

GRADE 8 COOKING & FOOD

First edition

8 units

32 lessons · one school year

A video for every lesson

FIRST EDITION

COURSE GUIDE

This course follows eight strands of cooking and food through the last year of the grammar-school ladder: kitchen and food safety, the food groups and the balanced meal, taste and smell, heat and cold, food chemistry, cravings and a balanced way of eating, fire, the grill and spice, and meal planning for the family table. Each unit is built around real people and real moments: John Snow mapping a London neighborhood street by street, the Pillsbury food scientists who planned safe meals for astronauts, Wilbur Atwater measuring the energy in food with a room-sized calorimeter, Brillat-Savarin writing the first great book on the pleasures of the table, Denis Papin sealing bones in his steam digester, Hippolyte Mège-Mouriès answering an emperor's prize, and Howard Moskowitz searching for the bliss point.

Every lesson follows the same path. First comes **the story**. Then **how they figured it out**: the question they faced, what they tried, what they saw and what they learned. Then **the kitchen science**, explained with real vocabulary and a little arithmetic: scaling recipes, cost per serving, grams and ounces, degrees Fahrenheit and Celsius. Last, **let's cook**: the student makes a full recipe for the family, and by the end of the year can plan, shop for and cook whole meals. Food is treated as God's good gift, received with thanks and shared with others. We talk about food in terms of skill, safety, nourishment, thankfulness and hospitality, never in terms of body size or appearance.

The year ends with a family feast: the student plans a three-course menu and a budget, makes a timeline for the day, shops, cooks, sets the table, welcomes the family and gives thanks. The old Latin saying *Fabricando fit faber*, "by making, one becomes a maker," fits the kitchen as well as the workshop: by cooking, one becomes a cook.

Most videos come from trusted public and teaching sources: universities and extension services, the American Chemical Society, TED-Ed, the Smithsonian, America's Test Kitchen, PBS, and careful cooking teachers chosen lesson by lesson. Every video was

previewed for content, accuracy and modest dress. A few history videos show old newspaper headlines or cartoons from the 1800s and early 1900s; the lesson notes mention them. Some channels end with an invitation to subscribe or a short message about their other videos; you can stop the video when the teaching ends. Pause whenever the lesson's note asks the student to predict what will happen next.

Start with Lesson 1.1 →

WHO IT IS FOR

Written for students in grade 8 (about ages 13–14) who read independently, measure accurately, work with fractions, decimals and percentages, and have some kitchen experience. A student new to cooking can begin here; the first unit teaches the safety habits and knife grips from the start. A parent or responsible adult is at home and nearby for all stove and oven work, present for pan-frying and grilling, and lights the grill. Nothing needs to be bought beyond an ordinary kitchen and ordinary groceries; an instant-read food thermometer is the one inexpensive tool we strongly recommend.

HOW TO USE THIS COURSE

1. **The weekly rhythm.** The year has 32 lessons, one a week, in two sessions. Session 1 (about 50–60 minutes) is the warm-up, the video, the teaching and the picture study. Session 2 (about 50–60 minutes, longer for bread and the feast) is the kitchen project: cook the recipe, run the experiment or calculation inside it, clean up, and write in the cook's notebook. In the last week of each unit, add a third session for the unit review and the unit challenge.
2. **An adult supervises all cooking.** A parent or responsible adult supervises every kitchen project in this course. Before cooking, check every recipe and every taste test against your own family's food allergies; each recipe card names the major allergens it contains and offers swaps where they are easy.
3. **The grade 8 safety ladder.** Eighth graders use a chef's knife after practicing the claw and bridge grips with an adult, on a board that cannot slide (a damp towel underneath). Once an adult has watched the student use the stove and oven safely, the student may cook with the adult at home and nearby rather than standing beside. Shallow pan-frying (oil no deeper than about $\frac{1}{4}$ inch) is done

with an adult present. There is no deep frying. At the grill, an adult lights it, and the student may cook on it with an adult beside. Students never handle lighter fluid; none of our recipes need it.

4. **Story, then science, then cooking.** The core ideas are written for the student to read. The paragraphs marked *The story* and *How they figured it out* tell what happened; *The kitchen science* explains what is happening to the food; *Let's cook* names the recipe and the one skill to do well and safely. After reading, have the student explain the science aloud in his or her own words, as if teaching a younger sibling.
5. **Picture study.** Each lesson has one painting or historic photograph of a kitchen, a harvest, a market, a table or a piece of food history. Look at it quietly for two minutes. Then put it away and have the student describe it from memory. Bring it back and work through the “look for” items and questions, which point to the food, the heat, the tools and the people in the picture.
6. **The cook's notebook.** Use one notebook for the whole year. For every recipe, write the date, the recipe in your own words, what you measured and observed, any calculations (scaling, cost, temperatures), a sketch or photo of the finished dish, a family rating, and one thing you would change next time. Then, when you can, cook it again and make that change. Cook it, record it, improve it.
7. **How we talk about food and bodies.** This course never discusses weight or how bodies look. Calories appear only as a unit of food energy, never as something to count or restrict. We call foods “nutrient-dense foods” and “treats,” never “good” or “bad.” Treats and feasts are good gifts in their place. Grades rest on effort, care, safety, cleanliness and improvement.
8. **Groceries.** The recipes use ordinary grocery-store ingredients and feed a family of four to six. Most weeks the kitchen project can be the family's supper, so the course adds little to the grocery bill beyond what the family already buys. Read the recipe card a few days ahead and add its ingredients to the shopping list. Unit 8 teaches the student to plan and price the family's groceries.
9. **Optional books and tools.** Some units list free charts, guides, cookbooks and simple tools. They are extras. Every recipe can be made without them.
10. **Unit review and unit challenge.** Each unit ends with a review (100 points, with a few worked calculations and short written answers) and a unit challenge: something real cooked, served and recorded, such as a food-safety plan for a

family meal, a family taste-memory recipe book, a loaf of bread with a rise log, or a grilled dinner. Keep the challenge pages and photographs in a folder for the year.

11. **The family feast.** In the last week the student plans, budgets, shops for and cooks a three-course meal for the family, using dishes from several units, sets the table, welcomes everyone and leads or joins in giving thanks.

SCOPE AND SEQUENCE

UNIT 1 • WEEKS 1–4

Kitchen & Food Safety

John Snow’s map and the Broad Street pump; good microbes and bad in a pot of homemade yogurt; Upton Sinclair, the Meat Inspection Act and ground meat cooked to 160 °F; and HACCP, the safety system first built for astronaut food, applied to a picnic.

- 1.1 John Snow and the Broad Street Pump
- 1.2 Food Microbes: Good and Bad
- 1.3 Upton Sinclair and the Meat Inspection Act
- 1.4 HACCP and Astronaut Food

UNIT 2 • WEEKS 5–8

Food Groups & the Balanced Meal

Wilbur Atwater and the calorie as a unit of food energy; Elmer McCollum and vitamin A in a sweet-potato soup; fueling growth and sport with carbohydrate, protein and water; and planning a weeknight family dinner with MyPlate.

- 2.1 Wilbur Atwater and the Calorie
- 2.2 Elmer McCollum and Vitamin A
- 2.3 Eating for Growth and Sport
- 2.4 Balanced Meals for a Family

UNIT 3 • WEEKS 9–12

Taste, Smell & Your Taste Buds

Brillat-Savarin's *Physiology of Taste* and a small tasting menu; Ikeda, glutamate and umami in mushroom-parmesan pasta; how taste changes over a lifetime, gathered in a family recipe interview; and texture engineering in a crisp-and-creamy parfait.

- 3.1 Brillat-Savarin and The Physiology of Taste
- 3.2 Umami and Glutamate: Ikeda's Discovery
- 3.3 Taste Buds Over a Lifetime
- 3.4 Texture and Food Engineering

UNIT 5 • WEEKS 17–20

Food Chemistry

Starch retrogradation, stale bread and fried rice; Mège-Mouriès, margarine and the fat layers of a flaky crust; gluten, egg and meat proteins in fresh pasta; and Eduard Buchner, yeast enzymes and an artisan loaf with a rise log.

- 5.1 Starch Retrogradation: Stale Bread and Fried Rice
- 5.2 Mège-Mouriès, Margarine and the Flaky Crust
- 5.3 Proteins: Gluten, Eggs and Fresh Pasta
- 5.4 Yeast Biology and Bread Science

UNIT 4 • WEEKS 13–16

Heat & Cold

Count Rumford, heat as motion and a slow-roasted beef roast; Papin's digester, pressure and a pot of beans; Nicolas Appert, acid, sugar and pectin in a batch of jam; and ice crystals and freezing-point depression in homemade ice cream.

- 4.1 Count Rumford and the Nature of Heat
- 4.2 Denis Papin's Digester and the Pressure Cooker
- 4.3 Nicolas Appert and the Science of Jam
- 4.4 Freezing Science: Ice Crystals and Ice Cream

UNIT 6 • WEEKS 21–24

Cravings, Reward & a Balanced Diet

Howard Moskowitz and the bliss point in a homemade tomato sauce; Olds, Milner and the reward system; satiety, fiber, protein and the satiety index in a grain bowl; and retraining taste buds with a two-week habit challenge.

- 6.1 Howard Moskowitz and the Bliss Point
- 6.2 The Reward System: Wanting, Learning and Habits
- 6.3 Satiety and the Balanced Diet
- 6.4 Habits That Last: Retraining Your Taste Buds

UNIT 7 • WEEKS 25–28

Fire, the Grill & Spice

Nutmeg and the Banda Islands in a roasted squash; American barbecue traditions and a dry-rubbed grilled chicken; smoke, indirect heat and grilled vegetables; and the science of flavor pairing in grilled pork chops with peach salsa.

- 7.1 Nutmeg and the Banda Islands
- 7.2 Barbecue Traditions and the Dry Rub
- 7.3 Smoke, Indirect Heat and Grilled Vegetables
- 7.4 The Science of Flavor Pairing

UNIT 8 • WEEKS 29–32

Meal Planning & the Family Table

Budgeting a month of groceries and cost per serving; a roast chicken planned to become two meals; the Harvey Houses and scaling a recipe for 12; and a three-course family feast the student plans, budgets and cooks.

- 8.1 Budgeting a Month of Groceries
- 8.2 Planning for Leftovers: Gather Up the Fragments
- 8.3 Cooking for a Crowd: The Harvey Houses
- 8.4 The Family Feast

WEEKLY PACING CALENDAR

WEEK	PLAN
1	• Session 1: Lesson 1.1 John Snow and the Broad Street Pump: warm-up, video, teaching and picture study • Session 2: Lesson 1.1 kitchen project (cook the recipe) and cook's notebook <i>Two sessions a week is the usual rhythm: one to learn, one to cook. Younger children can split a long session in two. Cook the week's recipe again at home whenever you can.</i>
2	• Session 1: Lesson 1.2 Food Microbes: Good and Bad: warm-up, video, teaching and picture study • Session 2: Lesson 1.2 kitchen project (cook the recipe) and cook's notebook
3	• Session 1: Lesson 1.3 Upton Sinclair and the Meat Inspection Act: warm-up, video, teaching and picture study • Session 2: Lesson 1.3 kitchen project (cook the recipe) and cook's notebook
4	• Session 1: Lesson 1.4 HACCP and Astronaut Food: warm-up, video, teaching and picture study • Session 2: Lesson 1.4 kitchen project (cook the recipe) and cook's notebook • Session 3: Unit 1 review and unit challenge
5	• Session 1: Lesson 2.1 Wilbur Atwater and the Calorie: warm-up, video, teaching and picture study

WEEK	PLAN
	Session 2: Lesson 2.1 kitchen project (cook the recipe) and cook's notebook
6	- Session 1: Lesson 2.2 Elmer McCollum and Vitamin A: warm-up, video, teaching and picture study - Session 2: Lesson 2.2 kitchen project (cook the recipe) and cook's notebook
7	- Session 1: Lesson 2.3 Eating for Growth and Sport: warm-up, video, teaching and picture study - Session 2: Lesson 2.3 kitchen project (cook the recipe) and cook's notebook
8	- Session 1: Lesson 2.4 Balanced Meals for a Family: warm-up, video, teaching and picture study - Session 2: Lesson 2.4 kitchen project (cook the recipe) and cook's notebook - Session 3: Unit 2 review and unit challenge
9	- Session 1: Lesson 3.1 Brillat-Savarin and The Physiology of Taste: warm-up, video, teaching and picture study - Session 2: Lesson 3.1 kitchen project (cook the recipe) and cook's notebook
10	- Session 1: Lesson 3.2 Umami and Glutamate: Ikeda's Discovery: warm-up, video, teaching and picture study - Session 2: Lesson 3.2 kitchen project (cook the recipe) and cook's notebook
11	- Session 1: Lesson 3.3 Taste Buds Over a Lifetime: warm-up, video, teaching and picture study - Session 2: Lesson 3.3 kitchen project (cook the recipe) and cook's notebook
12	- Session 1: Lesson 3.4 Texture and Food Engineering: warm-up, video, teaching and picture study - Session 2: Lesson 3.4 kitchen project (cook the recipe) and cook's notebook - Session 3: Unit 3 review and unit challenge
13	- Session 1: Lesson 4.1 Count Rumford and the Nature of Heat: warm-up, video, teaching and picture study - Session 2: Lesson 4.1 kitchen project (cook the recipe) and cook's notebook

WEEK	PLAN
14	• Session 1: Lesson 4.2 Denis Papin's Digester and the Pressure Cooker: warm-up, video, teaching and picture study • Session 2: Lesson 4.2 kitchen project (cook the recipe) and cook's notebook
15	• Session 1: Lesson 4.3 Nicolas Appert and the Science of Jam: warm-up, video, teaching and picture study • Session 2: Lesson 4.3 kitchen project (cook the recipe) and cook's notebook
16	• Session 1: Lesson 4.4 Freezing Science: Ice Crystals and Ice Cream: warm-up, video, teaching and picture study • Session 2: Lesson 4.4 kitchen project (cook the recipe) and cook's notebook • Session 3: Unit 4 review and unit challenge
17	• Session 1: Lesson 5.1 Starch Retrogradation: Stale Bread and Fried Rice: warm-up, video, teaching and picture study • Session 2: Lesson 5.1 kitchen project (cook the recipe) and cook's notebook
18	• Session 1: Lesson 5.2 Mège-Mouriès, Margarine and the Flaky Crust: warm-up, video, teaching and picture study • Session 2: Lesson 5.2 kitchen project (cook the recipe) and cook's notebook
19	• Session 1: Lesson 5.3 Proteins: Gluten, Eggs and Fresh Pasta: warm-up, video, teaching and picture study • Session 2: Lesson 5.3 kitchen project (cook the recipe) and cook's notebook
20	• Session 1: Lesson 5.4 Yeast Biology and Bread Science: warm-up, video, teaching and picture study • Session 2: Lesson 5.4 kitchen project (cook the recipe) and cook's notebook • Session 3: Unit 5 review and unit challenge
21	• Session 1: Lesson 6.1 Howard Moskowitz and the Bliss Point: warm-up, video, teaching and picture study • Session 2: Lesson 6.1 kitchen project (cook the recipe) and cook's notebook
22	• Session 1: Lesson 6.2 The Reward System: Wanting, Learning and Habits: warm-up, video, teaching and picture study • Session 2: Lesson 6.2 kitchen project (cook the recipe) and cook's notebook

WEEK	PLAN
23	• Session 1: Lesson 6.3 Satiety and the Balanced Diet: warm-up, video, teaching and picture study • Session 2: Lesson 6.3 kitchen project (cook the recipe) and cook's notebook
24	• Session 1: Lesson 6.4 Habits That Last: Retraining Your Taste Buds: warm-up, video, teaching and picture study • Session 2: Lesson 6.4 kitchen project (cook the recipe) and cook's notebook • Session 3: Unit 6 review and unit challenge
25	• Session 1: Lesson 7.1 Nutmeg and the Banda Islands: warm-up, video, teaching and picture study • Session 2: Lesson 7.1 kitchen project (cook the recipe) and cook's notebook
26	• Session 1: Lesson 7.2 Barbecue Traditions and the Dry Rub: warm-up, video, teaching and picture study • Session 2: Lesson 7.2 kitchen project (cook the recipe) and cook's notebook
27	• Session 1: Lesson 7.3 Smoke, Indirect Heat and Grilled Vegetables: warm-up, video, teaching and picture study • Session 2: Lesson 7.3 kitchen project (cook the recipe) and cook's notebook
28	• Session 1: Lesson 7.4 The Science of Flavor Pairing: warm-up, video, teaching and picture study • Session 2: Lesson 7.4 kitchen project (cook the recipe) and cook's notebook • Session 3: Unit 7 review and unit challenge
29	• Session 1: Lesson 8.1 Budgeting a Month of Groceries: warm-up, video, teaching and picture study • Session 2: Lesson 8.1 kitchen project (cook the recipe) and cook's notebook
30	• Session 1: Lesson 8.2 Planning for Leftovers: Gather Up the Fragments: warm-up, video, teaching and picture study • Session 2: Lesson 8.2 kitchen project (cook the recipe) and cook's notebook
31	• Session 1: Lesson 8.3 Cooking for a Crowd: The Harvey Houses: warm-up, video, teaching and picture study • Session 2: Lesson 8.3 kitchen project (cook the recipe) and cook's notebook

WEEK	PLAN
32	• Session 1: Lesson 8.4 The Family Feast: warm-up, video, teaching and picture study • Session 2: Lesson 8.4 kitchen project (cook the recipe) and cook's notebook • Session 3: Unit 8 review and unit challenge <i>Last week. Hold a family feast: the student plans the menu, shops with a parent, cooks a balanced meal with a dish from several units, sets the table, says grace with the family and shows the cook's notebook.</i>

MATERIALS

Cook's notebook (any notebook)

One for the whole year: recipes in your own words, observations, calculations, taste charts, sketches, family ratings and “what I would change next time.”

An instant-read food thermometer

The one tool we strongly recommend. Used from the first lesson to check soup, meat, eggs, yogurt, jam and leftovers.

A refrigerator thermometer

Optional and inexpensive. Leave it in the fridge to check that it stays at or below 40 °F (4 °C).

Measuring cups (dry and liquid), measuring spoons and a kitchen scale that reads in grams

Used in every recipe. The scale is especially helpful for bread, pasta and pie crust.

A chef's knife, a paring knife, a vegetable peeler and two cutting boards

One board for raw meat and one for ready-to-eat foods. Put a damp towel under the board so it cannot slide.

A large skillet, a large pot and a medium saucepan with lids, a Dutch oven or heavy oven-safe pot, a rimmed baking sheet, a loaf pan and oven mitts

Ordinary kitchen equipment for the stovetop and oven recipes.

Mixing bowls, a whisk, a wooden spoon, a spatula, a colander, a rolling pin and clean jars with lids

For mixing, draining, rolling dough and storing.

Clean dish towels, dish soap and paper towels

Cleanup is part of every recipe.

A timer, a calculator and a camera or phone

For timing, scaling and pricing recipes, and photographing finished dishes and unit challenges.

GRADING

Grades come mostly from the kitchen projects and the cook's notebook, because cooking is learned by doing, recording and trying again. A dish that flops but is honestly recorded and then made again with one improvement earns full credit.

PART	%
Kitchen projects (effort, safety, cleanliness and the improve round)	40
Cook's notebook (recipes in your own words, observations, calculations, taste charts)	20
Unit reviews	15
Unit challenges	25

Scale: A 90–100, B 80–89, C 70–79, D 60–69. Below 60: cook the recipe or redo the review again with help.

- Grade the cook, not the dish. Did the student wash up first, follow the safety steps, measure carefully, observe and record honestly, check temperatures, clean up, and try an improvement?
- A notebook page earns full marks when it has a date, the recipe in the student's own words, at least one observation or measurement, any calculation the lesson asks for with its work shown, a sketch or photo, a family rating and one sentence about what to change.
- A dish that flops but is honestly recorded and tried again earns full credit. A cracked pie crust or a flat loaf teaches as much as a perfect one.
- In the unit reviews, show the work for every calculation. A correct method with a small arithmetic slip earns most of the points.
- Never grade or comment on anyone's body, size or how much they ate. Grades rest on effort, care, safety, cleanliness and improvement.

A NOTE TO PARENTS

You do not need to be a chef to teach this course. Read the lesson, watch the video together, and then be the student's kitchen partner. In eighth grade your role shifts: once you have watched your student use the knife, stove and oven safely, step back and let him or her run the kitchen while you remain at home and nearby, coming in close for pan-frying, the grill and anything new. Keep asking the two questions every good cooking teacher asks: "What do you think will happen?" and "Why do you think it happened?"

Expect some flops. Crusts will crack, bread will come out flat, a sauce will scorch. Cooks learn by tasting, noticing and trying again, and the course is built so that a recorded mistake and a second try earn full credit. By the end of the year your student should be able to plan, price and cook a balanced dinner for the family on his or her own, which is a real gift to a household. *Fabricando fit faber*: by making, one becomes a maker.

Food in this course is a good gift to be received with thanks and shared. We keep the conversation on skill, nourishment, thankfulness and hospitality, never on weight or appearance, and we name foods neutrally as "nutrient-dense foods" and "treats." Teenagers are growing fast and need plenty of good food. Food allergies and any special medical needs belong to your family and your doctor: please read each recipe card's allergen note and make the swaps your family needs.

UNIT 1

KITCHEN & FOOD SAFETY

Every safe kitchen runs on habits that someone, somewhere, had to discover. In this unit you will follow four of those discoveries. You will walk the streets of London in 1854 with John Snow as he traced a deadly outbreak to a single water pump, and you will learn to think like a food-safety detective. You will meet the friendly bacteria that turn milk into yogurt and learn how to tell them apart from the harmful ones. You will read how one novel in 1906 led to federal meat inspection, and why ground meat must reach 160 °F. And you will see how food scientists making meals for astronauts invented a safety system called HACCP that nearly every food company in America uses today.

This is also the unit where your kitchen freedoms grow. Eighth graders use a chef's knife after practicing the claw and bridge grips with an adult, and once an adult has watched you cook safely at the stove and oven, you may cook with the adult at home and nearby instead of standing at your elbow. That freedom rests on the habits in this unit: clean hands and boards, raw meat kept apart, a thermometer in the thickest part, and leftovers in the refrigerator within two hours.

PREREQUISITES

- Can measure dry and liquid ingredients with cups and spoons
- Can read a thermometer in degrees Fahrenheit
- Can convert between °F and °C with a formula ($^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$), or is ready to learn
- A parent or responsible adult ready to supervise and to watch the student's first knife and stove work

MASTERY CHECKLIST

- ☐ I can tell how John Snow traced the 1854 Broad Street outbreak to a water pump, and explain how food-safety investigators still use his method of mapping cases.
- ☐ I can explain the difference between helpful microbes, like yogurt cultures, and pathogens, and make yogurt safely by controlling temperature.
- ☐ I can explain why ground meat must reach 160 °F but whole cuts only 145 °F with a rest, and check meat with a thermometer in the thickest part.
- ☐ I can name the seven steps of HACCP and use them to write a safety plan for a picnic or packed meal.
- ☐ I can use a chef's knife with the claw and bridge grips, keep raw meat separate, and chill leftovers within 2 hours (1 hour above 90 °F).

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **Partnership for Food Safety Education: Fight BAC!**: Free. Printable charts of the four steps (Clean, Separate, Cook, Chill) and safe internal temperatures. Tape one inside a cupboard door; you will use it all year.
- **An instant-read food thermometer**: The one tool this course strongly recommends. A digital one that reads in a few seconds is easiest to use.
- **A refrigerator thermometer**: Inexpensive. Leave it on a middle shelf to check that your refrigerator stays at or below 40 °F (4 °C). Used in the unit challenge.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

1.1 John Snow and the Broad Street Pump

2 sessions of 50–60 minutes

1.2 Food Microbes: Good and Bad

2 sessions of 50–60 minutes (plus 6–8 hours of resting time)

1.3 Upton Sinclair and the Meat Inspection Act

2 sessions of 50–60 minutes

1.4 HACCP and Astronaut Food

2 sessions of 50–60 minutes

UNIT 1 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**

Describe the steps John Snow used to trace the 1854 Broad Street outbreak. Name at least three.

2. **8 pts**

How do modern food-safety investigators use Snow's method? Give one tool they have that he did not.

3. **8 pts**

Explain how yogurt bacteria turn milk into yogurt. Use the words lactose, lactic acid and protein.

4. **8 pts**

Predict: you add the yogurt starter while the milk is still 160 °F. What will happen, and why?

5. **8 pts**

What did *The Jungle* lead to in 1906? Name both laws.

6. **10 pts**

Why must a hamburger reach 160 °F, while a whole steak is safe at 145 °F with a 3-minute rest?

7. **8 pts**

Calculation: convert 160 °F to degrees Celsius. Use $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$.

8. **8 pts**

Name the seven principles of HACCP.

9. **8 pts**

For a picnic chicken salad, name one critical control point and its critical limit.

10. **10 pts**

Calculation: your family sets out the potato salad at 12:40 p.m. on a 94 °F afternoon. By what time must it go back in the cooler or be thrown away? What if the day were 80 °F?

11. **8 pts**

Calculation: the chicken noodle soup serves 6. How much chicken and how many cups of broth do you need to make it for 9? (The recipe uses 1½ pounds of chicken and 8 cups of broth.)

12. **8 pts**

Short answer: In three or four sentences, explain why it is wrong to judge whether ground meat is cooked by its color, and what you should do instead.

ANSWER KEY

1. He counted the deaths (using the registrar's list), interviewed families about where they got their water, marked each death on a map, noticed the cluster around the Broad Street pump and the exceptions (the workhouse with its own well, the woman who had Broad Street water carried to her), and presented the evidence so the pump handle was removed.
2. They interview sick people, map the cases, look for a food they all shared, and test that food. Modern tools include DNA fingerprinting of bacteria to link cases in different states, and laboratory testing of the food.
3. The bacteria eat lactose, the sugar in milk, and make lactic acid. The acid makes the milk proteins (casein) unfold and link into a soft gel, so the milk thickens and sets, and it tastes tangy.
4. The milk will probably not set into yogurt, because temperatures that high kill the yogurt bacteria. The milk must cool to about 110–115 °F first.
5. Readers were shocked by how meat was handled, and on June 30, 1906, the Meat Inspection Act (federal inspectors in meat plants) and the Pure Food and Drug Act (no falsely labeled or unsafe food and drugs) were passed and signed.
6. Bacteria on meat live mostly on the outside surface. Searing a whole steak destroys them on the surface even if the center is pink. Grinding mixes surface bacteria all through the meat, so the center of ground meat must reach 160 °F.
7. $(160 - 32) \times \frac{5}{9} = 128 \times \frac{5}{9} = \frac{640}{9} \approx 71.1$ °C, about 71 °C.
8. (1) Conduct a hazard analysis; (2) identify critical control points; (3) set critical limits; (4) monitor; (5) set corrective actions; (6) verify the plan works; (7) keep records.
9. Examples: cooking the chicken, 165 °F in the thickest part; holding the salad cold, at or below 40 °F in the cooler; time out of the cooler, no more than 2 hours (1 hour above 90 °F).
10. Above 90 °F the limit is 1 hour, so by 1:40 p.m. On an 80 °F day the limit is 2 hours, so by 2:40 p.m.
11. Scale factor $9 \div 6 = 1.5$. Chicken: $1.5 \times 1.5 = 2.25$ pounds (2¼ pounds). Broth: $8 \times 1.5 = 12$ cups.
12. Ground meat can turn brown inside before it reaches a safe temperature, and some safely cooked meat stays pink. So color does not tell you whether bacteria

have been destroyed. Use a food thermometer in the thickest part and cook ground beef, pork and lamb to 160 °F (ground poultry to 165 °F).

UNIT CHALLENGE: A FAMILY FOOD-SAFETY PLAN

Choose one full family meal that includes raw meat or poultry (for example, the chicken noodle soup or the meatloaf with two side dishes). Write a HACCP plan for the whole meal, from the grocery store to the leftovers, with hazards, critical control points, critical limits, monitoring and corrective actions.

Then carry out a kitchen inspection: check and record the refrigerator and freezer temperatures (at or below 40 °F and 0 °F), the cutting boards, the hand-washing station and how leftovers are stored. Cook the meal following your plan, keep a record sheet of every temperature and time, and finish with a one-paragraph report of what worked and what you would change.

LOOK FOR	WHAT IT MEANS
HACCP plan	Every step from shopping to leftovers is covered, with correct USDA critical limits and sensible corrective actions.
Kitchen inspection	Refrigerator and freezer temperatures recorded honestly; boards, sink and storage checked; at least one improvement made.
Safe cooking	Raw meat kept separate, temperatures checked with a thermometer, leftovers chilled within 2 hours, kitchen cleaned completely.
Records	A neat record sheet with real times and temperatures, and calculations shown where needed.
Reflection	An honest report naming what worked, what did not, and one change for next time; a meal that had problems but is well recorded earns full credit.

1.1 JOHN SNOW AND THE BROAD STREET PUMP

OBJECTIVES

- Tell how John Snow traced the 1854 Broad Street cholera outbreak to a contaminated water pump, and why his method was new.
- Explain how modern food-safety investigators use the same steps (count the cases, map them, find what they share, test the idea) to trace outbreaks.
- Use a chef's knife safely with the claw and bridge grips, and cook a pot of chicken noodle soup with the chicken checked at 165 °F.

Warm-up. Imagine that six people in your neighborhood got sick on the same weekend. Write down three questions you would ask each of them to find out what made them sick. Keep your list; you will compare it with John Snow's questions.

WATCH

John Snow and the 1854 Broad Street cholera outbreak

Harvard Online • 8:02

<https://www.youtube.com/watch?v=INjrAXGRda4>

WHEN TO WATCH

After the story and before the kitchen science. Watch for the moment Snow's map shows the cluster of cases around the pump.

Note: From a Harvard course on the Broad Street outbreak, filmed in Soho, London. It shows two famous cartoons from the 1850s and 1860s that picture cholera as a skeleton, which was how newspapers of the time drew deadly disease, and an old engraving of a sick man. The video speaks plainly about deaths, as the story requires.

KEY TERMS

outbreak

Two or more people getting the same illness from the same source, such as one food, one meal or one water supply.

epidemiology

The science of finding out who gets sick, where and when, and why. John Snow is often called one of its founders.

pathogen

A germ that causes illness, such as certain bacteria, viruses and parasites. Cholera is caused by the bacterium *Vibrio cholerae*.

contaminated

Made unsafe by germs or harmful substances that should not be there.

simmer

To cook a liquid just below boiling, with small bubbles rising gently at the edges, about 185–205 °F (85–96 °C).

CORE IDEAS

The story. In late August 1854, cholera broke out in Soho, a crowded neighborhood of London. Within about ten days more than 500 people who lived near Broad Street had died, and many families fled. Most doctors of the day believed cholera spread through “miasma,” a bad smell in the air from rotting waste. Dr. John Snow, a London physician best known for his careful work with anesthesia, did not agree. Five years earlier he had published a paper arguing that cholera spread through water that had been dirtied by the waste of sick people.

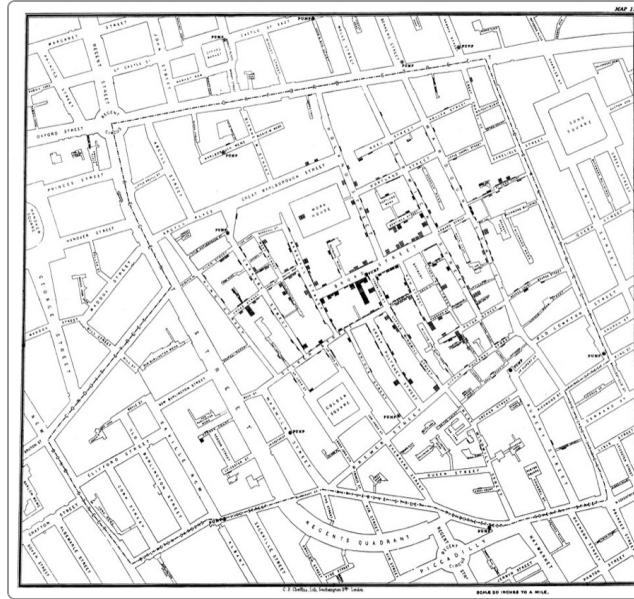
How they figured it out. Snow went door to door. He got a list of the dead from the registrar and asked families where they drew their water. Then he marked each death on a street map as a small black bar. The bars piled up around one public pump on Broad Street. He also noticed the exceptions: a workhouse nearby with its own well had very few deaths, while a widow who lived miles away but had Broad Street water carried to her because she liked its taste fell ill. On September 7, 1854, Snow presented his evidence to the parish board, and the next day the handle of the pump was removed. Later, a local minister, the Reverend Henry Whitehead, who had first doubted Snow, found that a leaking cesspool only a few feet from the well had carried waste from a sick baby’s home into the water. Snow did not have a microscope image of the germ; he solved the case with careful counting, mapping and reasoning.

The kitchen science. Today the same detective method protects our food. When people across the country get the same illness, health departments and the CDC interview the sick, map the cases, look for the food they share, and then test that food. DNA fingerprinting of bacteria lets them link a sick person in Ohio to one in

Oregon. Most outbreaks in kitchens come from a few causes: unwashed hands, water or produce that carried germs, raw meat touching ready-to-eat food, food not cooked hot enough, and food left too long in the **danger zone**, 40–140 °F (4–60 °C), where bacteria can double in as little as 20 minutes. Heat is our strongest tool: poultry is safe at 165 °F (74 °C), a temperature that destroys *Salmonella* almost instantly.

Let's cook. You will make a pot of chicken noodle soup from scratch. The skill to do well is **chef's-knife work**: the claw grip (fingertips curled under, knuckles guiding the blade) to dice onion, carrot and celery, and the bridge grip (thumb and fingers on either side, the blade passing under the bridge) to halve round vegetables safely first. You will check the chicken with a thermometer, cool the leftovers quickly, and think like an investigator: at every step, where could a germ get in, and what stops it?

PICTURE STUDY



Map of Cholera Deaths around Broad Street, Soho, John Snow (drawn and engraved by Charles Cheffins), 1854 · Printed map, from Snow's book *On the Mode of Communication of Cholera* (second edition, 1855) · Many copies; this one is reproduced on Wikimedia Commons

Image: [Wikimedia Commons](#), public domain

This is one of the most famous maps ever drawn. John Snow marked each cholera death in the 1854 outbreak with a small black bar beside the house where it happened. Look how a picture made from simple counting can show something that words alone cannot.

Look closely

- Find Broad Street and the pump marked on it. Where are the black bars thickest?
- Find a street where there are almost no bars, even though it is close by. What might explain it?
- Look for other pumps marked on the map. Why does it matter that people near those pumps had few deaths?
- Each bar is one person. Choose one short stretch of street and count the bars.

Talk about it

1. How is Snow's map like the questions you wrote in the warm-up? What did he ask that you did not?

2. If you mapped the sick people in a modern food outbreak, what would you be looking for them to share?
3. Snow was right, but many experts did not believe him for years. Why is careful evidence important even when people disagree?

Safety first. A parent or responsible adult supervises all cooking in this course, and every family checks each recipe against its own food allergies before cooking. Use the chef's knife only after practicing the claw and bridge grips with an adult watching, on a board that cannot slide (a damp towel underneath). Raw chicken goes on its own board; wash hands, the board and the knife in hot, soapy water after touching it.

KITCHEN PROJECT

Think Like an Investigator: Chicken Noodle Soup

You will cook a family pot of chicken noodle soup and, as you go, keep an “investigator’s log”: every place in the recipe where a germ could get in or grow, and the step that stops it. This is how food-safety professionals think, and it is the habit this whole unit builds.

You will need

- A large pot (5–6 quarts) with a lid
- Two cutting boards (one for vegetables, one for raw chicken), a damp towel and a chef’s knife
- A wooden spoon, a ladle, two forks and a clean plate
- Measuring cups and spoons
- An instant-read food thermometer
- Shallow containers with lids for leftovers

CHICKEN NOODLE SOUP FROM SCRATCH

Serves 6 (about 12 cups) • Prep 25 min • Cook 40 min

Ingredients

- 1½ pounds (680 g) boneless, skinless chicken thighs
- 1 tablespoon olive oil
- 1 large onion
- 3 carrots
- 3 ribs celery
- 3 cloves garlic, minced
- 1 teaspoon dried thyme
- 1 bay leaf
- 8 cups (2 L) low-sodium chicken broth
- 3 cups (about 6 ounces, 170 g) wide egg noodles
- 2 tablespoons chopped fresh parsley

- 1 tablespoon lemon juice
- Salt and black pepper to taste (start with ½ teaspoon salt)

Method

1. Wash your hands for 20 seconds. Rinse the carrots and celery under cool running water.
2. On the vegetable board, peel the onion, halve it with the bridge grip, lay it flat side down, and dice it with the claw grip. Peel and slice the carrots into ¼-inch coins and the celery into ¼-inch slices.
3. Heat the oil in the pot over medium heat. Add the onion, carrots and celery and cook, stirring now and then, 6–8 minutes, until the onion is soft. Add the garlic and thyme and stir for 30 seconds.
4. Pour in the broth and add the bay leaf. Turn the heat to high and bring to a boil, then lay the chicken thighs straight from the package into the pot (do not rinse them). Wash your hands.
5. Lower the heat so the soup simmers gently. Cover partly and cook 15–20 minutes, until the thickest piece of chicken reads 165 °F (74 °C) on the thermometer.
6. Lift the chicken onto a clean plate with tongs. Add the noodles to the pot and simmer 6–8 minutes, until tender. Meanwhile shred the chicken with two forks.
7. Return the chicken to the pot. Remove the bay leaf. Stir in the parsley and lemon juice, then taste and add salt and pepper a little at a time.
8. Serve hot. Within 2 hours, divide leftovers into shallow containers, cover and refrigerate. Reheat to 165 °F before eating. Clean up: wash boards, knife and pot in hot, soapy water and wipe the counters.

Allergy check: Contains wheat and eggs (in the egg noodles). For a wheat- and egg-free soup, use 1 cup of uncooked rice (simmer it 15–18 minutes) or a gluten-free pasta. Check your broth label for other allergens. Celery is not one of the nine major U.S. allergens but is a common allergy elsewhere.

Steps

1. **Investigator's log.** Before you cook, draw a two-column chart: “Where a germ could get in or grow” and “What stops it.” Fill in at least five rows as you read

the recipe (for example: raw chicken juice on the board / separate board and hot, soapy wash).

2. **Knife check.** Have an adult watch you dice the onion. Ask the adult to note whether your fingertips stayed curled and the board stayed still. Write down one thing to improve.
3. **Cook the recipe.** Record the temperature of the chicken when you first check it and when it reaches 165 °F, and how many minutes it took.
4. **Cooling test.** Put 2 cups of leftover soup in a shallow container and 2 cups in a tall, narrow one. After 1 hour in the refrigerator, take the temperature of the center of each. Which one left the danger zone faster? Why?
5. **Taste test.** Ask each family member to rate the soup from 1 to 5 for flavor, saltiness and texture of the noodles.
6. **Improve it.** Write one change for next time (more lemon, a different herb, egg noodles cooked separately so they stay firmer in the leftovers).
7. **Clean up:** wash, dry and put away everything, and wipe the stove top once it is cool.

Tips

- Thighs stay juicier than breasts in soup and are harder to overcook.
- If you plan to have leftovers for several days, cook the noodles separately and add them to each bowl, so they do not soak up all the broth.
- The fastest way to cool a big pot of soup is to divide it into shallow containers. Never leave a whole pot on the stove to cool overnight.

Check your work

- ☐ I can tell how John Snow traced the outbreak and how investigators use his method today.
- ☐ I diced vegetables with the claw and bridge grips while an adult watched.
- ☐ I cooked the chicken to 165 °F and chilled the leftovers within 2 hours.

COOK'S NOTEBOOK

1. Copy your investigator's log neatly. Star the step you think matters most and explain why.

2. Draw a simple map of your own kitchen. Mark the “raw meat zone,” the “ready-to-eat zone,” the sink and the refrigerator. Where do the paths of raw and ready-to-eat food cross?
3. Convert three temperatures to Celsius and show your work: 40 °F, 140 °F and 165 °F.

From history. Snow also carried out what he called his “grand experiment.” In south London, two water companies piped water to homes on the same streets: one drew it from the River Thames below the city’s sewage, the other upstream. Snow showed that homes supplied with the dirtier water had many times more cholera deaths. The bacterium that causes cholera was described by the Italian scientist Filippo Pacini in 1854 and studied in detail by Robert Koch in 1883.

COMMON MISTAKES

- Rinsing raw chicken in the sink. It does not remove bacteria; it splashes them onto the sink, the counter and you.
- Judging chicken by its color. Check it with a thermometer in the thickest part.
- Leaving a big pot of soup on the stove to cool. A deep pot stays in the danger zone for hours; divide it into shallow containers.

Make it a game • Find the Pump. Draw a street map on paper. While you look away, your parent marks eight cases with beans, clustered around one hidden pump spot. Study the map, then name where the pump must be. Now recite John Snow's four steps from memory: count the cases, map them, find what they share, test the idea. Swap roles and try again.

1.2 FOOD MICROBES: GOOD AND BAD

OBJECTIVES

- Tell how Stamen Grigorov identified the main yogurt bacterium in 1905 and how Élie Metchnikoff made yogurt famous.
- Explain how helpful bacteria turn milk into yogurt (fermentation, lactic acid, and proteins that set) and why pathogens cannot grow well in it.
- Make homemade yogurt by controlling temperature with a thermometer, and keep a temperature log.

Warm-up. Read the label on a carton of plain yogurt. Find the words “live and active cultures” and the names of the bacteria. Then answer: if bacteria can make people sick, why would anyone put them in food on purpose? Write your best guess.

WATCH

The Science of Yogurt: Why the Best Yogurt is Homemade | What's Eating Dan?

America's Test Kitchen • 7:54

<https://www.youtube.com/watch?v=fqvouttKjZ0>

WHEN TO WATCH

After the kitchen-science paragraph and before you make your yogurt. Watch for the two bacteria and the temperatures Dan uses.

Note: From America’s Test Kitchen’s food-science series. It names Stamen Grigorov and shows yogurt incubating in an oven with the light on, the method in our recipe.

BACKUP VIDEO

Why Are There Bacteria In My Yogurt?

SciShow • 3:29

<https://www.youtube.com/watch?v=Xs2xGeu6fHc>

A quick second explanation of the two yogurt bacteria and lactic acid.

KEY TERMS

microbe

A living thing too small to see without a microscope, such as a bacterium, a yeast or a mold.

culture

A batch of living microbes grown on purpose. A spoonful of yogurt with live cultures can start a new batch.

incubate

To keep something at a steady warm temperature so microbes can grow.

fermentation

A process in which microbes break down sugars without needing oxygen and make new substances, such as lactic acid in yogurt or carbon dioxide in bread.

lactic acid

The acid yogurt bacteria make from lactose, the sugar in milk. It makes yogurt tangy and thick and keeps many harmful germs from growing.

CORE IDEAS

The story. Shepherds and farm families around the Balkan Mountains, Turkey and the Middle East have made soured, thickened milk for thousands of years. In 1905 a young Bulgarian medical student named Stamen Grigorov, working in a laboratory in Geneva, Switzerland, looked at yogurt from his home country under the microscope and identified a rod-shaped bacterium that soured the milk. It was later named *Lactobacillus bulgaricus* in honor of Bulgaria. Two years later Élie Metchnikoff, a scientist at the Pasteur Institute in Paris who won a Nobel Prize in 1908 for his work on the body's defenses against germs, wrote that the soured milk eaten in Bulgaria might help people stay healthy. His books made yogurt famous across Europe.

How they figured it out. Grigorov grew the bacteria by themselves in fresh milk and showed that they alone could turn milk into yogurt. Scientists later found that yogurt is made best by two bacteria working together: *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Each one helps the other grow faster. Today the U.S. Food and Drug Administration says that any food sold as “yogurt” must be made with these two cultures.

