cervical region, followed by the thoracic, the lumbar, and finally the sacral region.¹⁵ The spinal nerves in each of these regions innervate specific parts of the body. See more information under the “Spinal Nerves” subsection.

Review the anatomy of the brain using following supplementary video.

14. This work is a derivative of [Anatomy & Physiology](#) by [OpenStax](#) and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

15. This work is a derivative of [Anatomy & Physiology](#) by [OpenStax](#) and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

Review for Anatomy of the Brain on YouTube¹⁶



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=1182#oembed-1>

Peripheral Nervous System

The peripheral nervous system (PNS) consists of cranial nerves and spinal nerves that exist outside of the brain, spinal cord, and autonomic nervous system. The main function of the PNS is to connect the limbs and organs to the central nervous system (CNS). Sensory information from the body enters the CNS through cranial and spinal nerves. Cranial nerves are connected directly to the brain, whereas spinal nerves are connected to the brain via the spinal cord.

Peripheral nerves are classified as sensory nerves, motor nerves, or a combination of both. **Sensory nerves** carry impulses from the body to the brain for processing. **Motor nerves** transmit motor signals from the brain to the muscles to cause movement.

Cranial Nerves

Cranial nerves are directly connected from the periphery to the brain.

16. Forciea, B. (2015, May 12). *Anatomy and physiology: Central nervous system: Brain anatomy v2.0* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/DBRdInd2-Vg>

They are primarily responsible for the sensory and motor functions of the head and neck. There are twelve cranial nerves that are designated by Roman numerals I through XII. See Figure 6.5¹⁷ for an image of cranial nerves. Three cranial nerves are strictly sensory nerves; five are strictly motor nerves; and the remaining four are mixed nerves.¹⁸ A traditional mnemonic for memorizing the names of the cranial nerves is “**O**n **O**ld **O**lympus **T**owering **T**ops **A** **F**inn **A**nd **G**erman **V**iewed **S**ome **H**ops,” in which the initial letter of each word corresponds to the initial letter in the name of each nerve. A second popular mnemonic to assist with memorization is “**O**h **O**nce **O**ne **T**akes **T**he **A**natomy **F**inal **V**ery **G**ood **V**acations **A**re **H**eavenly”.

- The **o**lfactory nerve is responsible for the sense of smell.
- The **o**ptic nerve is responsible for the sense of vision.
- The **o**culomotor nerve regulates eye movements by controlling four of the extraocular muscles, lifting the upper eyelid when the eyes point up and for constricting the pupils.
- The **t**rochlear nerve and the **a**bducens nerve are both responsible for eye movement but do so by controlling different extraocular muscles.
- The **t**rigeminal nerve regulates skin sensations of the face and controls the muscles used for chewing.
- The **f**acial nerve is responsible for the muscles involved in facial expressions, as well as part of the sense of taste and the production of saliva.
- The **a**uditory/**v**estibulocochlear nerve manages hearing and balance.
- The **g**lossopharyngeal nerve regulates the controlling muscles in the oral cavity and upper throat, as well as part of the sense of taste and the production of saliva.
- The **v**agus nerve is responsible for contributing to homeostatic control

17. “1320 The Cranial Nerves.jpg” by OpenStax is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/13-4-the-peripheral-nervous-system>

18. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

of the organs of the thoracic and upper abdominal cavities.

- The **a**ccessory nerve controls movements of the neck, along with cervical spinal nerves.
- The **h**ypoglossal nerve manages the muscles of the lower throat and tongue.¹⁹ Methods for assessing each of these nerves are described in the “Assessing Cranial Nerves” section.

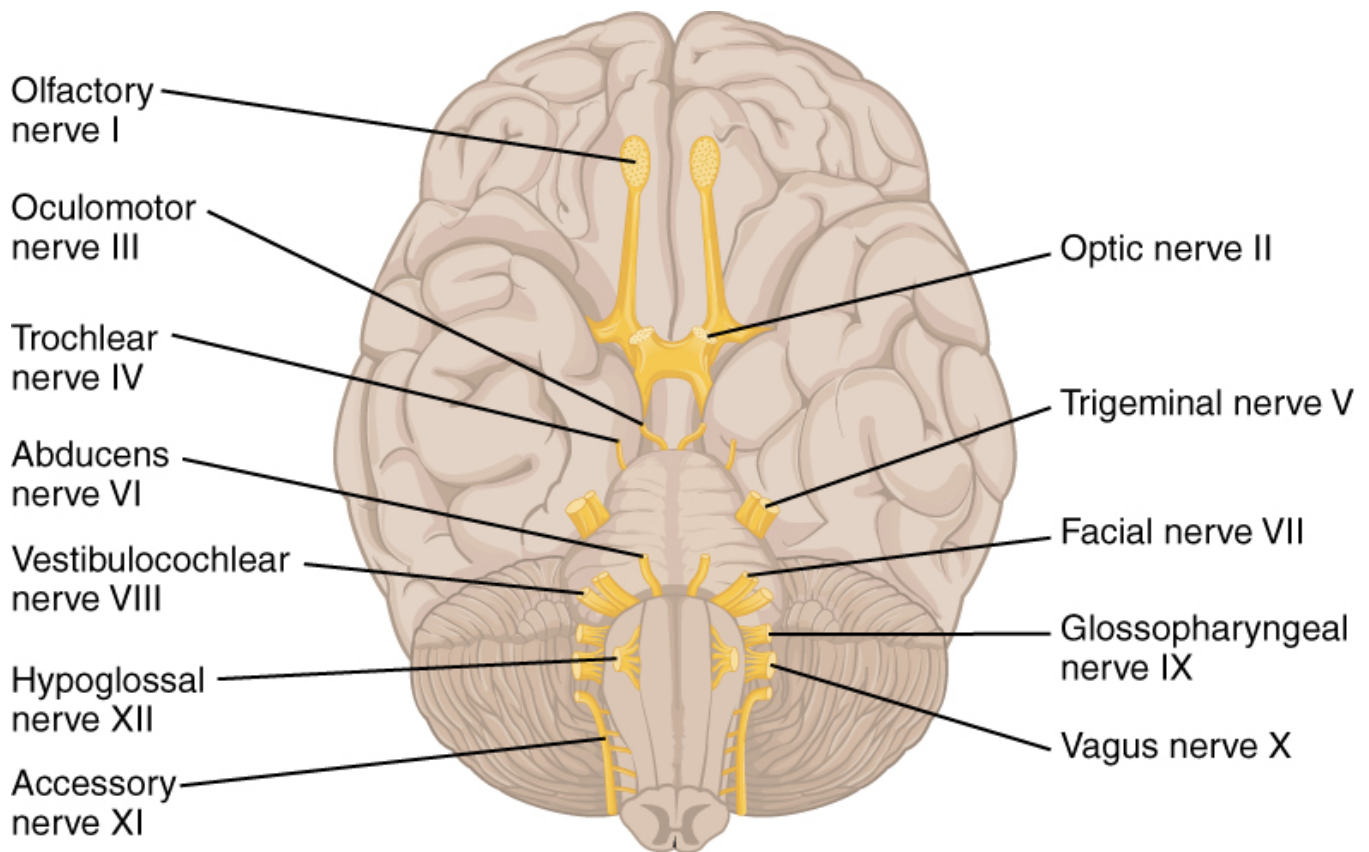


Figure 6.5 Cranial Nerves

19. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

Review of Cranial Nerves on YouTube²⁰



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=1182#oembed-2>

Spinal Nerves

There are 31 spinal nerves that are named based on the level of the spinal cord where they emerge. See Figure 6.6²¹ for an illustration of spinal nerves. There are eight pairs of cervical nerves designated C1 to C8, twelve thoracic nerves designated T1 to T12, five pairs of lumbar nerves designated L1 to L5, five pairs of sacral nerves designated S1 to S5, and one pair of coccygeal nerves. All spinal nerves are combined sensory and motor nerves. Spinal nerves extend outward from the vertebral column to innervate the periphery while also transmitting sensory information back to the CNS.²²

20. Forciea, B. (2015, May 12). *Anatomy and physiology: Nervous system: Cranial nerves (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/JBEZh6CHogo>

21. "1008694237-vector.png" by VectorMine on Shutterstock. All rights reserved. Image used with purchased permission.

22. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

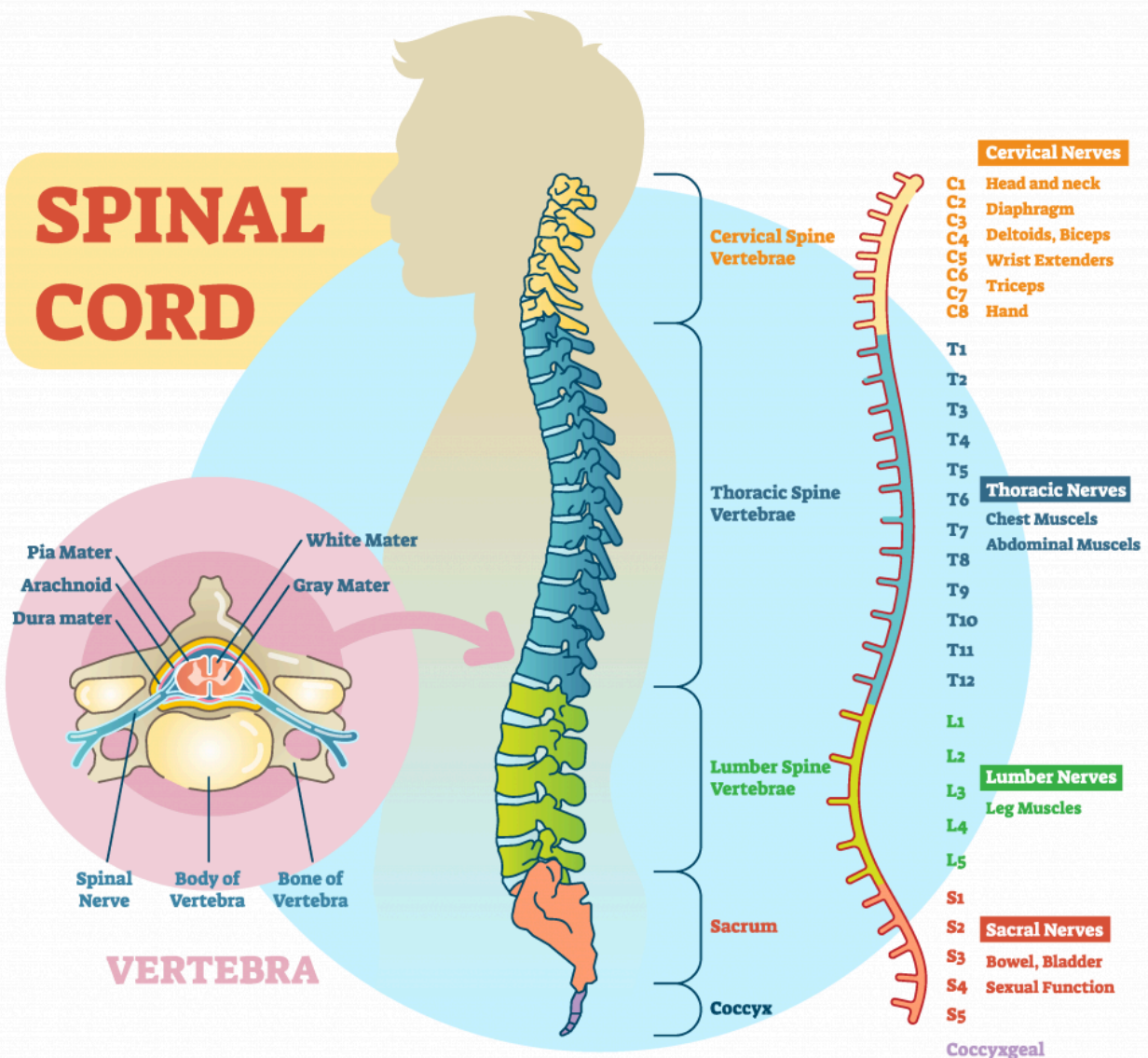


Figure 6.6 Spinal Cord and Spinal Nerves

FUNCTIONS OF SPINAL NERVES

Each spinal nerve innervates a specific region of the body:

