Flour Protein Experiment

Suggested Grade Level: 6-8

Time: Three 45-minute classes

Subject: Family and Consumer Science, Nutrition, Food Preparation, Science, Chemistry, Language Arts, Informational Reading, Research, Writing, Math, Ratios and Proportions, Agriculture, Wheat, Food Science

Overview: In this engaging, three-day lesson, students compare the protein content of different flours to see how gluten shapes the texture of baked goods. Through hands-on experiments, they apply science, math, reading, and communication skills while making real-world connections to agriculture and Kansas's wheat industry. Students mix and test flour samples, analyze the results, and then cook and taste pancakes to evaluate how the type of flour impacts the final product.

Objectives:

1. Identify the differences in protein content across four types of flour (cake, all-purpose, bread, and whole wheat)
2. Describe the role of gluten and flour protein content in dough formation.
3. Demonstrate a basic scientific experiment.
4. Evaluate the use of different types of flour in baking.

Background Information:

Wheat is a type of cereal grain. It contains gluten, which acts like a glue in baked goods such as bread, rolls, and pastries. Wheat kernels provide several crucial nutrients to our diet, and wheat flour is very low in fat and sodium. The three main parts of the wheat kernel are the endosperm, bran, and germ.

- Endosperm — The *endosperm*, which takes up 83 percent of the whole kernel weight, is the source of white flour. It contains the highest amounts of protein, carbohydrates, and iron. It also contains riboflavin, niacin, and thiamine.
- Bran — The *bran* takes up about 14 ½ percent of the kernel. It contains some protein, large amounts of riboflavin, niacin, and thiamine; trace minerals; and dietary fiber.
- Germ — The *germ*, or embryo, accounts for about 2 ½ percent of the kernel. This section is often separated from the rest of the kernel during processing because

it can lower the shelf life. It contains some high-quality protein, B vitamins, and trace minerals (Wheat Foods A Kernel).

Wheat can be found in breads, cookies, cakes, pies, pastries, cereals, crackers, pasta, flour tortillas, noodles, and more. Consuming 5 to 10 oz of wheat products per day meets the U.S. Department of Agriculture's Dietary Guidelines for Americans, as outlined by the U.S. Department of Health and Human Services. Additionally, Nutrition experts recommend that half of our daily grains come from whole-grain products. It's no secret that wheat is a staple of the American diet – each American consumes about 134 pounds of wheat flour annually. Besides humans, wheat can also be used to feed cattle, poultry, and other livestock, including fish and shrimp (Eat).

American wheat farmers grow six varieties, classed according to color, hardness, and growing season: red, white, soft, hard, winter, and spring. Red wheat produces more gluten, which is milled into flour and retains its shape when baked. Winter wheat is planted in the fall to germinate and develop into young plants. Then, it enters a dormant stage during the winter and resumes growth in the spring. Spring wheat is planted in early spring and grows quickly. It is harvested in late summer, around the same time winter wheat is harvested. Hard red winter wheat is most commonly grown in the United States. It is an all-purpose flour that can be used to bake bread, hard rolls, croissants, and flatbreads. Soft wheat flour has less gluten and protein. It is typically used to make cookies, crackers, pastries, and pretzels. Another type of wheat, known as durum, is primarily grown in the southwestern United States (Arizona and California). Durum is used for pasta and couscous (Wheat Foods 6). Most baked goods have historically been wheat-based, but alternative flours have been developed as gluten allergies have become more prevalent. Gluten-free flour can include a variety of ingredients, such as sorghum and tapioca. It contains xanthan gum or starches to mimic gluten's "glue" effect.