The kitchen science. Not every microbe is an enemy. Yogurt bacteria eat lactose, the sugar in milk, and turn it into **lactic acid**. As the acid builds up, the milk's main protein, casein, which normally floats in tiny separate clusters, loses its electric charge, unfolds and links into a soft gel: the milk sets. The acid also protects the yogurt: harmful bacteria such as *Listeria* and *Salmonella* grow poorly when the food is this sour, which is why fermented foods kept people fed long before refrigerators. Temperature decides which microbes win. Heating the milk to about 180 °F (82 °C) first kills stray bacteria and unfolds some whey proteins so the yogurt will be thicker. Then the milk must cool to 110–115 °F (43–46 °C), the yogurt bacteria's favorite temperature, before you add the starter; much hotter, and you would kill the cultures you want. Pathogens need the same care in reverse: we keep cold food at or below 40 °F and cook food hot enough to destroy them.

Let's cook. You will make a quart of homemade yogurt and serve it with fruit. The skill to do well is **temperature control**: heating milk gently without scorching it, cooling it to the right range, and holding it warm for 6–8 hours. You will keep a temperature log the way a food scientist would.

PICTURE STUDY



Louis Pasteur, Albert Edelfelt, 1885 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

The Finnish painter Albert Edelfelt painted Louis Pasteur in his laboratory in Paris. Pasteur showed that fermentation is the work of living microbes and that heat could destroy harmful ones. Metchnikoff, who made yogurt famous, later worked at the institute that bears Pasteur's name.

Look closely

- Find the glass jar in Pasteur's hand. What do you think he is looking for inside it?
- Look at the flasks and bottles on the table. Why would a scientist studying microbes need so many separate, closed containers?
- Find the notebooks and papers. Why does a scientist write down every result?
- Where is the light coming from? Why would a scientist work near a window?

Talk about it

1. Pasteur kept harmful microbes out of his flasks; a yogurt maker lets helpful ones in. How are these two jobs alike?
2. Your temperature log is like Pasteur's notebook. What could go wrong with your yogurt if you did not measure?

3. Why do you think Edelfelt painted a scientist at work instead of posing him in fine clothes?

Safety first. Use only pasteurized milk. Hot milk can scorch and boil over quickly, so stay at the stove, stir often, keep the handle turned in, and have an adult at home and nearby. Throw out any batch that smells rotten, turns pink or grows fuzzy mold; when in doubt, throw it out.

KITCHEN PROJECT

Grow a Good Culture: Homemade Yogurt

You will turn a quart of milk into yogurt using a few spoonfuls of store yogurt as your starter. Along the way you will log temperatures and times, test the yogurt's tang and thickness, and compare a batch made correctly with what the label calls "live and active cultures."

You will need

- A heavy-bottomed medium saucepan
- A whisk or heat-proof spatula
- An instant-read food thermometer
- A clean 1-quart glass jar or bowl with a lid (or four 1-cup jars), washed in hot, soapy water
- Your oven (light only) or a small cooler and a few jars of warm water
- A clock or timer

HOMEMADE PLAIN YOGURT WITH FRUIT

Serves 4 (about 1 quart) · Prep 30 min · Incubate 6–8 hr · Chill 3 hr

Ingredients

- 4 cups (1 quart, 946 mL) pasteurized whole or 2% milk
- 2 tablespoons plain yogurt with "live and active cultures" on the label, at room temperature
- **To serve:** 2 cups berries or chopped fruit
- Honey or maple syrup, to drizzle (optional)

Method

1. Wash your hands. Pour the milk into the saucepan and heat it over medium heat, stirring often and scraping the bottom, until it reaches 180 °F (82 °C) and steams with tiny bubbles at the edge, about 10–15 minutes. Do not let it boil over.
2. Turn off the heat and hold the milk at about 180 °F for 2 minutes, stirring. Then move the pan to a cool burner.

3. Let the milk cool, stirring now and then, until it reads 110–115 °F (43–46 °C), about 30–40 minutes. To speed it up, set the pan in a sink of cold water and stir.
4. Put the 2 tablespoons of starter yogurt in a small bowl and whisk in about ½ cup of the warm milk until smooth. Stir this back into the pan.
5. Pour the milk into the clean jar and cover it. Set it in the oven with only the oven light turned on (the oven itself stays off), or in a small cooler with jars of 120 °F water around it. Leave it still for 6–8 hours. Put a note on the oven door so no one turns it on.
6. After 6 hours, tilt the jar gently. If the yogurt has set like soft custard and pulls away from the side in one piece, it is done. If not, wait 1–2 more hours.
7. Refrigerate the yogurt at least 3 hours; it thickens as it chills. Serve with fruit and a drizzle of honey if you like. Save 2 tablespoons as the starter for your next batch within a week.
8. Clean up: soak the saucepan right away; milk proteins stick hard once they dry.

Allergy check: Contains milk. Lactose-free milk works for people who cannot digest lactose but not for a milk allergy. Honey is never given to babies under one year; use maple syrup if a baby will eat this.

Steps

1. **Predict.** Write down what you think will happen to the milk's thickness, smell and taste during incubation.
2. **Temperature log.** Make a table with columns for time and temperature. Record the milk's temperature every 5 minutes while heating and cooling, the exact time you add the starter, and the oven or cooler temperature at the start and end if you can.
3. **Set test.** Check the jar at 4, 6 and 8 hours. At each check, describe how it moves when tilted.
4. **Tang and texture test.** Taste a spoonful of your yogurt and a spoonful of store-bought plain yogurt side by side. Rate each from 1 to 5 for sourness, thickness and smoothness.

5. **Think it through.** In two or three sentences, explain why the milk had to be cooled to 110–115 °F before adding the starter, and what might happen at 150 °F or at 75 °F.
6. **Improve it.** Plan one change for your next batch (a longer incubation for more tang, straining it through a coffee filter for Greek-style yogurt, or whole milk instead of 2%).
7. Clean up: wash the pan, whisk and thermometer in hot, soapy water.

Tips

- A heavy pot and medium heat keep the milk from scorching on the bottom.
- For thicker yogurt, strain it in a colander lined with a coffee filter in the refrigerator for 1–2 hours. The yellow liquid that drains out is whey; it can go into pancakes or bread.
- Homemade yogurt keeps about 1–2 weeks in the refrigerator.

Check your work

- ☐ I can explain how yogurt bacteria turn milk into yogurt and why the acid protects it.
- ☐ I kept a temperature log and held the milk in the right range.
- ☐ I can tell the difference between a helpful culture and a pathogen.

COOK'S NOTEBOOK

1. Draw a timeline of your yogurt from cold milk to finished yogurt, with the temperature at each step and what is happening to the bacteria and the proteins.
2. Make a two-column chart: “Microbes we use on purpose” (yogurt, cheese, bread, sauerkraut) and “Microbes we keep out” (*Salmonella*, *Listeria*, *E. coli* O157:H7). For each pathogen, write one way we stop it.
3. Copy the recipe in your own words, and write what you would change next time.

From history. Grigorov later returned to Bulgaria and worked as a doctor. Bulgaria still honors him with a small museum of yogurt in his home village of Studen Izvor. Cheese, sour cream, buttermilk, sauerkraut and sourdough bread are all made with the help of friendly microbes too.

COMMON MISTAKES

- Adding the starter while the milk is still too hot. Temperatures much above 120 °F (49 °C) can kill the cultures, and the milk never sets.

- Stirring or moving the jar during incubation. The gel is forming; let it sit still.
- Using a starter yogurt with no live cultures, or one with added flavors and thickeners. Use plain yogurt whose label says “live and active cultures.”

Make it a game · Two Truths and a Culture. Take turns telling your parent three claims about yogurt microbes. Two are true; one is a tall tale. Use Grigorov, Metchnikoff, lactic acid, protein setting and why pathogens struggle in yogurt. Your parent guesses the tall tale and explains why. Score a point for each correct catch. Play three rounds each.

1.3 UPTON SINCLAIR AND THE MEAT INSPECTION ACT

OBJECTIVES

- Tell how Upton Sinclair’s 1906 novel *The Jungle* led Congress to pass the Meat Inspection Act and the Pure Food and Drug Act on the same day.
- Explain why ground meat must be cooked to 160 °F while a whole steak or roast is safe at 145 °F with a 3-minute rest.
- Bake a family meatloaf and prove it is done with a thermometer, not by its color.

Warm-up. Look at a package of ground beef or chicken (or a picture of one online with an adult). Find the round USDA inspection mark and the “Safe Handling Instructions” box. Copy what the box says. Who do you think decided that every package must carry it, and why?

WATCH

Alton Brown Makes His Good Eats Meatloaf | Food Network

Food Network · 4:47

<https://www.youtube.com/watch?v=tsyXL8zKTrM>

WHEN TO WATCH

After the kitchen science and before you cook. Watch how Alton mixes the meat gently and how he checks the temperature at the end.

Note: A short segment from *Good Eats*. Our recipe is simpler and is baked in a loaf pan or on a sheet pan.

BACKUP VIDEO

The Importance of Cooking to a Safe Internal Temperature and How to Use a Food Thermometer

USDAFoodSafety · 3:17

<https://www.youtube.com/watch?v=-2KkV2yFiN0>

Watch before you cook to review where to place the thermometer and the safe temperatures for each kind of meat.

KEY TERMS

inspection

A careful official check. Since 1906, federal inspectors have checked meat sold across state lines; today they work for the USDA's Food Safety and Inspection Service.

ground meat

Meat chopped very fine by a grinder, which mixes any bacteria from the surface all through the meat.

internal temperature

The temperature at the center or thickest part of a food, measured with a food thermometer.

carryover cooking

The rise in temperature that continues after meat leaves the heat, because the hot outside keeps warming the cooler center.

panade

A paste of bread or crumbs soaked in milk that keeps meatloaf and meatballs moist and tender. Say it "puh-NAHD."

CORE IDEAS

The story. In 1904 a young writer named Upton Sinclair spent seven weeks in the stockyards and packing plants of Chicago, which then sent meat all over the country. He wanted to write a novel about the hard lives of the families, many newly arrived from Europe, who worked there. His book, *The Jungle*, came out in 1906, and it did describe their hardships, but readers were most shocked by a few pages about how meat was handled: spoiled meat sold anyway, filthy floors, and no one checking. Sinclair later said that he aimed at the public's heart and "by accident I hit it in the stomach."

How they figured it out. Sales of American meat dropped, at home and abroad. The President sent two trusted investigators to Chicago to see whether the book was true. Their report confirmed many of the problems. On June 30, 1906, Congress passed and the President signed two laws on the same day: the Meat Inspection Act, which put federal inspectors in meat plants that ship across state lines, and the Pure Food and Drug Act, which banned falsely labeled and unsafe foods and medicines. Food safety in America has kept improving since. In 1993 an outbreak of a dangerous

strain of *E. coli* was traced to undercooked hamburgers; soon afterward the USDA ruled that this strain was not allowed in ground beef, added safe-handling labels to raw meat packages, and taught the country to use thermometers.

The kitchen science. Bacteria that may be on meat live mostly on the *outside* surface. When you sear or roast a whole steak, roast or chop, the hot surface destroys them, even if the inside is still pink. That is why whole cuts of beef, pork, veal and lamb are safe at 145 °F (63 °C) with a 3-minute rest. Grinding changes that: the outside is mixed all through the meat, so the center of a burger or meatloaf must get hot enough to destroy bacteria too. Ground beef, pork and lamb must reach 160 °F (71 °C), and ground chicken and turkey 165 °F (74 °C). Color is not a safe test. Ground meat can turn brown inside before it reaches 160 °F, and some safely cooked meat stays pink. Only a thermometer in the thickest part tells the truth. Meat also keeps cooking after it leaves the oven (**carryover cooking**), often rising 5 degrees or more in a large loaf, and resting lets the juices settle so they do not run out when you slice.

Let's cook. You will make a classic glazed meatloaf for the family. The skill to do well is **handling raw ground meat cleanly**: mixing with clean hands or a fork just until combined (overmixing makes it tough), keeping it on its own board and bowl, washing up right away, and proving it done with a thermometer.

PICTURE STUDY



The Kitchen Maid, Jean-Siméon Chardin, 1738 · Oil on canvas · National Gallery of Art, Washington, D.C.

Image: [Wikimedia Commons](#), public domain

Chardin, a French painter of quiet household scenes, shows a kitchen maid preparing vegetables for the family's meal. In 1738 there were no inspection stamps, no labels and no refrigerators. A cook had to judge the freshness of everything that came into her kitchen with her own eyes and nose, and cook it the same day.

Look closely

- Find the knife and the turnips. What job is she in the middle of, and why are the peeled turnips kept in water?
- Find the chopping block and the cleaver. What do you think was cut there?
- Look at her face. Is she tired, thinking, or listening to someone?
- Find the copper pot. How would she know when the food in it was cooked through?

Talk about it

1. How did a cook in 1738 decide whether meat from the market was safe to eat? How do you decide today?
2. The same block was probably used for meat and vegetables. What would a modern food-safety inspector say about that?

3. Chardin painted a servant with the dignity of a portrait. What does that tell you about how he saw ordinary work?

Safety first. Keep raw ground meat in its own bowl and on its own board, and wash your hands for 20 seconds after touching it and before touching anything else. Never taste raw meat mixture. The meatloaf is done only when the center reads 160 °F (71 °C); use oven mitts, and have an adult at home and nearby while you use the oven.

KITCHEN PROJECT

Prove It with a Thermometer: Classic Glazed Meatloaf

You will bake a meatloaf and track its center temperature as it cooks and as it rests, so you can see carryover cooking for yourself. You will also test the old idea that “brown inside means done.”

You will need

- A large mixing bowl and a fork, or clean hands
- A 9 × 5-inch loaf pan or a rimmed baking sheet lined with foil
- A small bowl and a spoon for the glaze
- A cutting board, a damp towel and a chef’s knife for the onion
- Measuring cups and spoons
- An instant-read food thermometer and oven mitts

CLASSIC GLAZED MEATLOAF

Serves 6–8 • Prep 20 min • Bake 60–70 min • Rest 10 min

Ingredients

- $\frac{3}{4}$ cup (about 85 g) plain dry breadcrumbs
- $\frac{1}{2}$ cup (120 mL) milk
- 2 large eggs
- 1 small onion, very finely diced (about $\frac{3}{4}$ cup)
- 2 cloves garlic, minced
- 1 teaspoon dried thyme or Italian seasoning
- 1 teaspoon salt and $\frac{1}{2}$ teaspoon black pepper
- 1 tablespoon Worcestershire sauce
- 2 pounds (900 g) ground beef (85% lean), or 1 pound ground beef and 1 pound ground pork
- **Glaze:** $\frac{1}{2}$ cup ketchup
- 2 tablespoons brown sugar
- 1 tablespoon apple cider vinegar

Method

1. Heat the oven to 350 °F (175 °C). Wash your hands.
2. In the large bowl, stir the breadcrumbs and milk together and let them soak 5 minutes to make a panade.
3. Add the eggs, onion, garlic, thyme, salt, pepper and Worcestershire sauce and stir well.
4. Add the ground meat. Mix gently with a fork or clean hands just until everything is evenly combined, about 1 minute. Wash your hands for 20 seconds.
5. Press the mixture into the loaf pan, or shape it into a 9 × 5-inch loaf on the lined baking sheet (a free-form loaf browns on more sides).
6. Stir the glaze ingredients together and spread half over the top. Bake 45 minutes.
7. Spread on the rest of the glaze and bake 15–25 minutes more, until a thermometer pushed into the center of the loaf reads 160 °F (71 °C).
8. Let the meatloaf rest 10 minutes before slicing. Pour off any fat into a can (not the sink). Refrigerate leftovers within 2 hours. Clean up: wash the bowl, board, knife and thermometer in hot, soapy water and wipe every surface the raw meat touched.

Allergy check: Contains milk, eggs and wheat (breadcrumbs). Most Worcestershire sauce contains anchovies (fish). For a wheat-free loaf, use $\frac{2}{3}$ cup quick oats or gluten-free crumbs; for milk-free, use broth instead of milk; check your Worcestershire label or leave it out.

Steps

1. **Predict.** Write down how many degrees you think the center will rise during the 10-minute rest.
2. **Temperature log.** Starting at 45 minutes, check the center every 5 minutes and record it. Note the time it reaches 160 °F.
3. **Carryover test.** Leave the thermometer in (or check again) at 5 and 10 minutes after the loaf leaves the oven. How much did the temperature rise?
4. **Color is not a test.** When you slice the loaf, look at the center. Is it brown, gray or a little pink? Write a sentence explaining why color cannot tell you whether ground meat is safe.

5. **Taste test.** Ask your family to rate the loaf for moistness, flavor and glaze from 1 to 5.
6. **Improve it.** Write one change for next time: a free-form loaf instead of a pan, more vegetables (grated carrot or zucchini) in the mix, or a different glaze.
7. Clean up completely, then do a “raw meat sweep”: list every surface and tool the raw meat touched and check that each one was washed.

Tips

- Grating the onion on a box grater, or dicing it very fine, keeps the loaf from falling apart.
- A free-form loaf on a sheet pan cooks a little faster than one in a loaf pan; start checking early.
- Leftover meatloaf makes excellent sandwiches. Reheat slices to 165 °F, or eat them cold the next day if they were refrigerated promptly.

Check your work

- ☐ I can explain how

Th led to the Meat Inspection Act in 1906.

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- ☐ I can explain why ground meat needs 160 °F but a whole roast needs 145 °F and a rest.
- ☐ I proved my meatloaf was done with a thermometer and measured carryover cooking.

COOK'S NOTEBOOK

1. Draw two cross-sections: a whole steak and a hamburger. Use dots to show where bacteria might be before cooking in each, and explain why the safe temperatures differ.
2. Graph your meatloaf's center temperature against time, from 45 minutes to the end of the rest. Mark 160 °F with a line.
3. Copy the USDA Safe Handling Instructions from a meat package in your own words, and explain the reason for each one.

From history. Before 1906, a few cities and the federal government inspected some meat, mostly animals for export, but there was no national system. Today USDA inspectors are present in every meat and poultry plant that sells across state lines. The Pure Food and Drug Act was largely the work of Harvey Wiley, a government chemist who had campaigned for safe, honestly labeled food for more than twenty years; the agency that grew from his work is today's FDA.

COMMON MISTAKES

- Cutting into the meatloaf to see if it is done. You lose juices, and color does not tell you. Use a thermometer.
- Overmixing the meat. It packs the proteins tightly and makes a tough, dense loaf; mix just until combined.
- Using the same platter for raw and cooked meat. Use a clean one for serving.

Make it a game • Call the Temperature. Your parent writes ten foods on slips: ground beef, steak, meatloaf, roast, and so on. Draw one at a time and call its safe temperature and rest rule within five seconds. Then give one sentence on what Upton Sinclair's book changed. Count your correct answers, then beat that score in a second round.

1.4 HACCP AND ASTRONAUT FOOD

OBJECTIVES

- Tell how Pillsbury food scientists, working with NASA in the 1960s, invented HACCP to make astronaut food safe.
- Name and explain the seven principles of HACCP, including critical control points and critical limits.
- Write a HACCP-style plan for a picnic lunch, then cook and pack the lunch so it stays out of the danger zone.

Warm-up. Imagine you are packing lunch for three astronauts on a two-week trip to the Moon. There is no refrigerator, no stove and no doctor. Write down three things that could go wrong with the food and one way to prevent each.

WATCH

The History of Space Food

Smithsonian National Air and Space Museum • 2:23

https://www.youtube.com/watch?v=kivw3nnSt_8

WHEN TO WATCH

After the story. Look for the bite-size cubes and the coatings that kept crumbs from floating around the spacecraft.

Note: A short tour of real space food in the Smithsonian's collection.

BACKUP VIDEO

What is HACCP? | Food Safety 101

Safe Food Alliance • 4:09

<https://www.youtube.com/watch?v=tu5FLi70rAI>

After the kitchen science, to review the seven principles as food companies use them.

KEY TERMS

HACCP

Hazard Analysis and Critical Control Points: a system for preventing food-safety problems by finding where hazards can enter and controlling them at key steps. Say it “HASS-ip.”

hazard

Anything in food that could cause harm: biological (germs), chemical (cleaners, allergens) or physical (glass, bone, metal).

critical control point

A step where control is essential to prevent or remove a hazard, such as cooking chicken to 165 °F or cooling food quickly.

critical limit

The exact line that must be met at a critical control point, such as “at or below 40 °F” or “165 °F in the thickest part.”

corrective action

What you do when a critical limit is not met, such as cooking longer, re-chilling, or throwing food away.

CORE IDEAS

The story. In 1959 the Pillsbury Company, famous for flour and baking mixes, was asked to help make food for America’s first astronauts. A Pillsbury scientist named Howard Bauman led the work, together with NASA and the U.S. Army’s food laboratories in Natick, Massachusetts. The problems were new. Crumbs floating in weightlessness could get into an astronaut’s eyes or the spacecraft’s instruments, so the team made bite-size cubes coated to hold crumbs in. And the food had to be as close to perfectly safe as possible: an astronaut sick from contaminated food, days from home, could put a whole mission at risk.

How they figured it out. The usual way to check food was to test samples of the finished product. Bauman’s team realized that to be sure about every bite, they would have to test so much food that almost none would be left to eat. So they turned the problem around. Instead of testing at the end, they studied every step of making the food, asked what could go wrong at each one, and set strict controls at the steps that mattered most, with measurements and records. Pillsbury presented the system to the public in 1971 as HACCP. In the 1990s the FDA and USDA began requiring it for

seafood, meat and poultry plants, and today it is used by food companies, school kitchens and restaurants around the world.

The kitchen science. HACCP has seven principles: (1) **analyze hazards** at each step; (2) find the **critical control points**; (3) set a **critical limit** for each, a number you can measure; (4) **monitor** it; (5) decide on **corrective actions** if the limit is missed; (6) **verify** that the plan works; and (7) **keep records**. For a picnic, the hazards are mostly bacteria growing in perishable food. The critical limits come from the USDA: cooked chicken reaches 165 °F; cold food stays at or below 40 °F (4 °C) in a cooler with ice or frozen gel packs; and perishable food spends no more than 2 hours out of the cooler, or 1 hour when the air is above 90 °F (32 °C). After that, it goes in the trash. A full cooler stays cold longer than a half-empty one, and a separate cooler for drinks keeps the food cooler's lid closed.

Let's cook. You will cook and pack a chicken pasta salad with a lemon vinaigrette for a family picnic or a packed lunch. The skill to do well is **cooling cooked food fast** and packing a cooler so that food stays at or below 40 °F, and you will write a short HACCP plan before you start. A vinaigrette with no mayonnaise is a good picnic choice, but every pasta salad with chicken is perishable and needs the cooler.

PICTURE STUDY



Rita Rapp with Apollo 16 Food Containers, NASA photographer, 1972 · Photograph · NASA Johnson Space Center, Houston, Texas

Image: [Wikimedia Commons](#), public domain

Rita Rapp was a NASA physiologist who led the team that planned and packed the astronauts' food during the Apollo missions to the Moon. She worked to make the food safe, nourishing and good enough that the astronauts would actually eat it. Here she sits with the packaged meals for Apollo 16, which flew in April 1972.

Look closely

- Look at how the food packets are arranged. Why would every meal be laid out in order and labeled?
- Find the clear packaging. Why might sealed, single-serving packs be safer than a large container?
- Look for labels or tags. What information would an astronaut need on each packet?
- What does the neat, organized table tell you about how carefully this food was planned?

Talk about it

1. Where in this photograph can you see HACCP thinking at work: a hazard controlled, a record kept, a step checked?

2. Space food had to be safe without a refrigerator. Which foods on your picnic are safe without one, and which are not?
3. Rita Rapp also cared whether the food tasted good. Why does flavor matter even for astronauts?

Safety first. Cook the chicken to 165 °F (74 °C) and cool it and the pasta quickly in shallow containers in the refrigerator. Pack perishable food in a cooler with ice or frozen gel packs at or below 40 °F, and throw it away if it has been out of the cooler more than 2 hours (1 hour above 90 °F). An adult is at home and nearby while you cook on the stove.

KITCHEN PROJECT

A HACCP Plan for a Picnic: Lemon Chicken Pasta Salad

You will write a one-page HACCP plan for a family picnic or a packed lunch, then cook, chill and pack the meal exactly as your plan says, checking temperatures and keeping records. At the end you will verify the plan by measuring the food's temperature when you unpack it.

You will need

- A large pot and a colander
- A large skillet with a lid
- Two cutting boards (one for raw chicken), a damp towel and a chef's knife
- A jar with a tight lid for the dressing
- Shallow containers with lids, a cooler, and ice or frozen gel packs
- An instant-read food thermometer and a refrigerator thermometer (or a second food thermometer for the cooler)

LEMON CHICKEN PASTA SALAD

Serves 6 • Prep 25 min • Cook 25 min • Chill 1 hr

Ingredients

- 12 ounces (340 g) rotini or other short pasta
- 1 pound (450 g) boneless, skinless chicken breasts or thighs
- 1 tablespoon olive oil, plus ½ teaspoon salt and ¼ teaspoon pepper for the chicken
- 1 cucumber
- 1 red or yellow bell pepper
- 1 pint (2 cups) cherry tomatoes
- ¼ red onion (optional)
- ½ cup (75 g) crumbled feta cheese (optional)
- 2 tablespoons chopped fresh parsley or basil
- **Lemon vinaigrette:** ⅓ cup (80 mL) olive oil
- ¼ cup (60 mL) lemon juice (about 2 lemons)

- 1 teaspoon Dijon mustard
- 1 clove garlic, minced
- 1 teaspoon dried oregano
- ½ teaspoon salt and ¼ teaspoon black pepper

Method

1. Wash your hands. Cook the pasta in a large pot of boiling salted water according to the package, until just tender. Drain it, rinse it with cold water to stop the cooking and cool it, and spread it in a shallow container in the refrigerator.
2. On the raw-meat board, pat the chicken dry and season it with salt and pepper. Wash your hands.
3. Heat the oil in the skillet over medium heat. Cook the chicken 5–7 minutes per side, until the thickest part reads 165 °F (74 °C). Move it to a clean plate, let it cool 10 minutes, then dice it on a clean board and refrigerate it in a shallow container.
4. On the vegetable board, use the bridge grip to halve the cucumber lengthwise and the tomatoes, then dice the cucumber and bell pepper with the claw grip. Mince the red onion if using.
5. Shake the vinaigrette ingredients in the jar until creamy.
6. When the pasta and chicken are cold (40 °F or below), toss them with the vegetables, feta, herbs and vinaigrette. Taste and adjust the salt and lemon.
7. Pack the salad in a shallow container in the cooler, with ice or gel packs below and on top. Keep the cooler in the shade with the lid closed.
8. Clean up: wash both boards, the knife and the skillet in hot, soapy water and wipe the counters.

Allergy check: Contains wheat (pasta) and milk (feta). Dijon mustard is not one of the nine major U.S. allergens, but check the label. For wheat-free, use a gluten-free pasta; for milk-free, leave out the feta or use olives.

Steps

1. **Write the plan.** Before you cook, make a HACCP table with columns: Step · Hazard · Critical control point? · Critical limit · How I will monitor ·

Corrective action. Include at least these steps: raw chicken handling, cooking the chicken, cooling, packing, holding at the picnic, and leftovers.

2. Cook and chill the recipe, filling in a record sheet with every temperature and time you measure.
3. **Cooler test.** Put a thermometer (or a cup of water with a thermometer in it) inside the cooler next to the salad. Record the temperature when you pack, when you arrive, and every 30 minutes until you eat.
4. **Verify.** When you serve, measure the salad's temperature. Did it stay at or below 40 °F? If not, which step in your plan failed, and what would you change?
5. **Taste test.** Ask your family to rate the salad from 1 to 5 for flavor and freshness.
6. **Improve it.** Write one change to the plan and one to the recipe.
7. Clean up: empty and wash the cooler, and refrigerate or throw away any leftovers according to your plan.

Tips

- Freeze a few water bottles to use as ice packs; they become cold drinks later in the day.
- Pack the cooler in reverse order: what you will eat last goes on the bottom.
- Pasta keeps soaking up dressing. Save a few tablespoons of vinaigrette to stir in just before serving.

Check your work

- ☐ I can tell how HACCP began with astronaut food and name its seven principles.
- ☐ I wrote a HACCP plan with critical limits and followed it.
- ☐ I kept my picnic food at or below 40 °F and recorded the temperatures.

COOK'S NOTEBOOK

1. Copy your final HACCP table neatly, with your actual measurements filled in.
2. Draw a cross-section of your packed cooler, labeling where the ice, the salad and the thermometer were.

3. Write a paragraph comparing testing the finished food with controlling each step. Why did Bauman's team choose the second way?

From history. Space food has come a long way. John Glenn, the first American to orbit the Earth in 1962, ate applesauce squeezed from a tube. By Apollo, astronauts had spoon-bowl packages they could fill with hot water. Today astronauts on the International Space Station eat from a menu of more than a hundred items, and each crew member helps choose his or her own meals.

COMMON MISTAKES

- Mixing warm pasta or chicken with the other ingredients and packing it right away. Chill each part first; warm food heats up the whole container and the cooler.
- Opening the cooler again and again. Keep drinks in a separate cooler.
- Bringing leftovers home after they sat out too long. If the food has been out of the cooler more than 2 hours (1 hour above 90 °F), throw it away.

Make it a game • Plan the Picnic. Your parent names a picnic hazard: chicken salad in the sun, a cooler with no ice, a cutting board shared with raw meat. You call out the critical control point, the critical limit and the corrective action. Then recite all seven HACCP principles in order. Each missed principle earns your parent a point.

Scripture. “A prudent man foreseeth the evil, and hideth himself; but the simple pass on, and are punished.” (Proverbs 22:3, KJV)

HACCP is prudence in the kitchen: looking ahead to what could go wrong and preparing for it, instead of hoping for the best.

UNIT 1

KITCHEN & FOOD SAFETY

Every safe kitchen runs on habits that someone, somewhere, had to discover. In this unit you will follow four of those discoveries. You will walk the streets of London in 1854 with John Snow as he traced a deadly outbreak to a single water pump, and you will learn to think like a food-safety detective. You will meet the friendly bacteria that turn milk into yogurt and learn how to tell them apart from the harmful ones. You will read how one novel in 1906 led to federal meat inspection, and why ground meat must reach 160 °F. And you will see how food scientists making meals for astronauts invented a safety system called HACCP that nearly every food company in America uses today.

This is also the unit where your kitchen freedoms grow. Eighth graders use a chef's knife after practicing the claw and bridge grips with an adult, and once an adult has watched you cook safely at the stove and oven, you may cook with the adult at home and nearby instead of standing at your elbow. That freedom rests on the habits in this unit: clean hands and boards, raw meat kept apart, a thermometer in the thickest part, and leftovers in the refrigerator within two hours.

PREREQUISITES

- Can measure dry and liquid ingredients with cups and spoons
- Can read a thermometer in degrees Fahrenheit
- Can convert between °F and °C with a formula ($^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$), or is ready to learn
- A parent or responsible adult ready to supervise and to watch the student's first knife and stove work

MASTERY CHECKLIST

- ☐ I can tell how John Snow traced the 1854 Broad Street outbreak to a water pump, and explain how food-safety investigators still use his method of mapping cases.
- ☐ I can explain the difference between helpful microbes, like yogurt cultures, and pathogens, and make yogurt safely by controlling temperature.
- ☐ I can explain why ground meat must reach 160 °F but whole cuts only 145 °F with a rest, and check meat with a thermometer in the thickest part.
- ☐ I can name the seven steps of HACCP and use them to write a safety plan for a picnic or packed meal.
- ☐ I can use a chef's knife with the claw and bridge grips, keep raw meat separate, and chill leftovers within 2 hours (1 hour above 90 °F).

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **Partnership for Food Safety Education: Fight BAC!**: Free. Printable charts of the four steps (Clean, Separate, Cook, Chill) and safe internal temperatures. Tape one inside a cupboard door; you will use it all year.
- **An instant-read food thermometer**: The one tool this course strongly recommends. A digital one that reads in a few seconds is easiest to use.
- **A refrigerator thermometer**: Inexpensive. Leave it on a middle shelf to check that your refrigerator stays at or below 40 °F (4 °C). Used in the unit challenge.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

1.1 John Snow and the Broad Street Pump

2 sessions of 50–60 minutes

1.2 Food Microbes: Good and Bad

2 sessions of 50–60 minutes (plus 6–8 hours of resting time)

1.3 Upton Sinclair and the Meat Inspection Act

2 sessions of 50–60 minutes

1.4 HACCP and Astronaut Food

2 sessions of 50–60 minutes

UNIT 1 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. (8 pts)

Describe the steps John Snow used to trace the 1854 Broad Street outbreak. Name at least three.

2. (8 pts)

How do modern food-safety investigators use Snow's method? Give one tool they have that he did not.

3. (8 pts)

Explain how yogurt bacteria turn milk into yogurt. Use the words lactose, lactic acid and protein.

4. (8 pts)

Predict: you add the yogurt starter while the milk is still 160 °F. What will happen, and why?

5. (8 pts)

What did *The Jungle* lead to in 1906? Name both laws.

6. (10 pts)

Why must a hamburger reach 160 °F, while a whole steak is safe at 145 °F with a 3-minute rest?

7. **8 pts**

Calculation: convert 160 °F to degrees Celsius. Use $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$.

8. **8 pts**

Name the seven principles of HACCP.

9. **8 pts**

For a picnic chicken salad, name one critical control point and its critical limit.

10. **10 pts**

Calculation: your family sets out the potato salad at 12:40 p.m. on a 94 °F afternoon. By what time must it go back in the cooler or be thrown away? What if the day were 80 °F?

11. **8 pts**

Calculation: the chicken noodle soup serves 6. How much chicken and how many cups of broth do you need to make it for 9? (The recipe uses 1½ pounds of chicken and 8 cups of broth.)

12. **8 pts**

Short answer: In three or four sentences, explain why it is wrong to judge whether ground meat is cooked by its color, and what you should do instead.

ANSWER KEY

1. He counted the deaths (using the registrar's list), interviewed families about where they got their water, marked each death on a map, noticed the cluster around the Broad Street pump and the exceptions (the workhouse with its own well, the woman who had Broad Street water carried to her), and presented the evidence so the pump handle was removed.
2. They interview sick people, map the cases, look for a food they all shared, and test that food. Modern tools include DNA fingerprinting of bacteria to link cases in different states, and laboratory testing of the food.
3. The bacteria eat lactose, the sugar in milk, and make lactic acid. The acid makes the milk proteins (casein) unfold and link into a soft gel, so the milk thickens and sets, and it tastes tangy.
4. The milk will probably not set into yogurt, because temperatures that high kill the yogurt bacteria. The milk must cool to about 110–115 °F first.
5. Readers were shocked by how meat was handled, and on June 30, 1906, the Meat Inspection Act (federal inspectors in meat plants) and the Pure Food and Drug Act (no falsely labeled or unsafe food and drugs) were passed and signed.
6. Bacteria on meat live mostly on the outside surface. Searing a whole steak destroys them on the surface even if the center is pink. Grinding mixes surface bacteria all through the meat, so the center of ground meat must reach 160 °F.
7. $(160 - 32) \times \frac{5}{9} = 128 \times \frac{5}{9} = \frac{640}{9} \approx 71.1$ °C, about 71 °C.
8. (1) Conduct a hazard analysis; (2) identify critical control points; (3) set critical limits; (4) monitor; (5) set corrective actions; (6) verify the plan works; (7) keep records.
9. Examples: cooking the chicken, 165 °F in the thickest part; holding the salad cold, at or below 40 °F in the cooler; time out of the cooler, no more than 2 hours (1 hour above 90 °F).
10. Above 90 °F the limit is 1 hour, so by 1:40 p.m. On an 80 °F day the limit is 2 hours, so by 2:40 p.m.
11. Scale factor $9 \div 6 = 1.5$. Chicken: $1.5 \times 1.5 = 2.25$ pounds (2¼ pounds). Broth: $8 \times 1.5 = 12$ cups.
12. Ground meat can turn brown inside before it reaches a safe temperature, and some safely cooked meat stays pink. So color does not tell you whether bacteria

have been destroyed. Use a food thermometer in the thickest part and cook ground beef, pork and lamb to 160 °F (ground poultry to 165 °F).

UNIT CHALLENGE: A FAMILY FOOD-SAFETY PLAN

Choose one full family meal that includes raw meat or poultry (for example, the chicken noodle soup or the meatloaf with two side dishes). Write a HACCP plan for the whole meal, from the grocery store to the leftovers, with hazards, critical control points, critical limits, monitoring and corrective actions.

Then carry out a kitchen inspection: check and record the refrigerator and freezer temperatures (at or below 40 °F and 0 °F), the cutting boards, the hand-washing station and how leftovers are stored. Cook the meal following your plan, keep a record sheet of every temperature and time, and finish with a one-paragraph report of what worked and what you would change.

LOOK FOR	WHAT IT MEANS
HACCP plan	Every step from shopping to leftovers is covered, with correct USDA critical limits and sensible corrective actions.
Kitchen inspection	Refrigerator and freezer temperatures recorded honestly; boards, sink and storage checked; at least one improvement made.
Safe cooking	Raw meat kept separate, temperatures checked with a thermometer, leftovers chilled within 2 hours, kitchen cleaned completely.
Records	A neat record sheet with real times and temperatures, and calculations shown where needed.
Reflection	An honest report naming what worked, what did not, and one change for next time; a meal that had problems but is well recorded earns full credit.

UNIT 2

FOOD GROUPS & THE BALANCED MEAL

Food is God's good gift, and He made it wonderfully varied: grains and beans, roots and leaves, fruit, milk, eggs, fish and meat, each carrying something the body needs. In this unit you will learn how scientists discovered what is inside our food. You will meet Wilbur Atwater, who measured the energy in food with a calorimeter big enough for a man to live in for days, and Elmer McCollum, who found the first vitamin hiding in butterfat. You will learn how carbohydrate, protein, fat, vitamins, minerals and water each serve a growing, active body.

Then you will put it together the way a cook does, in real meals: a breakfast bowl, a bright sweet-potato soup, a pasta dinner to fuel a game day, and a weeknight family dinner planned with MyPlate. In this course a calorie is simply a unit of food energy, like a gallon is a unit of gasoline. We never count or cut calories. A growing teenager needs plenty of good food, and the goal is a balanced way of eating that gives thanks and serves others.

PREREQUISITES

- Knows the danger zone and safe internal temperatures (Unit 1)
- Uses a chef's knife with the claw and bridge grips (Unit 1)
- Can multiply and divide decimals and fractions
- Can read a Nutrition Facts label (or is ready to learn)

MASTERY CHECKLIST

- ☐ I can explain what a food Calorie is and how Atwater found that carbohydrate and protein give about 4 Calories per gram and fat about 9.
- ☐ I can tell how McCollum and Davis discovered vitamin A, name foods rich in it, and explain why it needs a little fat to be absorbed.
- ☐ I can explain how carbohydrate, protein and water fuel growth and sport, and plan a pre-game meal.
- ☐ I can plan and cook a family dinner that fills a MyPlate with all five food groups.
- ☐ I can scale a recipe and estimate the energy in a food from its grams of carbohydrate, protein and fat.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **MyPlate.gov (USDA):** Free. The USDA's site for the five food groups, with a recipe collection and printable planning sheets. Used in Lessons 2.3 and 2.4.
- **FDA: How to Understand and Use the Nutrition Facts Label:** Free. A clear guide to every line on the label. Helpful for Lesson 2.1.
- **A digital kitchen scale:** Weighing foods in grams makes the energy calculations in Lesson 2.1 easy and is useful for the rest of the year.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

2.1 Wilbur Atwater and the Calorie	2 sessions of 50–60 minutes
2.2 Elmer McCollum and Vitamin A	2 sessions of 50–60 minutes
2.3 Eating for Growth and Sport	2 sessions of 50–60 minutes
2.4 Balanced Meals for a Family	2 sessions of 50–60 minutes

UNIT 2 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. 8 pts

What is a food Calorie? Explain using kilograms of water and degrees Celsius.

2. 8 pts

Describe how Atwater's respiration calorimeter worked.

3. 10 pts

Calculation: a granola bar has 29 g carbohydrate, 4 g protein and 7 g fat. Use the Atwater factors to estimate its energy.

4. 8 pts

What did McCollum and Davis discover in 1913, and how did they find it?

5. (8 pts)

Why does a carrot soup made with a little butter and cooked until soft give the body more vitamin A than plain raw carrots?

6. (8 pts)

What is glycogen, and what did the Swedish cycling studies of the 1960s show about it?

7. (8 pts)

Plan a pre-game meal (3–4 hours before) and a recovery snack. Explain each choice.

8. (8 pts)

Name the five MyPlate groups and one important nutrient each one gives.

9. (10 pts)

Calculation: the sheet-pan dinner uses 2 pounds of chicken for 6 people. How much chicken is that per person in ounces? How many pounds would you need for 9 people?

10. (8 pts)

Calculation: convert the oven temperature 425 °F to °C.

11. (8 pts)

Who wrote the USDA's first food guide, when, and how many groups did it have?

12. (8 pts)

Short answer: In three or four sentences, explain why this course treats a calorie as a unit of energy rather than something to count, and what we look at instead.

ANSWER KEY

1. A food Calorie (kilocalorie) is the amount of heat energy needed to raise the temperature of 1 kilogram of water by 1 °C.
2. A volunteer lived for days in a small sealed, insulated chamber. Water flowing through pipes carried away the body's heat; measuring how much the water warmed measured the energy given off. The scientists also weighed all food and measured oxygen used and carbon dioxide breathed out.
3. $29 \times 4 = 116$; $4 \times 4 = 16$; $7 \times 9 = 63$. $116 + 16 + 63 = 195$ Calories (about 190–200).
4. They found “fat-soluble A” (vitamin A). Young rats fed lard or olive oil stopped growing, but rats fed butterfat or egg-yolk fat grew; changing only the fat showed that those fats carried a needed substance.
5. Beta-carotene is fat-soluble, so a little fat helps the body absorb it. Cooking softens the cell walls and puréeing breaks them open, releasing more of the beta-carotene.
6. Glycogen is the stored form of carbohydrate in muscles and liver. The studies showed riders became exhausted when muscle glycogen ran low, and that meals rich in carbohydrate in the days before let muscles store more glycogen and ride much longer.
7. Example: spaghetti with turkey meat sauce, bread and fruit (mostly carbohydrate, some protein, not too greasy or high in fiber); recovery: chocolate milk or a turkey sandwich (carbohydrate to refill glycogen, protein to repair muscle). Water throughout.
8. Vegetables (vitamin A, fiber), fruits (vitamin C, potassium), grains (energy, B vitamins, fiber), protein (protein, iron), dairy (calcium, vitamin D). Other correct nutrients accepted.
9. 2 pounds = 32 ounces; $32 \div 6 \approx 5.3$ ounces per person. For 9 people: $2 \times 9 = 18$ pounds.
10. $(425 - 32) \times \frac{5}{9} = 393 \times \frac{5}{9} \approx 218$ °C, about 220 °C.
11. Caroline Hunt, in 1916 (*Food for Young Children*), with five groups.
12. A calorie only measures energy; it says nothing about vitamins, minerals, protein or fiber. Growing teenagers need plenty of energy and nutrients, so cutting or counting is not the goal. Instead we look at the whole plate: variety from all five groups, mostly nutrient-dense foods, regular meals, and treats in their place.

UNIT CHALLENGE: A WEEK OF BALANCED FAMILY DINNERS

Plan five weeknight family dinners on MyPlate drawings, each with all five food groups and at least three different protein foods across the week (for example, chicken, beans, eggs or fish). Write a grocery list for the week.

Cook at least two of the dinners yourself, with a timeline for each. Photograph or sketch each plate, collect a family rating, and write a short paragraph on what went well and what you would change.

LOOK FOR	WHAT IT MEANS
Balanced plans	Five dinners, each filling all five groups, with half the plate fruits and vegetables and variety across the week.
Grocery list	Complete, organized by store section, with amounts.
Cooking	Two dinners cooked safely with timelines, correct temperatures and a clean kitchen.
Records	Photos or sketches, family ratings and honest notes.
Reflection	Names what worked and one improvement; a dinner that had problems but is well recorded earns full credit.