- C1 provides motor innervation to muscles at the base of the skull.²³
- C2 and C3 provide both sensory and motor control to the back of the

23. This work is a derivative of [Anatomy and Physiology](#) by [Boundless.com](#) and is licensed under [CC BY-SA 4.0](#)

head and behind the ears.²⁴

- The phrenic nerve arises from nerve roots C3, C4, and C5. This is a vital nerve because it innervates the diaphragm to enable breathing. If a patient's spinal cord is transected above C3 from an injury, then spontaneous breathing is not possible.²⁵
- C5 through C8 and T1 combine to form the brachial plexus, a tangled array of nerves that serve the upper limbs and upper back.²⁶
- The lumbar plexus arises from L1-L5 and innervates the pelvic region and the anterior leg.²⁷
- The sacral plexus comes from the lower lumbar nerves L4 and L5 and the sacral nerves S1 to S4. The most significant systemic nerve to come from this plexus is the sciatic nerve. The sciatic nerve is associated with the painful medical condition sciatica, which is back and leg pain as a result of compression or irritation of the sciatic nerve.²⁸



When a patient experiences a spinal cord injury, the degree of paralysis can be predicted by the location of the spinal cord injury. It is also important to remember when a patient

24. This work is a derivative of [Anatomy and Physiology](#) by [Boundless.com](#) and is licensed under [CC BY-SA 4.0](#)

25. This work is a derivative of [Anatomy and Physiology](#) by [Boundless.com](#) and is licensed under [CC BY-SA 4.0](#)

26. This work is a derivative of [Anatomy and Physiology](#) by [Boundless.com](#) and is licensed under [CC BY-SA 4.0](#)

27. This work is a derivative of [Anatomy & Physiology](#) by [OpenStax](#) and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

28. This work is a derivative of [Anatomy & Physiology](#) by [OpenStax](#) and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

has a spinal cord injury and their motor nerves are damaged, their sensory nerves may still be intact. If this occurs, the patient can still feel sensation even if they can't move the extremity. Therefore, don't assume that a paralyzed patient cannot feel pain in the affected extremity because this is not always the case.

Functions of the Nervous System

The nervous system receives information about the environment around us (sensation) and generates responses to that information (motor responses). The process of integration combines sensory perceptions and higher cognitive functions such as memories, learning, and emotion while producing a response.

Sensation

Sensation is defined as receiving information about the environment. The major senses are taste, smell, touch, sight, and hearing. Additional sensory stimuli are also provided from inside the body, such as the stretch of an organ wall or the concentration of certain ions in the blood.²⁹

Response

The nervous system produces a response based on the stimuli perceived by sensory nerves. For example, withdrawing a hand from a hot stove is an example of a response to a painfully hot stimulus. Responses can be classified by those that are voluntary (such as contraction of a skeletal muscle) and those that are involuntary (such as contraction of smooth muscle in the intestine). Voluntary responses are governed by the somatic

29. This work is a derivative of [Anatomy & Physiology](https://openstax.org/books/anatomy-and-physiology) by OpenStax and is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

nervous system, and involuntary responses are governed by the autonomic nervous system.³⁰

Integration

Integration occurs when stimuli received by sensory nerves are communicated to the nervous system and the information is processed, leading to the generation of a conscious response. Consider this example of sensory integration. A batter in a baseball game does not automatically swing when they see the baseball thrown to them by the pitcher. First, the trajectory of the ball and its speed will need to be considered before creating the motor response of a swing. Then, integration will occur as the batter generates a conscious decision of whether to swing or not. Perhaps the count is three balls and one strike, and the batter decides to let this pitch go by in the hope of getting a walk to first base. Perhaps the batter is afraid to strike out and doesn't swing, or maybe the batter learned the pitcher's nonverbal cues the previous time at bat and is confident to take a swing at an anticipated fast ball. All of these considerations are included as part of the batter's integration response and the higher-level functioning that occurs in the cerebral cortex.³¹



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://wtcs.pressbooks.pub/nursingskills/?p=1182#h5p-41>

30. This work is a derivative of [Anatomy & Physiology](#) by [OpenStax](#) and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

31. This work is a derivative of [Anatomy & Physiology](#) by [OpenStax](#) and is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

6.3 Neurological Exam

The neurological exam is a clinical assessment of the functioning of the central nervous system (CNS) and peripheral nervous system (PNS). See Figure 6.7¹ for an image of the anatomical underpinnings of the neurological exam. Several tests are available when performing a neurological assessment; the tests included in the assessment are selected based on the patient's medical condition and the neurological symptoms they are experiencing. The range of tests that can be included in a neurological exam include evaluation of mental status, cranial nerves, sensory functioning, motor strength, cerebellar functioning, and reflexes. The mental status exam assesses the higher cognitive functions such as memory, orientation, and language associated with the cerebrum and cerebral cortex. The cranial nerve exam tests the sensory and motor functioning of the 12 cranial nerves that connect to the diencephalon and the brain stem. The sensory response and motor strength tests evaluate functions associated with the spinal nerves. The cerebellar function tests evaluate balance, muscle tone, and coordination of voluntary movements. Deep tendon reflexes may also be used to assess the health of the nervous system.² Each of these components of a neurological exam is further described in the remaining sections of this chapter.

1. "1601 Anatomical Underpinnings of the Neurological Exam-02.jpg" by OpenStax is licensed under CC BY 3.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/16-1-overview-of-the-neurological-exam>
2. This work is a derivative of *Anatomy & Physiology* by OpenStax and is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

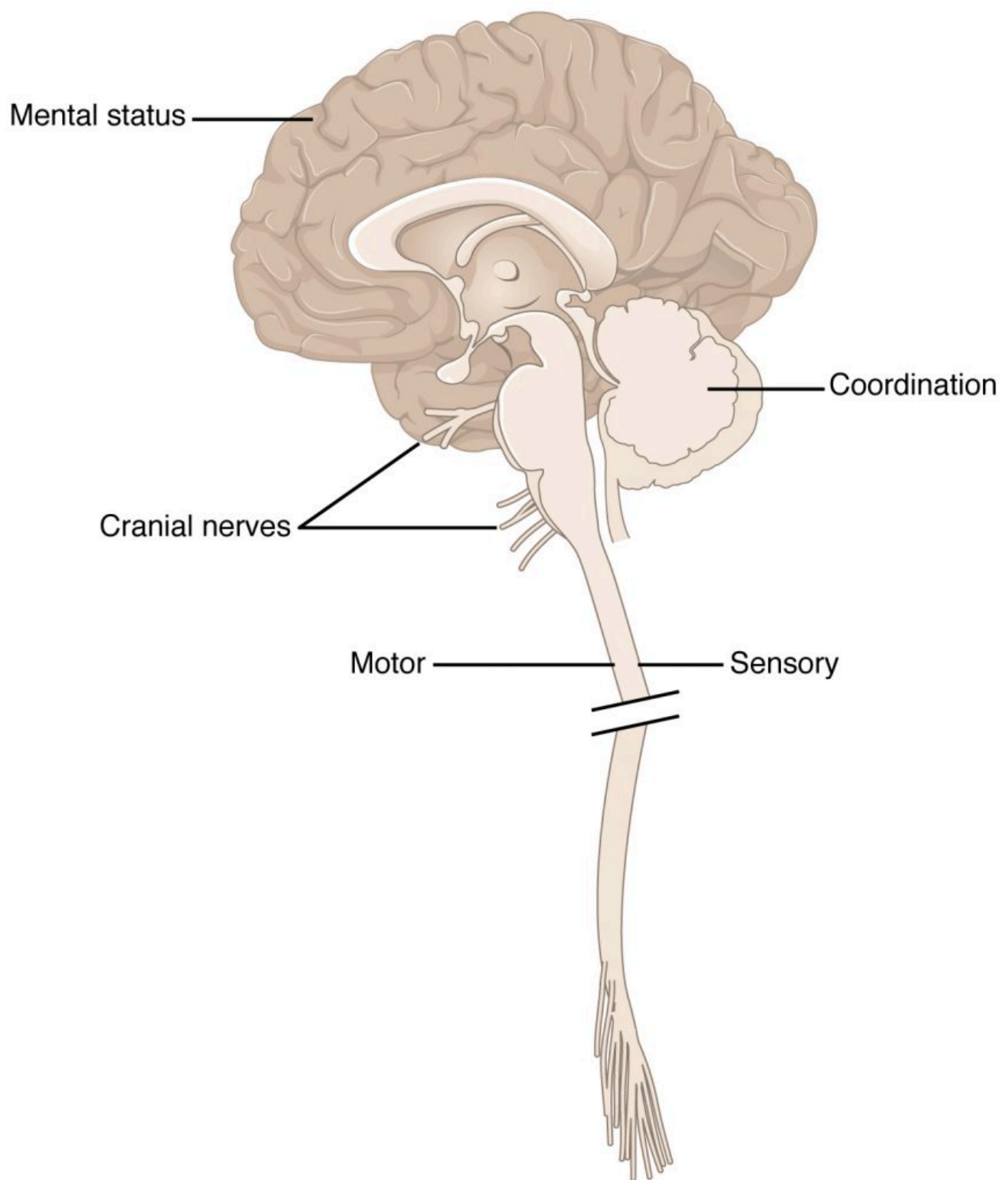


Figure 6.7 Anatomical Underpinnings of Neurological Exam

Types of Neurological Examinations

The type of neurological exam performed is based on the patient's reason for seeking care, their current medical condition, and the practice setting.

