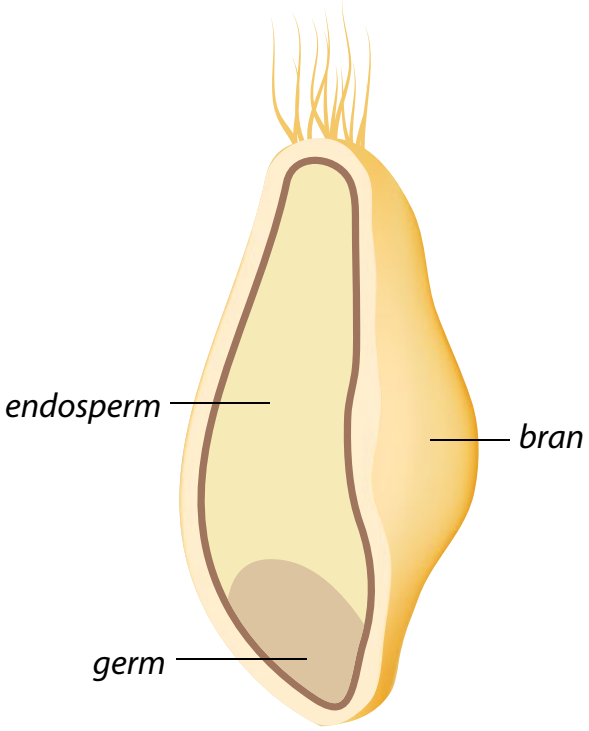
Chapter 7: Grains

FLOUR POWER

Did you know that all whole grains are composed of three parts?



Grains are made up of the ***bran, endosperm***, and ***germ.*** Each serves a different purpose for the grain and for human health. A ***whole grain*** contains all of the parts and nutrients of the grain seed. This includes the germ, bran, and endosperm. The bran is the outer layer of the kernel. It contains antioxidants, B vitamins, and fiber. The germ is the embryo, which can be used to sprout a new plant. It contains B vitamins, some protein, minerals, and healthy fats. The endosperm is the largest inner portion of the kernel, and provides the germ's food supply. ***Refined grains*** have been milled, which removes the bran and germ. Milling also removes the ***fiber***, iron, and many B vitamins from the grain. Carbohydrates that cannot be digested are called fiber. Fiber contains cellulose, which our bodies do not have the enzyme to digest. Fiber helps support a healthy digestive system. Most refined grains are enriched, which means that certain B vitamins and iron are added back after processing. You will learn more about the parts of grains in *Food Explorations Lab I* of this chapter.

All grains contain starch, because it is located in the endosperm. Starch is often called a ***complex carbohydrate***. Unlike ***simple carbohydrates***, complex carbohydrates are made of many units of carbohydrate that have been linked together to form a complex chain. Simple carbohydrates only have one to three units of carbohydrate in their chain.

Amylose is a type of starch that is made of a long chain-like molecule. In our mouth, chemical digestion begins when amylose is broken down into simple carbohydrates by an enzyme found in our saliva called ***amylase***. The largest source of starch is corn, but it can also be found in wheat, potatoes, and rice. Although corn and potatoes aren't necessarily grains, we identify them as starchy vegetables because they contain a large amount of starch. You will learn more about starch digestion in *Food Explorations Lab III* of this chapter.

Various types of protein can also be found in the grain seed. Among those proteins is ***gluten***. Gluten can easily be found in wheat, barley, and rye. When water is added to flour and the mixture is properly stirred or kneaded, flour proteins bond to form gluten. Gluten is necessary for the formation of dough and batter. As gluten develops, the mixture becomes elastic and strong, providing texture and chewiness to baked foods. Adding salt can strengthen the gluten development, but adding sugar, fat, or acids can weaken its formation. Gluten formation can be a very tedious process! You will learn more about gluten in *Food Explorations Lab II* of this chapter.

Some people are allergic to gluten. In severe cases it is called **Celiac disease**. Individuals who eat foods containing gluten will experience inflammation in the small intestine. The inflammation can cause damage to the small intestine and prevent absorption of some nutrients. It is important that people with Celiac disease avoid gluten in their diets. Gluten-free foods are now available to help people who cannot tolerate the protein. Grains and starches such as rice, corn, and buckwheat do not contain gluten and can be included in a gluten-free diet. No matter the gluten content, all grains are an important part of everyone's diet. Let's explore the structure and function of grains!