2.1 WILBUR ATWATER AND THE CALORIE

OBJECTIVES

- Tell how Wilbur Atwater measured the energy in food in the 1890s, and explain what a food Calorie is.
- Use the Atwater factors (carbohydrate 4, protein 4, fat 9 Calories per gram) to estimate the energy in a food from its label.
- Cook a balanced breakfast bowl with all five food groups and explain why breakfast matters for a growing body.

Warm-up. A match, a candle and a peanut all give off heat when they burn. Your body “burns” food too, but slowly and without flames. Where does the energy in food come from in the first place? Trace a slice of toast back through the wheat field to its source, and write the chain down.

WATCH

ChemMatters: The Science Behind Calories and Nutrition Facts Labels

[BytesizeScience](https://www.youtube.com/watch?v=G0O87gWv-Xk) · 6:11

<https://www.youtube.com/watch?v=G0O87gWv-Xk>

WHEN TO WATCH

After the story. Watch for Atwater’s respiration calorimeter and the 4-9-4 rule.

Note: Produced by the American Chemical Society. It mentions how many Calories average teens use in a day; these are only rough averages, and in this course we use calories to understand food energy, not to count them.

KEY TERMS

Calorie (food Calorie)

A unit of energy: the heat needed to warm 1 kilogram of water by 1 °C. A food Calorie is 1,000 small calories, so it is also called a kilocalorie (kcal).

calorimeter

An instrument that measures heat. Atwater’s respiration calorimeter measured the heat a person gave off; food scientists also burn food in a sealed steel calorimeter to measure its energy.

macronutrients

The three nutrients we need in large amounts that give energy: carbohydrate, protein and fat.

Atwater factors

The average energy in each macronutrient: about 4 Calories per gram of carbohydrate, 4 per gram of protein and 9 per gram of fat.

metabolism

All the chemical work the body does to turn food into energy and building materials.

CORE IDEAS

The story. Wilbur Olin Atwater was a chemistry professor at Wesleyan University in Middletown, Connecticut. As a young man he had studied in Germany, where scientists were beginning to measure what the body does with food. Atwater wanted to answer a practical question for American families: which foods give the most nourishment for the money? In 1896 he published tables listing the protein, fat, carbohydrate and energy in hundreds of American foods. He also served as the first director of the U.S. Department of Agriculture's Office of Experiment Stations.

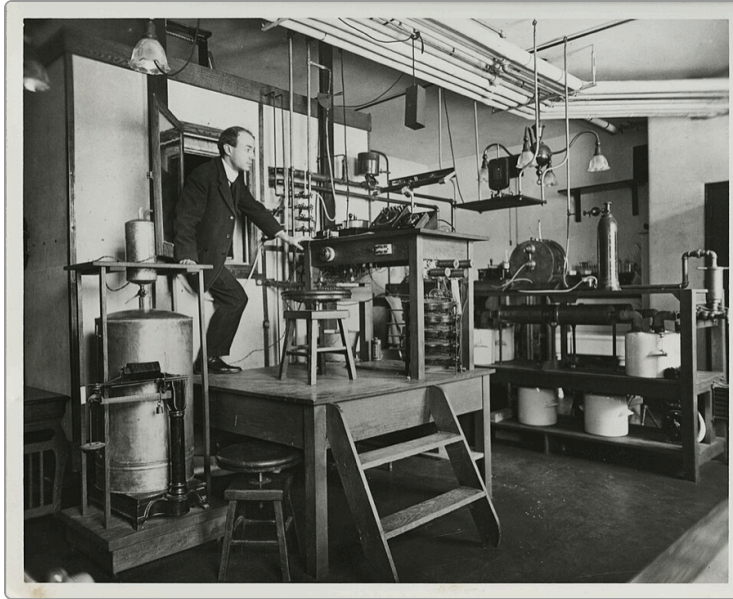
How they figured it out. With the physicist Edward Rosa, Atwater built a **respiration calorimeter**: a small, sealed, insulated room only a few feet wide and about as long as a bed, with a cot, a chair, a table and a little window for passing in food. A volunteer lived inside for several days at a time. Water flowing through pipes in the walls carried away the body's heat, and by measuring how much the water warmed, the scientists measured the energy the person gave off. They also weighed every bit of food going in and measured the oxygen used and the carbon dioxide breathed out. Atwater showed that the energy in the food eaten matched the energy the body gave off and stored, just as the law of conservation of energy predicted. From burning foods in a separate calorimeter and subtracting what the body could not digest, he arrived at the factors still printed behind every Nutrition Facts label: **about 4 Calories per gram of carbohydrate, 4 per gram of protein and 9 per gram of fat.**

The kitchen science. A food Calorie is a unit of energy, the heat that would warm a kilogram of water (about a quart) by 1 °C. All of it began as sunlight that plants captured and stored in sugar, starch, oil and protein. Your body uses that energy to keep your heart beating and your temperature at about 98.6 °F, to think, to move,

and, at your age, to **grow**: teenagers build bone and muscle faster than at almost any other time of life. That is why growing bodies need plenty of food, regular meals and a good breakfast. Calories only measure energy; they do not measure vitamins, minerals, fiber or protein. Two foods with the same energy can be very different in what else they bring. That is why we look at the whole plate, not a number.

Let's cook. You will make breakfast burrito bowls: scrambled eggs, crisp potatoes, black beans, cheese and salsa, with a whole-wheat tortilla, fruit and a glass of milk. The skill to do well is **timing several parts** so that everything is hot at once: start the potatoes first, warm the beans while they brown, and scramble the eggs last.

PICTURE STUDY



The Respiration Calorimeter, Photograph from W. O. Atwater and F. G. Benedict's reports for the U.S. Department of Agriculture, about 1900 · Photograph · Wesleyan University, Middletown, Connecticut

Image: [Wikimedia Commons](#), public domain

This is the instrument in which Atwater and his assistant Francis Benedict measured the energy of the human body. A volunteer lived inside it for days at a time while the scientists measured every bit of food, air and heat that went in and came out.

Look closely

- Find the scientist on the platform. What might he be checking?
- Find the pipes and instruments. Which ones do you think carried water to measure heat?
- Find the steps up to the platform. Where would the volunteer climb into the chamber?
- Look at how much equipment surrounds the chamber. Why did measuring a person's heat take so many instruments?

Talk about it

1. Why did Atwater need to measure the food going in and the heat coming out at the same time?
2. If the volunteer rode an exercise bicycle inside, what would happen to the heat measurement?

3. Calories measure energy only. What else in food matters that a calorimeter cannot measure?

Safety first. Use oven mitts and keep pan handles turned in. An adult is at home and nearby while you use the stove and oven. Egg dishes are cooked until no liquid egg remains (160 °F).

Fuel for the Morning: Breakfast Burrito Bowls

You will cook a breakfast that fills all five MyPlate groups, then use the Atwater factors to estimate the energy in one ingredient from its label and check your arithmetic against the label. The point is not to count, but to understand what the numbers on a label mean.

You will need

- A rimmed baking sheet and parchment paper
- A large nonstick skillet and a small saucepan
- A cutting board, a damp towel and a chef's knife
- A whisk and a heat-proof spatula
- Measuring cups and spoons
- A kitchen scale (optional) and a calculator

BREAKFAST BURRITO BOWLS

Serves 4 · Prep 15 min · Cook 30 min

Ingredients

- 1½ pounds (680 g) potatoes (about 3 medium), scrubbed
- 2 tablespoons olive oil, divided
- 1 teaspoon chili powder or smoked paprika, ½ teaspoon salt
- 1 can (15 ounces) black beans, rinsed and drained
- ¼ teaspoon ground cumin
- 8 large eggs
- ¼ cup (60 mL) milk
- ¼ teaspoon salt and a pinch of pepper
- ¾ cup (85 g) shredded cheddar or Monterey Jack cheese
- ½ cup salsa
- 1 avocado, sliced (optional)
- 4 small whole-wheat tortillas, warmed

- **On the side:** fresh fruit (orange slices or berries) and a glass of milk

Method

1. Heat the oven to 425 °F (220 °C). Wash your hands. Cut the potatoes into ¾-inch cubes using the bridge grip to halve them and the claw grip to cube them.
2. Toss the potatoes with 1 tablespoon oil, the chili powder and salt on the parchment-lined baking sheet. Roast 25–30 minutes, turning once, until crisp and golden.
3. While the potatoes roast, warm the beans and cumin in the small saucepan over low heat, stirring now and then.
4. Whisk the eggs, milk, salt and pepper in a bowl until no streaks of white remain.
5. When the potatoes have about 5 minutes left, heat the remaining 1 tablespoon oil in the skillet over medium-low heat. Add the eggs and stir slowly with the spatula, pushing the curds from the edge to the center, until no liquid egg remains, 3–4 minutes.
6. Build each bowl: potatoes, beans and eggs, topped with cheese, salsa and avocado. Serve with a warm tortilla, fruit and milk.
7. Clean up: soak the egg pan, wash everything, and wipe the counters and stove top once cool.

Allergy check: Contains eggs, milk (milk, cheese) and wheat (tortillas). For wheat-free, use corn tortillas. For milk-free, leave out the cheese and serve with a non-dairy milk. For egg-free, add more beans or crumbled firm tofu (soy) cooked with the spices.

Steps

1. **Plate check.** Before you serve, list which food in the meal belongs to each MyPlate group: grains, vegetables, fruits, protein and dairy.
2. **Atwater check.** Choose one packaged ingredient (the tortillas, the cheese or the beans). From its Nutrition Facts label, copy the grams of total carbohydrate, protein and fat per serving. Multiply by 4, 4 and 9 and add. Compare your answer with the Calories on the label and explain any small difference (labels round, and fiber gives less energy than other carbohydrate).

3. **Timing log.** Write down when you started each part and when it was ready. Did everything finish together? What would you start earlier next time?
4. **Taste test.** Ask your family to rate the bowls from 1 to 5 for flavor and how satisfied they felt.
5. **Improve it.** Write one change for next time (sautéed peppers and onions, a different cheese, or sweet potatoes instead of white potatoes).
6. Clean up: wash, dry and put away everything.

Tips

- Dry the potato cubes on a towel before oiling them; dry potatoes brown better.
- Low heat and slow stirring make soft, large egg curds. High heat makes small, tough ones.
- Roast a double batch of potatoes and keep the extra in the refrigerator for quick breakfasts later in the week.

Check your work

- ☐ I can explain what a food Calorie measures and how Atwater measured it.
- ☐ I used the 4-4-9 factors to check a food label.
- ☐ I cooked a breakfast with all five food groups, and the parts finished together.

COOK'S NOTEBOOK

1. Draw Atwater's respiration calorimeter from the picture and label what went in (food, oxygen) and what came out (heat, carbon dioxide).
2. Write your Atwater-check calculation neatly, with each step shown.
3. Draw your breakfast bowl from above and label the food group of each part.

From history. Atwater's assistant, Francis Gano Benedict, went on to lead the Carnegie Institution's Nutrition Laboratory in Boston, where he spent decades measuring how much energy people use at rest and at work. Atwater and Benedict's food tables were used by the USDA for many years, and their factors of 4, 4 and 9 are still used on Nutrition Facts labels today.

COMMON MISTAKES

- Thinking a calorie is something in food, like a vitamin. It is a unit of energy, the way an inch is a unit of length.
- Judging a food only by its Calories. Two foods with the same energy can bring very different protein, fiber, vitamins and minerals.
- Skipping breakfast on busy mornings. A growing body has gone all night without food; even a quick yogurt, fruit and toast helps.

Make it a game • Guess the Calories. Pick a cereal box or snack label. Before doing any math, you and your parent each write down a guess for the Calories in one serving. Then use the Atwater factors, 4 and 4 and 9, on the grams of carbohydrate, protein and fat. Closest guess wins. Repeat with two more labels.

Scripture. “Whether therefore ye eat, or drink, or whatsoever ye do, do all to the glory of God.” (1 Corinthians 10:31, KJV)

Even an ordinary breakfast can be eaten with thanks and for God’s glory. Food gives us strength for the work He gives us each day.

2.2 ELMER MCCOLLUM AND VITAMIN A

OBJECTIVES

- Tell how Elmer McCollum and Marguerite Davis discovered “fat-soluble A” in 1913, and how the idea of vitamins changed nutrition.
- Explain what vitamin A does in the body, where beta-carotene comes from, and why it is absorbed best with a little fat.
- Cook a sweet-potato and carrot soup and purée it safely.

Warm-up. Line up as many orange and dark-green foods as you can find in your kitchen (carrots, sweet potatoes, squash, cantaloupe, spinach). What do you think the bright color is doing in the plant? Write a guess, then keep reading.

WATCH

Vitamin A and Vision

[RCSBProteinDataBank](https://www.youtube.com/watch?v=C5f8q5ikrLo) · 4:25

<https://www.youtube.com/watch?v=C5f8q5ikrLo>

WHEN TO WATCH

After the story. Watch for the difference between fat-soluble and water-soluble vitamins.

Note: From PDB-101, the education site of the RCSB Protein Data Bank (Rutgers and UC San Diego, funded by the National Science Foundation and the NIH). A molecular animation of how the vitamin A from carrots lets the eye see in dim light; the last minute shows what happens without enough vitamin A.

KEY TERMS

vitamin

A substance the body needs in small amounts to work properly but cannot make enough of by itself, so it must come from food.

fat-soluble

Able to dissolve in fat but not in water. Vitamins A, D, E and K are fat-soluble; the body absorbs them best when a meal contains some fat.

beta-carotene

The orange pigment in carrots, sweet potatoes and many greens. The body turns it into vitamin A.

deficiency

Not getting enough of a nutrient, which can cause illness. Too little vitamin A can cause night blindness.

purée

To blend cooked food until completely smooth. Say it “pyoo-RAY.”

CORE IDEAS

The story. In the early 1900s scientists believed people needed only enough protein, carbohydrate, fat, minerals and water. Elmer McCollum, a farm boy from Kansas who became a chemist at the University of Wisconsin, was not so sure. In 1907 he began feeding young laboratory rats carefully purified foods. The rats ate all the right amounts of protein, starch, fat and minerals, yet they stopped growing. Something was missing.

How they figured it out. With his assistant Marguerite Davis, McCollum tried changing only one thing at a time: the kind of fat. Rats given lard or olive oil stayed small, but rats given butterfat or the fat from egg yolks grew well. In 1913 they reported that these fats carried a tiny amount of an unknown substance the body needs. McCollum called it “fat-soluble A.” A year earlier a Polish chemist, Casimir Funk, had proposed the word “vitamine” for such substances. Soon scientists were naming them by letters: A, B, C and D (McCollum helped discover vitamin D too). In 1919 Harry Steenbock, also in Wisconsin, noticed that yellow vegetables like carrots and sweet potatoes had vitamin A activity while white ones did not; the yellow-orange pigment, **beta-carotene**, turned out to be what the body turns into vitamin A.

The kitchen science. Vitamin A helps your eyes see in dim light (it is part of a light-sensing molecule in the retina), keeps skin and the linings of your body healthy, and helps the immune system fight germs. You get it ready-made from milk, eggs, cheese and fish, and as beta-carotene from orange and dark-green plants. Because vitamin A and beta-carotene are **fat-soluble**, a little fat in the meal (oil, butter, milk, cheese, nuts) helps you absorb them. Cooking helps too: heat softens the plant’s tough cell walls so the carotene can be released, and puréeing breaks the cells open even more.

That is why a smooth, cooked carrot soup with a little butter or oil gives your body more usable vitamin A than the same carrots eaten raw and plain.

Let's cook. You will make a velvety sweet-potato and carrot soup with ginger and a splash of lime. The skill to do well is **blending hot liquid safely**: use an immersion blender in the pot, or fill a countertop blender no more than one-third full, remove the center cap of the lid, cover the hole with a folded towel, and start on low, with an adult nearby.

PICTURE STUDY



Still Life with Cabbage, Carrots, Parsnips and Apples, Jan van Kessel, 17th century · Oil on panel · Private collection

Image: [Wikimedia Commons](#), public domain

Dutch painters of the 1600s loved to paint the vegetables of the market and the kitchen garden. Look closely at the carrots: in those days carrots came in purple, yellow and white as well as orange, and Dutch growers helped make the orange carrot common across Europe.

Look closely

- Find the carrots. What colors are they? Are they shaped like the carrots in our stores?
- Find the parsnips. How are they like carrots, and how are they different in color?
- Find the cabbage. Which of these vegetables would give the most beta-carotene, and how can you tell?
- Look at the light on each food. Which one did the painter make shine the most?

Talk about it

1. Using what you learned about beta-carotene, rank these foods from most to least vitamin A. Explain your order.

2. These vegetables keep well through the winter in a cool cellar. Why would that have mattered to a family in the 1600s?
3. If you made a soup from what you see here, what would you add to help the body absorb the vitamin A?

Safety first. Use the bridge grip to halve round sweet potatoes before cutting, and keep the board from sliding. Hot soup can burst out of a blender: fill it no more than one-third full, vent the lid under a folded towel, start on low, and have an adult nearby, or use an immersion blender kept below the surface.

KITCHEN PROJECT

Orange Is for Vitamin A: Sweet-Potato and Carrot Soup

You will cook a pot of sweet-potato and carrot soup and run a small color-and-fat test: you will see how beta-carotene colors oil and water differently, a quick proof that it is fat-soluble.

You will need

- A large heavy pot with a lid
- A cutting board, a damp towel, a chef's knife and a vegetable peeler
- A microplane or small grater for the ginger
- An immersion blender, or a countertop blender and a folded towel
- Measuring cups and spoons, a ladle
- Two small clear glasses for the color test

SWEET-POTATO AND CARROT SOUP WITH GINGER

Serves 6 (about 9 cups) · Prep 20 min · Cook 35 min

Ingredients

- 2 tablespoons butter or olive oil
- 1 large onion, chopped
- 2 cloves garlic, minced
- 1 tablespoon grated fresh ginger (or 1 teaspoon ground ginger)
- 1 teaspoon ground cumin (optional)
- 2 pounds (900 g) sweet potatoes (about 2 large), peeled and cut in 1-inch chunks
- 1 pound (450 g) carrots, peeled and sliced ½ inch thick
- 6 cups (1.4 L) low-sodium chicken or vegetable broth
- ½ cup (120 mL) milk or canned coconut milk
- 1 teaspoon salt, or to taste
- 1 tablespoon lime or lemon juice
- Plain yogurt and chopped parsley or cilantro, to serve (optional)

Method

1. Wash your hands and rinse the vegetables. Peel the sweet potatoes, cut them in half lengthwise with the bridge grip, lay them flat side down, and cut them into 1-inch chunks with the claw grip. Peel and slice the carrots.
2. Melt the butter in the pot over medium heat. Add the onion and cook 6–8 minutes until soft. Stir in the garlic, ginger and cumin for 30 seconds.
3. Add the sweet potatoes, carrots and broth. Bring to a boil, then cover, lower the heat and simmer 20–25 minutes, until a fork slides easily into the carrots.
4. Turn off the heat. Purée the soup in the pot with an immersion blender, keeping the blade below the surface. Or let it cool 10 minutes and blend it in batches no more than one-third full, with the lid vented and covered by a folded towel, starting on low.
5. Stir in the milk, salt and lime juice. Warm gently without boiling. Taste and adjust the salt and lime.
6. Serve with a swirl of yogurt and a sprinkle of herbs. Refrigerate leftovers in shallow containers within 2 hours; reheat to 165 °F.
7. Clean up: rinse the blender right away, then wash everything in hot, soapy water.

Allergy check: Contains milk (butter, milk, yogurt). For milk-free, use olive oil and coconut milk and leave out the yogurt. Coconut is not one of the nine major U.S. allergens, but some people with tree-nut allergies avoid it; check with your doctor. Check your broth label.

Steps

1. **Color test.** Grate 1 tablespoon of raw carrot. Put half in a glass with 2 tablespoons of water and half in a glass with 2 tablespoons of vegetable oil. Stir both and wait 10 minutes. Which liquid turned orange? What does that tell you about beta-carotene?
2. Cook the recipe. Record the time it took for the carrots to become tender.
3. **Before and after.** Taste a piece of cooked carrot before blending, and the soup after blending. Describe the difference in texture and sweetness.

4. **Taste test.** Ask your family to rate the soup from 1 to 5 for sweetness, spice and smoothness.
5. **Improve it.** Write one change for next time (roasting the vegetables first for deeper flavor, more ginger, or a squeeze more lime).
6. Clean up: wash, dry and put away everything.

Tips

- Cut the carrots thinner than the sweet potatoes; carrots take longer to soften.
- A squeeze of lime at the end brightens a sweet soup. Taste before and after adding it.
- This soup freezes well for up to 3 months. Leave an inch of space in the container for it to expand.

Check your work

- ☐ I can tell how McCollum and Davis discovered fat-soluble A.
- ☐ I can explain why beta-carotene is absorbed best with a little fat and when it is cooked.
- ☐ I puréed hot soup safely.

COOK'S NOTEBOOK

1. Draw McCollum's experiment as a simple chart: what each group of rats was fed and what happened.
2. Make a list of ten foods with vitamin A or beta-carotene, sorted into "from animals" and "from plants."
3. Copy the soup recipe in your own words, and write what your color test showed.

From history. McCollum later moved to Johns Hopkins University, where in 1922 he and his colleagues identified vitamin D, the vitamin that prevents rickets. He spent much of his life teaching families about good food, and he urged Americans to eat more milk and leafy green vegetables, which he called "protective foods."

COMMON MISTAKES

- Filling a blender to the top with hot soup. The steam pushes the lid off; fill it only one-third full and vent the lid.
- Thinking vitamins give energy. They give no Calories; they help the body use the energy from carbohydrate, protein and fat.

- Believing more is always better. Ready-made vitamin A in pills can be harmful in large amounts; food is the best source, and any vitamin pill is a question for your family and doctor.

Make it a game • Orange Hunt. Set a timer for three minutes and find every orange or deep green food in the kitchen. For each, say whether it holds beta-carotene. Then explain to your parent why a little oil on the carrots helps your body, and tell how McCollum and Davis found fat-soluble A. Beat your record next week.

2.3 EATING FOR GROWTH AND SPORT

OBJECTIVES

- Tell how Swedish scientists in the 1960s discovered that the carbohydrate stored in muscles (glycogen) fuels hard exercise.
- Explain what carbohydrate, protein, fat and water each do for an active, growing body, and when to eat before and after a game.
- Cook a pasta dinner with a turkey meat sauce, with the turkey checked at 165 °F.

Warm-up. Think of a day you played hard: a game, a long hike, a day of chores. How did you feel near the end? What had you eaten that day? Write down what you think your muscles were using for fuel.

WATCH

Sports Nutrition for Youth Athletes

Phoenix Children's • 3:49

<https://www.youtube.com/watch?v=cJ16BdzZ844>

WHEN TO WATCH

After the kitchen-science paragraph. Listen for what to eat before, during and after practice and games.

Note: From a children's hospital's sports-medicine team. It recommends real food and water.

KEY TERMS

glycogen

The form in which the body stores carbohydrate, in the muscles and the liver. It is the main fuel for hard, fast exercise.

carbohydrate

Sugars and starches, found in grains, fruit, vegetables, beans and milk. The body breaks them down to glucose for energy.

protein

A nutrient made of amino acids, used to build and repair muscle, bone, skin and blood. Found in meat, fish, eggs, beans, milk and grains.

hydration

Having enough water in the body. Sweat carries water away, and even mild dehydration makes you tired and slow.

recovery meal

A meal or snack after hard exercise, with carbohydrate to refill glycogen and protein to repair muscle.

CORE IDEAS

The story. In the 1960s, scientists in Stockholm, Sweden, wanted to know exactly what fuels a long, hard effort. Jonas Bergström, a doctor, had developed a way to take a tiny sample of muscle, about the size of a grain of rice, with a special hollow needle. With Eric Hultman and their colleagues, he could finally look inside working muscle and measure how much stored carbohydrate, called **glycogen**, it held before, during and after exercise.

How they figured it out. Volunteers rode exercise bicycles at a steady, hard pace until they could not go on. The scientists found that the moment of exhaustion came when the glycogen in the leg muscles ran nearly empty. Then they changed only one thing: what the riders ate for the days before. On meals rich in carbohydrate (bread, potatoes, pasta, fruit), the riders' muscles stored much more glycogen, and they could ride much longer. On meals with little carbohydrate, they ran out sooner. Their 1967 report changed how athletes eat before long events.

The kitchen science. **Carbohydrate** is your muscles' quickest fuel for running, jumping and sprinting, stored as glycogen and refilled by meals. **Protein** builds and repairs muscle and, at your age, helps build a body that is still growing taller; spreading it across meals (eggs at breakfast, beans or meat at lunch and dinner, milk or yogurt for snacks) works better than one huge serving. **Fat** fuels long, easy activity and carries vitamins. **Water** cools you through sweat. A good pre-game meal, about 3–4 hours before, is mostly carbohydrate with some protein and not too much fat or fiber, which digest slowly. An hour before, a small snack like a banana or toast is enough. Afterward, a meal or snack with carbohydrate and protein, like chocolate milk or a turkey sandwich, refills and repairs. Water is the best drink for most

practices. Athletes do not need powders, pills or special drinks; real food, enough of it, and good sleep do the job.

Let's cook. You will cook a classic pre-game dinner: spaghetti with a turkey and tomato sauce and a green salad. The skill to do well is **browning ground meat safely**: breaking it up as it cooks, cooking it until no pink remains and a thermometer reads 165 °F for ground turkey, then building a sauce on top.

PICTURE STUDY



Calling in the Gleaners, Jules Breton, 1859 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

Jules Breton grew up in a farming village in northern France and painted the hard, steady work of harvest. In this painting, at sunset, a village official calls an end to the day's gleanings, and the women carry home the wheat they have gathered. That wheat would become their bread: the fuel for the next day's work.

Look closely

- Find the women carrying bundles. How heavy do you think they are? Where are the bundles balanced?
- Look at the low sun. How long do you think these workers have been in the field?
- Find the man calling out. What is he telling them?
- Look at the stubble of the harvested field. What crop was cut here, and what will it become?

Talk about it

1. A day of field work is like a long, hard game. What would these workers need to eat to have energy for tomorrow?
2. Wheat is mostly carbohydrate. How does it become glycogen in the muscles of the people who eat it?

3. Breton painted these workers with great respect. What details show it?

Safety first. Cook ground turkey until a thermometer reads 165 °F (74 °C) and no pink remains. Drain pasta by pouring away from you into a colander in the sink, with an adult nearby; steam burns. Turn pot handles in.

KITCHEN PROJECT

A Pre-Game Dinner: Spaghetti with Turkey Meat Sauce

You will cook a family pasta dinner fit for the night before a game, plan a full game-day menu from breakfast to recovery snack, and compare how the meal fills the MyPlate groups.

You will need

- A large pot for the pasta and a colander
- A large, deep skillet or saucepan for the sauce
- A wooden spoon, a ladle and tongs
- A cutting board, a damp towel and a chef's knife
- A salad bowl
- An instant-read food thermometer

SPAGHETTI WITH TURKEY MEAT SAUCE

Serves 6 • Prep 15 min • Cook 35 min

Ingredients

- 1 tablespoon olive oil
- 1 onion, finely chopped
- 1 carrot, finely chopped
- 3 cloves garlic, minced
- 1 pound (450 g) ground turkey
- 1 can (28 ounces) crushed tomatoes
- 1 can (15 ounces) tomato sauce
- 1 teaspoon dried oregano and 1 teaspoon dried basil
- 1 teaspoon salt and ¼ teaspoon black pepper
- 1 pound (450 g) spaghetti (whole-wheat or regular)
- ½ cup (40 g) grated parmesan cheese
- **On the side:** a green salad and fruit

Method

1. Wash your hands. Fill the large pot with 4–5 quarts of water and 1 tablespoon of salt and set it over high heat to boil.
2. Heat the oil in the skillet over medium heat. Cook the onion and carrot 6–8 minutes until soft. Add the garlic for 30 seconds.
3. Add the turkey. Break it up with the wooden spoon and cook, stirring, 6–8 minutes until no pink remains and a thermometer in a thick clump reads 165 °F (74 °C). Wash your hands if you touched the raw turkey.
4. Stir in the crushed tomatoes, tomato sauce, oregano, basil, salt and pepper. Simmer uncovered 15–20 minutes, stirring now and then, until thickened.
5. Meanwhile cook the spaghetti in the boiling water according to the package, stirring in the first 2 minutes so it does not stick. Scoop out 1 cup of the pasta water, then drain the pasta, pouring away from you.
6. Toss the pasta with about half the sauce, adding a splash of pasta water if it seems dry. Serve topped with more sauce and parmesan, with salad and fruit on the side.
7. Refrigerate leftovers in shallow containers within 2 hours. Clean up: wash the pots, board and knife and wipe the stove once cool.

Allergy check: Contains wheat (pasta) and milk (parmesan). For wheat-free, use a gluten-free pasta; for milk-free, leave off the parmesan. Check your tomato products' labels.

Steps

1. **Game-day plan.** Before you cook, write a menu for a real or imaginary game day: breakfast, lunch, a snack 1 hour before, water during, and a recovery snack after. Next to each, write why you chose it.
2. Cook the recipe. Record the ground turkey's temperature when you checked it.
3. **Plate check.** Sketch a dinner plate and divide it into the MyPlate groups. Which groups does tonight's meal fill? Which one, if any, is missing?
4. **Scaling.** Your team of 12 is coming to dinner. Multiply the recipe by 2 and write the new amounts.
5. **Taste test.** Ask your family to rate the sauce from 1 to 5 for flavor and thickness.

6. **Improve it.** Write one change for next time (more vegetables grated into the sauce, a pinch of red pepper flakes, or ground beef cooked to 160 °F instead).
7. Clean up: wash, dry and put away everything.

Tips

- Salt the pasta water well; it is the only chance to season the pasta itself.
- Grating the carrot (or a zucchini) into the sauce adds vegetables that melt in and sweeten it.
- Save a cup of pasta water before draining. Its starch helps sauce cling to the noodles.

Check your work

- ☐ I can explain what glycogen is and what the Swedish cyclists showed.
- ☐ I can plan meals and snacks for a game day.
- ☐ I cooked ground turkey to 165 °F and served a balanced pasta dinner.

COOK'S NOTEBOOK

1. Make a simple bar graph comparing how long the cyclists could ride after low-carbohydrate meals and after high-carbohydrate meals (label it “more” and “less”; you do not need exact numbers).
2. Copy your game-day menu with the reason for each choice.
3. Copy the recipe in your own words and write the doubled amounts beside each ingredient.

From history. Bergström’s muscle-sampling needle became a standard tool in exercise science. Researchers later learned that the liver also stores glycogen to keep blood sugar steady for the brain, which is why a good breakfast after a night’s fast helps you think as well as play.

COMMON MISTAKES

- Eating a big, greasy meal right before a game. Fat and lots of fiber digest slowly; eat the main meal 3–4 hours before.
- Waiting until you feel thirsty. Drink water through the day and during practice.
- Thinking athletes need special powders or drinks. Real meals with enough carbohydrate and protein, plus water and sleep, are what growing athletes need.

Make it a game • Fuel Stop. Your parent calls out a moment: three hours before a game, halftime, thirty minutes after. You answer in ten seconds with what to eat or drink and which job it does: carbohydrate, protein, fat or water. Mention glycogen at least twice. Miss a moment, and your parent gets the next call. Try ten moments.

Scripture. “And the angel of the LORD came again the second time, and touched him, and said, Arise and eat; because the journey is too great for thee.” (1 Kings 19:7, KJV)

God sent Elijah food before a long journey. Eating well before hard work is not a weakness; it is wise care for the body God gave us.

2.4 BALANCED MEALS FOR A FAMILY

OBJECTIVES

- Tell how Caroline Hunt wrote the USDA's first food guide in 1916, and how its five groups compare with MyPlate (2011).
- Plan a weeknight family dinner that fills all five MyPlate groups, using half the plate for fruits and vegetables.
- Cook a sheet-pan dinner with chicken checked at 165 °F, and serve it with fruit and milk.

Warm-up. Write down everything your family ate for dinner last night. Draw a circle and divide it like MyPlate: half fruits and vegetables, a quarter grains, a quarter protein, with dairy on the side. Fill in your dinner. Which parts were full? Which were empty?

WATCH

MyPlate, MyWins: Real Solutions from Real Families

USDA • 3:27

<https://www.youtube.com/watch?v=A8KsDHCPwY>

WHEN TO WATCH

Before you plan your dinner. Listen for the families' tips for getting balanced meals on a busy weeknight.

BACKUP VIDEO

Start Simple With MyPlate

USDA • 2:00

https://www.youtube.com/watch?v=W7_i5tY-5BY

A quick review of the five food groups.

KEY TERMS

food guide

A simple picture or plan that helps families choose a balanced mix of foods. MyPlate is the U.S. food guide today.

whole grain

A grain food that keeps all three parts of the kernel (bran, germ and endosperm), such as brown rice, oatmeal and whole-wheat bread. MyPlate suggests making at least half your grains whole.

sheet-pan dinner

A meal in which the main dish and vegetables roast together on one baking sheet.

MyPlate

The USDA food guide introduced in 2011: a plate divided into fruits, vegetables, grains and protein, with a cup of dairy on the side.

nutrient-dense

Describes a food that brings a lot of vitamins, minerals, fiber or protein along with its energy, such as vegetables, fruit, beans, eggs and milk.

CORE IDEAS

The story. In 1916, a nutrition specialist at the U.S. Department of Agriculture named Caroline Hunt wrote a small booklet called *Food for Young Children*. It was America's first food guide. Hunt sorted foods into five groups: milk and meat; cereals (grains); vegetables and fruits; fats and fatty foods; and sugars and sugary foods. The next year she and Helen Atwater, the daughter of Wilbur Atwater, wrote *How to Select Foods* for whole families. Mothers could use the groups to plan meals without knowing any chemistry.

How they figured it out. Food guides have changed as scientists learned more. In 1916 no one knew much about vitamins. During World War II the USDA used the "Basic Seven." In 1956 came the "Basic Four," then the Food Guide Pyramid in 1992, and in 2011 MyPlate, which pictures a real dinner plate: half fruits and vegetables, a quarter grains, a quarter protein, and dairy on the side. Each new guide tried to make balance easier to see at a glance. The basic idea has stayed the same since

Caroline Hunt: no single food has everything, so a family eats a *variety* from every group.

The kitchen science. Each group brings something different. Vegetables and fruits bring vitamins A and C, potassium and fiber. Grains, especially whole grains, bring energy, B vitamins, iron and fiber. Protein foods (meat, poultry, fish, eggs, beans, nuts) bring protein, iron and zinc. Dairy brings calcium, vitamin D and protein for bones that are still growing; your teenage years are when you build most of the bone you will have for life. A balanced dinner does not need to be fancy: a roasted chicken thigh, potatoes, green beans, a piece of fruit and a glass of milk fills every group.

Let's cook. You will plan and cook a sheet-pan dinner of lemon-garlic chicken with potatoes and green beans, served with fruit and milk. The skill to do well is **planning by cooking time**: potatoes take longest, so they go in first; chicken goes in next; green beans, which cook fastest, go in last, so everything is done at once.

PICTURE STUDY



The Potato Eaters, Vincent van Gogh, 1885 · Oil on canvas · Van Gogh Museum, Amsterdam

Image: [Wikimedia Commons](#), public domain

Van Gogh painted a farming family in the Dutch village of Nuenen at their evening meal. He wanted to show, he wrote, that these people had dug the earth with the same hands they were now putting into the dish, and had honestly earned their food. The meal is simple: potatoes and a hot drink, shared around one lamp.

Look closely

- Find the dish of potatoes. Who is reaching for them?
- Find the hanging lamp. Where does its light fall, and what does it leave in shadow?
- Count the people at the table. How old do you think each one is?
- Look at the hands. What do they tell you about the family's work?

Talk about it

1. Which MyPlate groups are on this table? Which are missing? What could this family add if they had a little more?
2. Van Gogh thought this plain meal was worth painting. What makes a family meal valuable besides the food?
3. Your family's dinner is very different. What is the same?

Safety first. Keep raw chicken on its own board and wash your hands after handling it. Cook chicken to 165 °F (74 °C) in the thickest part. Use oven mitts to move the hot pan, and open the oven door with your face back to avoid the blast of heat. An adult is at home and nearby while you use the oven.

KITCHEN PROJECT

Fill the Plate: Lemon-Garlic Sheet-Pan Chicken Dinner

You will plan a weeknight family dinner with MyPlate, write a cooking timeline that gets every part done at once, then cook and serve it. You will finish by comparing your plan with what actually happened.

You will need

- A large rimmed baking sheet (or two), lined with foil or parchment
- Two cutting boards (one for raw chicken), a damp towel and a chef's knife
- A large bowl and a small bowl
- Measuring cups and spoons
- An instant-read food thermometer and oven mitts
- A timer

LEMON-GARLIC SHEET-PAN CHICKEN WITH POTATOES AND GREEN BEANS

Serves 4–6 • Prep 20 min • Cook 40–45 min

Ingredients

- 1½ pounds (680 g) small potatoes (red or gold), halved or quartered
- 3 tablespoons olive oil, divided
- 1 teaspoon salt, divided, and ½ teaspoon black pepper
- 2 pounds (900 g) bone-in, skin-on chicken thighs (6–8 thighs), or 1½ pounds boneless thighs
- 3 cloves garlic, minced
- 1 lemon (zest and juice)
- 1 teaspoon dried oregano or thyme
- 1 pound (450 g) green beans, ends snapped off
- **On the side:** whole-wheat rolls, fresh fruit and milk

Method

1. Heat the oven to 425 °F (220 °C). Wash your hands and the vegetables.

2. Toss the potatoes with 1 tablespoon oil, $\frac{1}{2}$ teaspoon salt and the pepper in the large bowl. Spread them on the baking sheet, cut side down, and roast 15 minutes.
3. Meanwhile, in the small bowl, stir together 1 tablespoon oil, the garlic, lemon zest, 1 tablespoon lemon juice, oregano and $\frac{1}{4}$ teaspoon salt. On the raw-meat board, pat the chicken dry and rub it all over with the mixture. Wash your hands.
4. With oven mitts, pull out the pan and push the potatoes to the edges. Lay the chicken in the middle, skin side up. Roast 15 minutes.
5. Toss the green beans with the last tablespoon of oil and $\frac{1}{4}$ teaspoon salt. Add them to the pan around the chicken and roast 10–15 minutes more, until the chicken reads 165 °F (74 °C) in the thickest part (not touching bone) and the potatoes are golden.
6. Squeeze the rest of the lemon over everything. Let the chicken rest 5 minutes, then serve with rolls, fruit and milk.
7. Refrigerate leftovers within 2 hours. Clean up: wash both boards and the knife in hot, soapy water and let the pan cool before washing it.

Allergy check: The sheet-pan dinner contains none of the nine major allergens. The rolls contain wheat and often milk and eggs; the milk contains milk. Choose sides that fit your family.

Steps

1. **Plan.** On a MyPlate drawing, write which food fills each group. Check that half the plate is fruits and vegetables.
2. **Timeline.** Write a cooking timeline backward from the time dinner will be served: when the oven goes on, when the potatoes go in, when the chicken goes in, when the green beans go in, and when you set the table.
3. **Cook the recipe.** Beside your timeline, write the actual time each step happened. Record the chicken's temperature.
4. **Compare.** Did your timeline work? Which step ran long or short?
5. **Taste test.** Ask your family to rate the meal from 1 to 5 and name their favorite part.
6. **Improve it.** Write one change for next time (a different vegetable, such as broccoli or carrots; a different herb; or sweet potatoes).

7. Clean up: wash, dry and put away everything.

Tips

- Do not crowd the pan. Vegetables piled up steam instead of browning; use two pans if needed.
- Thighs are forgiving: they stay juicy even if they cook a few minutes too long. Breasts dry out quickly.
- Cut the potatoes all the same size so they finish together.

Check your work

- ☐ I can tell how food guides changed from Caroline Hunt's five groups to MyPlate.
- ☐ I planned a family dinner that fills all five MyPlate groups.
- ☐ I followed a timeline so that every part was done at once, and the chicken reached 165 °F.

COOK'S NOTEBOOK

1. Draw a timeline of food guides: 1916, 1943, 1956, 1992 and 2011, with a small sketch of each.
2. Copy your dinner timeline with both the planned and actual times.
3. Plan three more weeknight dinners on MyPlate drawings, using different proteins (fish, beans, eggs).

From history. Caroline Hunt had been a home economics teacher and a writer before she joined the USDA. She also wrote a biography of Ellen Swallow Richards, the chemist who founded the field of home economics. Her five food groups were printed in USDA bulletins read by thousands of families.

COMMON MISTAKES

- Putting all the vegetables in at the same time as the chicken. Each food has its own cooking time; plan by the slowest first.
- Forgetting the fruit and dairy. A glass of milk and a bowl of fruit on the table fill two groups with no extra cooking.
- Checking the chicken temperature against the bone. Bone conducts heat and gives a false reading; measure in the thickest meat.

Make it a game • Fill the Plate. Your parent names a dinner, such as chicken, rice and green beans. In sixty seconds, sketch a plate on paper and label all five MyPlate groups, with half the plate fruits and vegetables. Find what is missing and fix it. Then name Caroline Hunt's year, 1916, and the five groups she used.

Scripture. “She riseth also while it is yet night, and giveth meat to her household, and a portion to her maidens.” (Proverbs 31:15, KJV)

The wise woman of Proverbs plans ahead to feed everyone in her house. Planning a balanced family dinner is a real way to serve the people you love.

UNIT 2

FOOD GROUPS & THE BALANCED MEAL

Food is God's good gift, and He made it wonderfully varied: grains and beans, roots and leaves, fruit, milk, eggs, fish and meat, each carrying something the body needs. In this unit you will learn how scientists discovered what is inside our food. You will meet Wilbur Atwater, who measured the energy in food with a calorimeter big enough for a man to live in for days, and Elmer McCollum, who found the first vitamin hiding in butterfat. You will learn how carbohydrate, protein, fat, vitamins, minerals and water each serve a growing, active body.

Then you will put it together the way a cook does, in real meals: a breakfast bowl, a bright sweet-potato soup, a pasta dinner to fuel a game day, and a weeknight family dinner planned with MyPlate. In this course a calorie is simply a unit of food energy, like a gallon is a unit of gasoline. We never count or cut calories. A growing teenager needs plenty of good food, and the goal is a balanced way of eating that gives thanks and serves others.

PREREQUISITES

- Knows the danger zone and safe internal temperatures (Unit 1)
- Uses a chef's knife with the claw and bridge grips (Unit 1)
- Can multiply and divide decimals and fractions
- Can read a Nutrition Facts label (or is ready to learn)

MASTERY CHECKLIST

- ☐ I can explain what a food Calorie is and how Atwater found that carbohydrate and protein give about 4 Calories per gram and fat about 9.
- ☐ I can tell how McCollum and Davis discovered vitamin A, name foods rich in it, and explain why it needs a little fat to be absorbed.
- ☐ I can explain how carbohydrate, protein and water fuel growth and sport, and plan a pre-game meal.
- ☐ I can plan and cook a family dinner that fills a MyPlate with all five food groups.
- ☐ I can scale a recipe and estimate the energy in a food from its grams of carbohydrate, protein and fat.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **MyPlate.gov (USDA):** Free. The USDA's site for the five food groups, with a recipe collection and printable planning sheets. Used in Lessons 2.3 and 2.4.
- **FDA: How to Understand and Use the Nutrition Facts Label:** Free. A clear guide to every line on the label. Helpful for Lesson 2.1.
- **A digital kitchen scale:** Weighing foods in grams makes the energy calculations in Lesson 2.1 easy and is useful for the rest of the year.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

2.1 Wilbur Atwater and the Calorie	2 sessions of 50–60 minutes
2.2 Elmer McCollum and Vitamin A	2 sessions of 50–60 minutes
2.3 Eating for Growth and Sport	2 sessions of 50–60 minutes
2.4 Balanced Meals for a Family	2 sessions of 50–60 minutes

UNIT 2 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**
What is a food Calorie? Explain using kilograms of water and degrees Celsius.
2. **8 pts**
Describe how Atwater's respiration calorimeter worked.
3. **10 pts**
Calculation: a granola bar has 29 g carbohydrate, 4 g protein and 7 g fat. Use the Atwater factors to estimate its energy.
4. **8 pts**
What did McCollum and Davis discover in 1913, and how did they find it?