Routine Exam

Routine neurological exams performed by registered nurses during their daily clinical practice include assessing mental status and level of consciousness, pupillary response, motor strength, sensation, and gait. The Glasgow Coma Scale is also frequently used to objectively monitor level of consciousness in patients with neurological damage such as a head injury or cerebrovascular accident (i.e., stroke).³

Comprehensive

A comprehensive neurologic exam is performed on patients with a neurological concern. This exam is more extensive and may be performed in specialty settings or by advanced practice nurses. In addition to the components included in a routine neurological exam, the examiner may also assess cranial nerves, detailed cerebellar function, deep tendon reflexes, and complete a Mini-Mental State Exam (MMSE).

Periodic Reevaluation

Periodic reevaluations are performed by registered nurses when the patient has experienced an acute injury or illness causing neurological deficits that require frequent monitoring for change in condition. For example, a patient admitted to the hospital for an acute cerebrovascular accident (i.e., stroke) will have their neurological status rechecked and

3. Giddens, J. F. (2007). A survey of physical examination techniques performed by RNs: Lessons for nursing education. *Journal of Nursing Education*, 46(2), 83-87. <https://doi.org/10.3928/01484834-20070201-09>

documented frequently according to agency policy. See Figure 6.8⁴ of a nurse assessing a patient's neurological status in an intensive care unit.



Figure 6.8 Nurse Assessing Patient's Neurological Status in ICU

4. ["US Navy 030424-N-6967M-240 Lt. j.g. Elavonta Thomas conducts a routine check on one of the patients in the Intensive Care Units \(ICU\) aboard USNS Comfort \(T-AH 20\).jpg"](#) by Photographer's Mate 1st Class Shane T. McCoy at U.S. Navy is in the [Public Domain](#).

6.4 Assessing Mental Status

Routine assessment of a patient's mental status by registered nurses includes evaluating their level of consciousness, as well as their overall appearance, general behavior, affect and mood, general speech, and cognitive performance.^{1,2} See the “[General Survey Assessment](#)” chapter for more information about an overall mental status assessment.

Level of Consciousness

Level of consciousness refers to a patient's level of arousal and alertness.³ Assessing a patient's orientation to time, place, and person is a quick indicator of cognitive functioning. Level of consciousness is typically evaluated on admission to a facility to establish a patient's baseline status and then frequently monitored every shift for changes in condition.⁴ To assess a patient's orientation status, ask, “What is your name? Where are you? What day is it?” If the patient is unable to recall a specific date, it may be helpful to ask them the day of the week, the month, or the season to establish a baseline of their awareness level.

A normal level of orientation is typically documented as, “Patient is alert and oriented to person, place, and time,” or by the shortened phrase, “Alert and oriented x 3.”⁵ If a patient is confused, an example of documentation is, “Patient is alert and oriented to self, but disoriented to time and place.”

1. Martin, D. C. The mental status examination. In Walker, H. K., Hall, W. D., Hurst, J. W. (Eds.), *Clinical methods: The history, physical, and laboratory examinations* (3rd ed.). Butterworths. <https://www.ncbi.nlm.nih.gov/books/NBK320/>
2. Giddens, J. F. (2007). A survey of physical examination techniques performed by RNs: Lessons for nursing education. *Journal of Nursing Education*, 46(2), 83-87. <https://doi.org/10.3928/01484834-20070201-09>
3. Huntley, A. (2008). Documenting level of consciousness. *Nursing*, 38(8), 63-64. <https://doi.org/10.1097/01.nurse.0000327505.69608.35>
4. McDougall, G. J. (1990). A review of screening instruments for assessing cognition and mental status in older adults. *The Nurse Practitioner*, 15(11), 18-28.
5. Huntley, A. (2008). Documenting level of consciousness. *Nursing*, 38(8), 63-64. <https://doi.org/10.1097/01.nurse.0000327505.69608.35>

There are many screening tools that can be used to further objectively assess a patient's mental status and cognitive impairment. Common screening tools used frequently by registered nurses to assess mental status include the Glasgow Coma Scale, the National Institutes of Health Stroke Scale (NIHSS), and the Mini-Mental State Exam (MMSE).

Glasgow Coma Scale

The Glasgow Coma Scale (GCS) is a standardized tool used to objectively assess and continually monitor a patient's level of consciousness when damage has occurred, such as after a head injury or a cerebrovascular accident (stroke). See Figure 6.9⁶ for an image of the Glasgow Coma Scale. Three primary areas assessed in the GCS include eye opening, verbal response, and motor response. Scores are added from these three categories to assign a patient's level of responsiveness. Scores ranging from 15 or higher are classified as the best response, less than 8 is classified as **comatose**, and 3 or less is classified as unresponsive.

6. "glasgow-coma-scale-gcs-600w-309293585.jpg" by joshya on Shutterstock. All rights reserved. Imaged used with purchased permission.

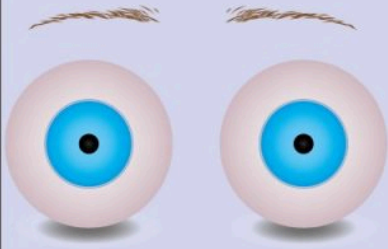
Behaviour	Response
 Eye Opening Response	4. Spontaneously 3. To speech 2. To pain 1. No response
 Verbal Response	5. Oriented to time, person and place 4. Confused 3. Inappropriate words 2. Incomprehensible sounds 1. No response
 Motor Response	6. Obeys command 5. Moves to localised pain 4. Flex to withdraw from pain 3. Abnormal flexion 2. Abnormal extension 1. No response

Figure 6.9 Glasgow Coma Scale

National Institutes of Health Stroke Scale

The National Institutes of Health Stroke Scale (NIHSS) is a standardized tool that is commonly used to assess patients suspected of experiencing an acute cerebrovascular accident (i.e., stroke).⁷ The three most predictive findings that occur during an acute stroke are facial drooping, arm drift/

7. National Institutes of Health. (n.d.). *NIH stroke scale*. <https://www.stroke.nih.gov/resources/scale.htm>

weakness, and abnormal speech. Use the box below to view the stroke scale.

A commonly used mnemonic regarding assessment of individuals suspected of experiencing a stroke is “BEFAST.” BEFAST stands for **B**alance, **E**yes, **F**ace, **A**rm, and **S**peech **T**est.

- **B:** Does the person have a sudden loss of balance?
- **E:** Has the person lost vision in one or both eyes?
- **F:** Does the person’s face look uneven?
- **A:** Is one arm weak or numb?
- **S:** Is the person’s speech slurred? Are they having trouble speaking or seem confused?
- **T:** Time to call for assistance immediately

▶ View the NIH Stroke Scale at the [National Institutes of Health](https://www.ninds.nih.gov/stroke/assessment-and-diagnosis/nihsstroke-scale).

Mini-Mental Status Exam

The Mini-Mental Status Exam (MMSE) is commonly used to assess a patient’s cognitive status when there is a concern of cognitive impairment. The MMSE is sensitive and specific in detecting delirium and dementia in patients at a general hospital and in residents of long-term care facilities.⁸ Delirium is acute, reversible confusion that can be caused by several medical conditions such as fever, infection, and lack of

8. McDougall, G. J. (1990). A review of screening instruments for assessing cognition and mental status in older adults. *The Nurse Practitioner*, 15(11), 18–28. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6751405/>

oxygenation. Dementia is chronic, irreversible confusion and memory loss that impacts functioning in everyday life.

Prior to administering the MMSE, ensure the patient is wearing their glasses and/or hearing aids, if needed.⁹ A patient can score up to 30 points by accurately responding and following directions given by the examiner. A score of 24-30 indicates no cognitive impairment, 18-23 indicates mild cognitive impairment, and a score less than 18 indicates severe cognitive impairment. See Figure 6.10¹⁰ for an image of one of the questions on the MMSE regarding interlocking pentagons.

- ▶ Visit the Oxford Medical Education website for more information about the [Mini-Mental Status Exam](#).

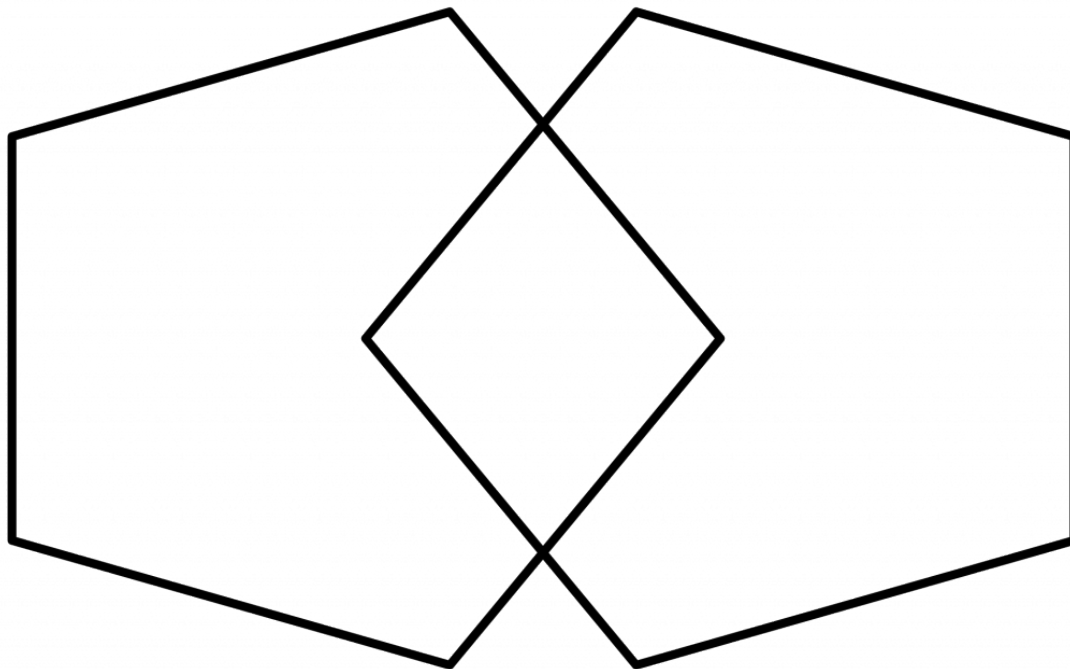


Figure 6.10 MMSE Question on Interlocking Pentagons

9. Koder-Anne, D., & Klahr, A. (2010). Training nurses in cognitive assessment: Uses and misuses of the mini-mental state examination. *Educational Gerontology*, 36(10/11), 827–833. <https://doi.org/10.1080/03601277.2010.485027>

10. “[InterlockingPentagons.svg](#)” by [Jfdwolff\[2\]](#) is licensed under [CC BY-SA 3.0](#)

6.5 Assessing Cranial Nerves

When performing a comprehensive neurological exam, examiners may assess the functioning of the cranial nerves. When performing these tests, examiners compare responses of opposite sides of the face and neck. Instructions for assessing each cranial nerve are provided below.

Cranial Nerve I – Olfactory

Ask the patient to identify a common odor, such as coffee or peppermint, with their eyes closed. See Figure 6.11¹ for an image of a nurse performing an olfactory assessment.