Kansas Connections:

Kansas has rightfully earned the nicknames "Wheat State" and "Breadbasket of the World." Our state leads wheat production, milling, and exports, producing about 320 million bushels harvested from an average of 7.5 million acres. That's almost the size of Maryland! About half of Kansas wheat gets exported to other U.S. states, which makes our central location very convenient. The other half is exported to other countries. Why do we produce so much wheat? Kansas's natural resources, including its climate, soil, and rainfall, create the ideal environment for wheat production. Unsurprisingly, Kansas farmers have been growing wheat for a long time. Wheat has been cultivated in Kansas since before the state was established. In 1874, Russian Mennonite immigrants introduced Turkey Red Wheat to Kansas. This hardy variety was planted in the fall and could withstand Kansas's cold and dry winters. Ninety-five percent of the wheat grown in Kansas is known as hard red winter wheat. Moreover, an additional three percent of the wheat grown by Kansas farmers is classified as hard white wheat.

Kansas is responsible for producing 40% of the U.S. Hard Red Winter wheat, higher than any other state. Hard Red Wheat is a good source of dietary fiber and betaine. Additionally, Hard Red Wheat provides antioxidants. Antioxidants neutralize free radicals, which prevents oxidative stress. This high-protein, high-gluten type also includes a variety of minerals. Oftentimes, you can find it in stores labeled "bread flour" for use in yeast bread, tortillas, cereal, and noodles. Another three percent of wheat grown by Kansas farmers is known as Hard White Wheat. This class grows in the western and central areas of Kansas. Hard White Wheat is a specialty wheat used for whole-wheat white flour for its sweeter and milder taste. Hard White Wheat has less protein and, therefore, less gluten than Hard Red Wheat. It can also be found in all-purpose flour for pan bread, flatbread, and specialty noodles. Finally, Soft Red Winter Wheat accounts for about one percent of the wheat in Kansas. Soft Red Winter Wheat is used in the production of flatbreads, cakes, pastries, and crackers. It can be found in all-purpose flours as well (Debes).
Kansas also ranks first in milling. There are 12 flour mills in the state and a total capacity of 114,626 cwts (Eat). Interestingly, Kansas State University is currently the *only* university in the United States that offers degrees in baking science, feed science, milling science, and management. KSU was even named the lead institution on wheat by the National Science Foundation (Tammen). Kansas's public education and private industry leadership in wheat is famous worldwide. The Kansas Wheat Innovation Center, established by the Kansas Wheat Commission through the Kansas Wheat Checkoff, is located at Kansas State University. The Kansas Wheat Innovation Center aims to improve and develop wheat varieties. It focuses on enhancing the production and disease resistance of wheat and other crops (Kansas). The Kansas Wheat Commission also supports the National Festival of Breads, a nationwide contest for innovative recipe development and demonstration for adults and adolescents.

Materials

Lesson Day 1:

Per group

- ½ cup measuring cup
- 1 cup liquid measuring cup
- Label four flours with different proteins (e.g., cake, all-purpose, bread, wheat, or pastry) as ABCD.
- water
- Four disposable bowls
- Four real forks or heavy plastic spoons
- Empty bags of the four types of flour or pictures of all four sides of the flour for each group. Four protein levels of flour (cake, 6-8%; all-purpose, 10-12%; bread, 12-13%; and whole wheat, 13-14%) are the easiest to find. Pastry flour could also be used (8-9 % protein)

Per student

- Flour Experiment Worksheet (provided)

Lesson Day 2:
Per group
- Wheat PowerPoint nationalfestivalofbreads.com/sites/default/files/field-to-flour.pdf
- Wheat Facts Handout (provided)
- Pictures of the four flour bags

Per student
- What Do We Know About Wheat? Worksheet (provided)

Lesson Day 3:
Per group
- Electric frying pan or griddle
- Spatula
- Two bowls
- Handmixer, whisk, or fork
- Wet ingredients - one egg, ⅔ cup/153 grams of milk, 1 1/2 tablespoons (21 grams) of melted butter
- Dry ingredients - ¾ cup (90 grams) flour, different types, 1 tsp. baking powder, 1 tablespoon sugar
- Syrup and extra butter (optional)
- Scale/measuring spoons (teaspoon, tablespoon, ⅔ cup, ¾ cup)
- Plate/platter labeled with the type of flour

Per student
- Paper plate
- Final Product Evaluation Form (provided)

Instructional Format:
1. Review background information.
2. Conduct engagement exercise.
3. Complete Lesson Day 1.
4. Complete Lesson Day 2.
5. Complete Lesson Day 3.
6. Conduct assessment exercise.