In the context of grains, simple carbohydrates are typically made from refined grains (top). Complex carbohydrates are typically made from whole grains (bottom).

Think About It

Food Explorations Lab I

1. The parts of a grain are bran, germ, and endosperm.

2. The endosperm provides the germ's food supply.

3. Refined grains have the bran and the germ parts removed during milling.

Food Explorations Lab II

1. Proteins found in grains combine with water to form gluten.

2. As gluten forms, dough becomes elastic and strong.

3. A person allergic to gluten may have Celiac disease.

Food Explorations Lab III

1. The starch in a grain is in the endosperm.

2. Simple carbohydrates have one to three units of carbohydrates, while complex carbohydrates have many.

3. The starch amylose is broken down by the enzyme amylase found in our saliva.

Food Explorations Lab I:
Great Grains

STUDENT LAB INVESTIGATIONS

Name: _____

Lab Overview

In this investigation, you will observe the parts of a kernel of corn (a whole grain), identify its structural parts, and test each part for starch.

Lab Objectives

In this lab, you will learn how to…

1. Identify the parts of a whole grain.

2. Determine the part of a whole grain that contains starch.

3. Explain the nutrition in whole grains.

4. Compare and contrast the nutrition of whole grains versus refined grains.

Lab Safety: Before beginning ANY investigation you should put on your safety goggles and apron. It is important to avoid getting chemicals on your hands. Always wash your hands following completion of an investigation. When handling food, you should also wash your hands *prior* to beginning an investigation.

Lab Question

Which part of the grain contains starch? (Circle your answer.)

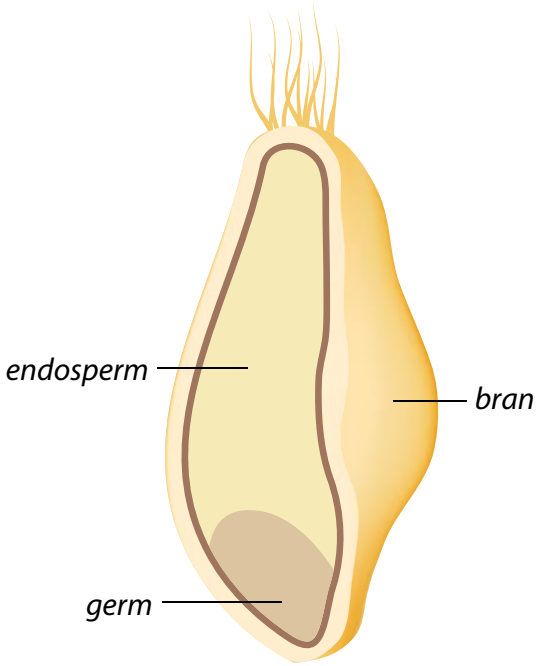
Bran Germ Endosperm

Predictions: I think the _____ contains the starch within a grain because…

Grain Anatomy

MATERIALS

safety goggles
aprons (optional)
1 corn kernel (pre-soaked in water)
1 paper plate
1 dissecting needle, scalpel, or push pin
1 mL iodine solution in a small cup
1 medicine dropper
1 black permanent marker
Hand lens (optional)



PROCEDURE

1. Using the black marker, divide the paper plate into 3 equal sections. Label the sections bran, germ, and endosperm.

2. Place 1 pre-soaked corn kernel on the labeled paper plate.

3. Carefully slice the kernel in half (the long way) using a dissecting needle, scalpel, or push pin.

4. Draw your *visual observations* of the grain in Table A under the column labeled "BEFORE Reacting with Iodine." Label the bran, germ, and endosperm. Use a hand lens for your observations, if available.

5. Describe your *visual observations* of each dissected portion of the corn kernel in Table B under the column labeled "BEFORE Reacting with Iodine."

6. Place 1 drop of iodine solution on each part of the dissected kernel. Draw your *visual observations* of the grain in Table A under the column labeled "AFTER Reacting with Iodine." Label the bran, germ, and endosperm.