1. “[Cranial Exam Image 11](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)



Figure 6.11 Assessing Cranial Nerve I (Olfactory)

Cranial Nerve II – Optic

Be sure to provide adequate lighting when performing a vision assessment.

Far vision is tested using the Snellen chart. See Figure 6.12² for an image of a Snellen chart. The numerator of the fractions on the chart indicates what the individual can see at 20 feet, and the denominator indicates the distance at which someone with normal vision could see this line. For example, a result of 20/40 indicates this individual can see this line at 20 feet but someone with normal vision could see this line at 40 feet.

Test far vision by asking the patient to stand 20 feet away from a Snellen chart. Ask the patient to cover one eye and read the letters from the lowest line they can see.³ Record the corresponding result in the furthestmost right-hand column, such as 20/30. Repeat with the other eye. If the patient is wearing glasses or contact lens during this assessment, document the results as “corrected vision.” Repeat with each eye, having the patient cover the opposite eye. Alternative charts are available for children or adults who can’t read letters in English.

2. “[Snellen chart.svg](#)” by [Jeff Dahl](#) is licensed under [CC BY-SA 3.0](#)

3. Koder-Anne, D., & Klahr, A. (2010). Training nurses in cognitive assessment: Uses and misuses of the mini-mental state examination. *Educational Gerontology*, 36(10/11), 827–833. <https://doi.org/10.1080/03601277.2010.485027>

E	1	20/200
F P	2	20/100
T O Z	3	20/70
L P E D	4	20/50
P E C F D	5	20/40
E D F C Z P	6	20/30
F E L O P Z D	7	20/25
D E F P O T E C	8	20/20
L E F O D P C T	9	
F D P L T C E O	10	
P E Z O L C F T D	11	

Figure 6.12 Snellen Chart

Near vision is assessed by having a patient read from a prepared card from 14 inches away. See Figure 6.13⁴ for a card used to assess near vision.

4. "111012-F-ZT401-067.JPG" by Airman 1st Class Brooke P. Beers for U.S. Air Force is licensed under CC0. Access for free at <https://www.pacaf.af.mil/News/Article-Display/Article/593609/keeping-sight-all-right/>



Figure 6.13 Assessing Near Vision

Cranial Nerve III, IV, and VI – Oculomotor, Trochlear, Abducens

Cranial nerve III, IV, and VI (oculomotor, trochlear, abducens nerves) are tested together.

- Test eye movement by using a penlight. Stand 1 foot in front of the patient and ask them to follow the direction of the penlight with only their eyes. At eye level, move the penlight left to right, right to left, up and down, upper right to lower left, and upper left to lower right. Watch for smooth movement of the eyes in all fields. An unexpected finding is involuntary eye movement which may cause the eye to move rapidly from side to side, up and down, or in a circle, and may slightly blur vision referred to as **nystagmus**.
- Test bilateral pupils to ensure they are equally round and reactive to light and **accommodation**. Dim the lights of the room before performing this test.
 - Pupils should be round and bilaterally equal in size. The diameter

of the pupils usually ranges from two to five millimeters.

Emergency clinicians often encounter patients with the triad of pinpoint pupils, respiratory depression, and coma related to opioid overuse.

- Test pupillary reaction to light. Using a penlight, approach the patient from the side, and shine the penlight on one pupil. Observe the response of the lighted pupil, which is expected to quickly constrict. The pupil where you shine the light should constrict (direct reaction) and so should the other one (consensual reaction). Repeat by shining the light on the other pupil. Both pupils should react in the same manner to light. See Figure 6.14⁵ for an image of a nurse assessing a patient's pupillary reaction to light. An unexpected finding is when one pupil is larger than the other or one pupil responds more slowly than the other to light, which is often referred to as a "sluggish response."
- Test eye **convergence** and accommodation. Recall that accommodation refers to the ability of the eye to adjust from near to far vision, with pupils constricting for near vision and dilating for far vision. Convergence refers to the action of both eyes moving inward as they focus on a close object using near vision. Ask the patient to look at a near object (4-6 inches away from the eyes), and then move the object out to a distance of 12 inches. Pupils should constrict while viewing a near object and then dilate while looking at a distant object, and both eyes should move together. See Figure 6.15⁶ for an image of a nurse assessing convergence and accommodation.
- The acronym PERRLA is commonly used in medical documentation and refers to, "pupils are equal, round and reactive to light and accommodation."

5. "[Cranial Exam Image 1](#)" and "[Pupillary Exam Image 1](#)" by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

6. "[Cranial Nerve Exam 8](#)" and "[Cranial Nerve Exam Image 3](#)" by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

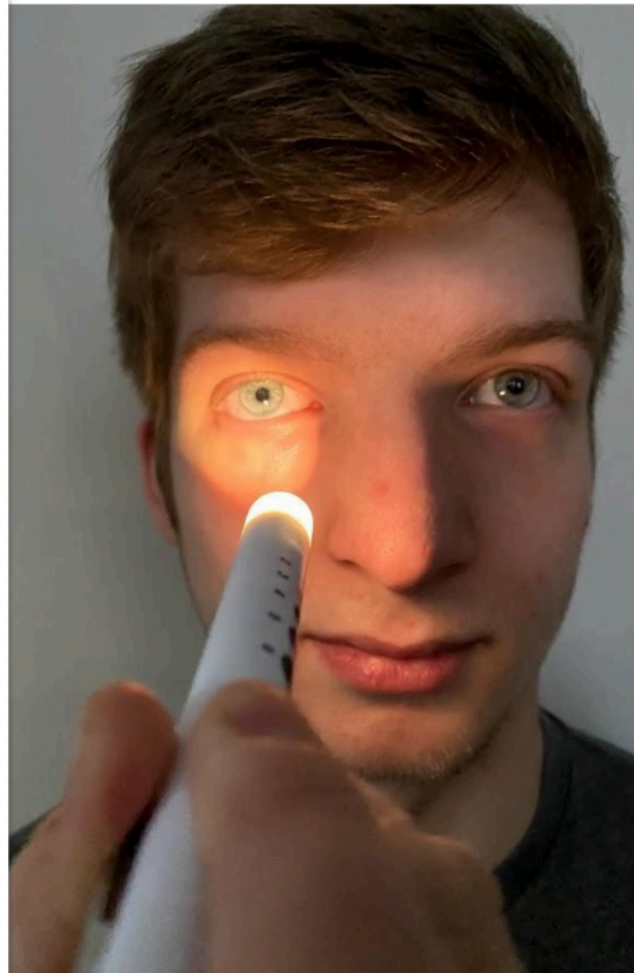


Figure 6.14 Assessing Pupillary Reaction to Light



Figure 6.15 Assessing Eye Convergence and Accommodation



Review for Assessment of the Cardinal Fields of Gaze on YouTube⁷



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=1188#oembed-2>

- ▶ Visit the National Library of Medicine's webpage for more details about assessing the [Pupillary Light Reflex](#).

Cranial Nerve V – Trigeminal

- Test sensory function. Ask the patient to close their eyes, and then use a wisp from a cotton ball to lightly touch their face, forehead, and chin. Instruct the patient to say “Now” every time they feel the placement of the cotton wisp. See Figure 6.16⁸ for an image of assessing trigeminal sensory function. The expected finding is that the patient will report every instance the cotton wisp is placed. An advanced technique is to assess the corneal reflex in comatose patients by touching the cotton

7. Registered NurseRN.(2018, June 5). *Six cardinal fields of gaze nursing / Nystagmus eyes, cranial nerve 3, 4, 6, test* [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/lrO4pLB95p0>

8. “Neuro Exam Image 28,” “Cranial Exam Image 12,” and “Neuro Exam Image 36” by Meredith Pomietlo for Chippewa Valley Technical College are licensed under [CC BY 4.0](#)

wisp to the cornea of the eye to elicit a blinking response.

- Test motor function. Ask the patient to clench their teeth tightly while bilaterally palpating the temporalis and masseter muscles for strength. Ask the patient to open and close their mouth several times while observing muscle symmetry. See Figure 6.17⁹ for an image of assessing trigeminal motor strength. The expected finding is the patient is able to clench their teeth and symmetrically open and close their mouth.

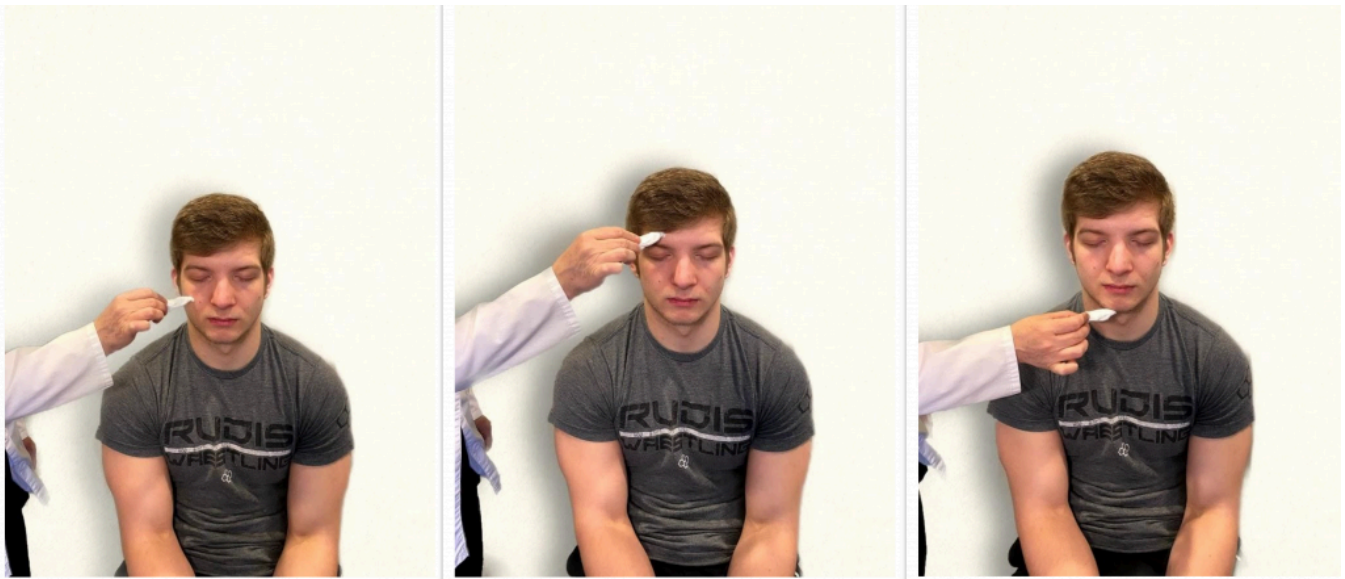


Figure 6.16 Assessing Trigeminal Sensory Function

9. “[Cranial Exam Image 11](#),” “[Neuro Exam Image 35](#),” and “[Neuro Exam Image 4](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