5. (8 pts)

Why does a carrot soup made with a little butter and cooked until soft give the body more vitamin A than plain raw carrots?

6. (8 pts)

What is glycogen, and what did the Swedish cycling studies of the 1960s show about it?

7. (8 pts)

Plan a pre-game meal (3–4 hours before) and a recovery snack. Explain each choice.

8. (8 pts)

Name the five MyPlate groups and one important nutrient each one gives.

9. (10 pts)

Calculation: the sheet-pan dinner uses 2 pounds of chicken for 6 people. How much chicken is that per person in ounces? How many pounds would you need for 9 people?

10. (8 pts)

Calculation: convert the oven temperature 425 °F to °C.

11. (8 pts)

Who wrote the USDA's first food guide, when, and how many groups did it have?

12. (8 pts)

Short answer: In three or four sentences, explain why this course treats a calorie as a unit of energy rather than something to count, and what we look at instead.

ANSWER KEY

1. A food Calorie (kilocalorie) is the amount of heat energy needed to raise the temperature of 1 kilogram of water by 1 °C.
2. A volunteer lived for days in a small sealed, insulated chamber. Water flowing through pipes carried away the body's heat; measuring how much the water warmed measured the energy given off. The scientists also weighed all food and measured oxygen used and carbon dioxide breathed out.
3. $29 \times 4 = 116$; $4 \times 4 = 16$; $7 \times 9 = 63$. $116 + 16 + 63 = 195$ Calories (about 190–200).
4. They found “fat-soluble A” (vitamin A). Young rats fed lard or olive oil stopped growing, but rats fed butterfat or egg-yolk fat grew; changing only the fat showed that those fats carried a needed substance.
5. Beta-carotene is fat-soluble, so a little fat helps the body absorb it. Cooking softens the cell walls and puréeing breaks them open, releasing more of the beta-carotene.
6. Glycogen is the stored form of carbohydrate in muscles and liver. The studies showed riders became exhausted when muscle glycogen ran low, and that meals rich in carbohydrate in the days before let muscles store more glycogen and ride much longer.
7. Example: spaghetti with turkey meat sauce, bread and fruit (mostly carbohydrate, some protein, not too greasy or high in fiber); recovery: chocolate milk or a turkey sandwich (carbohydrate to refill glycogen, protein to repair muscle). Water throughout.
8. Vegetables (vitamin A, fiber), fruits (vitamin C, potassium), grains (energy, B vitamins, fiber), protein (protein, iron), dairy (calcium, vitamin D). Other correct nutrients accepted.
9. 2 pounds = 32 ounces; $32 \div 6 \approx 5.3$ ounces per person. For 9 people: $2 \times 9 = 18$ pounds.
10. $(425 - 32) \times \frac{5}{9} = 393 \times \frac{5}{9} \approx 218$ °C, about 220 °C.
11. Caroline Hunt, in 1916 (*Food for Young Children*), with five groups.
12. A calorie only measures energy; it says nothing about vitamins, minerals, protein or fiber. Growing teenagers need plenty of energy and nutrients, so cutting or counting is not the goal. Instead we look at the whole plate: variety from all five groups, mostly nutrient-dense foods, regular meals, and treats in their place.

UNIT CHALLENGE: A WEEK OF BALANCED FAMILY DINNERS

Plan five weeknight family dinners on MyPlate drawings, each with all five food groups and at least three different protein foods across the week (for example, chicken, beans, eggs or fish). Write a grocery list for the week.

Cook at least two of the dinners yourself, with a timeline for each. Photograph or sketch each plate, collect a family rating, and write a short paragraph on what went well and what you would change.

LOOK FOR	WHAT IT MEANS
Balanced plans	Five dinners, each filling all five groups, with half the plate fruits and vegetables and variety across the week.
Grocery list	Complete, organized by store section, with amounts.
Cooking	Two dinners cooked safely with timelines, correct temperatures and a clean kitchen.
Records	Photos or sketches, family ratings and honest notes.
Reflection	Names what worked and one improvement; a dinner that had problems but is well recorded earns full credit.

UNIT 3

TASTE, SMELL & YOUR TASTE BUDS

“O taste and see that the LORD is good” (Psalm 34:8). God gave us senses that make eating one of life’s daily joys, and in this unit you will study them like a scientist. You will meet Jean Anthelme Brillat-Savarin, a French judge who wrote the first great book on the pleasures of the table and noticed, two hundred years ago, that smell and taste work as one sense. You will follow Kikunae Ikeda from a bowl of kelp broth to the discovery of glutamate and umami, learn how taste changes from infancy to old age, and see how food scientists describe and design texture.

Each week you will cook with the science in mind: a small tasting menu that balances the five tastes, a mushroom pasta full of umami, a family recipe gathered from an older relative, and a crisp-and-creamy parfait that tests how moisture ruins a crunch. Along the way you will practice the classical habit of attention: noticing carefully, naming exactly, and giving thanks for what you taste.

PREREQUISITES

- Can use a chef’s knife and the stove safely (Unit 1)
- Knows the five MyPlate groups (Unit 2)
- Checks every taste test against the family’s food allergies before starting
- Has a cook’s notebook ready for taste charts

MASTERY CHECKLIST

- ☐ I can name the five basic tastes, explain how taste and smell combine into flavor, and describe retronasal smell.
- ☐ I can tell how Ikeda discovered glutamate in 1908 and explain how umami ingredients work together.
- ☐ I can describe how taste changes from childhood to old age and why trying a food 8–15 times helps.
- ☐ I can describe a food’s texture with exact words and explain why moisture makes crisp foods soggy.
- ☐ I can balance a dish by tasting and adjusting salt, acid, sweetness and umami.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **Monell Chemical Senses Center**: Free. The Philadelphia research institute that studies taste and smell. Its site has short articles on how taste works and how it changes with age, helpful for Lessons 3.1 and 3.3.
- **A set of small tasting spoons or cups**: Plastic tasting spoons or small paper cups make blind taste tests neat and fair. Ordinary teaspoons work too.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

3.1 Brillat-Savarin and The Physiology of Taste	2 sessions of 50–60 minutes
3.2 Umami and Glutamate: Ikeda's Discovery	2 sessions of 50–60 minutes
3.3 Taste Buds Over a Lifetime	2 sessions of 50–60 minutes
3.4 Texture and Food Engineering	2 sessions of 50–60 minutes

UNIT 3 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**

Name the five basic tastes and give one food that shows each.

2. **8 pts**

What did Brillat-Savarin observe about taste and smell, and how did modern science confirm it?

3. **8 pts**

What is retronasal smell? Describe a test that shows it.

4. **8 pts**

How did Ikeda discover glutamate, and what did Kuninaka add in 1957?

5. (8 pts)

Predict: you crowd 1½ pounds of sliced mushrooms into a small pan. What will happen, and why?

6. (8 pts)

Why do aged cheese, ripe tomatoes and soy sauce taste so savory?

7. (8 pts)

Describe two ways taste changes from childhood to old age.

8. (8 pts)

A child refuses roasted Brussels sprouts at the first taste. What does research suggest the family do?

9. (8 pts)

What is moisture migration? Give an example and one way to prevent it.

10. (10 pts)

Calculation: the tasting menu serves 6. You want to serve 15 guests. By what factor do you multiply? How many pounds of carrots and tomatoes will you need (the recipe uses 1 pound of each)?

11. (10 pts)

Calculation: the crumble bakes at 350 °F. What is that in °C? A recipe from Britain says to bake at 180 °C. Is that hotter or cooler than 350 °F, and by about how many °F?

12. (8 pts)

Short answer: In three or four sentences, explain what Szczesniak contributed to food science and why words for texture matter to a cook.

ANSWER KEY

1. Sweet (honey, fruit), salty (salted crackers), sour (lemon), bitter (dark chocolate, coffee beans, kale), umami (parmesan, tomato, broth). Other correct examples accepted.
2. He noticed that food loses its taste when a person has a cold and concluded taste and smell work as one sense. Scientists found the tongue senses only five basic tastes while retronasal smell from the mouth to the nose supplies most of flavor.
3. Smelling aromas that rise from food in the mouth up the back of the throat into the nose while chewing and swallowing. Pinch your nose and eat apple and potato: they taste nearly the same until you let go.
4. Ikeda concentrated kombu broth and isolated crystals that he identified as glutamic acid; its salt, glutamate, gave the savory taste he named umami (1908). Kuninaka found guanylate in dried shiitake mushrooms and showed it greatly strengthens glutamate's umami (synergy).
5. They will steam in their own water, turn gray and rubbery and not brown, because the water they release cannot evaporate fast enough to let the surface get hot enough for browning.
6. Aging, ripening and fermenting break proteins apart and release free glutamate, which the tongue senses as umami.
7. Children on average prefer sweeter tastes and are more sensitive to some bitter compounds; these change through the teen years. In older adults the sense of smell often fades, especially after about 60, so food can seem bland.
8. Keep offering small tastes without pressure, prepared different ways; many children need 8–15 tastes before they accept a new food.
9. Water moving from a wetter food into a drier one until they are equally moist, which makes crisp foods soggy (cereal in milk, crumble in yogurt). Prevent it by keeping parts separate until serving or by a barrier such as a chocolate coating.
10. $15 \div 6 = 2.5$. You need 2.5 pounds of carrots and 2.5 pounds of tomatoes.
11. $(350 - 32) \times \frac{5}{9} = 318 \times \frac{5}{9} \approx 177$ °C. 180 °C $\times \frac{9}{5} + 32 = 356$ °F, about 6 °F hotter (essentially the same temperature).
12. She created a texture profile system in 1963 that named and measured qualities like hardness, chewiness, cohesiveness and crispness, and trained tasters to rate them. Words let cooks and scientists describe exactly what is wrong (too soggy, too chewy) and fix it, and they help us notice and enjoy food more carefully.

UNIT CHALLENGE: A FAMILY BLIND TASTE TEST

Choose one food and prepare it three ways (for example, carrots raw, steamed and roasted; or tomatoes fresh, roasted and in a sauce). Serve all three to at least four family members of different ages in a blind tasting, with each person rating sweetness, savoriness, bitterness, aroma and texture from 0 to 5.

Make a results chart, write a paragraph explaining the differences using what you learned about taste, smell, umami and texture, and add your family recipe from Lesson 3.3 to a family recipe collection. Finish with a “try it again” plan: a vegetable someone at your table dislikes, and three different ways you will prepare it over the next few weeks.

LOOK FOR	WHAT IT MEANS
Fair test	Same food, three methods, blind tasting, same rating card for every taster; allergies checked first.
Cooking	All three versions cooked carefully and safely, with a clean kitchen afterward.
Results chart	Clear chart with every taster’s ratings and averages.
Science explanation	Uses the ideas of basic tastes, retronasal smell, umami, browning and texture correctly.
Family recipe and try-again plan	Family recipe neatly recorded with its source, and a thoughtful plan for a disliked vegetable; honest records earn full credit even if tasters still disagree.

3.1 BRILLAT-SAVARIN AND THE PHYSIOLOGY OF TASTE

OBJECTIVES

- Tell who Brillat-Savarin was and what he observed about taste and smell in *The Physiology of Taste* (1825).
- Explain how the five basic tastes, smell (including retronasal smell) and texture combine into flavor.
- Plan, cook and serve a three-course tasting menu that balances the five tastes.

Warm-up. Pinch your nose and put a small piece of apple in your mouth. Chew. Now let go of your nose and keep chewing. What changed? Try the same with a piece of raw potato or pear. Could you tell them apart with your nose pinched? (Check for allergies first.)

WATCH

How Your Sense of Smell Helps You Savor Flavor | Body Stuff with Dr. Jen Gunter | TED

TED • 2:55

<https://www.youtube.com/watch?v=3NFTa9kTVRU>

WHEN TO WATCH

After the story and before the kitchen science. Watch how smell molecules travel from your mouth up into your nose as you chew.

Note: From TED's short series *Body Stuff* with a physician. Brief and clear.

KEY TERMS

flavor

The whole experience of a food in the mouth: taste, smell, texture, temperature and even the sound of a crunch, combined by the brain.

basic tastes

The five tastes sensed by the tongue: sweet, salty, sour, bitter and umami.

retronasal smell

Smelling food from inside the mouth, as aromas rise up the back of the throat into the nose while you chew and swallow. It provides most of what we call flavor.

palate

A person's sense of taste, or the roof of the mouth. A "trained palate" notices small differences.

gastronomy

The study and art of good food and eating. Brillat-Savarin helped make it a subject worth writing about.

CORE IDEAS

The story. Jean Anthelme Brillat-Savarin was born in 1755 in Belley, a small town in eastern France. He became a lawyer, a mayor and finally a judge in France's highest court. When violence swept France in the 1790s, he had to flee the country, and he spent about three years in the young United States, where he taught French, played the violin in a theater orchestra in New York, and went turkey hunting in Connecticut. All his life he studied food and the people who ate it. In December 1825 he published *The Physiology of Taste*, a book of essays, stories and observations about eating. He died two months later, in February 1826. It has never gone out of print.

How they figured it out. Brillat-Savarin had no laboratory; he used careful observation. He noticed that when a person has a bad cold, food seems to lose its taste, and he concluded that taste and smell together form one sense, with the mouth as the laboratory and the nose as its chimney. He noticed that flavor unfolds over time: a first impression on the tongue, a fuller one as you chew and swallow, and a last one that lingers afterward. Nearly two centuries later, scientists have shown he was right. Taste buds sense only five basic tastes, while the nose can tell apart thousands of smells. His most famous line is "Tell me what you eat, and I will tell you what you are."

The kitchen science. Your tongue holds a few thousand **taste buds**, each with 50–100 receptor cells. They sense five basic tastes: **sweet** (sugars, a sign of energy), **salty** (sodium, a mineral the body needs), **sour** (acids), **bitter** (a warning sign in many plants) and **umami** (savory glutamate, a sign of protein). Every part of the tongue can sense all five; the old "tongue map" was a myth. But most of a food's character

comes from smell. When you chew, aroma molecules rise from the back of the mouth into the nose; this **retronasal smell** is why pinching your nose turns an apple and a potato into nearly the same crunchy, watery thing. Texture, temperature and even sound add the rest. A cook balances a dish by adjusting the five tastes: a little salt to round out sweetness, acid to brighten richness, sweetness to calm bitterness.

Let's cook. You will plan and serve a small three-course tasting menu: a tomato bruschetta (sweet, sour, salty and umami), honey-roasted carrots with lemon (sweet against sour), and orange segments dipped in dark chocolate (bitter against sweet). The skill to do well is **tasting and adjusting**: taste each dish before serving, decide which basic taste it needs more of, and add it a little at a time.

PICTURE STUDY



Still Life with Brioche, Fruit and Vegetables, Anne Vallayer-Coster, 1775 · Oil on canvas ·
Nationalmuseum, Stockholm

Image: [Wikimedia Commons](#), public domain

Anne Vallayer-Coster was one of the finest still-life painters in France in the years when Brillat-Savarin was a young man. Here she arranges a small tasting on a marble ledge: a buttery brioche, sweet preserves, ripe peaches and sharp, peppery radishes.

Look closely

- Find the brioche. How did she show that its crust is glossy and browned?
- Find the glass bowl. What do you think is inside it, and what would it taste like?
- Find the radishes. How would their taste be different from the peaches?
- Look at the cracks in the marble and the dark background. How do they make the foods stand out?

Talk about it

1. Which basic tastes can you find on this ledge? Is any taste missing?
2. If you served these foods as a tasting menu, in what order would you serve them, and why?

3. Brillat-Savarin said flavor unfolds in stages. Describe how a bite of brioche with preserves would unfold.

Safety first. Check every food in a tasting against your family's allergies before you start. Toast the bread under the broiler with an adult at home and nearby, watching every second; broiled bread can burn in under a minute. Melt chocolate gently in short bursts so it does not scorch.

KITCHEN PROJECT

A Three-Course Tasting Menu

You will host a small tasting for your family the way Brillat-Savarin might have: three little courses, each built to show off a balance of basic tastes. Your guests will fill out a tasting card for each course.

You will need

- A rimmed baking sheet and parchment
- A cutting board, a damp towel, a chef's knife and a serrated bread knife
- A medium bowl, a small microwave-safe bowl and a spoon
- Small plates for serving
- Index cards for tasting cards

THREE-COURSE TASTING MENU: TOMATO BRUSCHETTA, HONEY-LEMON CARROTS AND CHOCOLATE ORANGES

Serves 6 (small tasting portions) · Prep 30 min · Cook 30 min

Ingredients

- **Tomato bruschetta:** 1 baguette, cut in 12 slices ½ inch thick
- 2 tablespoons olive oil, plus more for brushing
- 3 ripe tomatoes (about 1 pound), diced
- 1 small clove garlic, minced, plus 1 whole clove, peeled
- 6 fresh basil leaves, sliced thin
- 1 teaspoon lemon juice or apple cider vinegar
- ¼ teaspoon salt and a pinch of pepper
- 2 tablespoons grated parmesan (optional)
- **Honey-lemon carrots:** 1 pound (450 g) carrots, peeled and cut in 3-inch sticks
- 1 tablespoon olive oil, ¼ teaspoon salt
- 1 tablespoon honey and 1 teaspoon grated lemon zest plus 1 tablespoon lemon juice

- **Chocolate oranges:** 3 seedless oranges or mandarins, peeled and separated into segments
- 2 ounces (55 g) dark chocolate (60–70% cacao), chopped
- A pinch of flaky salt (optional)

Method

1. Heat the oven to 425 °F (220 °C). Wash your hands and the vegetables.
2. **Carrots:** Toss the carrots with the oil and salt on a parchment-lined baking sheet. Roast 20–25 minutes, turning once, until tender and browned at the edges. Toss with the honey, lemon zest and juice while hot.
3. **Bruschetta topping:** In the bowl, combine the tomatoes, minced garlic, basil, vinegar, 2 tablespoons oil, salt and pepper. Let it sit 15 minutes so the juices draw out.
4. **Toast:** Brush the bread slices lightly with oil. With an adult nearby, toast them under the broiler on a baking sheet about 5 inches from the heat, 1–2 minutes per side, watching constantly. Rub each warm toast once with the cut whole garlic clove.
5. **Chocolate oranges:** Microwave the chocolate in the small bowl in 20-second bursts, stirring between, until just melted. Dip one end of each orange segment, lay it on parchment, sprinkle with a few grains of salt, and chill 10 minutes to set.
6. Just before serving, spoon the tomato topping onto the toasts and sprinkle with parmesan.
7. Serve the courses one at a time on small plates: bruschetta, carrots, then chocolate oranges.
8. Clean up: wash the board, knives and bowls, and wipe the counters.

Allergy check: Contains wheat (baguette) and milk (parmesan; some dark chocolate contains milk). Dark chocolate may contain soy (lecithin) and may be made on equipment with tree nuts or peanuts; check the label. For wheat-free, serve the tomato topping on cucumber rounds. Honey is never given to babies under one year; use maple syrup if a baby will eat the carrots.

Steps

1. **Plan.** Before cooking, write a menu card listing the three courses and, for each, the basic tastes you expect it to show.
2. **Taste and adjust.** Taste the tomato topping and the carrots before serving. Decide whether each needs more salt, more acid or more sweetness, add a pinch or a squeeze, and taste again. Record what you changed.
3. **Tasting cards.** Give each guest a card for each course: rate sweet, salty, sour, bitter and umami from 0 to 3, and write one word for the aroma and one for the texture.
4. **Nose test.** Ask each guest to take one bite of a chocolate orange with nose pinched, then one without. Record what they say.
5. **Improve it.** From the cards, choose one course to improve and write exactly what you would change.
6. Clean up: wash, dry and put away everything.

Tips

- Ripe, room-temperature tomatoes have far more aroma than cold ones. Never refrigerate tomatoes you plan to serve fresh.
- A tiny pinch of salt on a sweet food makes it taste sweeter and less flat.
- Rubbing toast with a raw garlic clove gives garlic aroma without sharp bites of raw garlic.

Check your work

- ☐ I can tell what Brillat-Savarin observed about taste and smell.
- ☐ I can explain retronasal smell and name the five basic tastes.
- ☐ I served a three-course tasting and adjusted each dish by tasting.

COOK'S NOTEBOOK

1. Draw a side view of a head and trace the path of aroma from food in the mouth to the smell sensors in the nose. Label it “retronasal.”
2. Make a chart from your guests’ tasting cards with an average score for each taste in each course.
3. Copy Brillat-Savarin’s line “Tell me what you eat, and I will tell you what you are,” and write a paragraph on what you think he meant.

From history. Brillat-Savarin's name lives on in a rich French cheese and a ring-shaped cake, the savarin, both named in his honor. His book also includes some of the earliest careful writing on how people grow hungry, how they feel full, and why sharing a meal brings people together.

COMMON MISTAKES

- Believing the “tongue map.” Every area of the tongue that has taste buds can sense all five tastes.
- Adding a lot of salt or acid at once. Add a pinch or a few drops, taste, and repeat; you can add more but cannot take it out.
- Leaving bread under the broiler while you do something else. It goes from golden to black in seconds.

Make it a game • Pinch Your Nose. Close your eyes and pinch your nose. Your parent hands you a small piece of apple, onion or banana. Guess it by taste and texture alone, then let go of your nose and notice what changes. Describe it using the five basic tastes, smell and texture. Explain retronasal smell as Brillat-Savarin might. Check for allergies first.

Scripture. “O taste and see that the LORD is good: blessed is the man that trusteth in him.” (Psalm 34:8, KJV)

The psalmist uses tasting as a picture of knowing God's goodness for yourself. Our senses of taste and smell are themselves good gifts to be received with thanks.

3.2 UMAMI AND GLUTAMATE: IKEDA'S DISCOVERY

OBJECTIVES

- Tell how Kikunae Ikeda discovered glutamate in kombu broth in 1908 and named umami, and how scientists later found inosinate and guanylate.
- Explain umami synergy and why mushrooms, aged cheese, tomatoes and soy sauce make food taste savory.
- Cook mushroom and parmesan pasta, browning the mushrooms well, and test umami with a broth comparison.

Warm-up. Taste a spoonful of plain warm water with a pinch of salt. Then taste the same with a tablespoon of finely grated parmesan stirred in and strained out. What changed? Try to describe the new taste without using the words “salty” or “cheesy.” (Check for milk allergy first.)

WATCH

What is MSG, and is it actually bad for you? - Sarah E. Tracy

TED-Ed · 5:29

<https://www.youtube.com/watch?v=EKgEj5asL3o>

WHEN TO WATCH

After the story. Watch for Ikeda's kombu broth and what careful studies have found about MSG.

BACKUP VIDEO

What is Umami? The Fifth Taste Explained (with Umami Pizza).| Serving Up Science

PBS Food · 7:09

https://www.youtube.com/watch?v=_xi3FkPcCR0

Before you cook, for ideas about combining umami ingredients.

KEY TERMS

umami

The savory taste of glutamate, found in broth, aged cheese, ripe tomatoes, mushrooms, meat and soy sauce. A Japanese word meaning roughly “delicious taste.”

glutamate

A form of the amino acid glutamic acid. When it is free (not bound up in protein), the tongue senses it as umami.

MSG (monosodium glutamate)

Glutamate joined with sodium in a crystal that dissolves easily. Ikeda patented a way to make it in 1908.

synergy

When two things together have a stronger effect than the sum of each alone. Glutamate plus inosinate or guanylate tastes far more savory than either one.

kombu

A dried kelp (seaweed) used in Japan to make dashi broth. It is rich in free glutamate.

CORE IDEAS

The story. Kikunae Ikeda was a chemistry professor at Tokyo Imperial University. One evening, the story goes, he noticed how delicious his wife’s soup was, a *dashi* broth made from kombu kelp. The taste was not sweet, salty, sour or bitter, yet it was strong and satisfying. Ikeda wondered what in the seaweed made it.

How they figured it out. Ikeda boiled large amounts of kombu, concentrated the broth, and step by step removed other substances until he was left with crystals. In 1908 he identified them as glutamic acid, an amino acid already known to chemists, and found that its salt, glutamate, gave the taste he was after. He named the taste *umami*. He patented a method for making monosodium glutamate (MSG), and a company began selling it in 1909. Other Japanese scientists followed: in 1913 Shintaro Kodama found that inosinate from dried bonito fish flakes also tasted savory, and in 1957 Akira Kuninaka discovered guanylate in dried shiitake mushrooms and showed that it multiplies the umami of glutamate. For decades many Western scientists doubted umami was a true basic taste. Then, in the early

2000s, researchers found the receptors on the tongue that respond to glutamate, and umami was accepted as the fifth basic taste.

The kitchen science. Glutamate is in nearly all protein, but we only taste it when it is *free*, not locked inside protein chains. Ripening, aging, drying, fermenting and slow cooking all break proteins apart and free glutamate. That is why a ripe tomato, aged parmesan, soy sauce, long-simmered broth and dried mushrooms taste so savory.

Synergy is the cook's secret: glutamate (tomato, cheese, kombu) combined with inosinate (meat, fish) or guanylate (mushrooms, especially dried) tastes many times stronger than either alone. Think of a cheeseburger with tomato, or Japanese dashi made with kombu and bonito. Browning adds more savory flavor through the Maillard reaction. MSG has been studied carefully for decades; the FDA lists it as generally recognized as safe, and controlled studies have not found that ordinary amounts in food make people sick.

Let's cook. You will make a mushroom and parmesan pasta that stacks umami ingredients: browned mushrooms, parmesan, garlic and a splash of soy sauce. The skill to do well is **browning mushrooms**: a hot pan, a single layer, and patience. Crowded mushrooms steam in their own water and turn gray; spread out, they release their water, it evaporates, and they brown.

PICTURE STUDY



Mariko (from *The Fifty-Three Stations of the Tōkaidō*), Utagawa Hiroshige, about 1838 · Color woodblock print · The Metropolitan Museum of Art, New York

Image: [Wikimedia Commons](#), public domain

Hiroshige's famous series follows the Tōkaidō, the great road between Edo (Tokyo) and Kyoto, station by station. At Mariko, travelers stopped at a little shop famous for *tororo-jiru*, grated mountain yam stirred into a savory broth. Japanese cooks had been building umami into their broths for centuries before Ikeda gave the taste its name.

Look closely

- Find the travelers eating on the benches. What are they holding?
- Find the signboards hanging on the shop. What might they advertise?
- Find the packhorse and the travelers still walking. How far do you think they have come today?
- Find the big tree and the stone wall. How do they frame the scene?

Talk about it

1. A traveler on foot all day would be cold and hungry. Why would a hot, savory broth be especially welcome?
2. Japanese broths often combine kombu with dried fish or mushrooms. Using the idea of synergy, explain why.

3. Hiroshige made prints that ordinary people could afford. Why might travelers have wanted a picture of a place where they had eaten?

Safety first. Hot oil spatters when wet mushrooms hit it; pat the mushrooms dry and lay them in the pan away from you. Drain pasta by pouring away from you, with an adult nearby. Soy sauce contains soy and usually wheat; check allergies before the taste test.

KITCHEN PROJECT

Stack the Umami: Mushroom and Parmesan Pasta

You will run a small umami synergy test with broth, then cook a family pasta dinner built on browned mushrooms and parmesan, and compare a batch of mushrooms browned in a single layer with a crowded batch.

You will need

- A large pot and a colander
- A large skillet (12-inch is best) and a small skillet
- A cutting board, a damp towel and a chef's knife
- A grater for the parmesan
- Measuring cups and spoons, tongs
- Three small cups for the broth test

MUSHROOM AND PARMESAN PASTA

Serves 6 • Prep 15 min • Cook 30 min

Ingredients

- 1 pound (450 g) short pasta, such as penne or rigatoni
- 1½ pounds (680 g) cremini or white mushrooms, wiped clean and sliced ¼ inch thick
- 3 tablespoons olive oil, divided
- 2 tablespoons butter
- 1 shallot or ½ small onion, minced
- 3 cloves garlic, minced
- 1 teaspoon fresh thyme leaves (or ½ teaspoon dried)
- 1 tablespoon soy sauce
- ¾ cup (60 g) finely grated parmesan, plus more to serve
- 1 cup (240 mL) reserved pasta water
- 2 tablespoons chopped parsley
- 1 teaspoon lemon juice

- Salt and black pepper to taste

Method

1. Wash your hands. Bring a large pot of salted water to a boil for the pasta.
2. Heat 1½ tablespoons oil in the large skillet over medium-high heat. Add half the mushrooms in a single layer. Leave them alone 3–4 minutes until browned underneath, then stir and cook 3–4 minutes more until browned all over. Move to a plate. Repeat with the rest of the oil and mushrooms.
3. Cook the pasta according to the package. Scoop out 1 cup of the pasta water before draining.
4. Lower the heat to medium. Melt the butter in the skillet, add the shallot and cook 2 minutes, then the garlic and thyme for 30 seconds.
5. Return all the mushrooms to the pan and stir in the soy sauce.
6. Add the drained pasta, ½ cup of pasta water and the parmesan. Toss with tongs until a glossy sauce coats the pasta, adding more pasta water if it seems dry.
7. Stir in the parsley and lemon juice. Taste, then add salt and pepper as needed. Serve with extra parmesan.
8. Clean up: wash the pots, skillet, board and knife, and wipe the stove once cool.

Allergy check: Contains wheat (pasta, and most soy sauce), milk (butter, parmesan) and soy (soy sauce). For wheat-free, use gluten-free pasta and tamari labeled gluten-free. For soy-free, leave out the soy sauce and add a little more parmesan and salt. For milk-free, use olive oil instead of butter and skip the parmesan.

Steps

1. **Synergy test.** Make three small cups of warm low-sodium broth (or warm salted water). Leave cup A plain. In cup B stir in 1 teaspoon finely grated parmesan. In cup C, use the water from soaking 2 dried mushrooms (or a few chopped browned mushrooms) plus 1 teaspoon parmesan. Taste A, B and C in order and rate the savoriness from 0 to 5.
2. **Crowd test.** In the small skillet, cook a handful of mushrooms piled two layers deep while the first batch browns in a single layer in the large skillet.

After 6 minutes, compare color, texture and the amount of liquid in each pan.

3. Cook the recipe and serve it to your family.
4. **Taste test.** Ask your family to rate the pasta from 1 to 5 for savoriness, saltiness and texture.
5. **Improve it.** Write one change for next time (a few dried porcini soaked and chopped, a squeeze more lemon, or spinach wilted in at the end).
6. Clean up: wash, dry and put away everything.

Tips

- Do not rinse mushrooms under running water; they soak it up. Wipe them with a damp towel, or rinse quickly and dry well.
- Salt mushrooms after they brown. Salt added early pulls out water and slows browning.
- Save parmesan rinds in the freezer. Dropped into a pot of soup, they add deep umami.

Check your work

- ☐ I can tell how Ikeda discovered glutamate and named umami.
- ☐ I can explain umami synergy and give an example.
- ☐ I browned mushrooms in a single layer and served a balanced pasta dinner.

COOK'S NOTEBOOK

1. Draw a timeline of umami: 1908 Ikeda, 1913 Kodama, 1957 Kuninaka, early 2000s receptors found.
2. Make a chart of your synergy test with the savoriness scores for each cup.
3. List ten foods in your kitchen that are rich in umami, and sort them by how they got that way (ripened, aged, dried, fermented, cooked).

From history. Umami ingredients are found in many traditional cuisines: Italian cooks use parmesan and tomato, the ancient Romans used a fermented fish sauce called *garum*, Southeast Asian cooks use fish sauce, and English cooks have long used Worcestershire sauce, which is made with anchovies. People were combining umami ingredients long before anyone could name the taste.

COMMON MISTAKES

- Crowding the mushroom pan. They steam, turn gray and rubbery; cook in batches in a single layer.
- Thinking umami just means salty. Salt is sodium; umami is glutamate. They work together, but they are different tastes.
- Repeating old rumors about MSG as fact. Check claims against careful studies and reliable sources like the FDA.

Make it a game · Umami or Not. Write ten foods on slips: mushrooms, parmesan, soy sauce, tomatoes, apples, lettuce and others. Sort them into umami-rich and not in sixty seconds. Then teach your parent how Ikeda found glutamate in kombu broth and why tomato with parmesan tastes bigger than either one alone. Your parent challenges any sort they doubt.

3.3 TASTE BUDS OVER A LIFETIME

OBJECTIVES

- Explain how taste and smell change from infancy through childhood, the teen years and old age.
- Tell how researchers at the Monell Center studied children's taste, and why tasting a food 8–15 times can change how you feel about it.
- Interview an older relative, cook a family recipe with them or from their memory, and record it for the family.

Warm-up. Name a food you disliked when you were five but like now, and a food an adult in your family loves that you still do not. Why do you think tastes change? Write down two guesses.

WATCH

How Your Taste Buds Change Over Time

Seeker · 3:31

https://www.youtube.com/watch?v=NLLr_5ML_Ms

WHEN TO WATCH

After the kitchen-science paragraph. Listen for how often taste cells are replaced and what changes with age.

KEY TERMS

taste receptor cell

A cell inside a taste bud that responds to one kind of taste. These cells wear out and are replaced about every one to two weeks.

exposure

Tasting a food. Repeated small exposures help people learn to like new foods.

sensitivity

How small an amount of a taste or smell a person can notice. Children are more sensitive to some bitter tastes than most adults.

olfaction

The sense of smell. It usually fades more with age than the sense of taste does.

oral history

History gathered by interviewing people about what they remember, and recording their words.

CORE IDEAS

The story. At the Monell Chemical Senses Center in Philadelphia, founded in 1968 to study taste and smell, a researcher named Julie Mennella has spent decades studying how children taste. In one well-known study, published in 2001, mothers drank carrot juice for several weeks during pregnancy or while nursing. Later, their babies made fewer unhappy faces and ate more when first given cereal made with carrot juice than babies whose mothers had drunk only water. Flavors from a mother's food reach the baby, and babies learn to like them.

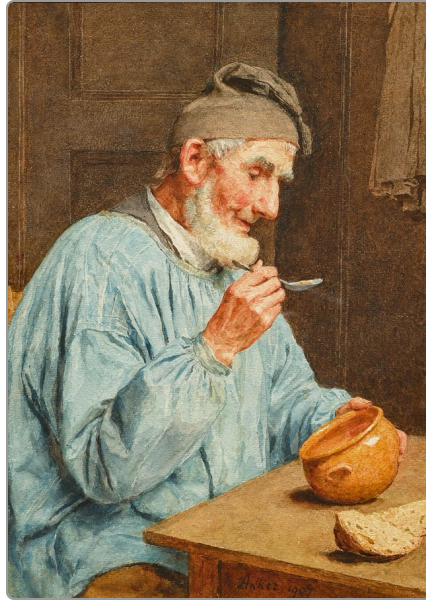
How they figured it out. Monell researchers have compared children and adults by giving them sips of sugar water at different strengths and asking which they like best. Children, on average, pick much sweeter solutions than adults do, and the preference fades during the teen years as the body finishes its fastest growth. Many children are also more sensitive to some bitter compounds, like those in raw broccoli and Brussels sprouts. Other researchers, such as Leann Birch, found that young children often need to taste a new food 8 to 15 times before they accept it. A frown at the first bite does not mean "never."

The kitchen science. Your taste receptor cells are replaced about every one to two weeks, and your brain keeps learning which foods are safe and good. That is why tastes broaden as you grow and keep trying things. In older adults, the sense of smell often fades, especially after about age 60, and since smell supplies most of flavor, food may seem bland. Older people may also take medicines that change taste. A cook for grandparents can help with brighter flavors: fresh herbs, a squeeze of lemon, toasted spices, good browning and varied textures, rather than simply more salt. Every age at a family table tastes the same dish a little differently, which is one reason good family recipes are worth learning: they have been adjusted over many years to please many people.

Let's cook. You will interview a grandparent or another older relative or friend about a dish they loved growing up, then cook it with them or from their directions, and write it down for the family. If no family recipe is at hand, use our model, an old-

fashioned chicken and dumplings. The skill to do well is **following an oral recipe**: asking good questions (“How much is a handful?” “How do you know it is done?”) and turning the answers into measured, written steps.

PICTURE STUDY



Farmer Eating Soup, Albert Anker, 1907 · Watercolor on paper · Private collection

Image: [Wikimedia Commons](#), public domain

Albert Anker, a Swiss painter, spent his life painting the people of his village: children at school, grandparents by the stove, families at the table. Here an old farmer eats his soup and bread with quiet attention. Anker painted the elderly with great respect.

Look closely

- Find the soup bowl and the bread. What kind of meal is this?
- Look at the farmer's face and hands. How old do you think he is? What work have his hands done?
- Look at how he holds his spoon and leans toward the bowl. Is he hurrying or taking his time?
- Look at the table and the room. What do they tell you about his life?

Talk about it

1. If this farmer's sense of smell had faded with age, how might his soup taste to him? What could a cook add to help?
2. What dish do you think he remembers from his own childhood? What questions would you ask him about it?
3. Why is it valuable to learn recipes from older people while you can?

Safety first. Follow every safe temperature, even in an old family recipe: chicken to 165 °F, and dumplings cooked until a toothpick comes out clean. Older recipes sometimes call for tasting uncooked dough or leaving food out to cool for hours; do not. Have an adult at home and nearby for the stove.

A Family Taste Memory: Recipe Interview and Cook-Along

You will gather a family recipe through an interview, cook it, serve it at a meal with several generations if you can, and record how people of different ages experienced the same dish.

You will need

- Your cook's notebook and a pen, or a phone to record the interview (with permission)
- A large heavy pot or Dutch oven with a lid
- Two cutting boards (one for raw chicken), a damp towel and a chef's knife
- A mixing bowl, a fork and measuring cups and spoons
- An instant-read food thermometer, a toothpick and a ladle

OLD-FASHIONED CHICKEN AND DUMPLINGS (MODEL FAMILY RECIPE)

Serves 6 • Prep 25 min • Cook 45 min

Ingredients

- **Stew:** 2 tablespoons butter or oil
- 1 onion, diced
- 2 carrots, sliced
- 2 ribs celery, sliced
- $\frac{1}{3}$ cup (40 g) all-purpose flour
- 6 cups (1.4 L) low-sodium chicken broth
- $1\frac{1}{2}$ pounds (680 g) boneless, skinless chicken thighs
- 1 teaspoon dried thyme, 1 bay leaf
- $\frac{1}{2}$ cup (120 mL) milk
- 1 cup (140 g) frozen peas
- Salt and pepper to taste
- **Dumplings:** $1\frac{1}{2}$ cups (190 g) all-purpose flour

- 2 teaspoons baking powder, ½ teaspoon salt
- ¾ cup (180 mL) milk
- 3 tablespoons melted butter
- 2 tablespoons chopped parsley

Method

1. Wash your hands and the vegetables. Melt the butter in the pot over medium heat. Cook the onion, carrots and celery 6–8 minutes until soft.
2. Sprinkle the flour over the vegetables and stir for 1 minute. Slowly whisk in the broth so no lumps form.
3. Add the chicken thighs whole, the thyme and the bay leaf. Bring to a simmer, cover and cook 20 minutes, until the chicken reads 165 °F (74 °C). Lift the chicken onto a clean board, shred it with two forks, and return it to the pot. Stir in the milk and peas, and season with salt and pepper. Remove the bay leaf.
4. **Dumplings:** In the bowl, stir together the flour, baking powder and salt. Add the milk, melted butter and parsley and stir just until a soft dough forms. Do not taste the uncooked dough.
5. Bring the stew back to a gentle simmer. Drop the dough by heaping tablespoons onto the surface, leaving space between (about 12 dumplings).
6. Cover tightly and simmer 15 minutes without lifting the lid. Check one dumpling: a toothpick in the center should come out clean.
7. Serve in bowls. Refrigerate leftovers within 2 hours and reheat to 165 °F.
8. Clean up: wash both boards, the knife and the pot in hot, soapy water.

Allergy check: Contains wheat (flour) and milk (butter, milk). For milk-free, use oil and an unsweetened plain plant milk. Family recipes vary: check every ingredient in your own recipe against your family's allergies.

Steps

1. **Interview.** Ask an older relative or friend at least eight questions: What did your family eat for supper when you were my age? Who cooked it? What did the kitchen look like? What dish do you miss? How did they make it? How did they know it was done? What did it smell like? Who sat at the table? Write down or record the answers.

2. **Write the recipe.** Turn the remembered recipe into measured ingredients and numbered steps. Mark any step you had to guess, and add modern safety steps (thermometer, refrigerating leftovers).
3. Cook the dish, with your relative beside you if possible.
4. **Ages at the table.** Serve it to family members of different ages. Ask each to rate it from 1 to 5 and say one word about the flavor. Record each person's age group (child, teen, adult, older adult). Do the youngest and oldest notice different things?
5. **Improve it.** Ask your relative: "Is this how you remember it?" Write what they say and one change for next time.
6. Clean up: wash, dry and put away everything, and thank your relative in writing.

Tips

- Ask to see an old recipe card if one exists. Photograph it; the handwriting is part of the family history.
- "A pinch," "a handful" and "until it looks right" can be measured: watch your relative do it, then measure what they used.
- Dumplings need steam to cook through. Keep the lid on for the full 15 minutes.

Check your work

- ☐ I can explain how taste and smell change from childhood to old age.
- ☐ I can explain why tasting a food many times helps.
- ☐ I gathered a family recipe by interview, cooked it safely and wrote it down.

COOK'S NOTEBOOK

1. Write up your interview as a one-page story, using at least two direct quotations from your relative.
2. Copy the family recipe neatly on a recipe card for the family recipe box, with the name of the person it came from.
3. Draw a chart of the ratings by age group and write two sentences about what you notice.

From history. The Monell Center is named for Ambrose Monell, whose family foundation helped fund it. It is one of the few research institutes in the world devoted entirely to taste and smell, and its scientists have studied everything from why cats do not taste sweetness to how a baby's first foods shape later choices.

COMMON MISTAKES

- Giving up on a food after one taste. Try small portions many times, prepared different ways.
- Adding more salt for an older diner whose food tastes bland. Brighter flavors (lemon, herbs, browning) help without extra salt.
- Following an old recipe's unsafe habits, such as cooling a pot of stew on the counter overnight. Keep the family flavor; use today's safety steps.

Make it a game • The Taste Reporter. Play a news reporter. Interview your parent about one food they disliked as a child and now enjoy, asking when it changed and why. Take notes. Then explain what Monell Center research says about tasting a food eight to fifteen times. Read your report back, aloud, in your best broadcast voice.

Scripture. "Doth not the ear try words? and the mouth taste his meat?" (Job 12:11, KJV)
Job compares tasting food to weighing words. Both take attention and practice, and both grow wiser with time.

3.4 TEXTURE AND FOOD ENGINEERING

OBJECTIVES

- Tell how Alina Szczesniak, a food scientist at General Foods, created a vocabulary for food texture in the 1960s.
- Explain how moisture moves from wet to dry foods and why crisp foods go soggy, and how sound affects how crisp a food seems.
- Bake a crisp oat crumble and build crisp-and-creamy parfaits, testing when to assemble them.

Warm-up. Close your eyes and have someone hand you a cracker, a slice of bread, a spoonful of yogurt and a grape (check allergies first). For each, write three words that describe how it feels in your mouth, without using “good” or “yummy.”

WATCH

Elasticity and texture of food

Harvard Online • 6:08

<https://www.youtube.com/watch?v=WU5RpSfvPjM>

WHEN TO WATCH

After the kitchen-science paragraph. Watch how scientists measure how firm or soft a food is.

Note: From Harvard’s Science and Cooking course.

BACKUP VIDEO

Does TEXTURE effect how something tastes? | Food Unwrapped

Food Unwrapped • 3:12

<https://www.youtube.com/watch?v=jLO6gDP9uHI>

A short second look at how texture changes what we taste.