7. Describe your *visual observations* of each dissected portion of the corn kernel in Table A under the column labeled "AFTER Reacting with Iodine."

Table A: Visual Observation Drawings of Corn Kernel

BEFORE Reacting with Iodine	AFTER Reacting with Iodine

Table B: Visual Observations of Iodine Reaction

	BEFORE Reacting with Iodine	AFTER Reacting with Iodine
Bran	White	White
Endosperm	White	Dark yellow/brown
Germ	Yellow	Yellow

Conclusion:

1. Which part of the grain contained starch? Support your answer with evidence from your data.

The endosperm contains starch because it reacted with the iodine.

2. Based on the reading, explain which parts of the grain contain the most nutrition.

The endosperm is the part of the grain that contains the most calories. It contains mostly carbohydrate and protein. The bran and germ, however, contain the most nutrients.

3. Based on the reading, compare and contrast whole grains and refined grains.

Refinement removes the bran and germ. With these removed, only carbohydrates and protein remain leaving little to no vitamins and minerals.

4. In your own words, explain why it is important to eat whole grains.

It is important to eat whole grains so we can include fiber, vitamins, and minerals in our diets.

Food Explorations Lab II:
Globs of Gluten

STUDENT LAB INVESTIGATIONS

Name: _____

Lab Overview

In this investigation, your class will determine the relative amounts and characteristics of the gluten formed by three different types of flour.

Lab Objectives:

In this lab, you will learn how to…

1. Describe the effect of stirring and kneading dough on the formation of gluten.
2. Determine the relative amount of gluten formed by different flour types.
3. Determine factors that affect the formation of gluten.
4. Identify high protein (gluten) flours.

Lab Safety: Before beginning ANY investigation you should put on your safety goggles and apron. It is important to avoid getting chemicals on your hands. Always wash your hands following completion of an investigation. When handling food, you should also wash your hands *prior* to beginning an investigation.

Lab Question

Which flour type will form the most gluten (protein)? (Circle your answer.)

Bread Flour Cake Flour All-Purpose Flour

Predictions: I think _____ flour has the most gluten (protein) because…

Experimenting with Flours Types with Varying Gluten Concentrations

MATERIALS

safety goggles
aprons (optional)
1 small bag containing 1 cup of assigned flour type
1 small plastic bowl
¼ cup of water
1 liquid measuring cup
1 large bowl
1 plastic fork
1 paper plate
1 kitchen timer or stopwatch
1 metric ruler
warm water to fill the large bowl (step 6)
1 strainer (wide mesh)

Obtain your flour assignment from you teacher. Record your group's flour type below (all-purpose, bread, or cake).

My group's flour type is: _____

PROCEDURE

1. Pour ½ the bag of flour into the small plastic bowl.
2. Describe the color and texture of your flour type. Record your answers in Table A for your assigned flour type.

TABLE A: Characteristics of Flour Types

Flour Type	Color	Texture
All-Purpose Flour	White	Very Smooth
Bread Flour	Cream or Off-White	A little grainy but smooth
Cake Flour	White	Very Smooth

3. Prepare your flour type using the directions below.

   - **Bread Flour**: Add ¼ cup of water. Stir your flour/water mixture with a plastic fork. Gradually, the flour should begin to form a small ball.
   - **All-Purpose Flour**: Add ¼ cup of water. Stir your flour/water mixture with a plastic fork. Gradually, the flour should begin to form a small ball.
   - **Cake Flour**: Add ⅛ cup of water. Stir your flour/water mixture with a plastic fork. Gradually, the flour should begin to form a small ball.

4. Sprinkle some of the leftover flour on your work surface. Rub some of the flour into your hands to prevent stickiness. Your hands and work surface should be lightly dusted with flour.

5. Place the flour ball onto your work surface. Using your timer, knead the flour ball for 15 minutes. Add the remaining flour from the zip-lock bag to the flour ball as you are kneading. The final flour ball should not be sticky, should have a consistent texture, and should maintain its shape.

6. Allow your flour ball to rest in its bowl for 10 minutes. While you wait, clear your materials and kneading surface. Also, obtain enough warm water from your teacher to fill your large bowl.