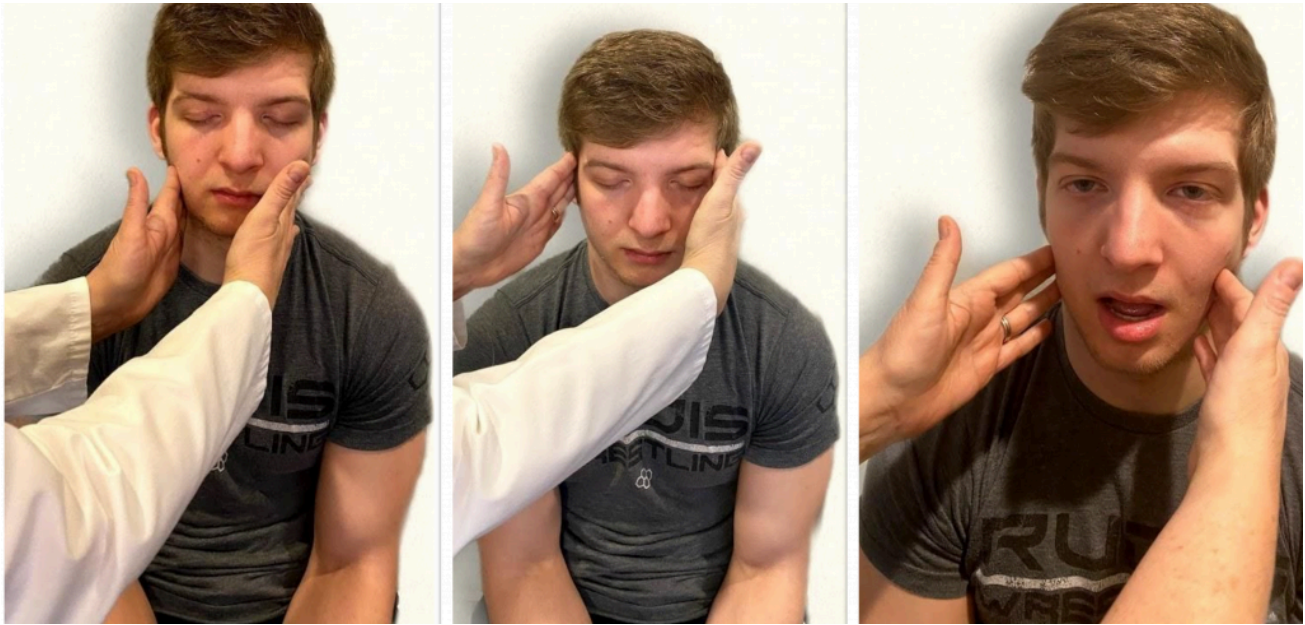


Figure 6.17 Assessing Trigeminal Motor Function

Cranial Nerve VII – Facial Nerve

- Test motor function. Ask the patient to smile, show teeth, close both eyes, puff cheeks, frown, and raise eyebrows. Look for symmetry and strength of facial muscles. See Figure 6.18¹⁰ for an image of assessing motor function of the facial nerve.
- Test sensory function. Test the sense of taste by moistening three different cotton applicators with salt, sugar, and lemon. Touch the patient's anterior tongue with each swab separately, and ask the patient to identify the taste. See Figure 6.19¹¹ for an image of assessing taste.

10. "[Cranial Exam image 15.png](#)," "[Cranial Exam Image 7.png](#)," and "[Cranial Exam Image 10.png](#)" by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

11. "[Neuro Exam Image 17.png](#)" by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)

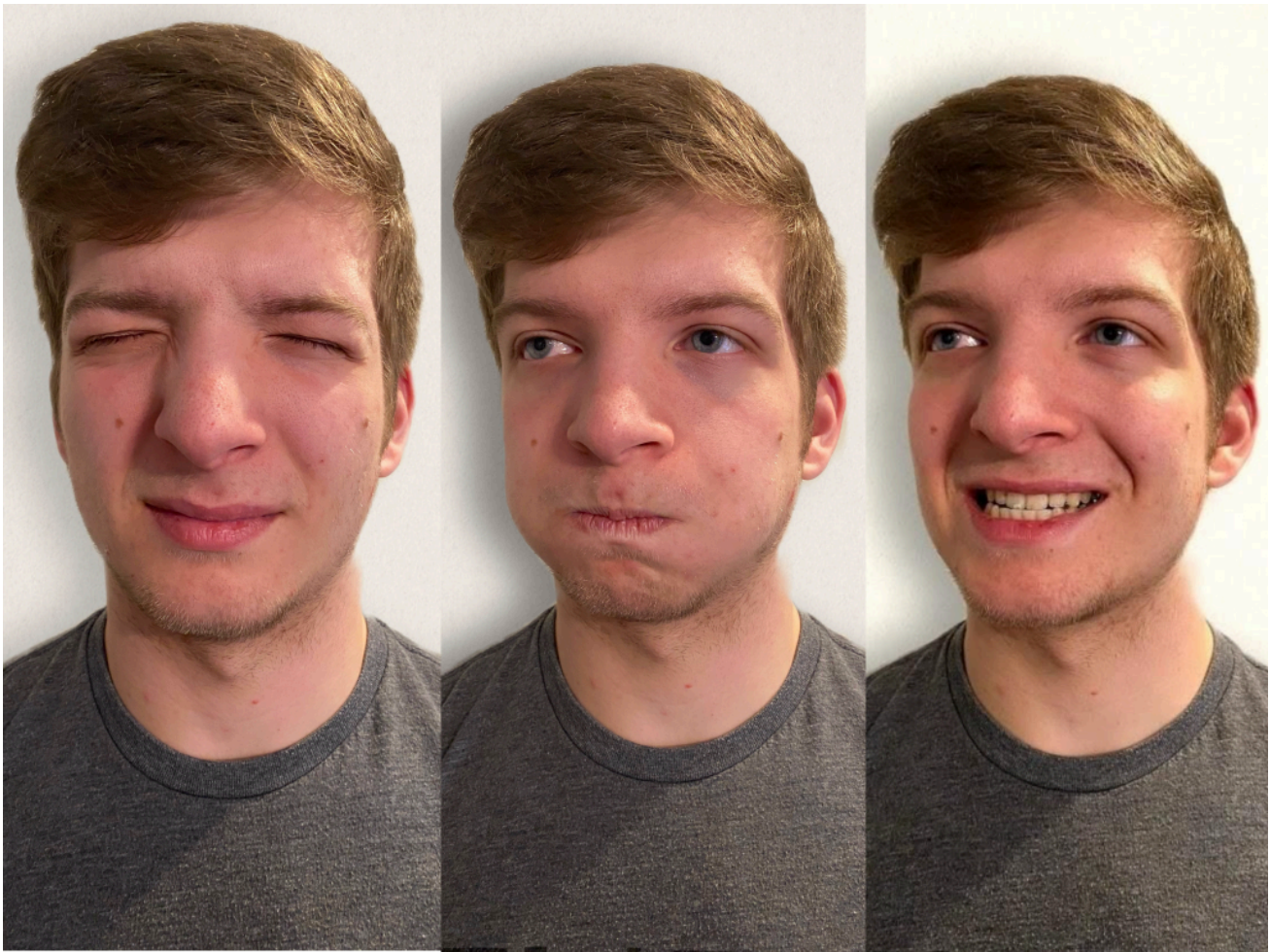


Figure 6.18 Assessing Motor Function of Facial Nerve



Figure 6.19 Assessing Sensory Function of Facial Nerve

Cranial Nerve VIII – Vestibulocochlear

- Test auditory function. Perform the whispered voice test. The whispered voice test is a simple test for detecting hearing impairment if done accurately. See Figure 6.20¹² for an image assessing hearing using the whispered voice test. Complete the following steps to accurately perform this test:
 - Stand at arm's length behind the seated patient to prevent lip reading.
 - Each ear is tested individually. The patient should be instructed to occlude the non-test ear with their finger.
 - Exhale before whispering and use as quiet a voice as possible.
 - Whisper a combination of numbers and letters (for example, 4-K-2), and then ask the patient to repeat the sequence.
 - If the patient responds correctly, hearing is considered normal; if the patient responds incorrectly, the test is repeated using a different number/letter combination.
 - The patient is considered to have passed the screening test if they repeat at least three out of a possible six numbers or letters correctly.
 - The other ear is assessed similarly with a different combination of numbers and letters.
- Test balance. The Romberg test is used to test balance and is also used as a test for driving under the influence of an intoxicant. See Figure 6.21¹³ for an image of the Romberg test. Ask the patient to stand with their feet together and eyes closed. Stand nearby and be prepared to assist if the patient begins to fall. It is expected that the patient will maintain balance and stand erect. A positive Romberg test occurs if the patient sways or is unable to maintain balance. The Romberg test

12. "[Whisper Test Image 1.png](#)" by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)

13. "[Neuro Exam Image 9.png](#)" by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)

is also a test of the body's sense of positioning (proprioception), which requires healthy functioning of the spinal cord.