KEY TERMS

texture

How a food feels in the mouth and hands: hard or soft, crisp or chewy, smooth or grainy, and so on.

mouthfeel

The physical sensations of a food or drink in the mouth, such as creaminess, thickness or dryness.

crisp

Breaking cleanly and loudly with little force, like a fresh cracker. Crisp foods are dry and brittle.

moisture migration

Water moving from a wetter food into a drier one when they touch, which makes crisp foods soggy.

water activity

A measure of how freely water in a food is available to move or to be used by microbes. Crisp foods have very low water activity.

CORE IDEAS

The story. In the 1950s and 1960s, American food companies were inventing new foods by the hundreds: instant puddings, boxed cake mixes, breakfast cereals and frozen dinners. At General Foods in Tarrytown, New York, a food scientist named Alina Szczesniak, who had come to the United States from Poland, noticed a problem. Tasters could describe flavor in detail, but when asked about texture they said only “good” or “bad.” Without words, no one could measure texture or fix it.

How they figured it out. In 1963 Szczesniak published a system for describing texture. She sorted it into mechanical qualities (hardness, cohesiveness, chewiness, springiness, adhesiveness or stickiness, and thickness), geometric qualities (the size, shape and arrangement of particles: grainy, fibrous, flaky), and qualities from fat and moisture (oily, juicy, moist). She trained panels of tasters to rate each one on a scale, and she worked with engineers on machines that squeeze food the way teeth do. Her “texture profile” is still used by food scientists around the world. Later researchers found that even sound matters: in a 2004 experiment at the University of Oxford, people ate potato chips while wearing headphones that played back their crunch louder or softer. Louder crunches made the same chips seem crisper and fresher.

The kitchen science. Crispness comes from dryness. A crisp cracker or crumble has so little water that its starch and sugar are stiff and glassy, and they snap with a sharp sound. When a crisp food touches a moist one, water moves from the wet food into the dry one (**moisture migration**) until both are equally damp. The starch softens and the crunch is gone; cereal in milk and crackers in a humid kitchen go soggy this way. Food engineers fight it with barriers: the thin chocolate coating inside some ice cream cones, fat in a pie crust, or simply keeping parts separate until the last moment. A good dish often puts contrasting textures together on purpose, crisp with creamy, chewy with tender, because the contrast keeps every bite interesting.

Let's cook. You will bake a crisp oat crumble and layer it with creamy yogurt and juicy berries into parfaits, then test what happens when you assemble them early. The skill to do well is **baking to crispness**: spreading the crumble thin and baking until deep golden, then letting it cool completely, because it only becomes crisp as it cools and dries.

PICTURE STUDY



Basket of Wild Strawberries, Jean-Siméon Chardin, 1761 · Oil on canvas · Musée du Louvre, Paris

Image: [Wikimedia Commons](#), public domain

Chardin piled tiny wild strawberries into a perfect cone in a woven basket. Next to it he placed a clear glass of water, two carnations and some fruit. He shows a whole range of textures on one ledge: soft, seedy berries, smooth fuzzy peach skin, glossy cherries, rough basketwork and clear glass.

Look closely

- Find the glass of water. How did Chardin show that it is clear?
- Look closely at the strawberries. How many different textures can you imagine just from looking?
- Find the basket. How is its texture different from everything on top of it?
- Find the peach and the cherries. Which would be juicy, which firm, which fuzzy?

Talk about it

1. If you added these strawberries to a crisp crumble, what would happen to the crumble after an hour? Why?
2. Write five exact texture words for the foods in this painting, using Szczesniak's kinds of words.

3. Why do you think contrasting textures, like crisp and creamy, make food more enjoyable?

Safety first. Do not taste the crumble mixture before it is baked; it contains raw flour. Use oven mitts and set the hot pan on a trivet. If you use nuts, check for tree-nut and peanut allergies first. An adult is at home and nearby while you use the oven.

Crisp Meets Creamy: Berry Parfaits with Oat Crumble

You will bake a crisp crumble, build parfaits, and run a timed soggiess test, assembling some parfaits right away and some just before serving. You will rate texture with exact words from Szczesniak's system, and measure crunch by sound.

You will need

- A rimmed baking sheet and parchment
- A medium bowl and a fork
- Measuring cups and spoons
- Six clear glasses or jars for parfaits
- A timer and a phone that can record sound (optional)

CRISP-AND-CREAMY BERRY PARFAITS WITH OAT CRUMBLE

Serves 6 · Prep 15 min · Bake 20 min · Cool 20 min

Ingredients

- **Oat crumble:** 1 cup (90 g) old-fashioned rolled oats
- ½ cup (65 g) all-purpose flour
- ⅓ cup (70 g) packed brown sugar
- ½ teaspoon ground cinnamon and ¼ teaspoon salt
- 5 tablespoons (70 g) butter, melted
- ⅓ cup sliced almonds or pumpkin seeds (optional)
- **Parfaits:** 3 cups (about 700 g) vanilla or plain Greek yogurt
- 1 tablespoon honey or maple syrup (if using plain yogurt)
- 3 cups (about 450 g) mixed berries: strawberries (hulled and sliced), blueberries, raspberries

Method

1. Heat the oven to 350 °F (175 °C). Wash your hands and line the baking sheet with parchment.

2. In the bowl, stir together the oats, flour, brown sugar, cinnamon, salt and almonds. Pour in the melted butter and stir with a fork until the mixture forms damp clumps. Do not taste it raw.
3. Spread the crumble in a thin, even layer on the baking sheet, squeezing some into small clusters.
4. Bake 18–22 minutes, stirring once halfway, until deep golden brown. Cool completely on the pan, about 20 minutes; it crisps as it cools.
5. If using plain yogurt, stir in the honey.
6. Build each parfait: a layer of yogurt, a layer of berries, a layer of crumble, then repeat, ending with crumble on top.
7. Serve right away. Store extra crumble in an airtight jar for up to a week.
8. Clean up: wash the bowl and pan and wipe the counters.

Allergy check: Contains milk (butter, yogurt) and wheat (flour); almonds are a tree nut. For nut-free, use pumpkin seeds or leave them out. For wheat-free, use oat flour and oats labeled gluten-free. For milk-free, use coconut oil and a plant-based yogurt. Honey is never given to babies under one year.

Steps

1. **Predict.** Write how long you think the crumble in a parfait will stay crisp.
2. **Sogginess test.** Assemble two parfaits 2 hours before dinner and refrigerate them. Assemble the rest just before serving. At dinner, taste the crumble in each. Rate crispness from 0 to 5.
3. **Sound test.** Bite a piece of fresh crumble and a piece from the early parfait close to a phone's voice recorder, or just listen carefully. Describe the difference in sound.
4. **Texture profile.** For each layer, write two exact texture words from this lesson (hardness, crispness, creaminess, juiciness, chewiness, smoothness).
5. **Improve it.** Write one way to keep the crunch longer (packing the crumble separately, coating it in a thin layer of melted chocolate, or using thicker yogurt).
6. Clean up: wash, dry and put away everything.

Tips

- Bake the crumble until it is deeper brown than you think; pale crumble softens quickly.

- Thick Greek yogurt has less free water than regular yogurt, so it softens crumble more slowly.
- Pack crumble in a separate small container for lunches and sprinkle it on at the last minute.

Check your work

- ☐ I can tell how Szczesniak gave food scientists words for texture.
- ☐ I can explain moisture migration and why crisp foods go soggy.
- ☐ I baked a crisp crumble and tested how timing affects crunch.

COOK'S NOTEBOOK

1. Draw a cross-section of a parfait. Use arrows to show water moving from the yogurt and berries into the crumble.
2. Make a texture profile chart for three foods from your kitchen, rating hardness, crispness, chewiness and moistness from 0 to 5.
3. Copy the recipe in your own words and record your sogginess-test results.

From history. Alina Szczesniak was born in Poland and came to the United States after World War II, where she earned a doctorate in food science. Her texture work at General Foods helped shape many foods still on grocery shelves, and food scientists today still train tasting panels with methods that grew from her texture profile.

COMMON MISTAKES

- Storing crisp food before it has cooled. Steam trapped in the jar softens it; cool completely first.
- Assembling parfaits or salads with crunchy toppings hours ahead. Add crunchy parts at the last minute.
- Tasting raw crumble or cookie dough. Raw flour can carry germs; wait until it is baked.

Make it a game • Crunch by Ear. Close your eyes while your parent crunches a cracker, an apple slice, a carrot and a chip near your ear. Name each one by sound only, then describe its texture using Szczesniak-style words such as crisp, chewy or mealy. Finally predict which of the four would go soggy first beside a damp paper towel, and why.

UNIT 3

TASTE, SMELL & YOUR TASTE BUDS

“O taste and see that the LORD is good” (Psalm 34:8). God gave us senses that make eating one of life’s daily joys, and in this unit you will study them like a scientist. You will meet Jean Anthelme Brillat-Savarin, a French judge who wrote the first great book on the pleasures of the table and noticed, two hundred years ago, that smell and taste work as one sense. You will follow Kikunae Ikeda from a bowl of kelp broth to the discovery of glutamate and umami, learn how taste changes from infancy to old age, and see how food scientists describe and design texture.

Each week you will cook with the science in mind: a small tasting menu that balances the five tastes, a mushroom pasta full of umami, a family recipe gathered from an older relative, and a crisp-and-creamy parfait that tests how moisture ruins a crunch. Along the way you will practice the classical habit of attention: noticing carefully, naming exactly, and giving thanks for what you taste.

PREREQUISITES

- Can use a chef’s knife and the stove safely (Unit 1)
- Knows the five MyPlate groups (Unit 2)
- Checks every taste test against the family’s food allergies before starting
- Has a cook’s notebook ready for taste charts

MASTERY CHECKLIST

- ☐ I can name the five basic tastes, explain how taste and smell combine into flavor, and describe retronasal smell.
- ☐ I can tell how Ikeda discovered glutamate in 1908 and explain how umami ingredients work together.
- ☐ I can describe how taste changes from childhood to old age and why trying a food 8–15 times helps.
- ☐ I can describe a food’s texture with exact words and explain why moisture makes crisp foods soggy.
- ☐ I can balance a dish by tasting and adjusting salt, acid, sweetness and umami.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **Monell Chemical Senses Center**: Free. The Philadelphia research institute that studies taste and smell. Its site has short articles on how taste works and how it changes with age, helpful for Lessons 3.1 and 3.3.
- **A set of small tasting spoons or cups**: Plastic tasting spoons or small paper cups make blind taste tests neat and fair. Ordinary teaspoons work too.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

3.1 Brillat-Savarin and The Physiology of Taste	2 sessions of 50–60 minutes
3.2 Umami and Glutamate: Ikeda's Discovery	2 sessions of 50–60 minutes
3.3 Taste Buds Over a Lifetime	2 sessions of 50–60 minutes
3.4 Texture and Food Engineering	2 sessions of 50–60 minutes

UNIT 3 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**
Name the five basic tastes and give one food that shows each.
2. **8 pts**
What did Brillat-Savarin observe about taste and smell, and how did modern science confirm it?
3. **8 pts**
What is retronasal smell? Describe a test that shows it.
4. **8 pts**
How did Ikeda discover glutamate, and what did Kuninaka add in 1957?

5. (8 pts)

Predict: you crowd 1½ pounds of sliced mushrooms into a small pan. What will happen, and why?

6. (8 pts)

Why do aged cheese, ripe tomatoes and soy sauce taste so savory?

7. (8 pts)

Describe two ways taste changes from childhood to old age.

8. (8 pts)

A child refuses roasted Brussels sprouts at the first taste. What does research suggest the family do?

9. (8 pts)

What is moisture migration? Give an example and one way to prevent it.

10. (10 pts)

Calculation: the tasting menu serves 6. You want to serve 15 guests. By what factor do you multiply? How many pounds of carrots and tomatoes will you need (the recipe uses 1 pound of each)?

11. (10 pts)

Calculation: the crumble bakes at 350 °F. What is that in °C? A recipe from Britain says to bake at 180 °C. Is that hotter or cooler than 350 °F, and by about how many °F?

12. (8 pts)

Short answer: In three or four sentences, explain what Szczesniak contributed to food science and why words for texture matter to a cook.

ANSWER KEY

1. Sweet (honey, fruit), salty (salted crackers), sour (lemon), bitter (dark chocolate, coffee beans, kale), umami (parmesan, tomato, broth). Other correct examples accepted.
2. He noticed that food loses its taste when a person has a cold and concluded taste and smell work as one sense. Scientists found the tongue senses only five basic tastes while retronasal smell from the mouth to the nose supplies most of flavor.
3. Smelling aromas that rise from food in the mouth up the back of the throat into the nose while chewing and swallowing. Pinch your nose and eat apple and potato: they taste nearly the same until you let go.
4. Ikeda concentrated kombu broth and isolated crystals that he identified as glutamic acid; its salt, glutamate, gave the savory taste he named umami (1908). Kuninaka found guanylate in dried shiitake mushrooms and showed it greatly strengthens glutamate's umami (synergy).
5. They will steam in their own water, turn gray and rubbery and not brown, because the water they release cannot evaporate fast enough to let the surface get hot enough for browning.
6. Aging, ripening and fermenting break proteins apart and release free glutamate, which the tongue senses as umami.
7. Children on average prefer sweeter tastes and are more sensitive to some bitter compounds; these change through the teen years. In older adults the sense of smell often fades, especially after about 60, so food can seem bland.
8. Keep offering small tastes without pressure, prepared different ways; many children need 8–15 tastes before they accept a new food.
9. Water moving from a wetter food into a drier one until they are equally moist, which makes crisp foods soggy (cereal in milk, crumble in yogurt). Prevent it by keeping parts separate until serving or by a barrier such as a chocolate coating.
10. $15 \div 6 = 2.5$. You need 2.5 pounds of carrots and 2.5 pounds of tomatoes.
11. $(350 - 32) \times \frac{5}{9} = 318 \times \frac{5}{9} \approx 177^\circ\text{C}$. $180^\circ\text{C} \times \frac{9}{5} + 32 = 356^\circ\text{F}$, about 6°F hotter (essentially the same temperature).
12. She created a texture profile system in 1963 that named and measured qualities like hardness, chewiness, cohesiveness and crispness, and trained tasters to rate them. Words let cooks and scientists describe exactly what is wrong (too soggy, too chewy) and fix it, and they help us notice and enjoy food more carefully.

UNIT CHALLENGE: A FAMILY BLIND TASTE TEST

Choose one food and prepare it three ways (for example, carrots raw, steamed and roasted; or tomatoes fresh, roasted and in a sauce). Serve all three to at least four family members of different ages in a blind tasting, with each person rating sweetness, savoriness, bitterness, aroma and texture from 0 to 5.

Make a results chart, write a paragraph explaining the differences using what you learned about taste, smell, umami and texture, and add your family recipe from Lesson 3.3 to a family recipe collection. Finish with a “try it again” plan: a vegetable someone at your table dislikes, and three different ways you will prepare it over the next few weeks.

LOOK FOR	WHAT IT MEANS
Fair test	Same food, three methods, blind tasting, same rating card for every taster; allergies checked first.
Cooking	All three versions cooked carefully and safely, with a clean kitchen afterward.
Results chart	Clear chart with every taster’s ratings and averages.
Science explanation	Uses the ideas of basic tastes, retronasal smell, umami, browning and texture correctly.
Family recipe and try-again plan	Family recipe neatly recorded with its source, and a thoughtful plan for a disliked vegetable; honest records earn full credit even if tasters still disagree.

UNIT 4

HEAT & COLD

Every cooking method is a way of moving heat into food or out of it. In this unit you will follow four people who changed how we think about heat and cold. Count Rumford proved that heat is a kind of motion, not a fluid, and accidentally discovered the secret of slow roasting. Denis Papin sealed a pot so tightly that water could get hotter than its boiling point, and softened beef bones “as soft as cheese.” Nicolas Appert learned to keep food for years in sealed jars, and Nancy Johnson invented the hand-cranked ice cream freezer.

You will cook with each idea: a slow-roasted beef roast that is evenly done from edge to center, a pot of beans that shows how pressure and salt change cooking, a batch of strawberry jam set with sugar, acid and pectin, and homemade ice cream frozen fast in a salt-and-ice bath. You will measure temperatures at every step and do a little physics and arithmetic along the way.

PREREQUISITES

- Uses a thermometer to check safe internal temperatures (Unit 1)
- Uses the stove and oven safely with an adult at home and nearby (Unit 1)
- Can convert between °F and °C
- Knows that proteins unfold and set when heated (taught again here)

MASTERY CHECKLIST

- ☐ I can explain how Rumford’s cannon-boring experiment showed that heat is motion, and why slow roasting cooks meat evenly.
- ☐ I can explain how pressure changes the boiling point of water and why a pressure cooker cooks faster.
- ☐ I can explain how sugar, acid and pectin make jam set, and why home canning must follow tested recipes.
- ☐ I can explain freezing-point depression and why fast freezing makes smoother ice cream.
- ☐ I can convert temperatures, calculate a sugar percentage and adjust boiling point for altitude.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **National Center for Home Food Preservation:** Free. Tested, research-based instructions for canning, freezing and drying from the University of Georgia. If your family wants to can jam for the shelf, use only their tested recipes (Lesson 4.3).
- **A clip-on candy or deep-fry thermometer:** Optional. Helpful for checking when jam reaches 220 °F (Lesson 4.3). An instant-read thermometer also works if you check quickly with an oven mitt on.
- **Rock salt or kosher salt and gallon zip-top bags:** Needed for the bag method in Lesson 4.4 if you do not have an ice cream maker. Inexpensive at any grocery store.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

4.1 Count Rumford and the Nature of Heat

2 sessions of 50–60 minutes (plus about 2 hours of roasting)

4.2 Denis Papin’s Digester and the Pressure Cooker

2 sessions of 50–60 minutes (plus overnight soaking)

4.3 Nicolas Appert and the Science of Jam

2 sessions of 50–60 minutes

4.4 Freezing Science: Ice Crystals and Ice Cream

2 sessions of 50–60 minutes

UNIT 4 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**

Describe Rumford’s cannon-boring experiment. What did it show about heat?

2. (8 pts)

Why does a roast cooked at 250 °F have a thinner overcooked band than one cooked at 450 °F?

3. (8 pts)

What is the safe internal temperature for a whole beef roast, and why is it lower than for ground beef?

4. (8 pts)

How did Papin's digester cook food faster? What did his safety valve do?

5. (8 pts)

Predict: you cook beans with tomatoes from the beginning. What will happen to the beans, and why?

6. (10 pts)

Calculation: water's boiling point drops about 1 °F for every 500 feet of altitude. About what is the boiling point in a town 5,000 feet above sea level? What would its jam set point be?

7. (8 pts)

Explain how sugar, acid and pectin work together to make jam set.

8. (10 pts)

Calculation: a batch of jam weighs 900 g and contains 300 g of added sugar. What percentage of the jam is added sugar? If the strawberries added another 40 g of natural sugar, what is the total sugar percentage?

9. (8 pts)

Why must a family that wants shelf-stable jam follow a tested canning recipe?

10. (8 pts)

Explain why salt makes ice colder.

11. (8 pts)

Calculation: your ice cream mix measured 3 cups before freezing and 4 cups after. What is the overrun?

12. **8 pts**

Short answer: In three or four sentences, explain why fast-frozen ice cream is smoother than slow-frozen ice cream, and connect it to another frozen food.

ANSWER KEY

1. He bored a brass cannon with a dull tool surrounded by cold water, turned by horses; after about two and a half hours the water boiled with no fire, and heat kept coming as long as the boring continued. Heat could be produced without limit by motion, so it is a form of motion, not a stored fluid (caloric).
2. Heat moves into a roast slowly by conduction. In a hot oven the outside gets far hotter than the center before the center is done, overcooking a thick outer band. In a low oven the temperature gradient is gentle, so the meat cooks evenly almost edge to edge.
3. 145 °F (63 °C) with at least a 3-minute rest. Bacteria live mainly on the surface of whole cuts, where searing and roasting destroy them; ground beef mixes surface bacteria all through, so it needs 160 °F.
4. The sealed pot trapped steam, raising the pressure, which raised the boiling point so the water got hotter than 212 °F and cooked food faster. The safety valve let steam escape if the pressure grew too high, so the pot would not burst.
5. They may stay firm and take much longer to soften, because acid strengthens the pectin and calcium in the bean skins. Add tomatoes after the beans are tender.
6. $5,000 \div 500 = 10$, so about $212 - 10 = 202$ °F. The jam set point is 8 °F higher: about 210 °F.
7. Pectin chains are negatively charged and push apart in water. Acid neutralizes some charge so they can come close. Sugar pulls water away from the pectin so the chains bump and link into a net that traps the juice.
8. $300 \div 900 \times 100 \approx 33.3\%$ added sugar. Total: $340 \div 900 \times 100 \approx 37.8\%$.
9. Safe canning depends on exact acidity, jar size, heating time and altitude, which have been tested in laboratories. Guessing can leave microbes alive that spoil the food or make people sick.
10. Salt dissolves in the water on the ice and gets in the way of water molecules refreezing (freezing-point depression). The ice keeps melting, and melting absorbs heat from the surroundings, so the brine becomes colder than 32 °F, down to about 0 °F.
11. $(4 - 3) \div 3 \times 100 \approx 33\%$.
12. Fast freezing and stirring make many tiny ice crystals at once, and none has time to grow large, so the texture feels smooth. Slow, still freezing lets a few crystals grow big and jagged, which feel icy. The same is true of frozen fish and

vegetables: Birdseye's fast freezing kept crystals small so they did less damage to the food.

UNIT CHALLENGE: SAME FOOD, FOUR HEATS

Choose one vegetable (potatoes, carrots or broccoli work well) and cook equal pieces four ways: boiled or steamed, roasted at 425 °F, microwaved, and pan-seared in a thin film of oil with an adult present. Record the cooking time, the temperature of each method, and the texture, color and taste of each result.

Then make a chart and write a one-page explanation using this unit's ideas: conduction, convection, radiation, the boiling point of water and browning. Finish by naming which method you would choose for a family dinner and why.

LOOK FOR	WHAT IT MEANS
Fair test	Same vegetable, same size pieces, four methods, with times and temperatures recorded.
Safe cooking	Stove, oven and microwave used safely; pan-searing done with an adult present; clean kitchen afterward.
Chart	A clear chart of time, temperature, texture, color and taste for each method, with family ratings.
Science explanation	Correctly uses heat transfer, boiling point and browning to explain the differences.
Choice and improvement	A reasoned choice for a family dinner and one honest improvement; results that surprised you, recorded honestly, earn full credit.

4.1 COUNT RUMFORD AND THE NATURE OF HEAT

OBJECTIVES

- Tell how Count Rumford's cannon-boring experiment in 1798 showed that heat is a form of motion, and how he discovered slow roasting by accident.
- Explain what happens to muscle proteins as meat heats, and why low oven heat cooks a roast more evenly.
- Sear and slow-roast a beef roast to 145 °F with a 3-minute rest, and slice it against the grain.

Warm-up. Rub your palms together hard for 15 seconds. What do you feel? Now hold a metal spoon and a wooden spoon in the same hand for a minute. Which feels colder, even though both are at room temperature? Write down your best explanation for each.

WATCH

How Count Rumford Fed the Poor

Two Slices - Food History · 9:26

<https://www.youtube.com/watch?v=6O19EWVbpt4>

WHEN TO WATCH

After the story. It tells Rumford's life in Munich, his stoves and his famous soup.

Note: A careful food-history channel. The video tells more of Rumford's life than our lesson does; his cannon experiment is in our story paragraph.

BACKUP VIDEO

Super Quick Video Tips: How To Make Roast Beef Like a Pro

America's Test Kitchen · 2:09

<https://www.youtube.com/watch?v=KEBh8dSHckE>

Before you cook. Watch the sear and the low oven. Our recipe cooks the roast to 145 °F, the USDA's safe temperature, which is more done than the roast shown.

KEY TERMS

heat

Energy that moves from a hotter thing to a cooler one. In matter, it is the motion of molecules: the hotter something is, the faster its molecules move.

conduction

Heat moving through a material or from one touching thing to another, molecule to molecule, as from a hot pan into a steak, or from the outside of a roast toward its center.

against the grain

Slicing across the long muscle fibers of meat, so each slice has short fibers and is tender to chew.

caloric theory

The old idea, common before 1800, that heat was an invisible fluid called “caloric” that flowed from hot things into cold ones.

temperature gradient

The change in temperature from one place to another, such as from the hot outside of a roast to its cooler center.

CORE IDEAS

The story. Benjamin Thompson was born in 1753 in Woburn, Massachusetts. After the War for Independence he went to Europe and served the ruler of Bavaria in Munich, where he reorganized the army, fed the city’s poor with nourishing soup, and designed better stoves. The ruler made him a count, and he chose the name Rumford, after the New Hampshire town where he had once lived. Rumford was always measuring. One day in 1798, watching workmen bore out the barrel of a brass cannon at the Munich arsenal, he noticed how astonishingly hot the metal and the shavings became.

How they figured it out. Most scientists then believed heat was a fluid called **caloric** that was squeezed out of a material. If so, Rumford reasoned, the metal should eventually run out. So he set up an experiment: he put a dull boring tool against a cannon, surrounded it with a box of cold water, and had horses turn the cannon. After about two and a half hours the water boiled, with no fire at all, and the heat kept coming as long as the horses kept turning. Heat could be made without limit by

motion, so it could not be a fluid stored in the metal. He concluded that heat is a kind of motion. In his kitchen experiments Rumford made another discovery. Once he put a shoulder of mutton into a low-heat oven he had built for drying potatoes and left it there. Hours later it was found perfectly cooked, tender and full of flavor. He wrote about it as proof that meat cooks well at a gentle heat, given time: the first recipe for slow roasting.

The kitchen science. Meat is mostly water held inside long muscle fibers made of protein. As meat heats, the proteins unfold and shrink. Around 140–150 °F (60–66 °C) the fibers begin to squeeze hard and push out juice; the hotter meat gets, the drier it becomes. Heat reaches the center of a roast by **conduction**, slowly, from the outside in. In a hot oven the outside races far past the center, so by the time the center is done, a thick gray band under the crust is overcooked. In a low oven, about 250 °F (120 °C), the **temperature gradient** is gentle, so the roast is evenly cooked almost from edge to edge, and it loses less juice. Searing first in a hot pan browns the outside for flavor through the Maillard reaction. Whole cuts of beef are safe at 145 °F (63 °C) with a 3-minute rest, because bacteria live on the surface, and the sear destroys those.

Let's cook. You will sear and slow-roast a beef roast. The skill to do well is **searing in a shallow film of hot oil**, with an adult present: dry the meat well, lay it in the pan away from you, and turn it with tongs so it browns on every side. Then the oven does the slow, patient work, and the thermometer tells you when to stop.

PICTURE STUDY



Camp Fire, Winslow Homer, 1880 · Oil on canvas · The Metropolitan Museum of Art, New York

Image: [Wikimedia Commons](#), public domain

Winslow Homer painted many scenes of hunters and fishermen in the Adirondack Mountains of New York. Here two men rest at night beside a blazing fire in front of a simple shelter. Fire was their stove, their furnace and their light.

Look closely

- Find the sparks. Where are they going, and why?
- Look at how the light falls on the men and the shelter. Which side of them is bright and which is dark?
- Find the lean-to. Why would campers build it open toward the fire?
- Look for anything that might be used for cooking. Where would you place meat to roast it slowly rather than burn it?

Talk about it

1. The men feel the fire's warmth even though they are not touching it. How is that heat traveling?
2. Rumford said heat is motion. What is moving in the fire and in the air above it?

3. A cook roasting meat over a campfire turns it slowly at a distance. How is that like a low oven?

Safety first. Searing uses a thin film of hot oil: do it with an adult present, dry the meat first, lay it in the pan away from you, and keep a lid nearby. If oil smokes heavily, turn off the heat. A grease fire is smothered with a lid or baking soda, never water. Cook whole beef to 145 °F (63 °C) and rest at least 3 minutes.

KITCHEN PROJECT

Low and Slow: Rumford's Roast Beef

You will slow-roast a beef roast and keep a temperature log of its center, then slice it and look closely at the color from edge to center. If you can, roast a small piece of the same meat in a hot oven too, and compare the two.

You will need

- A large oven-safe skillet (cast iron is best) or a skillet and a roasting pan with a rack
- Tongs, paper towels and a cutting board with a groove
- A sharp chef's knife or carving knife
- An instant-read food thermometer (a probe thermometer with a cord is ideal)
- Oven mitts and foil

SLOW-ROASTED BEEF WITH GARLIC AND ROSEMARY

Serves 6–8 • Prep 15 min • Salt 1–24 hr • Roast 1½–2 hr • Rest 15 min

Ingredients

- 1 boneless beef roast, 3 to 3½ pounds (1.4–1.6 kg): eye of round, top sirloin or top round
- 2 teaspoons kosher salt
- 1 teaspoon black pepper
- 2 cloves garlic, minced
- 1 tablespoon chopped fresh rosemary (or 1 teaspoon dried)
- 2 tablespoons vegetable oil, divided

Method

1. Wash your hands. Pat the roast dry with paper towels and rub it all over with the salt. Refrigerate it uncovered on a plate for at least 1 hour and up to 24 hours. Wash your hands, the plate area and anything the raw meat touched.
2. Set an oven rack in the middle and heat the oven to 250 °F (120 °C).

3. Stir together the pepper, garlic, rosemary and 1 tablespoon oil, and rub it over the roast.
4. With an adult present, heat the remaining 1 tablespoon oil in the skillet over medium-high heat until it shimmers. Lay the roast in the pan away from you and sear 2–3 minutes per side, turning with tongs, until browned all over, about 10 minutes in all.
5. Put the skillet (or the roast on a rack in a roasting pan) in the oven. Roast until a thermometer in the center reads 145 °F (63 °C), about 1½ to 2 hours. Start checking after 1 hour.
6. Move the roast to a cutting board, cover it loosely with foil and rest 15 minutes.
7. Find the direction of the long muscle fibers, then slice the roast thinly across them (against the grain). Serve with potatoes and a vegetable.
8. Refrigerate leftovers within 2 hours; thin slices make excellent sandwiches. Clean up: wash the board, knife, tongs and pan in hot, soapy water.

Allergy check: Contains none of the nine major allergens.

Steps

1. **Predict.** Write how long you think the roast will take to go from 100 °F to 145 °F in the center.
2. **Temperature log.** Record the center temperature every 15 minutes (or every 5 minutes near the end). Then graph it.
3. **Edge-to-center look.** After slicing, look at one slice closely. Is the color even from the edge to the center? Sketch it. If you roasted a small comparison piece at 450 °F, sketch a slice of it too and compare the gray band.
4. **Juice check.** Look at the cutting board after slicing. How much juice ran out? Write one sentence about why resting helps.
5. **Taste test.** Ask your family to rate the roast from 1 to 5 for tenderness, juiciness and flavor.
6. **Improve it.** Write one change for next time (a longer salting time, a different herb, or a different cut).

7. Clean up: wash, dry and put away everything.

Tips

- Salting ahead of time lets the salt soak in and season the meat deeply, and helps it hold its juices.
- Lean cuts like eye of round are tender only when sliced very thin. Ask an adult to help if your knife skills are still new.
- Low-heat roasts rise only a little after leaving the oven, so pull the roast at 145 °F, not before.

Check your work

- ☐ I can explain how Rumford showed that heat is motion.
- ☐ I can explain why a low oven cooks a roast evenly.
- ☐ I seared a roast safely, cooked it to 145 °F with a rest, and sliced it against the grain.

COOK'S NOTEBOOK

1. Draw Rumford's cannon-boring experiment and label where the heat came from.
2. Graph your roast's center temperature over time and mark 145 °F.
3. Draw two roast cross-sections, one from a low oven and one from a hot oven, shading the overcooked band in each.

From history. Rumford's inventions included a kitchen range with separate enclosed fires for each pot, a roaster, a drip coffee pot, and a fireplace that sent much less smoke into the room. His soup for the poor of Munich, made mainly from barley, dried peas, potatoes and bread, fed thousands of people cheaply and well.

COMMON MISTAKES

- Cutting the roast right out of the oven. Let it rest so the juices settle.
- Slicing with the grain. Each slice will have long, stringy fibers; slice across them.
- Searing wet meat. Water makes oil spatter and keeps the surface from browning; pat it dry.

Make it a game • Rub It In. Rub your hands together hard for twenty seconds and feel the heat. Now explain to your parent how Rumford's cannon-boring experiment showed that heat is motion, not a fluid. Then tell the accidental discovery of slow roasting and what happens to meat proteins as they heat. Your parent plays a doubter and asks for proof.

4.2 DENIS PAPIN’S DIGESTER AND THE PRESSURE COOKER

OBJECTIVES

- Tell how Denis Papin invented the steam digester in 1679 and added a safety valve.
- Explain how pressure raises the boiling point of water, and how altitude lowers it.
- Cook a pot of dried beans from scratch on the stove (or in an electric pressure cooker with an adult), testing how salt and timing affect them.

Warm-up. Water boils at 212 °F (100 °C) in a pot at sea level. At the top of Pikes Peak in Colorado, it boils at about 186 °F (86 °C). Predict: will pasta cook faster or slower there? Why do you think the boiling point changes?

WATCH

The Science Behind Pressure Cookers

America's Test Kitchen · 1:50

<https://www.youtube.com/watch?v=wMEAL-uRnbg>

WHEN TO WATCH

After the kitchen-science paragraph. Watch the thermometer inside the pot: how hot does water get under pressure?

Note: From America’s Test Kitchen. Short; read the story of Papin’s digester in the lesson first.

KEY TERMS

boiling point

The temperature at which a liquid boils. For water it depends on the air pressure above it: 212 °F (100 °C) at sea level, lower at high altitude, higher in a sealed pressure cooker.

pressure

Force pressing on an area. Steam trapped in a sealed pot pushes on the water and raises its boiling point.

safety valve

A part that opens to let steam escape if the pressure gets too high. Papin invented it for his digester.

legume

A plant whose seeds grow in pods, such as beans, peas and lentils. Dried legumes are rich in protein and fiber.

brining

Soaking food in salt water. Brined beans cook up with softer skins and creamier insides.

CORE IDEAS

The story. Denis Papin was a French physicist who worked in London with the great chemist Robert Boyle, studying air and vacuum. In 1679 he presented to the Royal Society a heavy iron pot with a lid clamped down so tightly that no steam could escape. He called it a “steam digester.” In 1681 he published a book about it, explaining that it could soften bones, cook tough meat quickly and save fuel. In April 1682 he cooked a supper for members of the Royal Society. The writer John Evelyn, who was there, recorded in his diary that the hardest beef bones had been made “as soft as cheese.”

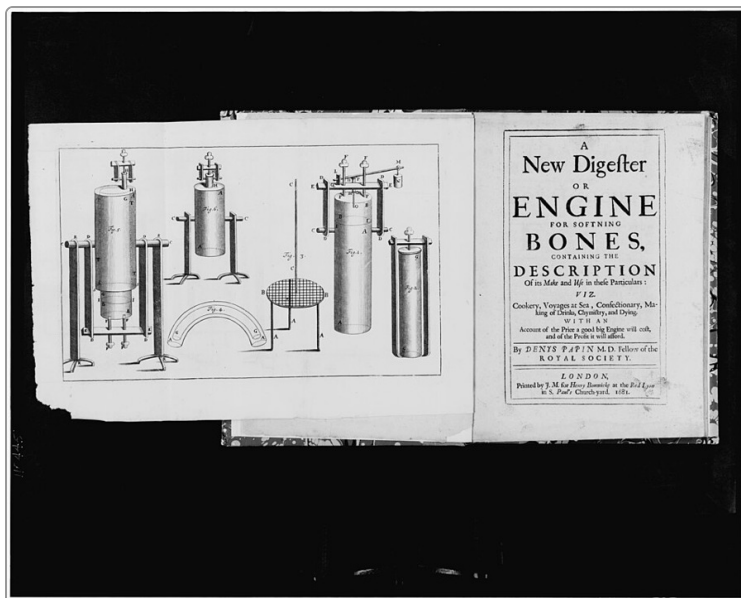
How they figured it out. Papin knew from his experiments with air that pressure affects how water behaves. In an open pot, water cannot get hotter than its boiling point; extra heat only makes more steam, which escapes. In his sealed pot, the steam could not escape, so the pressure rose, and the water could get much hotter than 212 °F before it boiled. Hotter water cooked food much faster. Papin also saw the danger: too much pressure could burst the pot. So he invented a **safety valve**, a weighted lever over a small hole that lifts and lets steam out before the pressure gets too high. Every pressure cooker and many steam engines since have used his idea.

The kitchen science. Water boils when its molecules move fast enough to push back against the air pressing down on it. Less pressure means a lower boiling point: in Denver, about a mile high, water boils at about 202 °F (94 °C), so foods take longer to cook. More pressure means a higher boiling point: a pressure cooker at full pressure (about 15 pounds per square inch above the air) reaches about 250 °F (121 °C), so dried beans that take 1–2 hours on the stove are done in a fraction of the time. Dried beans have tough skins and hard, starchy insides held together by pectin and calcium. Soaking them in **salt water** lets sodium replace some of the calcium in the

skins, which softens them; acid (tomatoes, vinegar) does the opposite and keeps beans firm, so acidic ingredients go in near the end. One important safety fact: raw and undercooked red kidney beans contain a natural substance that can make people very sick, and it is destroyed only by boiling. Always bring dried beans to a full boil, never just warm them in a slow cooker.

Let's cook. You will cook a pot of seasoned pinto beans from dry, the old-fashioned way on the stove, or in an electric pressure cooker with an adult handling the pressure release. The skill to do well is **holding a gentle simmer**: adjusting the burner so the beans bubble slowly. A hard boil breaks their skins and makes them mushy outside and hard inside.

PICTURE STUDY



Safety first. Only an adult opens the pressure-release valve or lid of a pressure cooker; steam can cause serious burns. Keep your face and hands away from the vent. Dried beans must reach a full boil; never cook dried kidney beans in a slow cooker without boiling them first. An adult is at home and nearby while you use the stove.

KITCHEN PROJECT

Under Pressure: A Pot of Pinto Beans

You will cook a pot of pinto beans and run a soaking test to see what salt does to bean skins. If your family has an electric pressure cooker, you can compare stovetop and pressure-cooker times.

You will need

- Two large bowls for soaking
- A large heavy pot with a lid (or an electric pressure cooker)
- A colander, a wooden spoon and a ladle
- A cutting board, a damp towel and a chef's knife
- Measuring cups and spoons
- An instant-read thermometer and a timer

SEASONED PINTO BEANS

Serves 8 (about 7 cups) • Soak 8–24 hr • Prep 15 min • Cook 1–1½ hr (pressure cooker: about 45 min in all)

Ingredients

- 1 pound (450 g) dried pinto beans
- **Brine:** 2 quarts (2 L) water and 1½ tablespoons salt
- 1 tablespoon olive oil
- 1 onion, diced
- 3 cloves garlic, minced
- 1 teaspoon ground cumin and 1 teaspoon chili powder
- 1 bay leaf
- 8 cups (2 L) water or low-sodium broth (6 cups for a pressure cooker)
- 1 teaspoon salt, or to taste
- 1 tablespoon lime juice or 1 can (10 ounces) diced tomatoes with green chiles, added at the end
- Chopped cilantro, to serve (optional)

Method

1. Spread the beans on a tray and pick out any small stones or shriveled beans. Rinse them in a colander.
2. Stir the salt into the 2 quarts of water in a large bowl, add the beans, and soak at room temperature 8–24 hours. Drain and rinse.
3. Heat the oil in the pot over medium heat. Cook the onion 5 minutes, then the garlic, cumin and chili powder for 30 seconds.
4. **Stovetop:** Add the beans, bay leaf and 8 cups water. Bring to a full boil for 10 minutes, then lower the heat to a gentle simmer. Cover partly and cook 1–1½ hours, stirring now and then, until the beans are creamy all the way through. Add water if the level drops below the beans.
5. **Pressure cooker (with an adult):** Add the beans, bay leaf and 6 cups water. Lock the lid, cook at high pressure 10 minutes, then let the pressure release naturally for 20 minutes. An adult opens the valve to release any remaining steam and opens the lid away from everyone's faces.
6. Taste three beans: all should be soft in the center. Stir in the salt and the lime juice or tomatoes, simmer 5 minutes more, and remove the bay leaf.
7. Serve with rice, warm tortillas and cheese, or as a side. Cool leftovers in shallow containers and refrigerate within 2 hours; they keep 4 days or freeze for 3 months.
8. Clean up: wash the pot and utensils and wipe the stove once cool.

Allergy check: Contains none of the nine major allergens. Check broth and canned tomato labels. Serve with corn tortillas for a wheat-free meal.

Steps

1. **Soak test.** Before brining the main batch, put ¼ cup of dried beans in plain water and ¼ cup in salted water. Cook a few of each side by side in a small pot at the end, and compare the skins and centers.
2. **Predict.** Write how long you think the beans will take to become fully tender.
3. **Doneness log.** Starting at 45 minutes (stovetop), taste three beans every 10 minutes and record: hard center, chalky, almost, or creamy.

4. **Boiling-point check.** Measure the temperature of the simmering liquid. Is it 212 °F? If not, how might your altitude or your thermometer explain it?
5. **Taste test.** Ask your family to rate the beans from 1 to 5 for creaminess and flavor.
6. **Improve it.** Write one change for next time (black beans, a smoked ham hock or bacon cooked in, or more spice).
7. Clean up: wash, dry and put away everything.

Tips

- Old dried beans take longer to soften. Buy from a store that sells a lot of them.
- Add acid (tomatoes, lime, vinegar) after the beans are tender, or they may stay firm.
- A pound of dried beans makes about as much as four or five cans, for much less money.

Check your work

- ☐ I can explain how Papin's digester and safety valve worked.
- ☐ I can explain how pressure and altitude change the boiling point of water.
- ☐ I cooked dried beans safely to a full boil and a creamy finish.

COOK'S NOTEBOOK

1. Draw a cross-section of a pressure cooker, labeling the lid seal, the safety valve, the steam and the water.
2. Record your soak test: draw a plain-water bean and a salt-brined bean, and describe their skins.
3. Copy the recipe in your own words and write your doneness log.

From history. Papin later built one of the first models of a steam-driven piston engine and even a paddle-wheel boat. He never became rich, and no one is sure exactly when or where he died, but his safety valve and his ideas about steam power helped lead to the steam engines of the next century.

COMMON MISTAKES

- Boiling beans hard the whole time. They split and turn mushy outside while staying hard inside; simmer gently.

- Adding tomatoes or vinegar at the start. Acid keeps the skins firm; add it at the end.
- Opening a pressure cooker before the pressure is released. Only an adult releases the pressure and opens the lid, away from faces.

Make it a game · Boiling Point Duel. You and your parent each write a guess for the boiling point of water at sea level, in a pressure cooker, and at 5,000 feet. Closest to each answer scores a point. Then explain how Papin's safety valve works and why the pressure inside lets beans cook faster. Play the duel again with different heights.

4.3 NICOLAS APPERT AND THE SCIENCE OF JAM

OBJECTIVES

- Tell how Nicolas Appert discovered how to preserve food in sealed, heated jars, winning a French government prize in 1810.
- Explain how sugar, acid and pectin make jam set and help preserve it, and why home canning must follow tested recipes.
- Cook a batch of strawberry jam to 220 °F, test the set with a cold plate, and store it safely in the refrigerator or freezer.

Warm-up. Look at the label of a jar of jam or jelly. Find the three ingredients after the fruit. Why do you think each one is there? Write a guess for each.

WATCH

FoodSHOTS Episode 3: Jams, fruit preserves and pectin

University of Nottingham · 11:01

<https://www.youtube.com/watch?v=agPGV388XvE>

WHEN TO WATCH

After the kitchen-science paragraph. Watch for how pectin, sugar and acid each help the gel form.

BACKUP VIDEO

Ask Martha: Using Liquid vs. Powdered Pectin

Penn State Extension · 6:21

https://www.youtube.com/watch?v=fYCCw_KN-J4

For families who want to try a jam with added pectin, from Penn State Extension's food-preservation educator.