7. After 10 minutes have passed, place the flour ball in the strainer and lower it into the large bowl filled with water. If there is sufficient sink space, your teacher may have you use the sink instead of a large bowl.

8. Knead the flour ball in the strainer under the water until the water-soluble parts (starch) wash away as a milky white liquid, leaving behind the protein (gluten). The gluten should be yellow-brown in color and feel like wet clay. Continue washing your ball until only a stringy, sticky ball remains. This process may take 10-15 minutes to complete.

9. Once your have created your gluten ball, place it on the paper plate. With a ruler, measure the diameter of the gluten ball. Record you measurement in Table B.

10. Share your findings with other groups. Be sure to record observations and data missing from your tables (A and B) for the flour types not assigned to your group.

11. Optional: Place the gluten ball in a plastic sandwich bag to be stored overnight in the refrigerator.

Table B: Flour Ball Measurements

Four Type	Flour Ball Diameter (cm)
All-Purpose Flour	Actual size will vary
Bread Flour	Actual size will vary Largest
Cake Flour	Actual size will vary Smallest

Conclusion:

1. Compare and contrast the gluten balls formed.

The bread flour formed a strong ball, but larger than the all-purpose flour. The cake flour did not produce a gluten ball (nothing more than what you could hold between two fingers).

2. Place the flours in order from greatest amount of protein formed (1) to least amount formed (3).

1. Bread Flour

2. All-Purpose Flour

3. Cake Flour

3. Using your observations and the "Flour Power" reading, describe what factors have an effect on the strength of gluten in flour.

The strength of gluten can be affected by the amount of flour, water, and agitation.

4. Explain the effect of "washing" the dough ball. What substances were removed and what was left behind?

The starch was washed away leaving only the gluten bonds (protein).

5. Based on the reading and your data, infer which flour type would be the best for baking breads and which would be best for baking cakes and pastry. Explain.

The best flour for baking breads would be bread flour or all-purpose flour because they have more gluten that will help provide the structure needed for these products. The best flour for baked goods (cakes and pastries) would be cake flour because it has less gluten that will make a more tender product.

6. If the gluten ball was refrigerated overnight, describe what changes occurred.

The gluten ball becomes stiffer.

Food Explorations Lab III:

Amylase in Action

STUDENT LAB INVESTIGATIONS

Name: _____

Lab Overview

In this investigation, you will observe the effect of your saliva's chemical digestion on the starch content in white and whole wheat breads.

Lab Objectives:

In this lab, you will learn how to…

1. Determine the differences in amylase digestion on starch in white and whole wheat bread.

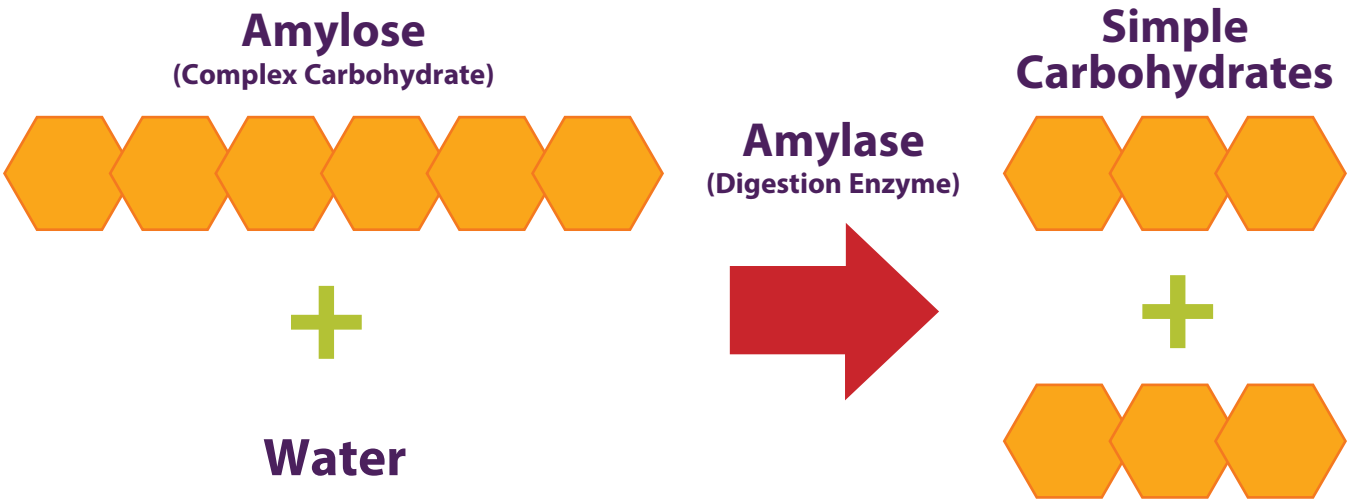
2. Describe the relationship between amylose and amylase.