Engagement:
Have four baked goods made with different types of flour (all-purpose flour, bread flour, cake flour, pastry flour, whole wheat flour). These could include four types of bread, biscuits, cupcakes, and other similar items. Students can view these as they enter class. Display a sheaf of wheat and bags of flour. Ask students what they know about each type of flour and the role of gluten. Use their responses to guide a class discussion that reinforces the lesson vocabulary.

Lesson Day 1
Procedures:

1. Divide students into groups and explain that each group will determine the differences in four types when mixed with water.
2. Instruct each group to label their bowls with the type of flour they are using.
3. Then, have them add ½ cup of the specific flour to each bowl.
4. Have the groups add six tablespoons or 3 ounces of water to the flour.
5. Finally, stir for two minutes. Compare the four mixtures.
6. Let the flour and water sit while they answer and recheck the questions.
7. Pass out the "Flour Experiment" Worksheet. Students may complete it individually or as a group.
8. Have the answers ready so students can complete a self-check before cleaning up their area.
9. While waiting for others, provide students with the Wheat PowerPoint https://nationalfestivalofbreads.com/sites/default/files/field-to-flour.pdf or the Wheat Facts Handout (provided).
10. After the Flour Experiment Worksheet and wheat PowerPoint/handout, introduce the cereal chemist career using the Career Information section. Ask: “What skills did you use today that a cereal chemist might need?”

Lesson Day 2:
Procedures:

1. You can begin this lesson with the PowerPoint or Wheat Facts handout or by reviewing or discussing it as a class if students viewed it the previous day.
2. Have students study the labels, maps, and pictures, then answer the questions provided on the "What Do We Know About Wheat?" worksheet. You could give each student one part to read, then ask them to share the most important parts of the map, diagram, or article. You could do this as a small or large group activity.
3. After completing the diagram, lead a class discussion. Ask your students, "Which flour would you want for bread? What type would you want for a light cake? What type would be helpful for most households?" Etc. Ensure students understand that the more protein the flour contains, the more gluten it provides.

Lesson Day 3
Procedures:

1. For this lesson, students will make pancakes using the four types of flour. Before you begin, separate your students into the same groups as before.
2. Distribute different types of flour to each group. Ensure there is enough flour to make enough pancakes for the whole class.
3. Discuss the types of flour as a class. Ask, "What do you think these pancakes will be like? Texture? Taste? What about these?"
4. Alternatively, you could follow a Bread in a Bag or Pizza in a Bag recipe (or any other recipe that uses dough). Pancakes were chosen here for speed in a lab situation.
5. Pass out the recipe instructions or write them on a whiteboard.

- Beat the eggs and milk until light and foamy, about three minutes at high speed.
- Stir in melted butter.
- Mix the flour, salt, baking powder, and sugar in another bowl.
- Gently add the dry ingredients to the egg and milk mixture. Do not overmix. Let the mixture set while the griddle is heating.
- Set the griddle to 375 degrees. To test the griddle, place a drop of water on it. The drop should skitter and evaporate immediately.
- Spread butter on the griddle and pour ¼ cup of batter to form a pancake.
- When bubbles appear across the top, it is ready to turn.

6. Place all the pancakes on the platter labeled with the type of flour used.
7. Each student should get one or part of a pancake made with each type of flour.
8. Then, have your students evaluate them with the Flour's Final Product Evaluation Form.