KEY TERMS

pectin

A natural fiber in the cell walls of fruit that can form a gel. Apples, citrus peels and slightly underripe fruit are rich in it; strawberries have only a little.

gel

A soft solid made of a network of long molecules that traps liquid, as in jam or gelatin.

acid

A substance with a sour taste and a low pH. In jam, lemon juice helps pectin strands join and helps keep spoilage microbes from growing.

set point

The stage when jam has cooked enough to gel, about 220 °F (104 °C) at sea level, or 8 °F above the boiling point of water where you live.

water activity

How much of the water in a food is free for microbes to use. Lots of sugar ties up water and lowers water activity, which helps preserve jam.

CORE IDEAS

The story. Nicolas Appert was a confectioner and cook in Paris, a maker of sweets and preserves. In the 1790s, France's armies and navy needed food that would last for months without spoiling. Appert began experimenting with a new idea: instead of drying, salting or smoking food, he would seal it in thick glass bottles, close them tightly with corks and wire, and heat the bottles in boiling water. In 1810 the French government awarded him a prize of 12,000 francs, on the condition that he publish his method. His book, *The Art of Preserving All Kinds of Animal and Vegetable Substances for Several Years*, appeared that year.

How they figured it out. Appert worked by trial and patient record-keeping, adjusting heating times for each kind of food. He did not know why his method worked; he guessed that it was keeping air out. Fifty years later Louis Pasteur showed that microbes cause spoilage, and that heat destroys them while a seal keeps new ones out. Modern scientists have since tested exactly how long each food must be heated, in what jars, at what altitude. That is why today's home canners follow tested recipes from the USDA and the National Center for Home Food Preservation, never guesses.

The kitchen science. Jam is a gel built from three partners. **Pectin** molecules are long chains that carry a negative electric charge, so they push each other apart in water. **Acid** from lemon juice neutralizes some of that charge so the chains can come close. **Sugar** pulls water molecules away from the pectin, so the chains bump into each other and link into a net that traps the fruit juice. The jam must also be boiled until enough water evaporates: it sets at about 220 °F (104 °C), 8 °F above water's

boiling point, when the sugar is concentrated to roughly two-thirds of the jam. That much sugar ties up water so tightly that most microbes cannot grow. A jam made with less sugar will not keep as long and should be refrigerated or frozen.

Let's cook. You will cook a small batch of strawberry jam with no added pectin, using lemon juice and the fruit's own pectin. The skill to do well is **reading the set**: watching the bubbles change from fast and frothy to slow and glossy, checking the temperature, and using the cold-plate test. Our jam is refrigerator or freezer jam; it is not canned for the shelf. Water-bath canning is an adult job and must follow a tested recipe exactly.

PICTURE STUDY



Farm Security Administration Client with Her Canned Goods, Photographer for the Farm Security Administration, about 1939 · Photograph · Library of Congress, Washington, D.C.

Image: [Wikimedia Commons](#), public domain

In the 1930s, the U.S. government's Farm Security Administration helped struggling farm families, and its photographers recorded their lives. Home canning let a family put up the summer's garden for the winter. Shelves of full jars like these meant a family would eat well until the next harvest.

Look closely

- Count the jars in one row, then the number of rows. About how many jars did this family put up?
- Look at the colors and shapes in the jars. Which fruits and vegetables can you identify?
- Look at her face and posture. How do you think she feels about her work?
- Find the lids. Why must every jar be sealed?

Talk about it

1. How is a shelf of home-canned food like Joseph storing grain in Egypt?
2. Appert did not know about microbes. What do we know today that makes home canning safer than in his time?

3. Which foods in your house today came from a can or jar? How long ago might they have been made?

Safety first. Boiling jam is much hotter than boiling water and sticks to skin. Use a large, deep pot (jam foams up), a long-handled spoon and oven mitts, keep your face back, and have an adult at home and nearby. Store this jam in the refrigerator (up to 3 weeks) or freezer (up to a year); shelf canning is an adult job that must follow a tested recipe.

Sugar, Acid and Pectin: Strawberry Jam

You will cook strawberry jam, logging its temperature and watching the bubbles change, and test the set with a frozen plate. You will also calculate what percentage of the jam is sugar.

You will need

- A large, deep, heavy pot (at least 4 quarts; jam foams up)
- A potato masher and a long-handled wooden spoon
- A cutting board and a paring knife
- A candy thermometer or an instant-read thermometer
- Two small plates in the freezer for the cold-plate test
- Three clean half-pint (8-ounce) jars with lids, washed in hot, soapy water
- A kitchen scale (optional) and a ladle

SMALL-BATCH STRAWBERRY JAM (REFRIGERATOR OR FREEZER)

Serves About 3 cups (three half-pint jars) • Prep 15 min • Cook 20–25 min • Cool 2 hr

Ingredients

- 2 pounds (900 g) fresh strawberries (about 6 cups whole), or frozen strawberries, thawed
- 1½ cups (300 g) sugar
- 3 tablespoons (45 mL) fresh lemon juice (about 1 lemon)
- A pinch of salt

Method

1. Put two small plates in the freezer. Wash your hands. Rinse the strawberries under cool running water, hull them, and cut them into quarters.
2. In the large pot, combine the strawberries, sugar, lemon juice and salt. Let stand 15 minutes until juicy, then mash about half the berries with the potato masher.

3. Set the pot over medium-high heat and stir until the sugar dissolves and the mixture boils. Keep it at a steady, rolling boil, stirring often and scraping the bottom, for 12–20 minutes.
4. Watch the bubbles. As water evaporates, they change from fast and foamy to slower, larger and glossier. Start checking the temperature at 10 minutes. The jam is near the set point at 220 °F (104 °C), or 8 °F above the temperature at which water boils where you live.
5. **Cold-plate test:** Spoon a little jam onto a frozen plate, wait 1 minute, and push it with your finger. If it wrinkles and holds a path, it is done. If it runs back together, boil 2 minutes more and test again.
6. Turn off the heat. Skim off any foam with a spoon.
7. Ladle the hot jam into the clean jars, leaving ½ inch of space at the top. Wipe the rims and put on the lids. Cool on a towel 2 hours, then refrigerate (up to 3 weeks) or freeze (up to 1 year).
8. Clean up: fill the pot with hot water right away to loosen the sugar, then wash everything.

Allergy check: Contains none of the nine major allergens.

Steps

1. **Temperature and bubble log.** Every 2 minutes, record the temperature and describe the bubbles (foamy, rolling, slow, glossy).
2. **Cold-plate record.** Write the temperature at each cold-plate test and whether it wrinkled.
3. **Sugar percentage.** Weigh your finished jam (subtract the weight of the empty jars). Calculate: $\text{sugar \%} = 300 \text{ g} \div (\text{weight of jam}) \times 100$. Strawberries also contain a little natural sugar, so the real total is a bit higher.
4. **Taste test.** After it has chilled, serve the jam on toast or biscuits. Ask your family to rate it from 1 to 5 for sweetness, firmness and fruit flavor.
5. **Improve it.** Write one change for next time (cooking a little longer for a firmer set, another fruit, or a blend such as strawberry-rhubarb).
6. Clean up: wash, dry and put away everything.

Tips

- Jam thickens as it cools. Do not cook it until it looks thick in the pot, or it will be stiff and candy-like.
- A wide pot lets water evaporate faster, so the jam sets sooner and tastes fresher.
- To find your boiling point, boil plain water and measure it before you start. Add 8 °F for your jam set point.

Check your work

- ☐ I can tell how Appert preserved food and what Pasteur later explained.
- ☐ I can explain how sugar, acid and pectin make a gel.
- ☐ I cooked jam to the set point, tested it, and stored it safely.

COOK'S NOTEBOOK

1. Draw pectin chains three ways: pushed apart in water, with acid making them less charged, and linked into a net with sugar pulling water away.
2. Graph your jam's temperature over time and mark the set point.
3. Write your sugar percentage calculation with all the work shown.

From history. In 1810, the same year Appert published his book, an Englishman named Peter Durand patented the idea of preserving food in tin-plated iron cans. Cans did not break like glass and soon fed sailors and explorers. Early cans were so thick that they had to be opened with a hammer and chisel; the can opener was not invented until decades later.

COMMON MISTAKES

- Using a small pot. Boiling jam foams up and can boil over; use a pot at least four times as large as the fruit.
- Cooking until the jam looks thick in the pot. It thickens as it cools; trust the thermometer and the cold plate.
- Storing refrigerator jam in the cupboard. Without tested canning, it must be refrigerated or frozen.

Make it a game • The Jam Team. Act out sugar, acid and pectin without speaking while your parent guesses which one you are. Then act the jar Appert sealed in 1810. After each round, say in one sentence what that ingredient does to make jam set and keep. Swap parts and play until you each have played all four.

4.4 FREEZING SCIENCE: ICE CRYSTALS AND ICE CREAM

OBJECTIVES

- Tell how Nancy Johnson of Philadelphia invented the hand-cranked ice cream freezer in 1843.
- Explain freezing-point depression and why salt makes ice colder, and why fast freezing and stirring make small ice crystals and smooth ice cream.
- Make vanilla ice cream with a salt-and-ice bath, measure the temperatures, and compare it with ice cream frozen slowly.

Warm-up. Put an ice cube on a plate and sprinkle salt on one side of it. Watch for five minutes. What happens on the salted side? Now hold a thermometer in a cup of plain ice water and then add 2 tablespoons of salt and stir. What happens to the temperature?

WATCH

Ice cream and freezing point depression

Harvard Online • 5:30

<https://www.youtube.com/watch?v=844OTThXP74>

WHEN TO WATCH

After the kitchen-science paragraph and before you make ice cream. Watch the temperature of the salted ice.

BACKUP VIDEO

Science Xplained: Ice Cream Chemistry

Yale University • 2:57

<https://www.youtube.com/watch?v=k1pel10ufmk>

A short second explanation of ice crystals, air and fat in ice cream.

KEY TERMS

freezing point

The temperature at which a liquid turns solid. Pure water freezes at 32 °F (0 °C).

freezing-point depression

The lowering of a liquid's freezing point when something, such as salt or sugar, is dissolved in it.

brine

Salt water. A salt-and-ice brine can fall well below 32 °F, cold enough to freeze ice cream.

ice crystal

A tiny, orderly piece of frozen water. Small crystals feel smooth on the tongue; large ones feel icy and gritty.

overrun

The extra volume ice cream gains from air beaten into it while it freezes.

CORE IDEAS

The story. Ice cream was a rare luxury in early America, because making it was hard work. A cook set a metal pot of sweet cream in a tub of ice and salt and stirred and scraped by hand, lifting the lid again and again, for an hour or more. In 1843 Nancy Johnson of Philadelphia patented a better way: a wooden tub for ice and salt, a metal cylinder for the cream, and inside it a paddle, called a dasher, turned by a crank on the lid. Turning the crank stirred and scraped the freezing cream without opening the can. She sold her patent for \$200. Hand-cranked freezers based on her idea soon made homemade ice cream a summer treat for ordinary families.

How they figured it out. Cooks had known for centuries that salt makes ice colder; scientists later explained why. When salt dissolves in the thin film of water on melting ice, it gets in the way of water molecules trying to join the ice. Ice keeps melting but water cannot easily refreeze, and melting takes heat. That heat comes from the surroundings, so the brine grows colder, down to about 0 °F (−18 °C) or lower with plenty of salt. That is cold enough to freeze sweet cream, which itself freezes below 32 °F because of the sugar dissolved in it.

The kitchen science. The smoothness of ice cream depends on the size of its ice crystals. When a mixture freezes slowly and sits still, a few crystals grow large and jagged. When it freezes fast and is stirred, many tiny crystals form at once and none has time to grow, so the texture is smooth and creamy. Stirring also beats in air (**overrun**), which makes ice cream lighter and keeps it scoopable. Fat from the cream coats the air bubbles and ice crystals and keeps them apart, and sugar keeps some water unfrozen, so ice cream stays soft enough to scoop instead of freezing into a block. The same idea explains why Clarence Birdseye's fast-frozen fish stayed firm: small crystals do less damage to food than large ones.

Let's cook. You will make Philadelphia-style vanilla ice cream (cream, milk and sugar, with no eggs) by the bag-in-a-bag method, or in an ice cream maker if your family has one. The skill to do well is **keeping it cold and moving**: plenty of ice and salt, steady shaking or turning, and a quick trip to the freezer once it is soft-set.

PICTURE STUDY



Ice Cream Parlor of L. C. Fish, Merced, California, Unknown photographer, about 1910 · Photograph · Library of Congress, Washington, D.C.
Image: [Wikimedia Commons](#), public domain

By about 1910, ice cream parlors and soda fountains had opened in towns across America. Ice cream was still made in large hand-cranked or machine-cranked freezers packed with ice and salt, much like Nancy Johnson's, and kept cold behind the counter in tubs surrounded by more ice and salt.

Look closely

- Find the counter. Where do you think the ice cream was kept cold?
- Find the little tables and chairs. Who might have come here, and when?
- Look at the decorations. Why would the owner want the room to feel cool and fresh?
- Look for any machines or tubs. What might they have been used for?

Talk about it

1. Before electric freezers, how would this shop keep ice cream frozen all day in a California summer?
2. Why was ice cream more of a special treat in 1910 than it is today?
3. If you opened an ice cream parlor, what would you make sure your customers could see and smell?

Safety first. Salted ice can be cold enough to hurt skin: wear gloves or wrap the bag in a towel while shaking, and seal the inner bag tightly so no salty brine gets into the ice cream. Rinse the outside of the inner bag before opening it.

KITCHEN PROJECT

Fast Freeze vs. Slow Freeze: Homemade Vanilla Ice Cream

You will measure how cold a salt-and-ice brine gets, make ice cream by the fast method, and compare it with the same mix frozen slowly in a freezer. Then you will taste and describe the difference in crystals.

You will need

- A large bowl and a whisk
- Quart-size and gallon-size heavy zip-top freezer bags (or an ice cream maker)
- A thermometer that reads below 32 °F
- Gloves or a kitchen towel
- A small container for the slow-freeze sample
- Measuring cups and spoons, a timer

PHILADELPHIA-STYLE VANILLA ICE CREAM

Serves 6 (about 1 quart) · Prep 10 min · Chill 1 hr · Freeze 10–15 min (bag) or 20–25 min (machine) · Firm up 1–2 hr

Ingredients

- 2 cups (480 mL) heavy cream
- 1 cup (240 mL) whole milk
- $\frac{2}{3}$ cup (130 g) sugar
- A pinch of salt
- 1 tablespoon vanilla extract
- **For the bag method (per quart bag):** about 6 cups ice and $\frac{1}{2}$ cup (about 140 g) rock salt or kosher salt

Method

1. Wash your hands. In the bowl, whisk the cream, milk, sugar, salt and vanilla until the sugar dissolves completely, about 2 minutes. Refrigerate the mix at least 1 hour; cold mix freezes faster.

2. Pour $\frac{1}{4}$ cup of the mix into the small container, cover, and put it in the freezer without stirring. This is your slow-freeze sample.
3. **Bag method:** Pour about $1\frac{1}{4}$ cups of mix into a quart bag, press out the air and seal it tightly. Put it inside a second quart bag and seal that too.
4. Fill a gallon bag half full of ice, add the salt, and put the sealed small bag in the middle. Add more ice on top and seal the gallon bag.
5. Wearing gloves or wrapping the bag in a towel, shake and knead it for 10–15 minutes, until the ice cream is thick like soft-serve. Repeat with the rest of the mix (a few friends or family members can shake bags at the same time).
6. **Machine method:** Freeze the mix in an ice cream maker according to its directions, 20–25 minutes.
7. Rinse the salty outside of the inner bag under cold water, then open it. Spoon the ice cream into a container and freeze 1–2 hours to firm up.
8. Clean up: pour the brine down the sink with lots of water, throw away the used bags, and wash the bowl and whisk.

Allergy check: Contains milk. Some vanilla extracts are made on equipment shared with nuts; check the label. For a milk-free version, use full-fat canned coconut milk and an unsweetened oat milk; the texture will be icier.

Steps

1. **Brine temperature.** Before you shake, measure the temperature of the ice and salt in the gallon bag (or in a bowl of the same ice and salt). Record it. Measure plain ice water too.
2. **Freezing log.** Record the time it takes for the mix to become soft-set.
3. **Crystal comparison.** After 2 hours, taste the fast-frozen ice cream and the slow-freeze sample side by side. Describe the texture of each, using the words smooth, icy, gritty, creamy or hard.
4. **Overrun estimate.** Did your ice cream end up with more volume than the liquid you started with? Measure both and calculate the percent increase: $(\text{final} - \text{starting}) \div \text{starting} \times 100$.
5. **Taste test.** Ask your family to rate the ice cream from 1 to 5 for smoothness and flavor.

6. **Improve it.** Write one change for next time (more salt for a faster freeze, crushed cookies or fruit stirred in, or chocolate ice cream with cocoa).
7. Clean up: wash, dry and put away everything.

Tips

- Rock salt and kosher salt work better than table salt because they dissolve more slowly and last longer.
- Homemade ice cream has no stabilizers, so it is best within a few days. Press plastic wrap on the surface to slow crystal growth.
- If the ice cream is too hard from the freezer, let it sit on the counter for 5–10 minutes before scooping.

Check your work

- ☐ I can tell how Nancy Johnson's freezer made ice cream easier to make.
- ☐ I can explain why salt makes ice colder and why fast freezing makes smooth ice cream.
- ☐ I measured the brine temperature and compared fast- and slow-frozen ice cream.

COOK'S NOTEBOOK

1. Draw two magnified views of ice cream: slow-frozen with large crystals and fast-frozen with tiny crystals, air bubbles and fat globules. Label each part.
2. Record your brine and ice-water temperatures and explain the difference in two sentences.
3. Show your overrun calculation.

From history. Before refrigerators, ice cream depended on natural ice cut from frozen lakes in winter and stored in icehouses packed with sawdust. In the 1800s, Frederic Tudor of Boston shipped New England ice as far as the Caribbean and India. Ice cream became an everyday treat only after electric home freezers spread in the 1900s.

COMMON MISTAKES

- Using too little salt. The brine will not get cold enough, and the ice cream stays soupy.
- Leaving the inner bag unsealed or opening it before rinsing. Salty brine ruins the ice cream.

- Freezing the mix without stirring and expecting smooth ice cream. Still freezing makes large, icy crystals.

Make it a game · Salt on Ice. Fill two cups with ice and a little water. Add salt to one only. Predict the temperature of each with a thermometer, write your guesses, then stir for one minute and measure. Explain freezing-point depression aloud. Then tell why Nancy Johnson's crank made ice cream smooth. Closest prediction wins the round.

UNIT 4

HEAT & COLD

Every cooking method is a way of moving heat into food or out of it. In this unit you will follow four people who changed how we think about heat and cold. Count Rumford proved that heat is a kind of motion, not a fluid, and accidentally discovered the secret of slow roasting. Denis Papin sealed a pot so tightly that water could get hotter than its boiling point, and softened beef bones “as soft as cheese.” Nicolas Appert learned to keep food for years in sealed jars, and Nancy Johnson invented the hand-cranked ice cream freezer.

You will cook with each idea: a slow-roasted beef roast that is evenly done from edge to center, a pot of beans that shows how pressure and salt change cooking, a batch of strawberry jam set with sugar, acid and pectin, and homemade ice cream frozen fast in a salt-and-ice bath. You will measure temperatures at every step and do a little physics and arithmetic along the way.

PREREQUISITES

- Uses a thermometer to check safe internal temperatures (Unit 1)
- Uses the stove and oven safely with an adult at home and nearby (Unit 1)
- Can convert between °F and °C
- Knows that proteins unfold and set when heated (taught again here)

MASTERY CHECKLIST

- ☐ I can explain how Rumford’s cannon-boring experiment showed that heat is motion, and why slow roasting cooks meat evenly.
- ☐ I can explain how pressure changes the boiling point of water and why a pressure cooker cooks faster.
- ☐ I can explain how sugar, acid and pectin make jam set, and why home canning must follow tested recipes.
- ☐ I can explain freezing-point depression and why fast freezing makes smoother ice cream.
- ☐ I can convert temperatures, calculate a sugar percentage and adjust boiling point for altitude.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **National Center for Home Food Preservation:** Free. Tested, research-based instructions for canning, freezing and drying from the University of Georgia. If your family wants to can jam for the shelf, use only their tested recipes (Lesson 4.3).
- **A clip-on candy or deep-fry thermometer:** Optional. Helpful for checking when jam reaches 220 °F (Lesson 4.3). An instant-read thermometer also works if you check quickly with an oven mitt on.
- **Rock salt or kosher salt and gallon zip-top bags:** Needed for the bag method in Lesson 4.4 if you do not have an ice cream maker. Inexpensive at any grocery store.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

4.1 Count Rumford and the Nature of Heat

2 sessions of 50–60 minutes (plus about 2 hours of roasting)

4.2 Denis Papin’s Digester and the Pressure Cooker

2 sessions of 50–60 minutes (plus overnight soaking)

4.3 Nicolas Appert and the Science of Jam

2 sessions of 50–60 minutes

4.4 Freezing Science: Ice Crystals and Ice Cream

2 sessions of 50–60 minutes

UNIT 4 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**

Describe Rumford’s cannon-boring experiment. What did it show about heat?

2. (8 pts)

Why does a roast cooked at 250 °F have a thinner overcooked band than one cooked at 450 °F?

3. (8 pts)

What is the safe internal temperature for a whole beef roast, and why is it lower than for ground beef?

4. (8 pts)

How did Papin's digester cook food faster? What did his safety valve do?

5. (8 pts)

Predict: you cook beans with tomatoes from the beginning. What will happen to the beans, and why?

6. (10 pts)

Calculation: water's boiling point drops about 1 °F for every 500 feet of altitude. About what is the boiling point in a town 5,000 feet above sea level? What would its jam set point be?

7. (8 pts)

Explain how sugar, acid and pectin work together to make jam set.

8. (10 pts)

Calculation: a batch of jam weighs 900 g and contains 300 g of added sugar. What percentage of the jam is added sugar? If the strawberries added another 40 g of natural sugar, what is the total sugar percentage?

9. (8 pts)

Why must a family that wants shelf-stable jam follow a tested canning recipe?

10. (8 pts)

Explain why salt makes ice colder.

11. (8 pts)

Calculation: your ice cream mix measured 3 cups before freezing and 4 cups after. What is the overrun?

12. **8 pts**

Short answer: In three or four sentences, explain why fast-frozen ice cream is smoother than slow-frozen ice cream, and connect it to another frozen food.

ANSWER KEY

1. He bored a brass cannon with a dull tool surrounded by cold water, turned by horses; after about two and a half hours the water boiled with no fire, and heat kept coming as long as the boring continued. Heat could be produced without limit by motion, so it is a form of motion, not a stored fluid (caloric).
2. Heat moves into a roast slowly by conduction. In a hot oven the outside gets far hotter than the center before the center is done, overcooking a thick outer band. In a low oven the temperature gradient is gentle, so the meat cooks evenly almost edge to edge.
3. 145 °F (63 °C) with at least a 3-minute rest. Bacteria live mainly on the surface of whole cuts, where searing and roasting destroy them; ground beef mixes surface bacteria all through, so it needs 160 °F.
4. The sealed pot trapped steam, raising the pressure, which raised the boiling point so the water got hotter than 212 °F and cooked food faster. The safety valve let steam escape if the pressure grew too high, so the pot would not burst.
5. They may stay firm and take much longer to soften, because acid strengthens the pectin and calcium in the bean skins. Add tomatoes after the beans are tender.
6. $5,000 \div 500 = 10$, so about $212 - 10 = 202$ °F. The jam set point is 8 °F higher: about 210 °F.
7. Pectin chains are negatively charged and push apart in water. Acid neutralizes some charge so they can come close. Sugar pulls water away from the pectin so the chains bump and link into a net that traps the juice.
8. $300 \div 900 \times 100 \approx 33.3\%$ added sugar. Total: $340 \div 900 \times 100 \approx 37.8\%$.
9. Safe canning depends on exact acidity, jar size, heating time and altitude, which have been tested in laboratories. Guessing can leave microbes alive that spoil the food or make people sick.
10. Salt dissolves in the water on the ice and gets in the way of water molecules refreezing (freezing-point depression). The ice keeps melting, and melting absorbs heat from the surroundings, so the brine becomes colder than 32 °F, down to about 0 °F.
11. $(4 - 3) \div 3 \times 100 \approx 33\%$.
12. Fast freezing and stirring make many tiny ice crystals at once, and none has time to grow large, so the texture feels smooth. Slow, still freezing lets a few crystals grow big and jagged, which feel icy. The same is true of frozen fish and

vegetables: Birdseye's fast freezing kept crystals small so they did less damage to the food.

UNIT CHALLENGE: SAME FOOD, FOUR HEATS

Choose one vegetable (potatoes, carrots or broccoli work well) and cook equal pieces four ways: boiled or steamed, roasted at 425 °F, microwaved, and pan-seared in a thin film of oil with an adult present. Record the cooking time, the temperature of each method, and the texture, color and taste of each result.

Then make a chart and write a one-page explanation using this unit's ideas: conduction, convection, radiation, the boiling point of water and browning. Finish by naming which method you would choose for a family dinner and why.

LOOK FOR	WHAT IT MEANS
Fair test	Same vegetable, same size pieces, four methods, with times and temperatures recorded.
Safe cooking	Stove, oven and microwave used safely; pan-searing done with an adult present; clean kitchen afterward.
Chart	A clear chart of time, temperature, texture, color and taste for each method, with family ratings.
Science explanation	Correctly uses heat transfer, boiling point and browning to explain the differences.
Choice and improvement	A reasoned choice for a family dinner and one honest improvement; results that surprised you, recorded honestly, earn full credit.

FOOD CHEMISTRY

A kitchen is a chemistry laboratory where the experiments are eaten. In this unit you will study the ingredients that do the most work in a recipe, one at a time, at a deeper level than before. You will learn why cooked starch hardens again as it cools, and why that makes stale bread a nuisance but day-old rice a gift. You will follow a French emperor's prize to the invention of margarine and learn how fat and steam make a pie crust flaky. You will meet the scientist who first washed a ball of dough until only gluten remained, and the one who proved that yeast does its work with enzymes.

Each discovery becomes a recipe: fried rice from yesterday's rice, a rustic apple galette in an all-butter crust, fresh egg pasta rolled by hand, and a crusty artisan loaf that rises slowly overnight. Jesus called Himself the bread of life and taught us to pray for our daily bread; by the end of this unit you will be able to make it.

PREREQUISITES

- Knows that starch thickens when heated in water and that proteins unfold and set with heat (earlier grades or Unit 4)
- Uses the stove and oven safely with an adult at home and nearby (Unit 1)
- Can shallow-fry in a thin film of oil with an adult present (Unit 4)
- Can work with percentages and ratios

MASTERY CHECKLIST

- ☐ I can explain starch gelatinization and retrogradation, why bread stales faster in the refrigerator, and why day-old rice makes better fried rice.
- ☐ I can tell how margarine was invented and explain how cold fat and steam make a flaky crust.
- ☐ I can explain how gluten forms from two wheat proteins and what eggs add to pasta.
- ☐ I can explain what Buchner discovered about yeast enzymes and how yeast, gluten and steam raise a loaf.
- ☐ I can use baker's percentages to describe a dough and keep a rise log.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **King Arthur Baking: Baker's Hotline and guides**: Free. Step-by-step baking guides with photographs, including pie crust and bread. Helpful for Lessons 5.2 and 5.4.
- **A digital kitchen scale**: Weighing flour in grams makes pie crust, pasta and bread come out the same every time, and makes baker's percentages easy.
- **A Dutch oven or heavy lidded pot that can go in a 450 °F oven**: Used for the artisan loaf in Lesson 5.4. A heavy baking sheet with a large metal bowl turned over the loaf works as a substitute.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

5.1	Starch Retrogradation: Stale Bread and Fried Rice	2 sessions of 50–60 minutes
5.2	Mège-Mouriès, Margarine and the Flaky Crust	2 sessions of 50–60 minutes
5.3	Proteins: Gluten, Eggs and Fresh Pasta	2 sessions of 50–60 minutes
5.4	Yeast Biology and Bread Science	2 sessions of 60–90 minutes (plus an overnight rise)

UNIT 5 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**

What did Boussingault's 1852 experiment show about stale bread?

2. **8 pts**

Explain retrogradation, and why bread goes stale faster in the refrigerator than on the counter.

3. **8 pts**

Predict: you make fried rice with hot, freshly cooked rice. What will happen, and why?

4. (6 pts)

How should cooked rice be stored, and why?

5. (8 pts)

Who invented margarine, when, and why was it needed?

6. (8 pts)

Explain the two jobs fat does in a pie crust.

7. (8 pts)

What did Beccari discover in 1728, and how?

8. (8 pts)

Name the two proteins that form gluten and what each contributes. What do kneading and resting each do?

9. (8 pts)

What did Buchner discover in 1897, and why was it surprising?

10. (10 pts)

Calculation: a dough uses 500 g flour, 350 g water, 10 g salt and 5 g yeast. Write its baker's percentages.

11. (10 pts)

Calculation: you want to make 1½ batches of the pie crust (160 g flour, 113 g butter, 65 g water per batch). How much of each do you need? How many tablespoons of butter is that if 1 tablespoon = 14 g?

12. (10 pts)

Short answer: In four or five sentences, describe what happens to a loaf of bread from the moment it enters a 450 °F oven until it is done.

ANSWER KEY

1. Bread sealed so it could not dry out still went stale while weighing almost the same, so staling is not just drying. Heating it made it soft again, showing a reversible change inside the bread (starch retrogradation).
2. As cooked starch cools, its chains slowly line up into firm bundles and squeeze out water. This happens fastest at refrigerator temperatures, so refrigerated bread stales faster; freezing nearly stops it.
3. It will turn sticky and mushy, because freshly cooked starch is soft and wet; day-old rice has retrograded, so its grains are firmer and drier and stay separate.
4. Cool it quickly in a shallow container, refrigerate within 2 hours (sooner is better) and use within 3–4 days, because spores of *Bacillus cereus* can survive cooking and grow if rice is left warm.
5. Hippolyte Mège-Mouriès, in 1869, in answer to Napoleon III's prize for a cheap, wholesome butter substitute that would keep, for the poor and the navy.
6. It coats flour so less gluten forms, keeping the crust tender (shortening). Cold flat pieces of butter make layers; in the oven their water turns to steam and pushes the layers apart, making flakes.
7. He isolated gluten by washing a flour-and-water dough until the starch washed away, leaving a sticky, stretchy protein mass that behaved like animal substances.
8. Gliadin (stretch) and glutenin (spring back). Kneading lines up and strengthens the gluten; resting relaxes it so dough can be rolled without shrinking.
9. That juice pressed from ground-up yeast, with no living cells, could still ferment sugar into carbon dioxide. It showed fermentation is done by enzymes (zymase), not a “vital force” of life.
10. Flour 100%; water $350 \div 500 \times 100 = 70\%$; salt $10 \div 500 \times 100 = 2\%$; yeast $5 \div 500 \times 100 = 1\%$.
11. Flour 240 g, butter 169.5 g (about 170 g), water 97.5 g (about 98 g). Butter: $170 \div 14 \approx 12$ tablespoons ($1\frac{1}{2}$ sticks).
12. Gas in the dough expands and water turns to steam, so the loaf springs up, and yeast works very fast until it dies at about 140 °F. Then the starch gelatinizes and the proteins set around 150–180 °F, fixing the airy crumb. The covered pot traps steam so the crust stays soft while the loaf rises; with the lid off, the dry surface

browns through the Maillard reaction. The loaf is done when the center reaches about 200–210 °F.

UNIT CHALLENGE: A LOAF WITH A RISE LOG

Bake the artisan loaf from Lesson 5.4 a second time, changing one thing on purpose (for example, a longer or shorter first rise, a cooler or warmer room, or 25% whole-wheat flour). Keep a full rise log both times: water temperature, room temperature, and the dough's height at regular times, plus the oven-spring measurement and the finished center temperature.

Photograph or draw the crumb of both loaves side by side. Write a one-page report explaining the differences using the ideas of yeast, enzymes, gluten, moisture and heat, with your baker's percentages, and serve the better loaf to your family with a word of thanks.

LOOK FOR	WHAT IT MEANS
Bread baked safely	Measured carefully, handled the dough well, worked safely with the adult at the hot pot, and cleaned up completely.
Fair comparison	Changed only one thing between the two loaves and recorded everything else the same way.
Rise logs and graph	Honest times, heights and temperatures for both loaves, with a graph.
Crumb photos or drawings	Both crumbs shown clearly side by side, with differences labeled.
Science explanation	Correctly explains the results in your own words; a loaf that flopped but is well recorded earns full credit.

5.1 STARCH RETROGRADATION: STALE BREAD AND FRIED RICE

OBJECTIVES

- Tell how Jean-Baptiste Boussingault showed in 1852 that bread goes stale even when it does not dry out.
- Explain gelatinization and retrogradation, and why refrigeration speeds staling.
- Cook vegetable fried rice from day-old rice, with an adult present for stir-frying, and handle cooked rice safely.

Warm-up. Leave one slice of soft bread in a sealed bag on the counter and another in a sealed bag in the refrigerator overnight. Today, squeeze and taste each. Which is firmer? Neither one could dry out in a sealed bag, so what happened?

WATCH

Starch Retrogradation | The Science of Stale Bread

PostHarvest • 3:40

<https://www.youtube.com/watch?v=13ICPBTnqKo>

WHEN TO WATCH

After the story. Watch what happens to the starch molecules as cooked starch cools and ages.

Note: A short food-science explainer on retrogradation.

KEY TERMS

amylose and amylopectin

The two kinds of starch molecules. Amylose is a long, straight chain; amylopectin is a large, bushy, branched one.

gelatinization

When starch granules heated in water soak it up, swell and release their chains, turning soft and thick.

retrogradation

When cooked starch cools and its chains slowly line up again into firm, partly crystal-like bundles, squeezing out water. It makes bread stale and cold rice firm.

stir-fry

To cook small pieces of food quickly in a little hot oil, stirring and tossing constantly.

spore

A tough, resting form of some bacteria that can survive cooking. Spores in rice can grow again if cooked rice is left warm too long.

CORE IDEAS

The story. Everyone knows that bread goes stale, and for centuries everyone assumed the reason was obvious: it dries out. In 1852 the French chemist Jean-Baptiste Boussingault decided to test that idea. He was a careful experimenter, known for weighing and measuring everything in his studies of plants and farming.

How they figured it out. Boussingault sealed fresh bread so that it could not lose water, and he weighed it. After several days the bread had become hard and crumbly, yet it weighed almost the same as before: it had hardly dried at all. Then he heated the stale bread in its sealed container, and it became soft again, almost like fresh. Something was happening *inside* the bread that heat could undo. More than a century later, chemists with X-ray instruments showed what it was: the starch was slowly re-forming crystals.

The kitchen science. Starch is made of two kinds of molecules, straight **amylose** and branched **amylopectin**, packed tightly in granules. When bread bakes or rice cooks, the granules soak up water and swell (**gelatinization**), and the chains loosen and tangle with water between them: soft and tender. As the food cools, the chains slowly line up with each other again into firm bundles and push water out (**retrogradation**). Amylose does this within hours; amylopectin keeps doing it over days. Retrogradation is fastest at refrigerator temperatures, so bread stales faster in the refrigerator than on the counter; freezing stops it almost completely. Reheating melts the bundles and brings back softness for a while, as Boussingault saw. For fried rice, retrogradation is a gift: day-old rice grains are firmer and drier on the

surface, so they separate and toast in the pan instead of turning to mush. Cooked rice needs care, though. Rice can carry spores of the bacterium *Bacillus cereus*, which survive cooking. Cool cooked rice quickly, refrigerate it within 2 hours (sooner is better), and use it within 3–4 days.

Let's cook. You will make vegetable and egg fried rice from rice cooked the day before. The skill to do well is **stir-frying**, with an adult present: having every ingredient cut and measured before you turn on the heat, using a very hot pan with a thin film of oil, and keeping the food moving.

PICTURE STUDY



Path through the Rice Fields at Ōmori, Utagawa Hiroshige, 1852 · Woodblock print · Reproduced on Wikimedia Commons

Image: [Wikimedia Commons](#), public domain

Rice has been the center of Japanese meals for centuries; the word for cooked rice, *gohan*, also means “meal.” Hiroshige shows travelers on a raised path between rice paddies near Ōmori, a village on the road out of Edo (Tokyo).

Look closely

- Find the rice fields. Why would rice be grown in flat, wet fields?
- Find the sheaves of rice hung to dry. Why dry the rice before storing it?
- Find Mount Fuji. What season do you think it is?
- Find the travelers. What are they carrying?

Talk about it

1. How many steps does rice go through between this field and your fried rice?
2. In many countries leftover rice is never wasted. Why do you think fried rice became such a common dish?
3. Hiroshige's prints show everyday work as beautiful. What everyday work in your home deserves that kind of attention?

Safety first. Stir-frying uses a hot pan and a thin film of oil: do it with an adult present, keep a lid nearby, and add food carefully so oil does not splash. Cooked rice must be refrigerated within 2 hours and used within 3–4 days; reheat fried rice leftovers to 165 °F. Sesame oil and soy sauce are major allergens; check first.

KITCHEN PROJECT

Yesterday's Rice: Vegetable and Egg Fried Rice

You will cook fried rice two ways in small test batches, once with freshly cooked warm rice and once with cold day-old rice, then cook the full family recipe with the better one. You will also run a bread-staling test with the slices from the warm-up.

You will need

- A large skillet (12-inch) or a wok, and a small skillet for the test
- A wide, thin spatula
- A cutting board, a damp towel and a chef's knife
- Small bowls for prepared ingredients
- Measuring cups and spoons
- A shallow container for cooling rice

VEGETABLE AND EGG FRIED RICE

Serves 4–6 · Prep 15 min (plus rice cooked a day ahead) · Cook 12 min

Ingredients

- 4 cups (about 600 g) cold cooked long-grain white rice (from 1½ cups uncooked rice, cooked the day before)
- 3 tablespoons vegetable oil, divided
- 3 large eggs, beaten with a pinch of salt
- 4 green onions, sliced, whites and greens kept separate
- 2 cloves garlic, minced
- 1 tablespoon grated fresh ginger
- 1½ cups (200 g) frozen peas and carrots, thawed
- 1 cup diced cooked ham or chicken (optional)
- 3 tablespoons soy sauce
- 1 teaspoon toasted sesame oil
- ¼ teaspoon white or black pepper

Method

1. **The day before:** Cook the rice according to the package. Spread it in a shallow container to cool, then cover and refrigerate within 1 hour.
2. Wash your hands. Break up any clumps of cold rice with your fingers. Set out every ingredient in small bowls near the stove before you turn on the heat.
3. With an adult present, heat 1 tablespoon oil in the large skillet over medium-high heat. Pour in the eggs and stir gently until just set, about 1 minute. Move them to a plate.
4. Add 1 tablespoon oil, then the green-onion whites, garlic and ginger. Stir for 30 seconds until fragrant.
5. Add the remaining 1 tablespoon oil and the rice. Spread it out and let it sit 1 minute to toast, then stir and toss. Repeat for 3–4 minutes until the rice is hot and some grains are lightly golden.
6. Add the peas and carrots and the ham or chicken. Stir-fry 2 minutes until hot.
7. Drizzle the soy sauce around the edge of the pan and toss. Add the eggs back, breaking them into pieces, along with the sesame oil, pepper and green-onion tops. Toss and serve hot.
8. Refrigerate leftovers within 2 hours and reheat to 165 °F. Clean up: wash the skillet, board and bowls, and wipe the stove once cool.

Allergy check: Contains eggs, soy (soy sauce) and sesame (sesame oil); most soy sauce also contains wheat. For wheat-free, use tamari labeled gluten-free. For sesame-free, leave out the sesame oil. For egg-free, leave out the eggs and add diced tofu (soy) or more vegetables.

Steps

1. **Rice test.** In the small skillet with 1 teaspoon oil, stir-fry $\frac{1}{2}$ cup of freshly cooked warm rice for 3 minutes. Then do the same with $\frac{1}{2}$ cup of cold day-old rice. Compare: do the grains stay separate? Is one mushy or sticky? Which one browns?
2. **Bread test.** Compare the counter slice and the refrigerator slice from the warm-up. Then warm the refrigerator slice in a toaster or a 300 °F oven for 5 minutes. Does it soften? Explain using Boussingault's experiment.

3. Cook the full recipe and serve it to your family.
4. **Taste test.** Ask your family to rate the fried rice from 1 to 5 for texture and flavor.
5. **Improve it.** Write one change for next time (shrimp or tofu, more vegetables, a splash of rice vinegar).
6. Clean up: wash, dry and put away everything.

Tips

- If you have only fresh rice, spread it on a baking sheet and refrigerate it uncovered for 1–2 hours to firm it up.
- Do not crowd the pan. If your skillet is small, cook the rice in two batches.
- Store bread you will not eat in two days in the freezer, not the refrigerator. Toast slices straight from frozen.

Check your work

- ☐ I can explain retrogradation and why bread stales faster in the refrigerator.
- ☐ I can explain why day-old rice makes better fried rice and how to store cooked rice safely.
- ☐ I stir-fried safely with an adult present.

COOK'S NOTEBOOK

1. Draw starch molecules three ways: packed in a raw granule, loose and tangled after cooking, and lined up in bundles after cooling (retrogradation).
2. Record your rice test and bread test results in a chart.
3. Copy the recipe in your own words, with the order of ingredients and why it matters.

From history. Retrogradation also creates “resistant starch,” starch that the body digests slowly, a little like fiber. Cooked and cooled potatoes, rice and pasta have more of it than freshly cooked ones. Food scientists study it to help make breads and other baked goods that stay fresh longer.

COMMON MISTAKES

- Using hot, freshly cooked rice. It is soft and sticky and turns into a gummy mass in the pan.

- Leaving a pot of cooked rice out on the stove for hours. Spores can grow; cool and refrigerate it promptly.
- Keeping bread in the refrigerator to keep it fresh. It stales faster there; keep it on the counter for a day or two, or freeze it.

Make it a game · Starch Match-Up. Make twelve cards: six terms such as gelatinization, retrogradation, amylose, amylopectin, stale bread and refrigerator, and six matching meanings. Shuffle them face down and play memory match with your parent. Each time you make a match, explain it in your own words. The player with more pairs wins.

5.2 MÈGE-MOURIÈS, MARGARINE AND THE FLAKY CRUST

OBJECTIVES

- Tell how Hippolyte Mège-Mouriès invented margarine in 1869 in answer to an emperor's prize.
- Explain how butter is an emulsion of water in fat, and how cold fat and steam make a crust flaky and tender.
- Make an all-butter pie crust and bake a rustic apple galette.

Warm-up. Set out a stick of butter, a spoonful of solid vegetable shortening and a spoonful of oil. Press each with a spoon. Which is hardest? Which melts fastest in your warm palm? Which do you think would make the flakiest crust, and why?

WATCH

The Great Pie Crust Experiment | Chemists in the Kitchen

LabX • 16:38

<https://www.youtube.com/watch?v=7gT7MnBpGgo>

WHEN TO WATCH

After the kitchen science and before you make the crust. Watch how each change to the fat and water changes the crust.

Note: From LabX, a science program of the National Academy of Sciences. It is long; you may watch it in two parts.

KEY TERMS

margarine

A spread made to look and act like butter, first from beef fat and milk (1869), today mostly from vegetable oils, water and salt.

emulsion

A mixture of two liquids that normally do not mix, with tiny droplets of one spread through the other. Butter is a water-in-fat emulsion; milk is fat-in-water.

shortening

A solid fat, or the effect of fat in dough: fat coats flour and “shortens” gluten strands, making baked goods tender.

laminated

Made of many thin, separate layers. A flaky crust is roughly laminated with sheets of fat between sheets of dough.

galette

A free-form, open-faced tart: pie dough rolled into a round, filled, and folded up around the edges. Say it “guh-LET.”