3. Explain mechanical and chemical digestion of carbohydrates.

Lab Safety: Before beginning ANY investigation you should put on your safety goggles and apron. It is important to avoid getting chemicals on your hands. Always wash your hands following completion of an investigation. When handling food, you should also wash your hands *prior* to beginning an investigation.

Special Note: Iodine is POISON! DO NOT consume any food with iodine on it under any circumstances.

Observation of Amylase in Action



Lab Question

Which bread type will test positive for starch after being exposed to salivary amylase? (Circle your answer.)

White Wheat Bread Whole Wheat Bread Both Neither

Predictions: I predict _____ will test positive for starch after being exposed to salivary amylase because…

MATERIALS

safety goggles
aprons (optional)
½ slice of white bread
½ slice of whole wheat bread
1 paper plate (pre-labeled)
1 dropper
1 stopwatch or kitchen timer
iodine solution (teacher will provide ONLY after you have finished chewing your bread samples)

PROCEDURE

1. Tear each ½ slice of bread into thirds. Place one piece (**⅓** of the half slice of bread) of each type of bread on the paper plate in the section labeled "Control." Record your *visual* observations in Table A under the column labeled "Control."

2. Choose one person in your group to chew the white bread sample. Take one piece of the white bread, place it in your mouth and chew it for **30 seconds**. Do not swallow the bread!

3. After chewing the bread for 30 seconds, spit it out onto the section labeled "30 seconds" under white bread. Record your *visual* observations in Table A under the column labeled "30 seconds." Drink water in between chewing, if your mouth feels dry.

4. Take another piece of the white bread, place it in your mouth, and chew it for **1 ½ minutes**. Do not swallow the bread!

5. After chewing the bread for 1 ½ minutes, spit it out onto the Section labeled "1 ½ minutes" under white bread. Record your *visual* observations in Table A under the column labeled "1.5 minutes."

6. Repeat steps 2-5 with the slice of whole wheat bread. Spit samples out on the plate sections chosen for wheat bread.

7. After you have finished chewing **all** of your bread samples, obtain iodine from your teacher.

8. Place two drops of iodine solution on each piece of un-chewed bread (this is the control). Record your observation in Table B under the column labeled "Control." A positive test for starch will turn dark brown or black where the iodine comes into contact with the bread. Iodine will have little to no color when it comes into contact with a bread sample in which starch is no longer present (or present in negligible amounts).

9. Place two drops of iodine in the middle and on the sides of each chewed bread sample for each chewed bread type. Wait 10 seconds and then report if each test was positive or negative for starch in Table B under the columns labeled "30 seconds" and "1.5 minutes."

Table A: Bread Chewing Observations Before Iodine Reaction

Bread Type	Appearance BEFORE Reacting with Iodine		
	CONTROL	30 SECONDS	1.5 MINUTES
White	White with a light brown crust	No change occurred	No change occurred
Whole Wheat	Light brown color with a darker brown crust	No change occurred	No change occurred

Table B: Bread Chewing Observations After Iodine Reaction

Bread Type	Appearance AFTER Reacting with Iodine		
	CONTROL	30 SECONDS	1.5 MINUTES
White	The bread turned a dark brown/black color	The bread turned a dark brown/black color, but the color was not as dark as in the control sample	No change occurred
Whole Wheat	The bread turned a dark brown/black color	The bread turned a dark brown/black color, but the color was not as dark as in the control sample	No change occurred

Conclusion:

1. Describe the color changes observed for both breads when iodine was placed on the control pieces.

   Both breads turned a dark brown/blue color where the iodine was placed.