Figure 6.20 Assessing Auditory Function

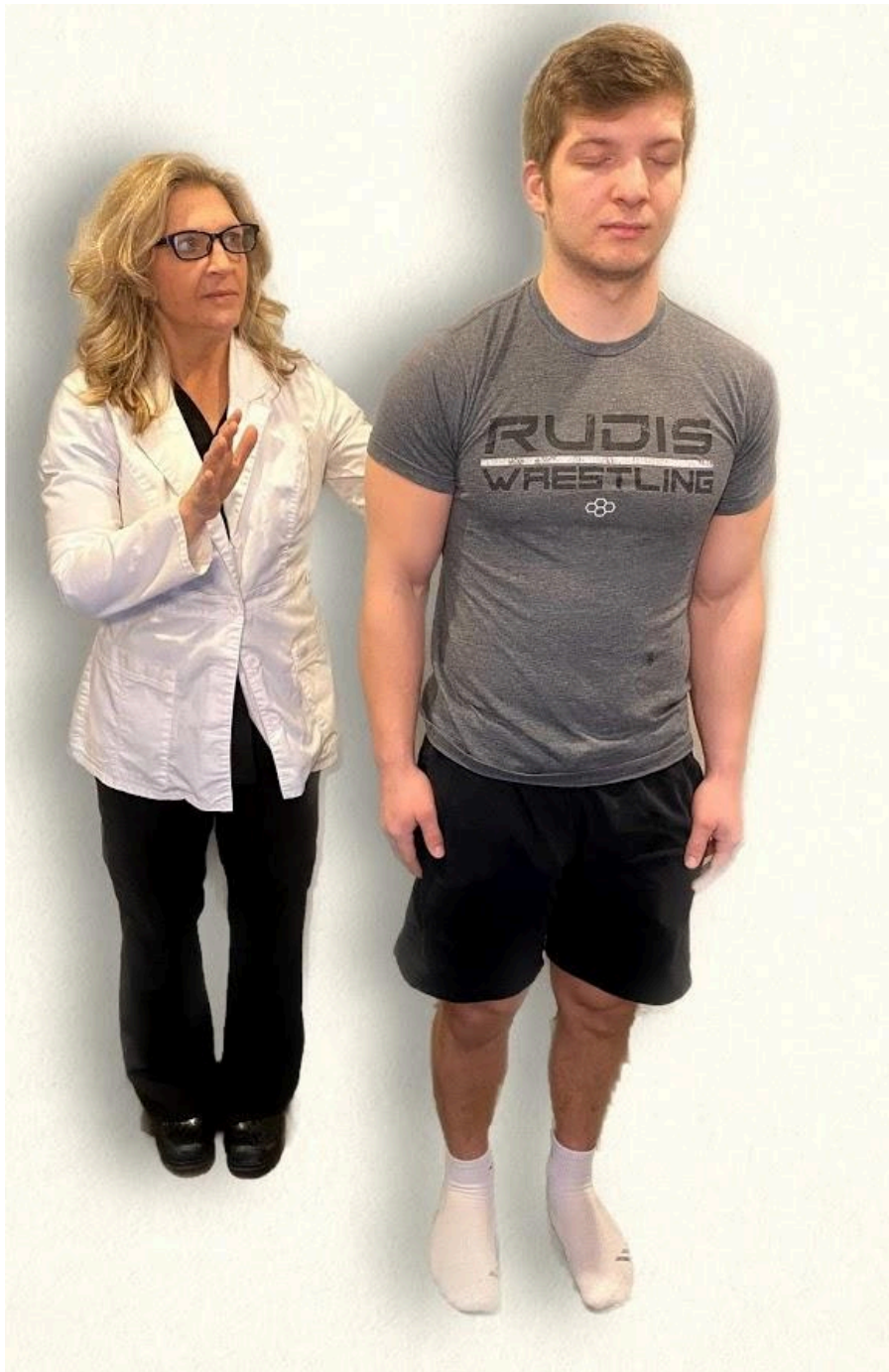


Figure 6.21 Romberg Test

Cranial Nerve IX – Glossopharyngeal

Ask the patient to open their mouth and say “Ah” and note symmetry of the upper palate. The uvula and tongue should be in a midline position

and the uvula should rise symmetrically when the patient says “Ah.” (See Figure 6.22.¹⁴)

14. “Oral Exam Image 2.png” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)



Figure 6.22 Assessing Glossopharyngeal Nerve

Cranial Nerve X – Vagus

Use a cotton swab or tongue blade to touch the patient's posterior pharynx and observe for a gag reflex followed by a swallow. The

glossopharyngeal and vagus nerves work together for integration of gag and swallowing. See Figure 6.23¹⁵ for an image of assessing the gag reflex.



Figure 6.23 Observing the Gag Reflex

15. "Oral Exam.png" by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)

Cranial Nerve XI – Spinal Accessory

Test the right sternocleidomastoid muscle. Face the patient and place your right palm laterally on the patient's left cheek. Ask the patient to turn their head to the left while resisting the pressure you are exerting in the opposite direction. At the same time, observe and palpate the right sternocleidomastoid with your left hand. Then reverse the procedure to test the left sternocleidomastoid.

Continue to test the sternocleidomastoid by placing your hand on the patient's forehead and pushing backward as the patient pushes forward. Observe and palpate the sternocleidomastoid muscles.

Test the trapezius muscle. Ask the patient to face away from you and observe the shoulder contour for hollowing, displacement, or winging of the scapula and observe for drooping of the shoulder. Place your hands on the patient's shoulders and press down as the patient elevates or shrugs the shoulders and then retracts the shoulders.¹⁶ See Figure 6.24¹⁷ for an image of assessing the trapezius muscle.

16. Walker, H. K. Cranial nerve XI: The spinal accessory nerve. In Walker, H. K., Hall, W. D., Hurst, J. W. (Eds.), *Clinical methods: The history, physical, and laboratory examinations* (3rd ed.). Butterworths.
<https://www.ncbi.nlm.nih.gov/books/NBK387/>

17. "Neuro Exam image 10" by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)



Figure 6.24 Assessing Cranial Nerve XI

Cranial Nerve XII – Hypoglossal

Ask the patient to protrude the tongue. If there is unilateral weakness present, the tongue will point to the affected side due to unopposed action of the normal muscle. An alternative technique is to ask the patient to press their tongue against their cheek while providing resistance with a

finger placed on the outside of the cheek. See Figure 6.25¹⁸ for an image of assessing the hypoglossal nerve.

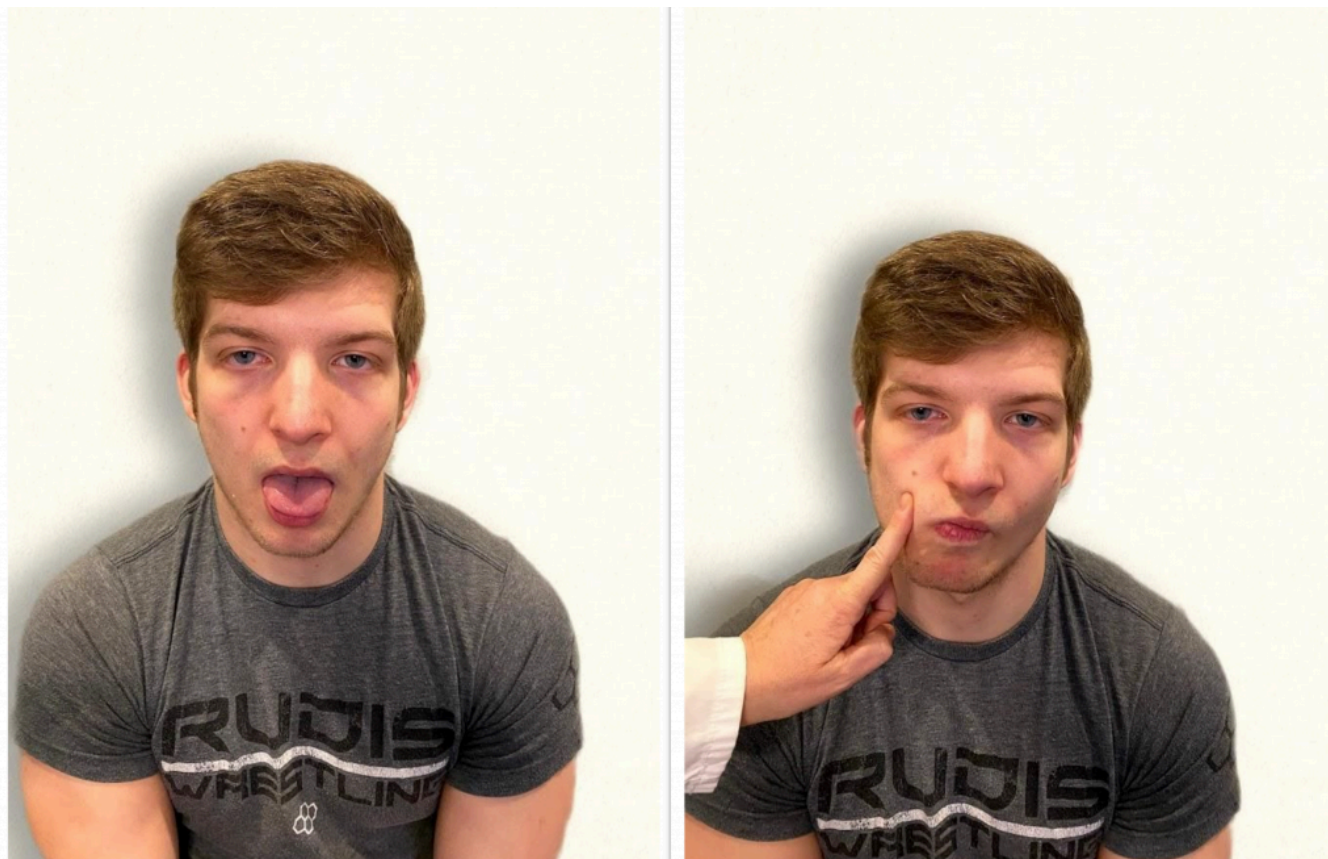


Figure 6.25 Assessing the Hypoglossal Nerve

18. “Cranial Nerve Exam Image 9.png” and “Cranial Nerve Exam Image 11.png” by Meredith Pomietlo for Chippewa Valley Technical College are licensed under [CC BY 4.0](#)

Review of Cranial Nerve Assessment on YouTube¹⁹



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/nursingskills/?p=1188#oembed-1>

Expected Versus Unexpected Findings

See Table 6.5 for a comparison of expected versus unexpected findings when assessing the cranial nerves.

Table 6.5 Expected Versus Unexpected Findings of an Adult Cranial Nerve Assessment

19. RegisteredNurseRN. (2018, April 8). *Cranial nerve examination nursing / Cranial nerve assessment I-XII (1-12)*. [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/oZGFrwogx14>

Cranial Nerve	Expected Finding	Unexpected Finding (Dysfunction)
I. Olfactory	Patient is able to describe odor.	Patient has inability to identify odors (anosmia).
II. Optic	Patient has 20/20 near and far vision.	Patient has decreased visual acuity and visual fields.
III. Oculomotor	Pupils are equal, round, and reactive to light and accommodation.	Patient has different sized or reactive pupils bilaterally.
IV. Trochlear	Both eyes move in the direction indicated as they follow the examiner's penlight.	Patient has inability to look up, down, inward, outward, or diagonally. Ptosis refers to drooping of the eyelid and may be a sign of dysfunction.
V. Trigeminal	Patient feels touch on forehead, maxillary, and mandibular areas of face and chews without difficulty.	Patient has weakened muscles responsible for chewing; absent corneal reflex; and decreased sensation of forehead, maxillary, or mandibular area.
VI. Abducens	Both eyes move in coordination.	Patient has inability to look side to side (lateral); patient reports diplopia (double vision).
VII. Facial	Patient smiles, raises eyebrows, puffs out cheeks, and closes eyes without difficulty; patient can distinguish different tastes.	Patient has decreased ability to taste. Patient has facial paralysis or asymmetry of face such as facial droop.
VIII. Vestibulocochlear (Acoustic)	Patient hears whispered words or finger snaps in both ears; patient can walk upright and maintain balance.	Patient has decreased hearing in one or both ears and decreased ability to walk upright or maintain balance.
IX. Glossopharyngeal	Gag reflex is present.	Gag reflex is not present; patient has dysphagia .
X. Vagus	Patient swallows and speaks without difficulty.	Slurred speech or difficulty swallowing is present.

XI. Spinal Accessory	Patient shrugs shoulders and turns head side to side against resistance.	Patient has inability to shrug shoulders or turn head against resistance.
XII. Hypoglossal	Tongue is midline and can be moved without difficulty.	Tongue is not midline or is weak.

6.6 Assessing Sensory Function

The sensory function exam tests the somatic senses, meaning those senses that are consciously perceived. Assessing sensory function includes two components, the sensory response that occurs when stimuli are perceived by afferent nerves in the peripheral nervous system and the cortical processing that occurs in the cerebral cortex of the brain.