CORE IDEAS

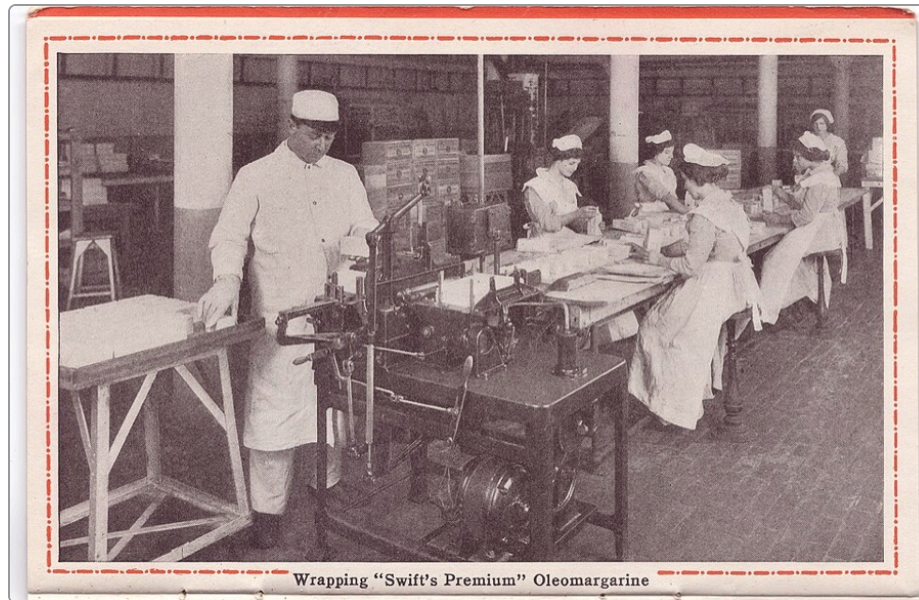
The story. In the 1860s butter was expensive in France, and the poor and the navy could rarely get enough of it. The Emperor Napoleon III offered a prize for anyone who could make a cheap, wholesome substitute that would keep well. Hippolyte Mège-Mouriès, a French chemist who had already found ways to make bread from more of the wheat kernel, took up the challenge.

How they figured it out. Mège-Mouriès knew that butter is mostly fat. He took clean beef fat, gently warmed and pressed out its softer part, and churned it with milk and water into a smooth, pale spread. He patented it in 1869 and called it “oleomargarine.” The name came from *oleum* (oil) and margaric acid, a fatty acid named years earlier by the chemist Michel Chevreul from the Greek word for pearl, because of its pearly shine. The idea spread quickly to the Netherlands and America. Later, food makers learned to make margarine from vegetable oils instead of beef fat, and the recipe has been changed many times since.

The kitchen science. Butter is about 80 percent fat and 16–18 percent water, with tiny droplets of water held inside solid fat: a water-in-fat **emulsion**. In a pie crust, fat does two jobs. First, fat coats some of the flour so that water cannot reach its proteins, and less gluten forms. That is why fat is called **shortening**: it keeps gluten strands short, and the crust tender. Second, when cold butter is left in flat pieces, the dough becomes a stack of thin layers of dough separated by sheets of fat. In a hot oven the butter melts and its water turns to steam, which puffs the layers apart, and the flour sets around the gaps: flakes. If the butter is warm, it smears into the flour and the crust bakes up tough or crumbly instead of flaky. So pie-makers keep everything cold, add only enough ice water to hold the dough together, and handle it as little as possible.

Let's cook. You will make an all-butter pie crust and bake an apple galette. The skill to do well is **cutting in cold butter:** working the butter into the flour with your fingertips or a pastry blender until some pieces are the size of peas and some are flattened into thin flakes, then adding ice water a little at a time.

PICTURE STUDY



Wrapping "Swift's Premium" Oleomargarine, Swift & Company (advertising postcard), early 1900s ·

Photographic postcard · Reproduced on Wikimedia Commons

Image: [Wikimedia Commons](#), public domain

Within a few decades of Mège-Mouriès's invention, American meat-packing companies were making oleomargarine in large factories. This postcard, made to advertise the product, shows workers cutting and wrapping blocks by hand. The white uniforms were meant to show customers that the food was made cleanly.

Look closely

- Find the machine on the left. What is it doing to the margarine?
- Find the women at the long table. What are they doing with their hands?
- Look at the clothing. Why would a food company want its workers in white caps and aprons?
- Look for boxes or stacks. How would the margarine be shipped?

Talk about it

1. Margarine was invented as a cheaper substitute for butter. Why might a family choose one or the other for a pie crust?
2. Why would a company put a picture of its clean factory on a postcard?

3. How is the work in this factory like the work you do when you make a pie crust? How is it different?

Safety first. Do not taste unbaked pie dough or the uncooked egg wash. Use oven mitts and set the hot pan on a rack; apple filling can bubble out and is very hot. An adult is at home and nearby while you use the oven.

KITCHEN PROJECT

Cold Fat, Hot Oven: All-Butter Apple Galette

You will make an all-butter pie crust, watch for the flakes of butter in the dough, and bake a free-form apple galette. You will also bake two small test pieces of dough, one made with cold butter and one with soft butter, and compare the flakes.

You will need

- A large mixing bowl and a pastry blender or your fingertips
- A rolling pin and a little extra flour
- A rimmed baking sheet and parchment paper
- A cutting board, a paring knife or chef's knife and a vegetable peeler
- Plastic wrap, a small bowl and a pastry brush
- Measuring cups and spoons, a kitchen scale (optional)

RUSTIC APPLE GALETTE WITH ALL-BUTTER CRUST

Serves 6–8 • Prep 30 min • Chill 1 hr • Bake 40–45 min

Ingredients

- **Crust:** 1¼ cups (160 g) all-purpose flour
- 1 tablespoon sugar and ½ teaspoon salt
- 8 tablespoons (1 stick, 113 g) cold unsalted butter, cut in ½-inch cubes
- 4–5 tablespoons ice water
- **Filling:** 3 medium apples (about 1¼ pounds, 570 g), such as Honeycrisp, Granny Smith or Golden Delicious
- ¼ cup (50 g) sugar
- 1 tablespoon flour
- ½ teaspoon ground cinnamon
- 1 tablespoon lemon juice
- **Finish:** 1 egg beaten with 1 tablespoon water, and 1 tablespoon coarse or plain sugar

Method

1. Wash your hands. In the bowl, whisk the flour, sugar and salt. Add the cold butter and toss to coat. Work it in with a pastry blender or quick fingertips until the pieces are the size of peas, and press some of them flat into thin flakes.
2. Sprinkle on 4 tablespoons ice water and toss with a fork. Squeeze a handful: if it holds together, stop; if it crumbles, add more water 1 teaspoon at a time. Press the dough into a disk, wrap it, and refrigerate at least 1 hour.
3. Heat the oven to 400 °F (200 °C). Peel and core the apples, then slice them ¼ inch thick, using the claw grip. Toss them with the sugar, flour, cinnamon and lemon juice.
4. On a floured counter, roll the dough from the center outward into a 12-inch circle about ⅛ inch thick, turning it a quarter turn now and then so it does not stick. Move it to the parchment-lined baking sheet.
5. Arrange the apples in the center, leaving a 2-inch border. Fold the border up over the edge of the apples, pleating it as you go.
6. Brush the crust with the egg wash and sprinkle it with sugar. Bake 40–45 minutes, until the crust is deep golden and the juices bubble.
7. Cool on the pan at least 20 minutes before slicing. Serve warm or at room temperature.
8. Clean up: wash the bowl, rolling pin and board, and wipe the counter of flour.

Allergy check: Contains wheat (flour), milk (butter) and eggs (egg wash). For egg-free, brush the crust with milk or cream instead. For milk-free, use a solid plant-based butter; the crust will taste different but can still be flaky.

Steps

1. **Flake test.** Before chilling, pinch off two walnut-size pieces of dough. Into one, knead a little extra soft butter until it is smooth and greasy. Roll both pieces flat and bake them on a corner of the baking sheet with the galette for 12–15 minutes. Break each and compare: which has layers? Which is crumbly or hard?
2. **Look closely.** When you roll out the dough, look for streaks and flakes of butter. Sketch what you see.

3. Bake the galette and record the bake time and the crust's color.
4. **Taste test.** Ask your family to rate the galette from 1 to 5 for flakiness, tenderness and flavor.
5. **Improve it.** Write one change for next time (pears instead of apples, a little whole-wheat flour, or a longer chill if the dough was soft).
6. Clean up: wash, dry and put away everything.

Tips

- If the butter starts to feel soft or greasy while you work, put the whole bowl in the freezer for 10 minutes.
- A free-form galette is forgiving: cracks in the folded edge look rustic and bake up fine.
- Extra dough scraps can be sprinkled with cinnamon sugar and baked for 10–12 minutes as a snack.

Check your work

- ☐ I can tell how margarine was invented and why it was needed.
- ☐ I can explain how cold butter and steam make a crust flaky and how fat keeps it tender.
- ☐ I made an all-butter crust and baked a galette safely.

COOK'S NOTEBOOK

1. Draw a magnified cross-section of pie dough before and after baking: sheets of butter between layers of dough, then gaps where steam pushed the layers apart.
2. Record your flake test with a sketch of each test piece.
3. Copy the crust recipe and calculate the ratio of flour to fat to water by weight (for example, 160 : 113 : 65).

From history. In America, dairy farmers worried that margarine would hurt butter sales, and for many years some states required margarine to be sold white instead of yellow. Families bought it with a capsule of yellow coloring and squeezed it in at home. The color rules were dropped by the 1960s.

COMMON MISTAKES

- Using soft butter or warm hands. The butter smears into the flour, and the crust is not flaky.

- Adding too much water. Wet dough forms more gluten and shrinks and toughens in the oven.
- Rolling back and forth hard over the dough. Roll from the center outward with gentle pressure, and turn the dough often.

Make it a game · Draw the Flaky Crust. Play a drawing-and-guessing game. Without words or letters, sketch one idea at a time: Mège-Mouriès and the emperor's prize, butter as water in fat, cold fat in dough, steam making layers. Your parent guesses each one and says the science behind it. Swap roles and see who guesses the most in five minutes.

5.3 PROTEINS: GLUTEN, EGGS AND FRESH PASTA

OBJECTIVES

- Tell how Jacopo Beccari first isolated gluten from wheat dough in Bologna in 1728.
- Explain how gluten forms from two wheat proteins, what kneading and resting do, and what eggs add to pasta.
- Make fresh egg pasta by hand, roll and cut it, and cook it with a simple garlic-butter sauce.

Warm-up. Mix 2 tablespoons of flour with 1 tablespoon of water into a small ball of dough. Stretch it. Now hold it under a gentle trickle of cold water and squeeze and rub it for 3–4 minutes. What washes away? What is left in your hand? (Wash your hands afterward and do not taste it.)

WATCH

Science: What is Gluten? Here's How to See and Feel Gluten

America's Test Kitchen • 3:24

<https://www.youtube.com/watch?v=zDEcvSc2UKA>

WHEN TO WATCH

Before the warm-up and again after the kitchen science: it shows the same dough-washing test Beccari did, and the two gluten proteins.

Note: From America's Test Kitchen's science series.

KEY TERMS

gluten

A stretchy network of proteins that forms when wheat flour is mixed with water and worked. It gives bread its chew and pasta its bite.

gliadin and glutenin

The two wheat proteins that join to make gluten. Gliadin lets dough stretch; glutenin makes it spring back.

kneading

Pressing, folding and turning dough to line up and strengthen its gluten.

resting

Letting dough sit covered so the gluten relaxes and the flour fully absorbs the liquid, making it easier to roll.

al dente

Italian for “to the tooth”: pasta cooked until tender but still slightly firm when bitten.

CORE IDEAS

The story. In 1728 Jacopo Bartolomeo Beccari, a professor of medicine and science in Bologna, Italy, gave a lecture to his city’s Academy of Sciences about wheat, the grain that fed all of Europe. He described a simple experiment. He made a dough of flour and water and washed it in clean water, kneading it again and again.

How they figured it out. As Beccari washed the dough, the water turned milky and white: the starch was washing out. What remained in his hands was a sticky, rubbery, stretchy mass that would not dissolve. Beccari noticed that it behaved more like the substances that come from animals, like egg white or meat, than like a plant. He had isolated **gluten**, the protein part of wheat. His work was published in 1745. Later chemists found that gluten is made of two kinds of protein, and that the same experiment works with no other common grain.

The kitchen science. Wheat flour contains two families of protein, **gliadin** and **glutenin**. Dry, they do nothing. Add water and work the dough, and they unfold and link into long, springy strands: gluten. Gliadin lets dough stretch; glutenin makes it snap back. **Kneading** lines the strands up and makes the network strong and smooth; **resting** lets them relax so the dough can be rolled thin without shrinking back. In egg pasta, the eggs supply all the liquid. Their proteins add richness and color and firm up when cooked, so fresh pasta holds together and has a tender bite, and their fat and lecithin make the dough silky. When pasta boils, its surface starch gelatinizes while its proteins set; that is why it is soft outside and slightly firm in the center when cooked **al dente**. Some people cannot eat gluten at all because of celiac disease or a wheat allergy, and that is a matter for the family and the doctor.

Let’s cook. You will make fresh egg pasta by hand, with nothing but flour, eggs, salt and a rolling pin, cut it into fettuccine, and toss it with garlic butter and parmesan. The skill to do well is **kneading and rolling dough**: kneading until smooth and springy, resting it, then rolling it thin enough to see your hand through.

PICTURE STUDY



Macaroni Drying in the Streets of Naples, Underwood & Underwood (stereograph), 1897 · Stereograph photograph · Reproduced on Wikimedia Commons

Image: [Wikimedia Commons](#), public domain

In the 1800s, Naples and the nearby town of Gragnano were famous for dried pasta. Pasta makers hung long strands over poles in the streets and courtyards, where the sea breeze and the warm sun dried them. Photographers sold pictures like this one as stereographs, double photographs that looked three-dimensional in a special viewer.

Look closely

- Find the long strands hanging on the poles. Why hang them instead of piling them up?
- Look at the workers. What jobs do you think they are doing?
- Look at the street. What might blow onto the pasta as it dried?
- Find the drying racks. How tall are they compared to the people?

Talk about it

1. The photographer's caption called the streets "dirty." What do we do today to keep pasta clean as it is made and dried?
2. Dried pasta keeps for a long time; fresh pasta does not. Why? Think about water and microbes.

3. What makes pasta made from only flour and water hold together without eggs? Use the word gluten.

Safety first. Do not taste raw pasta dough; it contains uncooked egg and flour. Wash your hands after cracking eggs. Drain pasta by pouring away from you, with an adult nearby. Fresh pasta cooks in 2–4 minutes; taste a cooked strand, not a raw one.

KITCHEN PROJECT

Flour, Eggs and a Rolling Pin: Fresh Fettuccine

You will repeat Beccari's gluten-washing experiment, then make fresh egg pasta by hand. You will test how kneading and resting change the dough, and cook the pasta for a family dinner.

You will need

- A large bowl or a clean counter, and a fork
- A bench scraper or spatula
- Plastic wrap
- A rolling pin and extra flour
- A chef's knife and a cutting board
- A large pot, a colander and tongs
- A kitchen scale (optional)

FRESH FETTUCCINE WITH GARLIC BUTTER AND PARMESAN

Serves 4 • Prep 30 min • Rest 30 min • Roll and cut 20 min • Cook 5 min

Ingredients

- **Pasta:** 2 cups (250 g) all-purpose flour, plus more for rolling
- 3 large eggs, at room temperature
- ½ teaspoon salt
- 1 teaspoon olive oil
- **Sauce:** 4 tablespoons (56 g) butter
- 2 cloves garlic, minced
- ½ cup (40 g) finely grated parmesan, plus more to serve
- ½ cup reserved pasta water
- 2 tablespoons chopped parsley, black pepper, and a squeeze of lemon
- **On the side:** a green salad or steamed broccoli

Method

1. Wash your hands. Put the flour and salt in the bowl (or in a mound on the counter) and make a deep well in the center. Crack the eggs into the well and add the oil. Wash your hands again.
2. Beat the eggs with a fork, slowly pulling in flour from the sides, until a shaggy dough forms. Then press it together with your hands.
3. Knead on a lightly floured counter 8–10 minutes: push the dough away with the heel of your hand, fold it back, turn it a quarter turn, and repeat, until smooth and springy. If it sticks, add a little flour; if it cracks, wet your hands.
4. Wrap the dough in plastic and let it rest at room temperature 30 minutes.
5. Cut the dough in four pieces; keep three covered. Roll one piece on a floured counter, from the center outward, turning and flouring often, into a thin sheet about $\frac{1}{16}$ inch thick, thin enough to see the shadow of your hand through it.
6. Dust the sheet with flour, roll it loosely into a flat log, and cut it crosswise into $\frac{1}{4}$ -inch strips. Unroll the strips, toss them with flour, and lay them in loose nests. Repeat with the rest of the dough.
7. Bring a large pot of salted water to a boil. Cook the pasta 2–4 minutes, until tender with a slight bite. Save $\frac{1}{2}$ cup pasta water, then drain, pouring away from you.
8. Melt the butter in the empty pot over medium-low heat, add the garlic for 1 minute, then add the pasta, parmesan and a splash of pasta water. Toss until glossy. Add parsley, pepper and lemon, and serve. Clean up: scrape dried dough off the counter with the bench scraper before wiping, and wash everything.

Allergy check: Contains wheat (flour), eggs and milk (butter, parmesan). For milk-free, toss the pasta with olive oil, garlic and herbs. Wheat and eggs are the heart of this pasta; for a wheat- or egg-free meal, use a purchased pasta made for those needs.

Steps

1. **Beccari's experiment.** Make a ball from $\frac{1}{2}$ cup flour and about 3 tablespoons water. Knead it 2 minutes, rest it 10 minutes, then wash it under a thin stream of cold water over a bowl, squeezing and rubbing, until the water

runs nearly clear. Describe what is left. Stretch it. (Throw it away; do not taste it.)

2. **Kneading test.** Before kneading the pasta dough, pinch off a marble-size piece and set it aside. After kneading, compare the two pieces: stretch each and describe the difference.
3. **Resting test.** Try to roll a small corner of dough right after kneading, then again after the 30-minute rest. Which shrinks back more? Why?
4. Cook and serve the pasta. Record how many minutes it took to reach al dente.
5. **Taste test.** Ask your family to rate the pasta from 1 to 5 for texture and flavor, and compare it with dried pasta if you have some.
6. **Improve it.** Write one change for next time (thinner rolling, a different shape such as pappardelle, or a tomato sauce).
7. Clean up: wash, dry and put away everything.

Tips

- Flour soaks up eggs differently depending on the size of the eggs and the weather. Go by feel: the dough should be firm and not sticky.
- Dust the cut pasta generously with flour so the strands do not stick together.
- Fresh pasta can be frozen in nests on a tray, then bagged. Cook it straight from frozen for a minute or two longer.

Check your work

- ☐ I can tell how Beccari isolated gluten.
- ☐ I can explain how kneading and resting change gluten and what eggs do in pasta.
- ☐ I made, rolled, cut and cooked fresh pasta.

COOK'S NOTEBOOK

1. Draw gluten three ways: gliadin and glutenin separate in dry flour, tangled after mixing, and lined up in strong strands after kneading.
2. Record your kneading and resting tests with drawings.
3. Copy the pasta recipe in your own words, and write the ratio of flour to eggs by weight.

From history. Pasta was made in Italy by the Middle Ages, and dried pasta was being traded from Sicily by the 1100s. Pasta made from durum wheat semolina and water dries hard and keeps well; egg pasta, softer and richer, became a specialty of northern Italy, especially around Bologna, Beccari's own city.

COMMON MISTAKES

- Adding lots of extra flour when the dough feels sticky at first. Knead a few minutes before adding more; the dough smooths as gluten forms.
- Skipping the rest. The dough fights back and shrinks when you roll it.
- Cooking fresh pasta as long as dried. Fresh pasta cooks in 2–4 minutes.

Make it a game • Pasta Teach-Back. Be the pasta teacher for five minutes. Explain to your parent how Beccari found gluten in 1728, how gliadin and glutenin join, what kneading and resting do, and what eggs add. Your parent slips in one wrong fact. Catch it for a point. If you miss it, the point goes to your parent.

5.4 YEAST BIOLOGY AND BREAD SCIENCE

OBJECTIVES

- Tell how Eduard Buchner proved in 1897 that the enzymes inside yeast, not life itself, carry out fermentation.
- Explain how yeast, enzymes, gluten, steam and heat work together to raise and set a loaf, and calculate baker's percentages.
- Bake a crusty artisan loaf with an overnight rise, keep a rise log, and check doneness with a thermometer.

Warm-up. Stir 1 teaspoon of sugar and $\frac{1}{2}$ teaspoon of instant yeast into $\frac{1}{2}$ cup of warm water (about 105 °F) in a clear glass. In a second glass, do the same with water straight from the refrigerator. Watch for 10 minutes. Describe what happens in each glass, and why you think they differ.

WATCH

This No-Knead Loaf with Seeds & Spices is Everything

King Arthur Baking Company · 10:36

<https://www.youtube.com/watch?v=0FhiJr6WCGI>

WHEN TO WATCH

Before you mix your dough. Watch how the dough looks after the long rise and how the baker shapes it and handles the hot pot.

Note: From King Arthur Baking. Our recipe is plainer (no seeds or spices) but uses the same long, slow, no-knead method.

BACKUP VIDEO

How Does Bread Rise?

BrainStuff - HowStuffWorks · 2:08

<https://www.youtube.com/watch?v=GvD-8ZfxFOY>

After the kitchen-science paragraph, for a short review of yeast, gas and gluten.

KEY TERMS

yeast

A single-celled fungus. Baker's yeast, *Saccharomyces cerevisiae*, feeds on sugars and gives off carbon dioxide gas and flavor compounds.

fermentation

The breaking down of sugars by microbes without needing oxygen. In bread dough it makes gas and flavor.

baker's percentage

A way of writing a bread recipe in which the flour is 100% and every other ingredient is a percentage of the flour's weight.

enzyme

A protein that speeds up a chemical reaction in living things, such as breaking starch into sugar or sugar into carbon dioxide.

oven spring

The quick rise of a loaf in the first minutes of baking, as gas expands, water turns to steam and the yeast works fast before the heat stops it.

CORE IDEAS

The story. By the 1860s Louis Pasteur had shown that yeast is alive and that fermentation happens when yeast grows. Many scientists then believed fermentation needed some mysterious “vital force” found only in living cells. In 1897 a German chemist named Eduard Buchner was trying to make an extract from yeast for medical research. He ground yeast cells with fine sand until they were torn apart, squeezed out the juice through a cloth under great pressure, and was left with a liquid that held no living yeast at all.

How they figured it out. To keep the yeast juice from spoiling, Buchner's team added a large amount of sugar, which was a common way to preserve things. To their surprise, the juice began to bubble with carbon dioxide, just as if live yeast were present. There were no living cells, yet fermentation was happening. Buchner concluded that fermentation is carried out by chemicals made inside the yeast. He named this substance “zymase,” and we now know it is a team of many **enzymes**. For this discovery he received the Nobel Prize in Chemistry in 1907, and his work helped begin the science of biochemistry.

The kitchen science. In bread dough, enzymes are busy from the moment flour meets water. Enzymes in the flour break some starch into sugars; enzymes in the yeast turn those sugars into carbon dioxide and flavor compounds. Meanwhile, gluten forms. In a long, slow, cool rise (12–18 hours), gluten strands line up by themselves without kneading, and the slow fermentation builds deep flavor. The gas inflates thousands of tiny pockets held by the gluten net. In a hot oven the loaf springs up: gas expands, water turns to steam, and yeast works furiously until it dies at about 140 °F (60 °C). Then the starch gelatinizes and the proteins set (around 150–180 °F), fixing the airy crumb in place, while the dry outside browns into a crust through the Maillard reaction. Baking inside a covered pot traps steam for the first part, keeping the crust soft so the loaf can rise fully, then the lid comes off so the crust can brown and crisp. A lean loaf is done when the center reads about 200–210 °F (93–99 °C).

Let's cook. You will bake a crusty no-knead artisan loaf in a Dutch oven. The skill to do well is **shaping and handling a wet dough**: using floured hands and a bench scraper to fold it into a tight ball, and lowering it into the very hot pot on a parchment sling while an adult handles the lid and the pot.

PICTURE STUDY



Baking Bread, New Mexico, Unknown photographer (Detroit Publishing Company), about 1910 ·
Photograph · Library of Congress, Washington, D.C.
Image: [Wikimedia Commons](#), public domain

For centuries the Pueblo people of New Mexico have baked bread in *hornos*, beehive-shaped ovens made of adobe clay. A fire is built inside to heat the thick walls, the ashes are swept out, and the loaves are set inside to bake in the stored heat, with the door sealed. It works much like the Dutch oven in your kitchen.

Look closely

- Find the opening of the oven. How would the baker get the loaves in and out?
- Look at the thickness of the oven walls. Why would thick clay walls be useful?
- Find the loaves or the baker's tools. What can you see?
- Look at the landscape around the oven. Why would an oven be built outdoors?

Talk about it

1. An horno is heated with fire and then the fire is removed. How is that like preheating a Dutch oven?
2. Why would sealing the oven door help the bread rise and form a good crust? Use the word steam.

3. Bread has been baked in some form by nearly every people on earth. Why do you think it is so widespread?

Safety first. A Dutch oven heated to 450 °F causes serious burns. An adult handles the hot pot and lid with thick, dry oven mitts while you lower the dough on a parchment sling, keeping your arms clear of the pot's edges. Never taste unbaked dough. Set the hot pot on a trivet or the stove, never on the counter.

Slow Rise, Hot Pot: A Crusty Artisan Loaf

You will mix a no-knead dough, let the yeast and enzymes work overnight, and bake a crusty loaf. You will keep a rise log, calculate the dough's baker's percentages, and check doneness with a thermometer.

You will need

- A large bowl and a sturdy spoon or spatula
- Plastic wrap or a plate to cover the bowl
- A kitchen scale (recommended) and measuring cups and spoons
- Masking tape and a marker for the rise log
- Parchment paper and a bench scraper
- A 5- to 7-quart Dutch oven or heavy oven-safe pot with a lid
- Thick oven mitts, a cooling rack and an instant-read thermometer

CRUSTY NO-KNEAD ARTISAN BREAD

Serves 1 large loaf (about 12 slices) • Mix 10 min • Rise 12–18 hr • Shape and rise 1½–2 hr • Bake 45–50 min • Cool 1 hr

Ingredients

- 3 cups (390 g) all-purpose or bread flour, plus more for shaping
- 1½ teaspoons (9 g) salt
- ½ teaspoon (2 g) instant yeast
- 1½ cups (345 g) room-temperature water

Method

1. **Evening:** Wash your hands. In the large bowl, stir together the flour, salt and yeast. Add the water and stir about 30 seconds, until no dry flour remains and the dough is shaggy and sticky. Cover the bowl and leave it at room temperature (about 70 °F) for 12–18 hours. Put a strip of tape on the bowl at the top of the dough.
2. **Next day:** The dough should have more than doubled, with bubbles on the surface. Dust the counter and your hands with flour and scrape the

dough out.

3. Fold the edges of the dough into the center, all the way around, to make a rough ball. Flip it seam side down and gently drag it toward you on the counter a few times to tighten the surface.
4. Set the ball seam side down on a large piece of parchment. Dust it with flour, cover loosely, and let it rise 1½–2 hours, until puffy.
5. About 45 minutes before baking, put the covered Dutch oven in the oven and heat to 450 °F (230 °C).
6. With a sharp knife, cut a shallow slash across the top of the loaf. An adult takes out the hot pot and removes the lid. Holding the parchment by its edges, lower the dough into the pot. The adult covers the pot and returns it to the oven.
7. Bake 30 minutes covered. The adult removes the lid, and you bake 15–20 minutes more, until deep brown and the center reads about 205 °F (96 °C).
8. The adult lifts the loaf out by the parchment onto a rack. Cool at least 1 hour before slicing; the inside is still setting. Clean up: scrape dough from the bowl before it dries, then wash everything.

Allergy check: Contains wheat.

Steps

1. **Baker's percentages.** Using the flour as 100%, calculate the percentage for the water, salt and yeast. (Water: $345 \div 390 \times 100 \approx 88\%$. Do the others yourself.) This is a high-hydration dough; compare it with a sandwich bread at about 60–65%.
2. **Rise log.** Mark the dough's height with tape at the start, and record its height and the room temperature at 2 hours, 6 hours (or bedtime), the next morning and before shaping.
3. **Oven spring.** Measure the shaped loaf's height before it goes into the pot and the baked loaf's height after. How much did it grow in the oven?
4. **Doneness.** Record the center temperature when you take the loaf out. Tap the bottom (with a mitt on): does it sound hollow?

5. **Taste test.** When cool, have an adult slice the loaf. Look at the holes in the crumb and sketch them. Ask your family to rate the crust and crumb from 1 to 5.
6. **Improve it.** Write one change for next time (a longer rise for more flavor, $\frac{1}{2}$ cup whole-wheat flour, or a handful of seeds).
7. Clean up: wash, dry and put away everything.

Tips

- If your kitchen is cool, the first rise may take the full 18 hours; if it is warm, 12 may be plenty. Watch the dough, not the clock.
- Wet dough is supposed to be sticky. Use flour on your hands and the counter, not in the dough.
- Slicing hot bread lets steam escape and makes the crumb gummy. Wait the full hour.

Check your work

- ☐ I can tell what Buchner discovered and why it mattered.
- ☐ I can explain how yeast, enzymes, gluten, steam and heat raise and set a loaf.
- ☐ I baked a loaf safely, kept a rise log and calculated baker's percentages.

COOK'S NOTEBOOK

1. Draw a flow chart of a loaf's life: flour and water, enzymes and yeast, gluten network, rising, oven spring, setting and browning. Label the temperature of each oven stage.
2. Graph your rise log: height against time.
3. Draw a slice of your bread showing the holes, and copy the recipe with baker's percentages beside each ingredient.

From history. Before commercial yeast was sold, bakers kept a piece of the last batch of dough, a starter or leaven, to raise the next one. That is the leaven Jesus spoke of in His parables. Sourdough bakers still do the same today, keeping a living culture of wild yeasts and bacteria going for years.

COMMON MISTAKES

- Using hot water. Water above about 130 °F (54 °C) can kill yeast; room-temperature water works for a long rise.

- Adding lots of flour to make the dough easy to handle. It will bake up dense; keep the dough wet and use flour only on the surface.
- Tasting unbaked dough. Raw flour can carry germs; wait for the baked loaf.

Make it a game · Baker's Math Duel. Say you have 500 grams of flour. Your parent calls out a baker's percentage: water 70, salt 2, yeast 1. You race to say the grams. Do ten rounds, then change the flour weight. Then tell in two sentences what Buchner proved about yeast enzymes in 1897. Record your fastest ten.

Scripture. “Give us this day our daily bread.” (Matthew 6:11, KJV)

Jesus taught us to ask God for our daily bread. Even a loaf we bake ourselves begins with His gifts: wheat, water, salt, yeast and the hands to work.

FOOD CHEMISTRY

A kitchen is a chemistry laboratory where the experiments are eaten. In this unit you will study the ingredients that do the most work in a recipe, one at a time, at a deeper level than before. You will learn why cooked starch hardens again as it cools, and why that makes stale bread a nuisance but day-old rice a gift. You will follow a French emperor's prize to the invention of margarine and learn how fat and steam make a pie crust flaky. You will meet the scientist who first washed a ball of dough until only gluten remained, and the one who proved that yeast does its work with enzymes.

Each discovery becomes a recipe: fried rice from yesterday's rice, a rustic apple galette in an all-butter crust, fresh egg pasta rolled by hand, and a crusty artisan loaf that rises slowly overnight. Jesus called Himself the bread of life and taught us to pray for our daily bread; by the end of this unit you will be able to make it.

PREREQUISITES

- Knows that starch thickens when heated in water and that proteins unfold and set with heat (earlier grades or Unit 4)
- Uses the stove and oven safely with an adult at home and nearby (Unit 1)
- Can shallow-fry in a thin film of oil with an adult present (Unit 4)
- Can work with percentages and ratios

MASTERY CHECKLIST

- ☐ I can explain starch gelatinization and retrogradation, why bread stales faster in the refrigerator, and why day-old rice makes better fried rice.
- ☐ I can tell how margarine was invented and explain how cold fat and steam make a flaky crust.
- ☐ I can explain how gluten forms from two wheat proteins and what eggs add to pasta.
- ☐ I can explain what Buchner discovered about yeast enzymes and how yeast, gluten and steam raise a loaf.
- ☐ I can use baker's percentages to describe a dough and keep a rise log.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **King Arthur Baking: Baker's Hotline and guides**: Free. Step-by-step baking guides with photographs, including pie crust and bread. Helpful for Lessons 5.2 and 5.4.
- **A digital kitchen scale**: Weighing flour in grams makes pie crust, pasta and bread come out the same every time, and makes baker's percentages easy.
- **A Dutch oven or heavy lidded pot that can go in a 450 °F oven**: Used for the artisan loaf in Lesson 5.4. A heavy baking sheet with a large metal bowl turned over the loaf works as a substitute.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

5.1 Starch Retrogradation: Stale Bread and Fried Rice	2 sessions of 50–60 minutes
5.2 Mège-Mouriès, Margarine and the Flaky Crust	2 sessions of 50–60 minutes
5.3 Proteins: Gluten, Eggs and Fresh Pasta	2 sessions of 50–60 minutes
5.4 Yeast Biology and Bread Science	2 sessions of 60–90 minutes (plus an overnight rise)

UNIT 5 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**

What did Boussingault's 1852 experiment show about stale bread?

2. **8 pts**

Explain retrogradation, and why bread goes stale faster in the refrigerator than on the counter.

3. **8 pts**

Predict: you make fried rice with hot, freshly cooked rice. What will happen, and why?

4. (6 pts)

How should cooked rice be stored, and why?

5. (8 pts)

Who invented margarine, when, and why was it needed?

6. (8 pts)

Explain the two jobs fat does in a pie crust.

7. (8 pts)

What did Beccari discover in 1728, and how?

8. (8 pts)

Name the two proteins that form gluten and what each contributes. What do kneading and resting each do?

9. (8 pts)

What did Buchner discover in 1897, and why was it surprising?

10. (10 pts)

Calculation: a dough uses 500 g flour, 350 g water, 10 g salt and 5 g yeast. Write its baker's percentages.

11. (10 pts)

Calculation: you want to make 1½ batches of the pie crust (160 g flour, 113 g butter, 65 g water per batch). How much of each do you need? How many tablespoons of butter is that if 1 tablespoon = 14 g?

12. (10 pts)

Short answer: In four or five sentences, describe what happens to a loaf of bread from the moment it enters a 450 °F oven until it is done.

ANSWER KEY

1. Bread sealed so it could not dry out still went stale while weighing almost the same, so staling is not just drying. Heating it made it soft again, showing a reversible change inside the bread (starch retrogradation).
2. As cooked starch cools, its chains slowly line up into firm bundles and squeeze out water. This happens fastest at refrigerator temperatures, so refrigerated bread stales faster; freezing nearly stops it.
3. It will turn sticky and mushy, because freshly cooked starch is soft and wet; day-old rice has retrograded, so its grains are firmer and drier and stay separate.
4. Cool it quickly in a shallow container, refrigerate within 2 hours (sooner is better) and use within 3–4 days, because spores of *Bacillus cereus* can survive cooking and grow if rice is left warm.
5. Hippolyte Mège-Mouriès, in 1869, in answer to Napoleon III's prize for a cheap, wholesome butter substitute that would keep, for the poor and the navy.
6. It coats flour so less gluten forms, keeping the crust tender (shortening). Cold flat pieces of butter make layers; in the oven their water turns to steam and pushes the layers apart, making flakes.
7. He isolated gluten by washing a flour-and-water dough until the starch washed away, leaving a sticky, stretchy protein mass that behaved like animal substances.
8. Gliadin (stretch) and glutenin (spring back). Kneading lines up and strengthens the gluten; resting relaxes it so dough can be rolled without shrinking.
9. That juice pressed from ground-up yeast, with no living cells, could still ferment sugar into carbon dioxide. It showed fermentation is done by enzymes (zymase), not a “vital force” of life.
10. Flour 100%; water $350 \div 500 \times 100 = 70\%$; salt $10 \div 500 \times 100 = 2\%$; yeast $5 \div 500 \times 100 = 1\%$.
11. Flour 240 g, butter 169.5 g (about 170 g), water 97.5 g (about 98 g). Butter: $170 \div 14 \approx 12$ tablespoons ($1\frac{1}{2}$ sticks).
12. Gas in the dough expands and water turns to steam, so the loaf springs up, and yeast works very fast until it dies at about 140 °F. Then the starch gelatinizes and the proteins set around 150–180 °F, fixing the airy crumb. The covered pot traps steam so the crust stays soft while the loaf rises; with the lid off, the dry surface

browns through the Maillard reaction. The loaf is done when the center reaches about 200–210 °F.

UNIT CHALLENGE: A LOAF WITH A RISE LOG

Bake the artisan loaf from Lesson 5.4 a second time, changing one thing on purpose (for example, a longer or shorter first rise, a cooler or warmer room, or 25% whole-wheat flour). Keep a full rise log both times: water temperature, room temperature, and the dough's height at regular times, plus the oven-spring measurement and the finished center temperature.

Photograph or draw the crumb of both loaves side by side. Write a one-page report explaining the differences using the ideas of yeast, enzymes, gluten, moisture and heat, with your baker's percentages, and serve the better loaf to your family with a word of thanks.

LOOK FOR	WHAT IT MEANS
Bread baked safely	Measured carefully, handled the dough well, worked safely with the adult at the hot pot, and cleaned up completely.
Fair comparison	Changed only one thing between the two loaves and recorded everything else the same way.
Rise logs and graph	Honest times, heights and temperatures for both loaves, with a graph.
Crumb photos or drawings	Both crumbs shown clearly side by side, with differences labeled.
Science explanation	Correctly explains the results in your own words; a loaf that flopped but is well recorded earns full credit.

CRAVINGS, REWARD & A BALANCED DIET

God made us able to enjoy food, and He made eating a pleasure on purpose. Sweet fruit, a salty pretzel, a rich bowl of soup: our brains learn to want foods that taste good and give energy. In this unit you will learn how that wanting works, told plainly and accurately. You will meet Howard Moskowitz, who measured the exact sweetness that people like best, and the scientists who found the brain's reward system. You will learn what makes a meal satisfying, why some packaged snacks are designed to be hard to stop eating, and how taste buds and habits can be retrained.

This unit is not about good foods and bad foods, and it is never about bodies. Nutrient-dense foods are the everyday heart of a balanced diet, and treats and feasts are good gifts in their place. The goal is wisdom and self-control, which Scripture calls a fruit of the Spirit, and real cooking skill: when you can make a sauce, a snack or a dessert yourself, you decide what goes into it.

PREREQUISITES

- Knows the five MyPlate groups and what macronutrients do (Unit 2)
- Knows the five basic tastes and how smell creates flavor (Unit 3)
- Can read a Nutrition Facts label (Unit 2)
- Can work with ratios and percentages

MASTERY CHECKLIST

- ☐ I can tell how Moskowitz found the bliss point and explain why some packaged foods are easy to eat past full.
- ☐ I can explain accurately that dopamine is a messenger chemical tied to wanting and learning, not pleasure itself, and how cues trigger cravings.
- ☐ I can explain what makes a meal satisfying (fiber, protein, water and time) and cook a filling grain bowl.
- ☐ I can describe how taste buds adjust to less added sugar or salt over several weeks, and plan a habit change.
- ☐ I can convert grams of sugar to teaspoons and compare added sugar in drinks and snacks.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **FDA: Added Sugars on the Nutrition Facts Label**: Free. Explains the Added Sugars line on the label and the Daily Value. Helpful for Lessons 6.1 and 6.4.
- **Monell Chemical Senses Center**: Free. The research institute whose studies showed that taste for salt and sugar can change over weeks. Short articles on taste and habits.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

6.1	Howard Moskowitz and the Bliss Point	2 sessions of 50–60 minutes
6.2	The Reward System: Wanting, Learning and Habits	2 sessions of 50–60 minutes
6.3	Satiety and the Balanced Diet	2 sessions of 50–60 minutes
6.4	Habits That Last: Retraining Your Taste Buds	2 sessions of 50–60 minutes

UNIT 6 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**
What is the bliss point, and how did Moskowitz find it?
2. **8 pts**
Why can some packaged snack foods be easy to eat past full? Describe what the food does, not what kind of person eats it.
3. **8 pts**
What did Olds and Milner discover in 1954?
4. **8 pts**
Explain accurately what dopamine does in the reward system. What is the difference between wanting and liking?

5. (8 pts)

Give two examples of food cues and one way to change each.

6. (8 pts)

What did Holt's 1995 satiety index study find? Name the most satisfying food and one of the least.

7. (8 pts)

Name three things that help a meal keep you satisfied, and explain one.

8. (10 pts)

Calculation: a 20-ounce bottle of sweet tea lists 52 g of added sugars. About how many teaspoons is that ($4\text{ g} \approx 1\text{ teaspoon}$)? The Daily Value for added sugars is 50 g. What percent of the Daily Value is it?

9. (10 pts)

Calculation: a recipe uses $\frac{1}{2}$ cup of sugar. You step it down by 25% for the next batch and another 25% of the original for the batch after that. How much sugar is in each batch, in cups and tablespoons (1 cup = 16 tablespoons)?

10. (8 pts)

What did the Monell salt and sugar studies show about taste preferences?

11. (8 pts)

Why does the stomach's 20-minute signal matter for how fast you eat?

12. (8 pts)

Short answer: In four or five sentences, explain how a Christian might think about treats, cravings and self-control, using what you learned in this unit.

ANSWER KEY

1. The amount of an ingredient such as sugar or salt at which people like a food most. He had many versions of a food made with different amounts, had ordinary people taste and rate them, and graphed liking against the amount; the peak of the curve is the bliss point.
2. They combine sugar, salt and fat near their bliss points, often with textures that melt away quickly so the mouth does not tire, and little fiber or protein to bring satisfaction, so it is easy to keep eating before fullness signals arrive.
3. That when a tiny signal reached a certain area of a rat's brain, the rat would press a lever again and again to get it, revealing a brain system that motivates seeking rewards (the reward system).
4. Dopamine is a messenger chemical tied to wanting, motivation and learning what is rewarding; it rises especially when we expect something good. Wanting is the pull toward a reward; liking is the enjoyment when we get it. They are different, and dopamine is mainly about wanting.
5. Examples: a snack bag on the counter (put fruit there instead); an advertisement (turn it off or notice it); walking past a bakery (take another route or plan a snack); boredom (do something active, drink water first). Other reasonable answers accepted.
6. Foods given in equal-energy portions differed greatly in how long they kept people satisfied; foods with more protein, fiber and water and less fat were most filling. Boiled potatoes were most satisfying; croissants, cake and doughnuts were among the least.
7. Protein, fiber, water (and time, eating slowly). Example: fiber adds bulk, holds water and slows digestion so energy is released steadily.
8. $52 \div 4 = 13$ teaspoons. $52 \div 50 \times 100 = 104\%$ of the Daily Value.
9. Original: $\frac{1}{2}$ cup = 8 tablespoons. 25% of 8 = 2 tablespoons. Second batch: 6 tablespoons ($\frac{3}{8}$ cup). Third batch: 4 tablespoons ($\frac{1}{4}$ cup).
10. After several weeks to a few months of eating less salt (1982) or sugar (2016), people's taste adjusted: lower amounts tasted stronger, and they came to prefer less salty or less sweet foods.
11. Fullness signals take about 20 minutes to reach the brain, so eating very fast can mean eating past full before you notice; eating slowly gives the signals time to arrive.

12. Food, including treats and feasts, is a good gift from God to be enjoyed with thanks. Our brains were made to want good-tasting food, and knowing how cues and designed foods work helps us choose wisely instead of being pulled along. Temperance is a fruit of the Spirit, grown with God's help and practice, not a joyless rule. Planning treats, eating slowly, building satisfying meals and changing habits gradually are practical ways to enjoy food in its right place.