2. Compare and contrast the control bread pieces with iodine to those tested with iodine after 30 seconds and 1.5 minutes.

   The control iodine was darker and changed the color of the bread instantly, while the bread that had been chewed for 30 seconds only had grainy spots of color change and the bread that was chewed for 1.5 minutes had little/no color change.

3. Using your observations, explain if your original response to the lab question was supported by the results.

   Both breads tested positive for starch after being chewed for 30 seconds.

4. Compare and contrast your iodine test results for the white bread (made from milled grain) to the iodine results for the whole wheat bread (made from whole grain).

   There were no differences in the iodine test results for the white and whole wheat breads. The fiber in whole grain bread does not interfere with amylase's ability to breakdown starch.

5. Using your answer to question 4, infer if the chemical digestion of amylase in whole grains is easier or more difficult than in milled grains.

The chemical digestion of amylase is more difficult in whole grains because they contain more amylose.

6. Describe how this investigation demonstrated both mechanical digestion and chemical digestion.

Mechanical digestion occurred through mastication (chewing the bread). Chemical digestion occurred when the enzyme amylase (found in saliva) began to break down the amylose.

7. Referring to the reading "Flour Power" and the diagram shown at the beginning of this lab investigation, explain what happens to the starch, amylose, during digestion in a person's mouth.

Amylose, a complex carbohydrate, is broken down by the enzyme amylase to a simple carbohydrate, which does not contain starch. Amylase is found in the saliva in a person's mouth.

Student Investigations Lab Extension

With help from your teacher, create a class chart reporting the results of starch tests of each group. Report if each test was positive or negative for starch.

Table C: Class Chart

Flour Type	Group	Appearance BEFORE Reacting with Iodine		Appearance AFTER Reacting with Iodine	
		30 SECONDS	1.5 MINUTES	30 SECONDS	1.5 MINUTES
White	GROUP 1				
	GROUP 2				
	GROUP 3				
	GROUP 4				
	GROUP 5				
	GROUP 6				
Whole Wheat	GROUP 1				
	GROUP 2				
	GROUP 3				
	GROUP 4				
	GROUP 5				
	GROUP 6				

1. Provide possible reasons to explain why varying results might occur.

If the 30 seconds samples sat out too long, the tests may produce a false-negative outcome because the amylase will continue to breakdown the starch present in the bread.

2. Brainstorm with your group other foods that might contain whole grains. List a minimum of three below.

whole wheat, graham flour

oatmeal

whole oats

brown rice

wild rice

whole-grain corn

popcorn

whole-grain barley

whole-wheat bulgur

whole rye

Investigating Your Health:

Gratifying Grains

Name: _____

Objective: Investigate grains by comparing nutritional differences between whole and processed grains, identify if a bread is a whole grain by examining the ingredient list, and research other food sources that contain whole grains.

A ***whole grain*** contains all of the parts and nutrients of the entire grain seed. This includes the germ, bran, and endosperm. The ***germ*** is the embryo of the grain. The ***bran*** is the tough, protective outer layer of the kernel. The ***endosperm*** is the largest inner portion of the kernel, and provides the germ's food supply.

Refined grains have been milled, which removes the bran and the germ. Milling also removes the fiber, iron, and many B vitamins from the grain. Most refined grains are enriched, which means that certain B vitamins and iron are added back after processing. Unfortunately, fiber is not usually added back to enriched grains. Eating whole grains instead of refined grains can reduce your risk of stroke, type 2 diabetes, heart disease, and will help with weight management. You should be eating 6 ounces of grains every day, and half of those (3 ounces) should be whole grains.

There are many different ways to identify whole grain foods. Most foods have a stamp to identify them as whole grains. Another way to identify whole grains is to look at the ingredients. The first ingredient should contain the word "whole," for example "whole wheat flour." If there are two grain ingredients and the second one has the word "whole," the food item is not considered 100% whole grain. The food packaging may also have key words to identify it as a whole grain. Whole grain, whole wheat, stoneground whole, brown rice, oats, oatmeal, and wheat berries are key words to look for to identify food as a whole grain.