Sensory Response

Testing of peripheral sensation begins with examining the response to light touch according to regions of the skin known as dermatomes. A **dermatome** is an area of the skin that is supplied by a single spinal nerve that sends information to the brain for processing. See Figure 6.26¹ for an illustration of color-coded dermatomes according to their associated spinal nerves. See more information about spinal nerves in the “[Basic Neurological Concepts](#)” section.

To test the sensory fields, ask the patient to close their eyes, and then gently touch the soft end of a cotton-tipped applicator on random locations of the skin according to the dermatome region. Instruct the patient to report “Now” when feeling the placement of the applicator. If a patient is unable to feel the sensation of a cotton applicator, an advanced technique is to use ice or even the prick of a pin in comatose patients.

1. “1611 Dermatomes-02.jpg” by OpenStax Anatomy and Physiology is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/16-4-the-sensory-and-motor-exams>

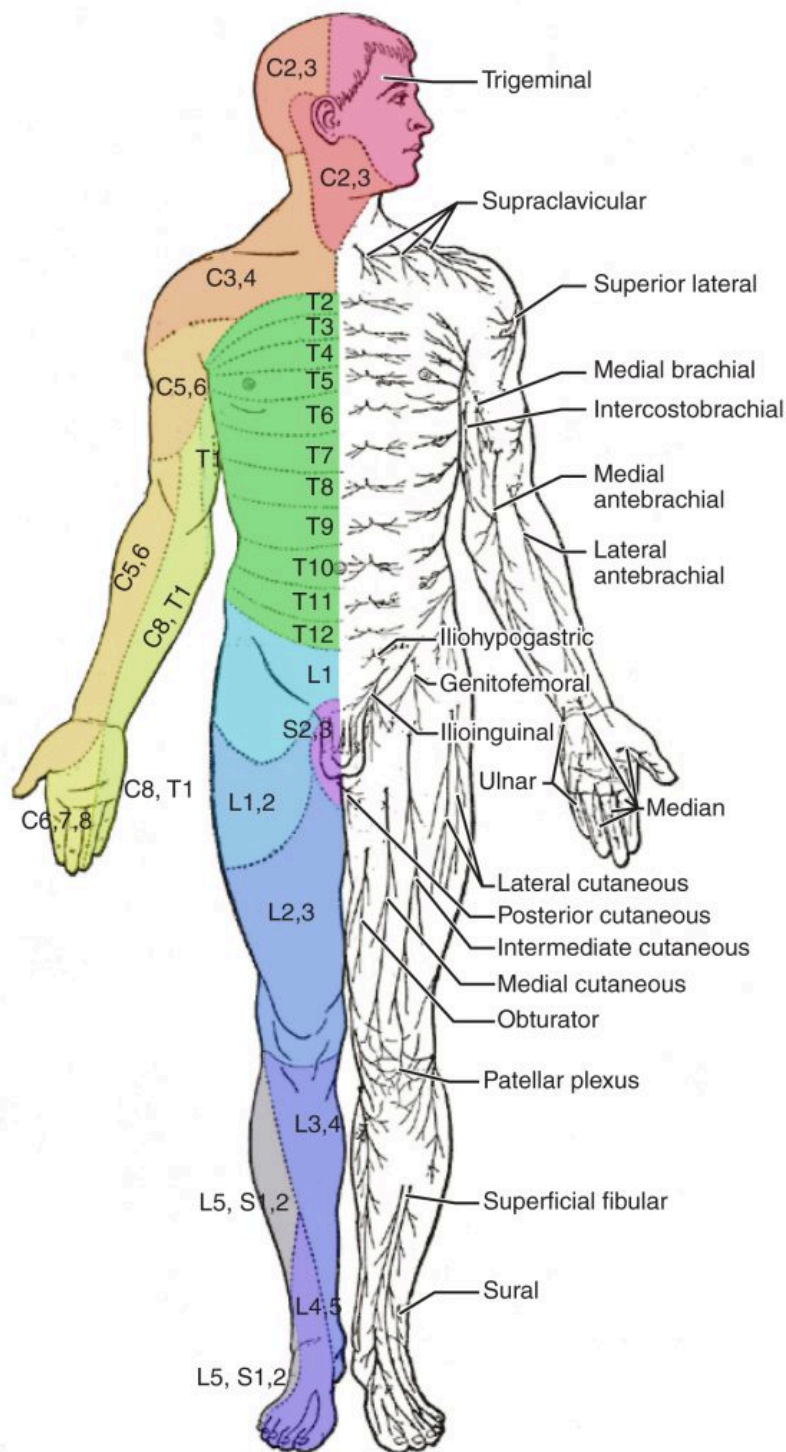


Figure 6.26 Dermatomes

It is not necessary to test every part of the skin's surface during a routine neurological exam; testing a few distal areas with light touch is usually sufficient. In-depth testing is performed when the patient is exhibiting neurological symptoms such as motor deficits, numbness, tingling, and

weakness. See Figure 6.27² demonstrating assessment of the sensory response.



Figure 6.27 Assessing Sensory Response

Cortical Processing

Cortical processing that occurs in the cerebral cortex of the parietal lobe is assessed using stereogenesis. **Stereognosis** is the ability to perceive the physical form and identity of a familiar object such as a key or paper clip based on tactile stimuli alone.³ The person typically uses the finger to move the object around and then correctly names the object.

To perform the stereognosis test, ask the patient to close their eyes; then place a familiar object in their hand and ask them to name it. Each hand should be tested with a different object. See Figure 6.28⁴ for an image of a patient being tested for stereognosis.

Graphesthesia tests assess both cortical sensation and primary sensation. Graphesthesia is the ability to recognize a tracing on the skin while using

2. “[Neuro Exam Image 25](#),” “[Cranial Exam Image 12](#),” “[Neuro Exam Image 26](#),” and “[Neuro Exam Image 30](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

3. This work is a derivative of [StatPearls](#) by Schermann and Tadi and is licensed under [CC BY 4.0](#)

4. “[Neuro Exam Image 8.png](#)” and “[Neuro Exam Image 31.png](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

the sensation of touch. To test graphesthesia, trace a number or letter on the patient's outstretched palm and ask them to identify it.

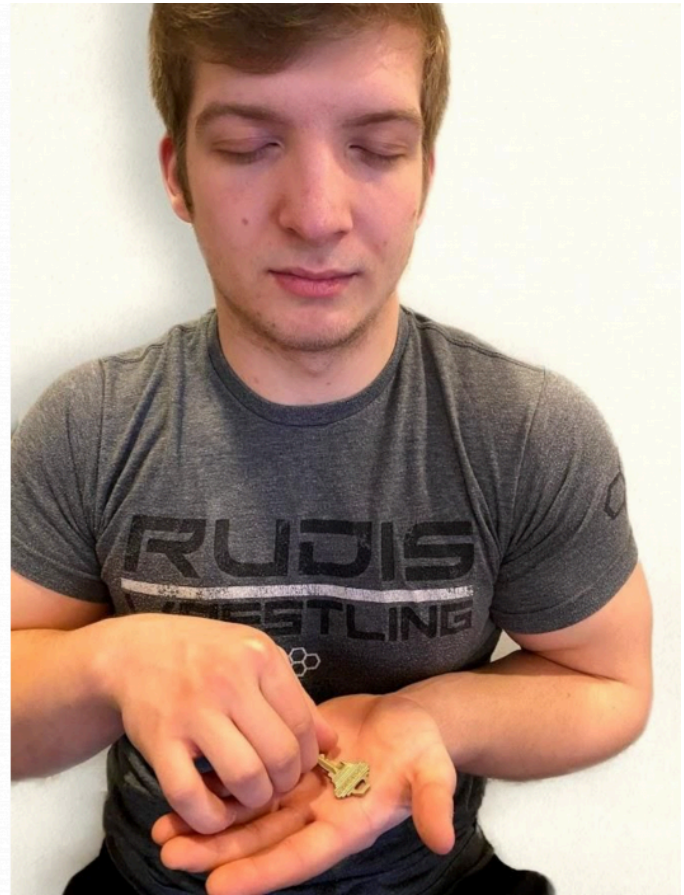


Figure 6.28 Assessing Stereognosis

6.7 Assessing Motor Strength

A brief musculoskeletal assessment is performed as part of the neurological assessment to determine the neurological stimulation of bilateral strength. Read more details about muscles and musculoskeletal assessment in the “[Musculoskeletal Assessment](#)” chapter. Unequal extremity motor strength can indicate underlying neurological disease or injury. Assessing motor strength includes comparing bilateral hand grasps, upper extremity strength, and lower extremity strength. Keep in mind that extremities on the dominant side are usually slightly stronger than the nondominant side.

Hand Grasps

To perform a hand grasp test, extend two fingers on both hands toward the patient. Ask the patient to squeeze both of your hands and compare for similar bilateral strength. See Figure 6.29¹ for an image of assessing hand grasp strength.

1. “[Neuro Exam Image 38.png](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)



Figure 6.29 Assessing for Equal Strength in Bilateral Hand Grasps

Upper Extremity Strength

To test upper extremity strength, ask the patient to extend their forearms with palms facing upwards. Place your hands on their inner forearms and ask them to pull their arms toward them while you provide resistance. An

expected finding is the patient strongly bilaterally pulls against resistance with both arms.

An alternative test is to ask the patient to put their hands in the air with their palms facing you. Place your palms against theirs and ask them to push while you provide resistance. See Figure 6.30² for an image of assessing upper body strength.



Figure 6.30 Assessing for Equal Upper Extremity Strength

Lower Body Strength

To assess lower body strength while the patient is in a seated position, place your hands behind their calves. Ask them to pull backwards with their lower legs while you provide resistance in the opposite direction.

Alternative tests are to place your hands on the patient's lower thighs and

2. "Neuro Exam Image 41.png" and "Neuro Exam Image 39.jpg" by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

ask them to lift their legs upwards while you provide downward resistance or place your hands on the top of their feet and ask them to pull their toes upwards while you provide resistance. In a similar manner, you can also place your hands underneath their feet and ask them to press downwards “like pressing the gas pedal of a car,” while providing resistance. Compare lower extremity strength on both sides. See Figure 6.31³ for images of assessing lower extremity strength.



Figure 6.31 Assessing for Equal Strength in Lower Extremities

3. “[Musculoskeletal Exam Image 2.png](#),” “[Neuro Exam image 6.png](#),” and “[Musculoskeletal Exam Image 7.png](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

6.8 Assessing Cerebellar Function

The neurological aspect of motor function is based on the activities of the cerebellum. The cerebellum is responsible for equilibrium, coordination, and the smoothness of movement. Specific tests used to evaluate cerebellar function include assessment of gait and balance, pronator drift, the finger-to-nose test, rapid alternating action, and the heel-to-shin test.