Vocabulary:

- **All-purpose flour**: made from hard, soft, or a blend of wheat, usually made by the mill closest to its production, may be bleached or unbleached, and is enriched.
- **Bread flour**: unbleached, has higher protein (11-14%), is strong or high in gluten, and is made from hard red spring wheat or winter wheat, which is best for yeast breads.
- **Cake flour**: enriched, bleached, low protein (7-8%), suitable for angel food or chiffon cakes
- **Pastry flour**: bleached or unbleached, enriched, low protein (8-9%), used for cookies, brownies, made from white winter or soft winter wheat.
- **Whole wheat flour**: contains all the parts of the entire kernel of wheat.
- **Enriched**: Three B vitamins, iron, folic acid, and sometimes calcium, are added and made from the endosperm of the wheat kernel.
- **Gluten**: a protein that gives dough its elasticity, helping it rise and keep its shape

Kansas Curricular Standards:

Next Generation Science

Matter and Its Interactions

MS-PS1-2 Analyze and interpret data on the properties of substances before and after substances interact to determine if a chemical reaction has occurred.

MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes

From Molecules to Organisms: Structures and Processes

MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Engineering Design

MS-ETS-1 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Language Arts

6th Grade

Reading: Informational

Key Ideas and Details

RI.6.1 Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

Integration of Knowledge and Ideas

RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

Writing

Text Types and Purposes

W.6.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly through the selection, organization and analysis of relevant content.

Research to Build and Present Knowledge

W.6.7 Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.

W.6.9 Draw evidence from literary or informational texts to support analysis, reflection and research.

Speaking and Listening

SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on sixth-grade topics, texts and issues, building on others' ideas and expressing their own clearly.

SL.6.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text or issue under study.

7th Grade

Reading: Informational

Key Ideas and Details

RI.7.1 Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

Writing

Text Types and Purposes

W.7.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts and information through the selection, organization and analysis of relevant content.

Research to Build and Present Knowledge

W.7.7 Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation.

Speaking and Listening

Comprehension and Collaboration

SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on seventh grade topics, texts and issues, building on others' ideas and expressing their own clearly.

8th Grade

Reading: Informational

Key Ideas and Details

RI.8.1 Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.

Writing
Text Types and Purposes
W.8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts and information through the selection, organization and analysis of relevant content.
Research to Build and Present Knowledge
W.8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
W.8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
Speaking and Listening
Comprehension and Collaboration
SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on eighth-grade topics, texts and issues, building on others' ideas and expressing their own clearly.

Math
Ratios and Proportional Relationships
6.RP.1. Use unit rate language ("for each one", "for every one" and "per") and unit rate notation to demonstrate understanding of the concept of a unit rate associated with a ratio.

Family and Consumer Science
1.0 Nutrition and Wellness
1.0 Demonstrate nutrition and wellness practices that enhance individual and family wellbeing across the lifespan.
1.3 Apply the concepts to acquire, handle and use foods to meet nutritional and wellness needs of individuals and families across the lifespan.
1.5 Evaluate the influence and impact of science and technology on food consumption, safety, and related issues.
1.9 Examine and apply appropriate skills and ethical behavior when using technology.
7.0 Family, Career and Community Connections
7.4 Demonstrate applying the Family and Consumer Sciences process skills to solve practical problems.
7.5 Demonstrate skills needed to enhance life independence.

National Agricultural Literacy Standards:
Agriculture and the Environment
- Recognize how climate and natural resources determine the types of crops and livestock that can be grown and raised for consumption (T-1. 6-8 g.)

Plants and Animals for Food, Fiber, and Energy
- Identify where labeling indicates the origin of food and fiber (fabric or clothing) 9T-2. 6-8 f.)

Food, Health, and Lifestyle
- Demonstrate safe methods for food handling, preparation, and storage in the home (T-3. 6-8 a.)

- Evaluate food labels to determine food sources that meet nutritional needs (T3 6-8 b.)
- Explain the benefits and disadvantages of food processing (T3 6-8 e.)
- Identify agricultural products (foods) that provide valuable nutrients for a balanced diet (T3 6-8 g.)
- Identify forms and sources of food contamination relative to personal health and safety (T3 6-8 h.)
- Identify sources of agricultural products that provide food, fuel, clothing, shelter, medical, and other non-food products for their community, state, and/or nation (T3 6-8 i.)
- Identify the careers in food production, processing, and nutrition that are essential for a healthy food supply (T3 6-8 j.)