One easy way to increase the amount of whole grains you eat is to replace half of the refined grains with whole grains. Popcorn is a whole grain, and can be a healthy snack if there isn't added salt or butter. Ask your parents to buy whole wheat pasta; at some stores it costs the same as regular pasta. Adding rolled oats to your yogurt is a very easy way to increase the amount of whole grains in your diet. There are many other ways you can add whole grain to your diet. Use the *Try This at Home* recipe to make a healthy snack with whole grains!

Comparing Bread

1. Go to the grocery store and look at the Nutrition Facts label on whole grain bread and white (refined) bread. Make sure you choose bread that has the same serving size. Try to find different breads from the same brand. If you are unable to go to the grocery store, use the handout provided by your teacher or access the nutrient database on USDA's website: http://ndb.nal.usda.gov/ndb/search/list. Complete the table below.

	Whole Grain Bread	White Bread
Calories	100	120
Total Fat	2g	1.5g
Sodium	115mg	220mg
Fiber	4g	1g
Sugar	3g	4g
Protein	5g	4g
Folic Acid	2%	10%
Iron	6%	6%
Thiamin	6%	10%
Niacin	8%	8%
Riboflavin	4%	8%

2. What are the nutritional differences between the whole grain bread and white bread?

At first glance it may appear the white bread is a healthier option because it is higher in vitamins and minerals. However, these values are higher due to enrichment. Enrichment is the adding of vitamins and minerals that were removed during processing back into the bread. Unfortunately, the enriched white bread has less protein and more calories, sodium, and sugar. Additionally, the whole grain bread has 3 more grams of fiber than the processed bread. The best option is the whole grain bread.

3. Look at a bread label found at home or use a label provided by your teacher. Explain whether the bread is a whole grain or not.

Bread Name: Honey Wheat Bread

It is NOT a whole grain. The first ingredient is enriched flour. Whole grain would have the word "whole" in the ingredients list as well as a higher fiber content.

4. Identify 3 more food sources of whole grains other than loaf bread.

1. Multiple answers are possible. Popcorn, Bran Muffin, Whole Oats, Brown Rice, Whole Wheat Crackers, Bran Cereal, Bran Flakes, Granola
2.
3.

5. List 2 ways you can include more whole grains in your diet.

   1. Multiple answers are possible. Choose popcorn as a snack. Choose whole wheat bread (vs. white bread) when making my sandwiches. Choose whole-wheat crackers as a snack. Eat bran cereal, oatmeal, or flakes for breakfast.

   2.

6. Research 3 reasons why it is important to eat whole grains. Use the Internet and or the "Gratifying Grains" reading on page 197 to help with your search. Make sure to use reliable sources of information, for example the United States Department of Agriculture.

   Multiple answers are possible. Grains are important sources of nutrients like dietary fiber, B vitamins (thiamin, riboflavin, niacin, and folate), and minerals (iron, magnesium, and selenium). Dietary fiber from whole grains may help reduce blood cholesterol levels and lower the risk of heart disease, obesity, and type 2 diabetes. Fiber-containing foods help provide a feeling of fullness with fewer calories.

TRY THIS AT HOME:

Make Your Own Trail Mix

Makes six ½-cup servings

You will need:

½ cup dried fruit
- **Cranberries**
- **Banana chips**
- **Mango slices**
- **Raisins**
- **Crystallized ginger**
- **Pineapple**
- **Apple**
- **Papaya**

½ cup nuts
- **Unsalted roasted peanuts**
- **Unsalted cashews**
- **Unsalted raw sunflower seeds**
- **Unsalted roasted almonds**
- **Soy nuts**
- **Chopped walnuts**

1 cup crunchy grains
- **Low-fat granola**
- **Crispy whole wheat, corn, rice, or oat cereal squares**
- **Pretzels**
- **Sesame sticks**

1 cup other
- **Low-sodium or unsalted pretzels**
- **Chocolate-coated nuts or dried fruit**
- **Shredded unsweetened coconut**
- **Mini-marshmallows**

INSTRUCTIONS:

1. Add one ingredient from each category.

2. Enjoy!