Gait and Balance

When assessing gait and balance, ask the patient to perform the following actions, using an assistive device if needed:

- Walk 10 feet, pivot, and walk back
- Look straight ahead and walk heel to toe
- Walk on tiptoes
- Walk on heels

Steps should be equal with a regular pace while arms are swinging and coordinated with walking. Balance should be maintained. A change in gait, weakness, shuffling, jerky movements, loss of balance, or incoordination of arm swing can indicate a neurological dysfunction. See Figure 6.32¹ for an image of assessing gait and balance.



When performing assessment of gait and balance, be aware that the older

1. "Neuro Exam image 14.png," "Neuro Exam Image 19.png," "Neuro Exam image 40.png," and "Neuro Exam Image 34.png" by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

patient may have a mild degree of muscle weakness or decreased balance associated with aging. When feasible, obtain the patient's baseline ability and compare current findings to their baseline.



Figure 6.32 Assessing Gait and Balance

Pronator Drift

Assessing for pronator drift helps to detect mild upper limb weakness. Ask the patient to close their eyes and extend both arms at 90 degrees at shoulder level with the palms facing upwards. The patient should try to maintain this position for 20 to 30 seconds. Closing the eyes accentuates the effect because the brain is deprived of visual information about the position of the body and must rely on proprioception. **Proprioception** is the awareness of body position and movement. The expected finding is both arms will maintain this position equally. If the patient is unable to maintain the position, the result is referred to as a positive pronator drift test. Patients with weakness in one arm will not be able to keep the affected arm raised, and ultimately the palm may begin to pronate (palm facing down). In some patients, the arm may remain supinated but will drop lower than the unaffected arm.

Finger-to-Nose Test

The finger-to-nose test assesses equilibrium and coordination. Place the patient in a seated or standing position and ask them to close their eyes. Instruct the patient to extend their arms outward from the sides of the body, and then touch the tip of the nose with the right index finger and return the arm to extended position. Repeat with the left side and continue to repeat touching the nose with alternating movements by both arms.

The expected finding is the patient will smoothly touch the nose with alternating left and right index fingers and return their arms to an extended position repeatedly. An abnormal result occurs when the patient is unable to alternate fingers or demonstrates the inability to touch the nose. For example, the patient may touch the cheek or other part of the face, or movement may be clumsy with stops and restarts. See Figure 6.33² for an image of a finger-to-nose test.

2. “[Neuro Exam Image 7.png](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)



Figure 6.33 Finger-to-Nose Test

Rapid Alternating Action

To perform a rapid alternating action test, place the patient in a seated position with palms down on thighs. Ask the patient to turn their hands so their palms face upwards and then quickly return them to a downward position and repeat. Instruct the patient to alternate this movement at a fast pace. The expected finding is the rhythm, rate, and movement are

smooth and coordinated as pace increases. An abnormal finding is when the patient is unable to alternate movements or can only do so at a slow pace. See Figure 6.34³ for an example of the rapid alternating action test.

An alternative test is to have the patient touch the thumb to each finger on their hand in sequence and gradually increase the pace. Repeat this test on the other hand. See Figure 6.35⁴ for an alternative finger touch test.



Figure 6.34 Rapid Alternating Action Test

3. “[Neuro Exam Image 20.jpg](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)
4. “[Neuro Exam Image 15.png](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)

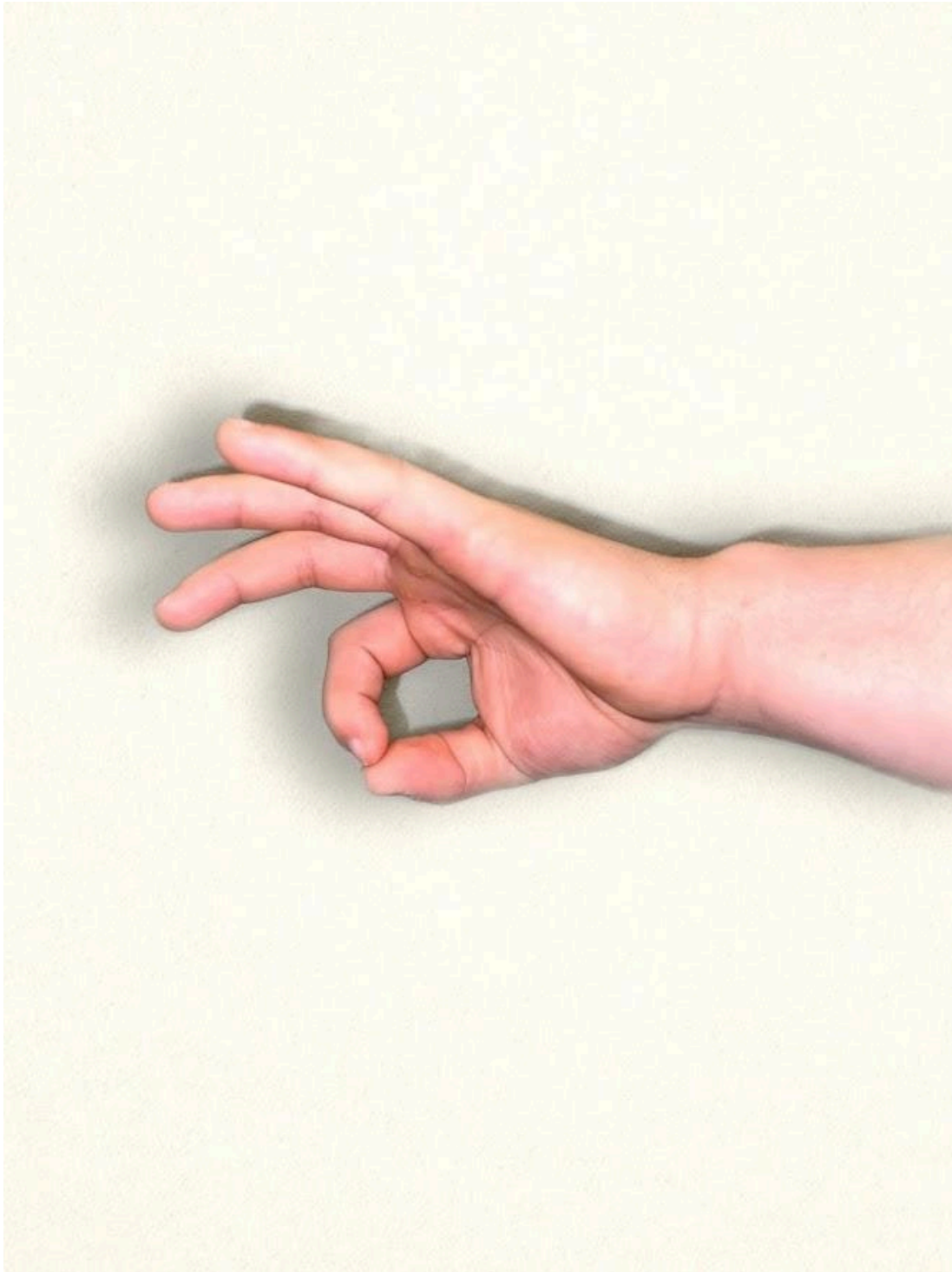


Figure 6.35 Alternative Finger Touch Test

Heel-to-Shin Test

To perform a heel-to-shin test, place the patient in a supine position. Ask the patient to place the heel of the right foot just below their left kneecap,

and then slide the right heel in a straight line down the shin bone to the ankle. Ask them to repeat this procedure on the left leg. The expected action is a smooth and straight movement of both legs. An abnormal finding is if the heel falls off the lower leg or the patient is not able to complete the movement smoothly in a straight motion. See Figure 6.36⁵ for an image of the heel-to-shin test.



Figure 6.36 Heel-to-Shin Test



Visit [Stanford Medicine 25's "Cerebellum Exam" video on YouTube](#) for a review of cerebellar exam.⁶

5. "Neuro Exam Image 1.png" and "Neuro Exam Image 2.png" by Meredith Pomietlo for [Chippewa Valley Technical College](#) are licensed under [CC BY 4.0](#)

6. Stanford medicine 25. (2014, March 18). *Cerebellum exam (Stanford medicine 25)* [Video]. YouTube. All rights reserved. https://youtu.be/Imu1kk_gOKA

6.9 Assessing Reflexes

Assessment of reflexes is not typically performed by registered nurses as part of a routine nursing neurological assessment of adult patients, but it is used in nursing specialty units and in advanced practice. Spinal cord injuries, neuromuscular diseases, or diseases of the lower motor neuron tract can cause weak or absent reflexes. To perform deep reflex tendon testing, place the patient in a seated position. Use a reflex hammer in a quick striking motion by the wrist on various tendons to produce an involuntary response. Before classifying a reflex as absent or weak, the test should be repeated after the patient is encouraged to relax because voluntary tensing of the muscles can prevent an involuntary reflexive action.

Reflexes are graded from 0 to 4+, with “2+” considered normal:

- 0: Absent
- 1+: Hypoactive
- 2+: Normal
- 3+: Hyperactive without clonus
- 4+: Hyperactive with clonus (involuntary muscle contraction)

To observe assessment of deep tendon reflexes, view the following video.



View Stanford Medicine's [Assessment of Deep Tendon Reflexes](https://youtu.be/OsqClzuotWo) video on YouTube.¹

1. Stanford Medicine 25. (2014, March 16). *Deep tendon reflexes (Stanford medicine 25)* [Video]. YouTube. All rights reserved. <https://youtu.be/OsqClzuotWo>

Brachioradialis Reflex

The brachioradialis reflex is used to assess the cervical spine nerves C5 and C6. Ask the patient to support their arm on their thigh or on your hand. Identify the insertion of the brachioradialis tendon on the radius and briskly tap it with the reflex hammer. The reflex consists of flexion and supination of the forearm. See Figure 6.37² for an image of obtaining the brachioradialis reflex.

2. “[Deep Reflex Exam Image 4.png](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)



Figure 6.37 Brachioradialis Reflex

Triceps Reflex

The triceps reflex assesses cervical spine nerves C6 and C7. Support the patient's arm underneath their bicep to maintain a position midway between flexion and extension. Ask the patient to relax their arm and

allow it to fully be supported by your hand. Identify the triceps tendon posteriorly just above its insertion on the olecranon. Tap briskly on the tendon with the reflex hammer. Note extension of the forearm. See Figure 6.38³ for an image of the triceps reflex exam.

3. “[Deep Reflex Exam Image 2.png](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)



Figure 6.38 Triceps Reflex

Patella (Knee Jerk) Reflex

The patellar reflex, commonly referred to as the knee jerk test, assesses lumbar spine nerves L2, L3, and L4. Ask the patient to relax the leg and allow it to swing freely at the knee. Tap the patella tendon briskly, looking

for extension of the lower leg. See Figure 6.39⁴ for an image of assessing a patellar reflex.

4. “[Deep Reflex Exam Image 3.jpg](#)” by Meredith Pomietlo for [Chippewa Valley Technical College](#) is licensed under [CC BY 4.0](#)