Culture, Society, Economy, and Geography

- Identify agricultural products that are exported and imported (T-5. 6-8 g.)

Supporting Resources:

Baking Science PowerPoint with muffin recipes:
https://nationalfestivalofbreads.com/sites/default/files/comparing-flours.pdf

Food Source Information: https://fsi.colostate.edu/flour-draft/

Kansas Farm Bureau Kansas wheat poster:
kfb.org/WebsitePageFile/file/d35474eb-cac9-4547-b1ed-61b4d89143dd/part%202%20-%20What's%20Growing%20in%20Kansas%20(1).pdf

Making Bread in the Classroom: Wheat Science Lesson (Bread in a Bag)

YouTube: K-State: Grain Science and Industry:
https://www.youtube.com/watch?v=OmovNdwsV0U

Wheat Byproducts Poster:
https://ksagclassroom.org/supporting-resources/wheat-byproducts/

Wheat Fun Facts Poster: https://ksagclassroom.org/supporting-resources/wheat-fun/

Wheat Growth Cycle Poster:
https://ksagclassroom.org/supporting-resources/wheat-growth/

Wheat Plant Part Labelling:
https://ksagclassroom.org/supporting-resources/wheat-plant/

Career Information: Cereal Chemist

Cereal chemists are specialized food scientists who focus on the structure, chemistry, modification, and functional properties of cereal grains, including wheat, corn, rice, oats, and barley. Their work involves analyzing and improving the quality and performance of grains throughout various stages of processing and consumption. They play a key role in developing nutritious, cost-effective, sustainable grain varieties. Cereal chemists

often collaborate with professionals in agriculture, food manufacturing, consumer goods, and healthcare to enhance the safety, taste, shelf life, and nutritional value of grain-based products. Cereal chemists often require a bachelor's degree in a related field.

Assessment:
Have students complete the questionnaire from Day 1, questions from Day 2, and the Final Product Evaluation from Day 3.

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Name: _____ Date: _____

Flour Experiment Worksheet

1. Which flour is the least stringy or elastic (less gluten)?

_____

2. Which two flours show the most strength (toughest)?

_____ and _____

Ask your teacher for the labels or bags of different types of flour. Read the labels carefully and try to determine which flour is which.

I think...

3. Flour A is _____ because _____

4. Flour B is _____ because _____

5. Flour C is _____ because _____

6. Flour D is _____ because _____

Name: _____ Date: _____

What Do We Know About Wheat?

1. What type of wheat is grown the most in Kansas? _____
2. How is that type of wheat typically used? _____
3. What state grows mostly durum and hard red spring wheat? _____
4. What geographical/climate difference makes the type of wheat farmers choose to grow in Kansas different compared to the state above?

_____

_____

5. What climate differences are there where soft white wheat is grown?

_____

_____

6. What type of wheat has the highest gluten content? _____
7. Why do you think Kansas is number one in wheat exports?

_____

_____

8. Why would you not recommend tasting the flour?

_____

_____

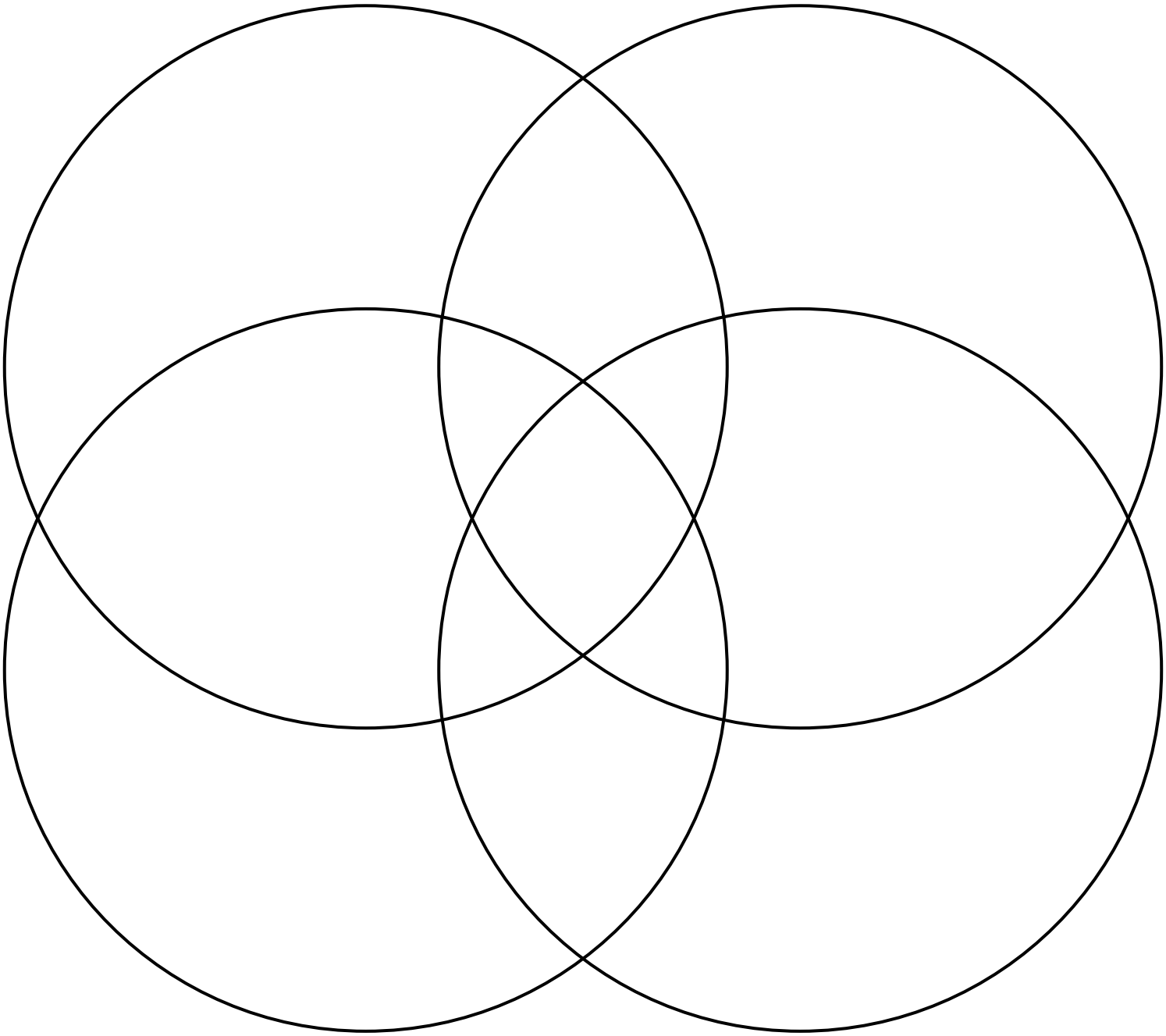
9. What is the newest variety of wheat and what is its purpose? _____

_____

10. What are the three parts of a wheat kernel? _____, _____, _____

What Do We Know About Wheat?

Complete the Venn Diagram to your best ability using the four flour labels.



Final Product Evaluation Form

Flour Type	All Purpose	Bread	Cake	Whole Wheat	Pastry
Visual differences in batter					
Color of baked product					
Texture of baked product					
Moisture rating 1-5 1 low, 5 high					
Flavor rating 1-5 1 low, 5 high					

1. Which of the flours would you use if you chose to make this product again? Why?

_____

_____

2. Which of the flours would you use to make bread? Why?

_____

_____

3. Which of the flours would you use to make cookies? Why?

_____

_____