UNIT CHALLENGE: A TWO-WEEK DRINKS AND SNACKS SWAP

Plan and carry out a two-week swap for one drink or snack habit: for example, water or sparkling water with fruit instead of a sweet drink at lunch, or a homemade snack (hummus and vegetables, baked oatmeal, popcorn you season yourself) instead of a packaged one. Cook at least two homemade snacks during the two weeks.

Keep a daily log of what you chose, how it tasted (1–5), your hunger and energy, and any cravings and their cues. At the end, write a one-page reflection on what your taste buds noticed, which cues mattered most, and what habit you will keep. Do not record weight or body measurements; this challenge is about taste, habits and cooking.

LOOK FOR	WHAT IT MEANS
Plan	A clear, specific swap with a step-by-step plan for both weeks.
Cooking	At least two homemade snacks cooked safely and recorded, with recipes in your own words.
Daily log	Fourteen honest entries with taste ratings, hunger and energy, cravings and cues.
Reflection	Uses the ideas of taste adaptation, cues, satiety and temperance correctly and honestly.
Next step	Names a habit to keep and how; a swap that was hard and honestly recorded earns full credit.

6.1 HOWARD MOSKOWITZ AND THE BLISS POINT

OBJECTIVES

- Tell how Howard Moskowitz used careful taste testing to find the “bliss point” and how food companies used it.
- Explain why liking rises and then falls as sweetness or saltiness increases, and how some packaged foods are designed to be easy to keep eating.
- Cook a homemade marinara sauce and run a blind sweetness test to find your family’s own bliss point.

Warm-up. Read the ingredient list on a jar of store-bought pasta sauce, a box of crackers and a bottle of ketchup. Is sugar (or corn syrup) listed? Where? Why do you think a company would add sugar to a sauce or a cracker?

WATCH

On spaghetti sauce - Malcolm Gladwell

TED-Ed • 17:34

<https://www.youtube.com/watch?v=VkhFh5Ms1vc>

WHEN TO WATCH

After the story. The writer Malcolm Gladwell tells the spaghetti-sauce story in his own words. Watch the first 12 minutes; the end is about choice and happiness more broadly.

Note: A famous talk, posted by TED-Ed. Listen for how Moskowitz tested many versions of the same food.

KEY TERMS

bliss point

The amount of an ingredient, such as sugar or salt, at which people like a food the most. More or less than that, and liking drops.

psychophysics

The science of measuring how people’s senses and feelings respond to physical things, such as how sweet a drink tastes at different amounts of sugar.

hedonic scale

A rating scale for how much a person likes something, often from 1 (dislike extremely) to 9 (like extremely).

blind test

A taste test in which tasters do not know which sample is which, so their expectations do not affect their ratings.

added sugar

Sugar or syrup put into a food when it is made, as opposed to sugar naturally in fruit or milk. The Nutrition Facts label lists it separately.

CORE IDEAS

The story. Howard Moskowitz studied experimental psychology at Harvard and then went to work at the U.S. Army’s food laboratories in Natick, Massachusetts, in the early 1970s, trying to find out what foods soldiers would actually eat. He became an expert in testing what people like. Later, working for food companies, he became famous for an idea he called the **bliss point**. In the 1980s, for example, a soup company asked him to help with a spaghetti sauce. Instead of searching for one perfect recipe, he had cooks make dozens of versions, sweeter and less sweet, thinner and chunkier, and had ordinary people taste and rate them all.

How they figured it out. When Moskowitz graphed how much people liked a food against how much sugar it contained, the line rose, reached a peak, and then fell. Too little sugar was flat; too much was sickly. The top of the curve was the bliss point. He also found that people did not all like the same thing: in the spaghetti-sauce study, a large group loved an extra-chunky sauce that no company was then selling, and the new chunky sauce sold very well. Food companies began testing many products this way, adjusting sugar, salt and fat to the exact point that most people liked best. The 9-point “hedonic scale” that tasters often use had been invented earlier, in the 1950s, at an Army food laboratory in Chicago.

The kitchen science. Sweetness signals energy, saltiness signals minerals, and richness signals fat, and the brain learns to want all three. A packaged snack that combines sugar, salt and fat at their bliss points, with a texture that melts away quickly so the mouth is never tired, can make it very easy to keep eating past the point of being full. That is not a failing of the person eating it; it is how such foods are designed. Knowing this helps you choose. When you cook, *you* decide the sugar

and salt. Most homemade tomato sauce needs no added sugar at all if the tomatoes are good and the sauce simmers long enough to concentrate their natural sweetness, though a pinch can tame a very acidic can of tomatoes.

Let's cook. You will make a pot of marinara sauce and serve it with baked meatballs. Then you will find your family's own bliss point with a blind test of the same sauce at three sweetness levels. The skill to do well is **seasoning to taste**: adding salt and acid a little at a time and tasting after each addition, and knowing when to stop.

PICTURE STUDY



The Market at Gisors, Camille Pissarro, 1889 · Painting on paper · Reproduced on Wikimedia Commons

Image: [Wikimedia Commons](#), public domain

Camille Pissarro painted the weekly market in the small Normandy town of Gisors many times. Farm families brought what they had grown, and townspeople came to buy. Everything was fresh, sold by the person who raised it, with no packages or ingredient lists at all.

Look closely

- Find the baskets. What foods can you see or guess are in them?
- Look at the sellers and the buyers. Who is doing the talking?
- Find the white caps and aprons. Who do you think the sellers are?
- Look at the crowd. How is this different from walking down a grocery aisle?

Talk about it

1. At this market, how would a shopper know how a food was made? How do we find out today?
2. No company tested these foods for a bliss point. What made people want to buy them?
3. If you made a sauce only from what was sold in this market, what would you need?

Safety first. Cook meatballs to 160 °F (71 °C) for beef or pork, 165 °F for turkey or chicken. Keep raw meat on its own board and wash hands after handling it. Simmering tomato sauce spatters; stir with a long spoon and partly cover the pot.

KITCHEN PROJECT

Find the Bliss Point: Homemade Marinara with Baked Meatballs

You will cook a family dinner of marinara and baked meatballs, then run a blind test with three cups of sauce at different sweetness levels. You will graph your family's liking against sugar and see whether you get the rise-and-fall curve Moskowitz found.

You will need

- A large heavy saucepan and a wooden spoon
- A large bowl and a rimmed baking sheet lined with foil
- A cutting board, a damp towel and a chef's knife
- Three small cups or bowls labeled A, B and C on the bottom, and spoons
- Measuring cups and spoons
- An instant-read food thermometer

HOMEMADE MARINARA WITH BAKED MEATBALLS

Serves 6 · Prep 25 min · Cook 35 min

Ingredients

- **Marinara:** 2 tablespoons olive oil
- 1 onion, finely chopped
- 4 cloves garlic, minced
- 2 cans (28 ounces each) crushed tomatoes
- 1 teaspoon dried oregano
- ½ teaspoon salt, more to taste
- ¼ teaspoon red pepper flakes (optional)
- A handful of fresh basil leaves, torn
- **Meatballs:** ½ cup (55 g) plain dry breadcrumbs
- ⅓ cup (80 mL) milk
- 1 large egg
- ¼ cup (20 g) grated parmesan

- 2 cloves garlic, minced, and 2 tablespoons chopped parsley
- 1 teaspoon salt and $\frac{1}{4}$ teaspoon pepper
- $1\frac{1}{2}$ pounds (680 g) ground beef, or half beef and half pork
- **To serve:** 1 pound spaghetti or crusty bread, and a green salad

Method

1. **Sauce:** Wash your hands. Heat the oil in the saucepan over medium heat. Cook the onion 6–8 minutes until soft, then the garlic for 30 seconds.
2. Add the tomatoes, oregano, salt and pepper flakes. Bring to a simmer, partly cover, and cook 25–30 minutes, stirring now and then, until thickened. Stir in the basil. Do not add sugar yet.
3. **Meatballs:** Heat the oven to 400 °F (200 °C). In the large bowl, soak the breadcrumbs in the milk for 5 minutes. Add the egg, parmesan, garlic, parsley, salt and pepper and stir. Add the meat and mix gently with clean hands just until combined. Wash your hands.
4. Roll the mixture into $1\frac{1}{2}$ -inch balls (about 24) and set them on the foil-lined baking sheet. Wash your hands again.
5. Bake 15–18 minutes, until browned and a thermometer in the center of a large meatball reads 160 °F (71 °C).
6. Before the meatballs go into the sauce, set aside 1 cup of plain sauce for the bliss-point test. Then add the meatballs to the pot and simmer 5 minutes.
7. Serve over spaghetti or with crusty bread, with a salad. Refrigerate leftovers within 2 hours.
8. **Clean up:** wash the boards, bowls and baking sheet and wipe every surface the raw meat touched.

Allergy check: Contains wheat (breadcrumbs, pasta, bread), milk (milk, parmesan) and eggs. For wheat-free, use gluten-free crumbs or quick oats labeled gluten-free and serve over rice or gluten-free pasta. For milk-free, use broth and leave out the parmesan.

Steps

1. **Set up the blind test.** Divide the reserved cup of sauce into three $\frac{1}{3}$ -cup portions. Stir nothing into cup A, $\frac{1}{4}$ teaspoon sugar into cup B, and 1

teaspoon sugar into cup C. Have someone else mix the cups up so you do not know which is which.

2. **Taste and rate.** Each family member tastes all three on plain bread or a spoon, sipping water between, and rates each on a 9-point scale (1 = dislike extremely, 9 = like extremely).
3. **Graph.** Reveal the labels. Plot sugar (0, $\frac{1}{4}$, 1 teaspoon) on the bottom and the average rating up the side. Did your family's line rise and fall? Where was your bliss point?
4. **Label check.** Look at a jar of store sauce. How many grams of added sugar are in $\frac{1}{2}$ cup? Divide by 4 to find teaspoons. Compare with your cups.
5. **Improve it.** Write one change for next time (a longer simmer for natural sweetness, roasted garlic, or turkey meatballs to 165 °F).
6. Clean up: wash, dry and put away everything.

Tips

- Taste a can of tomatoes before you cook. Some are much sweeter and less acidic than others; good tomatoes need no sugar.
- Wet your hands with cold water when rolling meatballs so the mixture does not stick.
- A blind test must be truly blind: let someone else label and serve the cups.

Check your work

- ☐ I can tell how Moskowitz found the bliss point.
- ☐ I can explain why some packaged foods are easy to keep eating, without blaming the person eating them.
- ☐ I cooked a sauce and meatballs safely and ran a fair blind test.

COOK'S NOTEBOOK

1. Draw your family's bliss-point graph and label the peak.
2. Copy the ingredient lists of two packaged foods and circle every kind of added sugar and salt you find.
3. Write a paragraph: when a food is designed to be hard to stop eating, what can a wise eater do?

From history. Moskowitz's spaghetti-sauce story became widely known after the writer Malcolm Gladwell told it in a popular talk in 2004. Its lesson for food makers was that people's tastes fall into groups, and that offering several kinds can please more people than searching for one perfect product.

COMMON MISTAKES

- Thinking that more sugar or salt always tastes better. Liking rises to a peak and then falls.
- Running a taste test where the tasters know which sample is which. Expectations change ratings; make it blind.
- Adding sugar to fix sauce before it has simmered. Simmering concentrates the tomatoes' own sweetness; taste first.

Make it a game • Find Your Bliss Point. Mix three cups of lemonade with one, two and three teaspoons of sugar. Label them secretly on the bottom. Everyone tastes blind and scores each from one to nine. Graph the family's scores and see where liking peaks and then falls. Explain how Howard Moskowitz used this same idea to find a bliss point.

Scripture. "Be not desirous of his dainties: for they are deceitful meat." (Proverbs 23:3, KJV)

Proverbs warns that some rich foods can pull at us more than they should. Knowing how a food is designed to be wanted helps us enjoy it with wisdom.

6.2 THE REWARD SYSTEM: WANTING, LEARNING AND HABITS

OBJECTIVES

- Tell how James Olds and Peter Milner discovered the brain's reward system in 1954.
- Explain accurately that dopamine is a messenger chemical tied to wanting, motivation and learning, and how cues trigger cravings.
- Make homemade hummus and baked pita chips, and keep a craving journal that tracks cues, cravings and choices.

Warm-up. Think of the last time you suddenly wanted a particular food. What happened just before? Did you see it, smell it, see an advertisement, walk past a kitchen, or feel bored or tired? Write down the cue and the craving.

WATCH

2-Minute Neuroscience: Reward System

Neuroscientifically Challenged • 2:04

<https://www.youtube.com/watch?v=f7E0mTJQ2KM>

WHEN TO WATCH

After the story. Pause at the diagram and find the brain areas named in the lesson.

Note: From a neuroscientist's teaching channel. It mentions in passing that drugs can affect the same system; our lesson is about food, habits and learning.

KEY TERMS

reward system

A set of connected brain areas that helps us notice, want and learn to seek things that are good for us, such as food, water and rest.

dopamine

A messenger chemical in the brain. In the reward system it is tied to wanting, motivation and learning what is rewarding, especially when we expect something good. It is not pleasure itself.

neurotransmitter

A chemical messenger that carries signals from one nerve cell to the next.

cue

A sight, smell, place, time or feeling that the brain has learned to link with a reward, and that can set off wanting.

habit

A behavior repeated so often that a cue sets it off almost automatically.

CORE IDEAS

The story. In 1954, at McGill University in Montreal, two young scientists, James Olds and Peter Milner, were studying how the brain stays alert. They placed a very fine wire into the brain of a laboratory rat to deliver a tiny electrical signal. The wire happened to land in a different spot than they intended. The rat kept returning to the corner of its box where it had received the signal, as if it wanted more.

How they figured it out. Olds and Milner set up a lever the rat could press to turn on the signal itself. It pressed the lever again and again. When the wire was placed in other areas, the rats ignored the lever. They had found a brain system whose job seemed to be motivating an animal to seek something. Later scientists learned that this system uses the messenger chemical **dopamine**. In the 1990s, Wolfram Schultz in Switzerland showed that dopamine cells fire most when something good is *expected* or turns out better than expected, and Kent Berridge at the University of Michigan showed that dopamine drives *wanting* a reward rather than *liking* it. Wanting and liking are different: you can want something intensely and then find it only so-so.

The kitchen science. God made the reward system to keep us alive: it helps us want food when we need energy and learn where to find it. When you eat something sweet, salty or rich, your brain learns to link that food with the **cues** around it: the crinkle of a bag, a logo, the smell of a bakery, the time of day, even boredom. The next time the cue appears, dopamine rises and you feel a pull of wanting, sometimes even when you are not hungry. Repeated often enough, cue and response become a **habit**. This is learning, and learning can be retrained: you can change the cue (keep a fruit bowl where the chip bag used to be), change the response (a glass of water and a short walk first), or plan the treat ahead. Remember, too, that the stomach

takes about 20 minutes to send “I’m satisfied” signals to the brain, so eating slowly helps you notice when you have had enough.

Let’s cook. You will make homemade hummus and crisp baked pita chips, a snack that is satisfying and easy to portion, and keep a craving journal for a week. The skill to do well is **blending to the right texture**: adding liquid a little at a time while the food processor runs until the hummus is smooth and creamy.

PICTURE STUDY



Cutting the Pies and Cakes at the Barbecue Dinner, Pie Town, New Mexico, Russell Lee, for the Farm Security Administration, 1940 · Color slide photograph · Library of Congress, Washington, D.C.

Image: [Wikimedia Commons](#), public domain

At the yearly fair in the homesteading town of Pie Town, New Mexico, families brought pies and cakes to share after the barbecue dinner. The photographer Russell Lee caught the moment the desserts were being cut, with children lined up and watching every slice.

Look closely

- Find the children. Where are their eyes looking?
- Count the different pies and cakes you can see. Which would you want?
- Find the women cutting. How large are the pieces?
- Look at the crowd. How long do you think they have been waiting?

Talk about it

1. What cues in this photograph would make a person start wanting dessert, even if they had just eaten?
2. These treats were shared at a once-a-year feast. How is that different from treats that are always within reach?
3. How do you think the children felt when their slice finally came? How is waiting part of enjoying a treat?

Safety first. Food processor blades are very sharp: put the blade in first, add food, and lift it out by its center post only after the machine has stopped and been unplugged. Bake pita chips with an adult at home and nearby, and use oven mitts. Hummus contains sesame (tahini); check allergies first.

Cues and Cravings: Homemade Hummus and Baked Pita Chips

You will make a satisfying snack and portion it into containers for the week, then keep a craving journal: each time you notice a strong wanting for a food, you will write down the cue, the feeling, what you chose and how you felt 20 minutes later.

You will need

- A food processor or blender
- A rimmed baking sheet and a pastry brush
- A cutting board and a chef's knife or kitchen scissors
- A can opener, a strainer and measuring cups and spoons
- Small containers with lids for portions
- Your cook's notebook for the craving journal

HOMEMADE HUMMUS WITH BAKED PITA CHIPS AND VEGETABLES

Serves 6 (about 2 cups hummus) · Prep 20 min · Bake 10–12 min

Ingredients

- **Hummus:** 2 cans (15 ounces each) chickpeas
- 1/3 cup (80 g) tahini (sesame paste), well stirred
- 3 tablespoons lemon juice (about 1½ lemons)
- 1 small clove garlic
- ½ teaspoon ground cumin and ¾ teaspoon salt
- 3–5 tablespoons ice water or reserved chickpea liquid
- 2 tablespoons olive oil, plus more to drizzle
- Paprika and chopped parsley, to garnish
- **Pita chips:** 4 pita breads (whole wheat or white)
- 2 tablespoons olive oil, ½ teaspoon salt, and ½ teaspoon dried oregano or za'atar
- **Vegetables:** carrots, cucumbers, bell peppers and cherry tomatoes, washed and cut into sticks

Method

1. Heat the oven to 375 °F (190 °C). Wash your hands and the vegetables.
2. **Pita chips:** Cut each pita into 8 wedges (kitchen scissors work well).
Separate the two layers if you like thinner chips. Spread them on the baking sheet, brush lightly with oil, and sprinkle with salt and oregano. Bake 10–12 minutes, until golden and crisp. Cool on the pan.
3. **Hummus:** Drain the chickpeas, saving $\frac{1}{4}$ cup of their liquid. Rinse them.
4. In the food processor, blend the tahini and lemon juice for 1 minute until thick and pale. Add the garlic, cumin and salt and blend 30 seconds.
5. Add the chickpeas and olive oil and blend 1 minute. With the machine running, add ice water 1 tablespoon at a time until the hummus is smooth and creamy, scraping the sides once or twice.
6. Taste and adjust the salt and lemon. Spoon into a bowl, drizzle with olive oil, and sprinkle with paprika and parsley.
7. Serve with the pita chips and vegetables. Portion the rest into small containers for the week; hummus keeps 5 days in the refrigerator.
8. Clean up: unplug the processor, lift the blade out by its center, and wash it carefully, sharp edge away from your hand.

Allergy check: Contains sesame (tahini) and wheat (pita). For wheat-free, serve with vegetables or gluten-free crackers. For sesame-free, replace the tahini with 2 extra tablespoons of olive oil and a spoonful of plain yogurt (milk) or sunflower-seed butter; it will taste different but is still good.

Steps

1. **Start the journal.** Make a table with columns: Day and time · Cue (what happened just before) · How strong the wanting was (1–5) · Hungry or not? · What I chose · How I felt 20 minutes later.
2. Make the recipe. Portion the hummus, chips and vegetables into containers for the week.
3. **Slow-eating test.** At one snack, set a timer and eat your portion slowly, putting the chip down between bites. Rate your fullness from 1 to 10 right after and again 20 minutes later. What changed?

4. Keep the craving journal for 7 days. At the end, look for patterns: Which cues came up most? Which times of day? Were you usually hungry, or something else (bored, tired, thirsty)?
5. **Plan.** Write one cue you will change and how (for example, moving a snack out of sight, drinking water first, or planning an afternoon snack ahead).
6. **Improve it.** Write one change to the recipe (roasted red pepper or garlic hummus, or more lemon).
7. Clean up: wash, dry and put away everything.

Tips

- Blending tahini and lemon first, then adding ice water, is the secret to light, smooth hummus.
- Pita chips keep a week in an airtight container. Let them cool completely first.
- Thirst can feel like hunger. In your journal, try a glass of water first and see whether the wanting fades.

Check your work

- ☐ I can tell what Olds and Milner discovered.
- ☐ I can explain accurately what dopamine does and the difference between wanting and liking.
- ☐ I made a satisfying snack and kept a craving journal that found my cues.

COOK'S NOTEBOOK

1. Draw the habit loop as a circle: cue, wanting, action, reward, learning. Write one food example of your own around it.
2. Summarize your craving journal in a chart and write three sentences about the patterns you found.
3. Copy the hummus recipe in your own words and note what you would change.

From history. James Olds and Peter Milner's 1954 discovery came partly by accident, when an electrode landed in a different place than planned. Many important discoveries have come the same way, but only because the scientists noticed something odd and tested it carefully instead of ignoring it.

COMMON MISTAKES

- Calling dopamine the “pleasure chemical.” It is more about wanting, motivation and learning what is rewarding.
- Thinking a strong craving means you must be hungry. Cues, tiredness, boredom and thirst can all set off wanting.
- Putting fingers near the food processor blade or lifting it by its edges. Handle it only by its center post, after unplugging.

Make it a game • Cue Charades. Act out cues without speaking: a jingle, a smell from the oven, the end of school, a bag crinkling. Your parent guesses the cue, then names the craving it triggers. Tell your parent how Olds and Milner found the reward system. Then correct this idea: dopamine is wanting and learning, not simply pleasure.

Scripture. “for I have learned, in whatsoever state I am, therewith to be content.” (Philippians 4:11, KJV)

Paul says contentment is something he learned. Our wants can be trained too, by practice and by God’s help.

6.3 SATIETY AND THE BALANCED DIET

OBJECTIVES

- Tell how Susanne Holt and her team at the University of Sydney measured how filling different foods are in 1995.
- Explain how fiber, protein, water and time help us feel satisfied, and the body's hunger and fullness signals.
- Cook a hearty grain bowl and keep a fullness log that compares how long different meals keep you satisfied.

Warm-up. Rate how hungry you are right now from 1 (starving) to 10 (stuffed). Then think back to yesterday: which meal or snack kept you satisfied the longest? Which one left you hungry again soonest? What was different about them?

WATCH

Hormone control of hunger

[khanacademymedicine](https://www.youtube.com/watch?v=EVkFPeP5sFI) · 3:37

<https://www.youtube.com/watch?v=EVkFPeP5sFI>

WHEN TO WATCH

After the kitchen-science paragraph. Listen for the hormone that says “hungry” and the ones that say “satisfied.”

Note: From Khan Academy's medicine series. It uses a few medical terms; the lesson explains them simply.

KEY TERMS

satiety

The feeling of being satisfied after eating, and how long that feeling lasts before hunger returns. Say it “suh-TY-uh-tee.”

satiation

The feeling during a meal that tells you to stop eating.

fiber

The part of plant foods the body cannot digest. It adds bulk, slows digestion and feeds helpful gut microbes. Found in whole grains, beans, vegetables and fruit.

ghrelin

A hormone made mainly in the stomach that rises before meals and signals hunger. Say it “GREL-in.”

energy density

How much energy a food has for its weight. Foods with lots of water and fiber, like soups, vegetables and fruit, have low energy density.

CORE IDEAS

The story. In the early 1990s, a nutrition researcher named Susanne Holt and her colleagues at the University of Sydney in Australia asked a simple question: if people eat the same amount of energy from different foods, which foods keep them satisfied the longest? Almost no one had measured this carefully for everyday foods.

How they figured it out. Holt’s team chose 38 common foods, from fruit and potatoes to cakes, cereals, fish and beans, and served volunteers portions that all contained the same amount of food energy. After eating, each volunteer rated his or her hunger every 15 minutes for two hours, and then was allowed to eat freely from a buffet while the researchers quietly measured how much was eaten. They published their “satiety index” in 1995, comparing every food to white bread. Plain boiled potatoes came out the most satisfying of all, more than three times as filling as white bread; fish, oatmeal, oranges, apples, beans and beef were high too. Croissants, cake and doughnuts were among the least filling. Foods with more protein, fiber and water, and less fat, kept people satisfied longest.

The kitchen science. Satisfaction comes from several signals working together. When food stretches the stomach, nerves report to the brain. As food moves into the intestine, it releases hormones that say “satisfied,” while **ghrelin**, the hunger hormone, falls. **Protein** sends strong satisfied signals. **Fiber** adds bulk, holds water and slows digestion, so energy is released steadily instead of all at once. **Water** in foods like soups, vegetables and fruit fills the stomach with few calories, making these foods low in **energy density**. And all of this takes time: about 20 minutes after

you start eating. A meal built from whole grains, beans, vegetables and some protein keeps a growing body fueled for hours; a snack that is mostly sugar and refined flour can leave you hungry again soon. This is not about eating less; teenagers need plenty. It is about eating meals that truly satisfy.

Let's cook. You will cook hearty grain bowls with brown rice, roasted sweet potatoes and chickpeas, greens, and a lemon-yogurt sauce. The skill to do well is **building a balanced bowl**: a base of whole grains, plenty of vegetables, a protein, a little healthy fat and a bright sauce, so every bite has contrast in taste and texture.

PICTURE STUDY



The Harvesters, Pieter Bruegel the Elder, 1565 · Oil on wood · The Metropolitan Museum of Art, New York

Image: [Wikimedia Commons](#), public domain

Bruegel painted the August wheat harvest in Flanders, one of a series of paintings of the seasons. Some of the workers have stopped for their midday meal under a pear tree: bread, bowls of porridge or milk, cheese and fruit, simple, filling food that would carry them through the long afternoon.

Look closely

- Find the group eating under the tree. What foods can you see?
- Find the worker sleeping. How long do you think he has been working?
- Look at the people still working in the field. What are they doing?
- Find the loaves and the bowls. Who do you think made this meal?

Talk about it

1. Using the satiety index, which of the foods in this meal would keep the workers satisfied longest? Why?
2. These workers needed energy for hours of hard work. How is their meal like a grain bowl?
3. Bruegel shows rest and food as part of the work day. Why are rest and a good meal important for doing work well?

Safety first. Use the bridge grip to halve sweet potatoes before cubing; they are hard and can roll. Use oven mitts and let the hot pan cool before handling. An adult is at home and nearby while you use the oven. Cool and refrigerate leftover rice within 2 hours.

KITCHEN PROJECT

Satisfying by Design: Roasted Vegetable and Chickpea Grain Bowls

You will cook grain bowls for the family and keep a two-day fullness log: one day after a lunch of the grain bowl, and one day after a lunch of your choice. The goal is to notice how different meals keep you satisfied and focused, not to eat less.

You will need

- A medium saucepan with a lid
- Two rimmed baking sheets and parchment
- A cutting board, a damp towel and a chef's knife
- A small bowl and a whisk
- Measuring cups and spoons
- Your cook's notebook for the fullness log

ROASTED VEGETABLE AND CHICKPEA GRAIN BOWLS WITH LEMON-YOGURT SAUCE

Serves 4–6 • Prep 20 min • Cook 40 min

Ingredients

- 1½ cups (285 g) brown rice (or farro or quinoa)
- 2 medium sweet potatoes (about 1½ pounds, 680 g), cut in ¾-inch cubes
- 1 head broccoli, cut into florets
- 1 can (15 ounces) chickpeas, drained, rinsed and patted dry
- 3 tablespoons olive oil, divided
- 1 teaspoon smoked paprika, 1 teaspoon ground cumin, ¾ teaspoon salt
- 4 cups baby spinach or chopped kale
- **Lemon-yogurt sauce:** ¾ cup (180 g) plain Greek yogurt
- 2 tablespoons lemon juice and 1 teaspoon grated lemon zest
- 1 small clove garlic, grated
- 2 tablespoons chopped dill or parsley, ¼ teaspoon salt, 1–2 tablespoons water

- **Toppings:** crumbled feta, toasted pumpkin seeds, sliced cucumber (optional)

Method

1. Wash your hands and the vegetables. Cook the rice according to the package (brown rice takes about 40 minutes).
2. Heat the oven to 425 °F (220 °C). On one parchment-lined sheet, toss the sweet potatoes with 1½ tablespoons oil and half the spices and salt. On the other, toss the broccoli and chickpeas with the rest of the oil, spices and salt.
3. Roast both pans 25–30 minutes, stirring once, until the sweet potatoes are tender and browned and the chickpeas are crisp at the edges.
4. Whisk the sauce ingredients together, adding water until it drizzles.
5. In the last 5 minutes, stir the spinach into the hot rice so it wilts (or serve kale raw, massaged with a pinch of salt).
6. Build each bowl: rice and greens, then sweet potatoes, broccoli and chickpeas, then a drizzle of sauce and your toppings.
7. Refrigerate leftovers within 2 hours; the parts keep 4 days in separate containers for packed lunches.
8. Clean up: wash the pans, board and pot.

Allergy check: Contains milk (yogurt, feta). For milk-free, make the sauce with 3 tablespoons tahini (sesame) thinned with lemon juice and water, and skip the feta. Contains no wheat if you use rice or quinoa; farro is wheat.

Steps

1. **Fullness log.** On two different days, eat a normal breakfast, then for lunch eat a grain bowl one day and a lunch of your own choosing the other. Rate your hunger from 1 to 10 just before lunch, right after, and every hour for 4 hours. Note your focus and energy too.
2. **Graph.** Plot both days on one graph. Which lunch kept you satisfied longer? Look at the fiber and protein in each.
3. **Satiety detective.** Look up the fiber and protein (in grams) in one serving of brown rice, chickpeas and a plain croissant or doughnut, using labels or the

USDA FoodData Central site with an adult. Explain the differences in satiety using what you learned.

4. **Taste test.** Ask your family to rate the bowls from 1 to 5 for flavor and how satisfied they felt.
5. **Improve it.** Write one change (a soft-cooked egg on top, a different grain, or roasted cauliflower).
6. Clean up: wash, dry and put away everything.

Tips

- Dry chickpeas well before roasting; wet ones steam instead of crisping.
- Cook a big pot of grains on the weekend, cool it quickly and refrigerate it for fast bowls all week.
- A good bowl has contrast: something crisp, something creamy, something tangy and something fresh.

Check your work

- ☐ I can tell how Holt's team measured the satiety of different foods.
- ☐ I can explain how fiber, protein, water and time help us feel satisfied.
- ☐ I cooked a balanced grain bowl and kept an honest fullness log.

COOK'S NOTEBOOK

1. Draw a simple diagram of the body's hunger and fullness signals: stomach stretch, ghrelin, "satisfied" hormones from the gut, and the brain.
2. Draw your fullness graph for both days.
3. Plan a week of satisfying after-school snacks that each include fiber or protein.

From history. The satiety index study used a clever test at the end: a buffet where volunteers could eat as much as they wanted. The researchers found that people who had eaten the most satisfying foods two hours earlier ate less at the buffet, showing that the hunger ratings matched real behavior.

COMMON MISTAKES

- Eating so fast that you finish before your body can signal that you are satisfied. Slow down and give it 20 minutes.
- Thinking satisfying means heavy or greasy. Some of the most filling foods, like potatoes, beans, oatmeal and fruit, are not rich at all.

- Skipping meals and then eating whatever is closest. Planned, balanced meals keep hunger steady.

Make it a game · Rank the Filling. Write six foods on slips: boiled potato, croissant, apple, oatmeal, cookie and fish. Each of you ranks them from most to least filling. Reveal Holt's findings from Sydney: potatoes near the top, croissants near the bottom. Use fiber, protein, water and time to explain the order. Fewest misplaced foods wins.

6.4 HABITS THAT LAST: RETRAINING YOUR TASTE BUDS

OBJECTIVES

- Tell how researchers at the Monell Center showed that people's taste for salt and sugar shifts after weeks of eating less of it.
- Explain how taste adaptation and habit change work, and plan a two-week habit challenge.
- Bake an apple-cinnamon baked oatmeal and step down its sweetness over two batches.

Warm-up. Sip a little plain water, then a sip of a sweet drink such as juice, then plain water again. Does the water taste different the second time? Why do you think the sweet drink changed how the water tasted?

WATCH

Lowering Salt Intake - Breakthrough Science

[MonellCenter](#) · 2:03

<https://www.youtube.com/watch?v=u09Cb36thzc>

WHEN TO WATCH

After the story. Listen for how long it took people's salt preference to change.

Note: From the Monell Chemical Senses Center, the Philadelphia research institute whose studies are described in this lesson.

BACKUP VIDEO

Salt's Hidden Power Over Your Taste Buds

[MonellCenter](#) · 10:22

<https://www.youtube.com/watch?v=ujqsHMvouUY>

For a longer talk by Monell scientists on how salt taste works.

KEY TERMS

taste adaptation

The way our sense of taste adjusts to what we usually eat. After weeks of less salt or sugar, smaller amounts taste stronger.

habit loop

A cue that sets off a routine, which brings a reward. Repeated, the loop becomes automatic.

step-down

Reducing something gradually, a little at a time, so the change is easy to accept.

sensory adaptation

Any sense becoming less responsive to a steady signal, such as no longer noticing a smell in a room after a few minutes.

temperance

Self-control and moderation, especially in food and drink. Scripture lists it among the fruit of the Spirit.

CORE IDEAS

The story. At the Monell Chemical Senses Center in Philadelphia, scientists wanted to know whether a person's liking for salt is fixed or can change. In a study published in 1982, Mary Bertino, Gary Beauchamp and Karl Engelman asked volunteers to eat foods with much less salt for several months, while another group ate as usual. Every few weeks, all of them tasted soups and crackers with different amounts of salt and said which they liked best.

How they figured it out. At first, the low-salt group found their food bland. But after a couple of months, their liking had shifted: the saltiness they used to prefer now tasted too salty, and they liked less salty soups and crackers best. Years later, in 2016, another Monell team tried the same idea with sugar. People who cut back on sugary foods for three months began to rate puddings as tasting sweeter than before. In both studies the change came gradually, over several weeks to a few months, and it happened without anyone trying to force themselves to like the taste. The taste system simply adjusted to what it met every day.

The kitchen science. Taste is relative. Your taste system adjusts to what it meets most often, the way your eyes adjust to a dim room. If most of your drinks and snacks are very sweet, fruit and plain milk taste dull by comparison; after some

weeks with less added sugar, fruit starts to taste sweet again. Taste receptor cells renew every one to two weeks, and the brain keeps recalibrating. Habits work the same way: a habit is a cue, a routine and a reward, repeated. The most lasting changes are small and steady: a **step-down** of a little less sugar in your oatmeal each week, water instead of a sweet drink at lunch, a planned treat instead of a constant one. Scripture calls this kind of steady self-rule **temperance**, and it is a fruit of the Spirit, grown with God's help and practice, not a rule that makes food joyless.

Let's cook. You will bake an apple-cinnamon baked oatmeal for family breakfasts, then bake it again a week later with less sweetener, and see whether your family notices. The skill to do well is **using flavor to replace sweetness**: cinnamon, vanilla, a pinch of salt, ripe fruit and toasted nuts make a dish taste rich and sweet with less added sugar.

PICTURE STUDY



Girl Eating Soup, Albert Anker, 1898 · Oil on canvas · Private collection

Image: [Wikimedia Commons](#), public domain

Albert Anker often painted children of his village in Switzerland at their everyday meals: soup, bread, potatoes, milk. These were the foods they ate day after day, and the habits of their tables shaped them for life.

Look closely

- Find the bowl, the spoon and the bread. What kind of meal is this?
- Look at how the girl is sitting and eating. Is she hurried or calm?
- Look at the table and the room. What do they tell you about her family?
- What colors did Anker use? How do they make the scene feel?

Talk about it

1. This girl ate simple foods most days. How might her sense of taste be different from that of a child who eats many sweet snacks?
2. What everyday food habit from your childhood do you think you will keep for life?
3. Why do you think Anker found ordinary meals worth painting?

Safety first. Baked oatmeal contains eggs: bake until the center is set and reads 160 °F (71 °C). Use oven mitts and an adult at home and nearby. Do not taste the raw batter. If you add nuts, check for tree-nut allergies first.

KITCHEN PROJECT

Two-Week Habit Challenge: Step-Down Apple-Cinnamon Baked Oatmeal

You will choose one food habit to change gradually over two weeks, such as less added sugar at breakfast or water instead of a sweet drink with lunch, and keep a daily log. You will start by baking a family breakfast, then bake it again with less sweetener and run a blind comparison.

You will need

- An 8 × 8-inch or 9 × 9-inch baking dish
- Two mixing bowls, a whisk and a spatula
- A cutting board, a damp towel and a chef's knife
- Measuring cups and spoons
- An instant-read food thermometer and oven mitts
- Your cook's notebook for the habit log

APPLE-CINNAMON BAKED OATMEAL

Serves 6 · Prep 15 min · Bake 35–40 min

Ingredients

- 2 cups (180 g) old-fashioned rolled oats
- 1 teaspoon baking powder
- 1½ teaspoons ground cinnamon
- ½ teaspoon salt
- 2 cups (480 mL) milk
- 2 large eggs
- ⅓ cup (80 mL) maple syrup or honey (first batch); ¼ cup (60 mL) for the step-down batch
- 2 tablespoons butter, melted, plus a little for the dish
- 1½ teaspoons vanilla extract
- 2 apples, cored and diced (no need to peel)
- ½ cup (55 g) chopped walnuts or pecans (optional)

Method

1. Heat the oven to 375 °F (190 °C). Butter the baking dish. Wash your hands and the apples.
2. In one bowl, stir together the oats, baking powder, cinnamon and salt.
3. In the other bowl, whisk the milk, eggs, maple syrup, melted butter and vanilla.
4. Spread the diced apples in the dish. Sprinkle the oat mixture over them, then pour the milk mixture evenly over the top. Gently press the oats down so they are wet. Sprinkle with nuts.
5. Bake 35–40 minutes, until the top is golden and the center is set and reads 160 °F (71 °C).
6. Cool 10 minutes, then cut into squares. Serve warm with a splash of milk or a spoon of yogurt.
7. Refrigerate leftovers within 2 hours; reheat squares in the microwave for quick breakfasts all week.
8. Clean up: wash the bowls and whisk and soak the baking dish.

Allergy check: Contains milk, eggs, and tree nuts if you add them. For milk-free, use an unsweetened oat or soy milk (soy is a major allergen) and oil. Oats are often processed with wheat; use oats labeled gluten-free if needed. Honey is never given to babies under one year.

Steps

1. **Choose your habit.** Write one specific habit to step down over two weeks, with a plan for each week (for example: week 1, half as much sugar in my morning cereal; week 2, plain cereal with fruit).
2. Bake the first batch with $\frac{1}{3}$ cup maple syrup and serve it to your family.
3. **Habit log.** Each day for two weeks, record whether you kept the step, how the food tasted (1–5) and any cravings.
4. **Step-down batch.** A week later, bake the oatmeal again with $\frac{1}{4}$ cup maple syrup. Serve a square from each batch blind (save one square of the first batch in the freezer). Can your family tell which is which? Which do they prefer?
5. **Calculate.** $\frac{1}{3}$ cup is about $5\frac{1}{3}$ tablespoons; $\frac{1}{4}$ cup is 4 tablespoons. By what percent did you reduce the sweetener? (Answer: $1\frac{1}{3} \div 5\frac{1}{3} = 25\%$.)

6. **Reflect.** At the end of two weeks, write a paragraph: Did your taste change? Was the step-down easier or harder than you expected? What will you keep doing?

7. Clean up: wash, dry and put away everything.

Tips

- Very ripe, sweet apples (Fuji, Gala, Honeycrisp) add natural sweetness.
- A pinch of salt and plenty of cinnamon and vanilla make food taste sweeter than it is.
- Change one habit at a time. Small, steady changes last longer than big, sudden ones.

Check your work

- ☐ I can tell what the Monell studies found about salt and sugar taste.
- ☐ I can explain taste adaptation and the habit loop.
- ☐ I baked a breakfast, stepped down its sweetener, and kept a two-week habit log.

COOK'S NOTEBOOK

1. Draw a habit loop for your chosen habit before and after your change.
2. Graph your daily taste ratings over the two weeks.
3. Write the recipe with both sweetener amounts and your percent-reduction calculation.

From history. The Monell salt study helped health scientists understand why lowering salt in packaged foods works best when done gradually: when companies cut salt a little at a time over years, most customers never notice. The same idea is now used to reduce added sugar in many foods.

COMMON MISTAKES

- Trying to change everything at once. One small, steady change is more likely to last.
- Expecting taste to change in a day or two. It usually takes several weeks.
- Thinking self-control means never enjoying a treat. Temperance means enjoying good things in their right place and amount.

Make it a game • The Habit Loop. Your parent names a habit, such as a sweet drink every afternoon. You answer fast: cue, routine, reward, and one small step-down for two weeks. Then explain taste adaptation and the Monell results about salt and sugar. Make a paper chain of fourteen links, one for each day, and tear off one a day.

Scripture. “But the fruit of the Spirit is love, joy, peace, longsuffering, gentleness, goodness, faith, Meekness, temperance: against such there is no law.” (Galatians 5:22-23, KJV)

Temperance, or self-control, grows like fruit: slowly, with care and with God’s help. It sits beside joy in the list, not against it.

CRAVINGS, REWARD & A BALANCED DIET

God made us able to enjoy food, and He made eating a pleasure on purpose. Sweet fruit, a salty pretzel, a rich bowl of soup: our brains learn to want foods that taste good and give energy. In this unit you will learn how that wanting works, told plainly and accurately. You will meet Howard Moskowitz, who measured the exact sweetness that people like best, and the scientists who found the brain's reward system. You will learn what makes a meal satisfying, why some packaged snacks are designed to be hard to stop eating, and how taste buds and habits can be retrained.

This unit is not about good foods and bad foods, and it is never about bodies. Nutrient-dense foods are the everyday heart of a balanced diet, and treats and feasts are good gifts in their place. The goal is wisdom and self-control, which Scripture calls a fruit of the Spirit, and real cooking skill: when you can make a sauce, a snack or a dessert yourself, you decide what goes into it.

PREREQUISITES

- Knows the five MyPlate groups and what macronutrients do (Unit 2)
- Knows the five basic tastes and how smell creates flavor (Unit 3)
- Can read a Nutrition Facts label (Unit 2)
- Can work with ratios and percentages

MASTERY CHECKLIST

- ☐ I can tell how Moskowitz found the bliss point and explain why some packaged foods are easy to eat past full.
- ☐ I can explain accurately that dopamine is a messenger chemical tied to wanting and learning, not pleasure itself, and how cues trigger cravings.
- ☐ I can explain what makes a meal satisfying (fiber, protein, water and time) and cook a filling grain bowl.
- ☐ I can describe how taste buds adjust to less added sugar or salt over several weeks, and plan a habit change.
- ☐ I can convert grams of sugar to teaspoons and compare added sugar in drinks and snacks.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **FDA: Added Sugars on the Nutrition Facts Label**: Free. Explains the Added Sugars line on the label and the Daily Value. Helpful for Lessons 6.1 and 6.4.
- **Monell Chemical Senses Center**: Free. The research institute whose studies showed that taste for salt and sugar can change over weeks. Short articles on taste and habits.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

6.1	Howard Moskowitz and the Bliss Point	2 sessions of 50–60 minutes
6.2	The Reward System: Wanting, Learning and Habits	2 sessions of 50–60 minutes
6.3	Satiety and the Balanced Diet	2 sessions of 50–60 minutes
6.4	Habits That Last: Retraining Your Taste Buds	2 sessions of 50–60 minutes

UNIT 6 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**
What is the bliss point, and how did Moskowitz find it?
2. **8 pts**
Why can some packaged snack foods be easy to eat past full? Describe what the food does, not what kind of person eats it.
3. **8 pts**
What did Olds and Milner discover in 1954?
4. **8 pts**
Explain accurately what dopamine does in the reward system. What is the difference between wanting and liking?

5. (8 pts)

Give two examples of food cues and one way to change each.

6. (8 pts)

What did Holt's 1995 satiety index study find? Name the most satisfying food and one of the least.

7. (8 pts)

Name three things that help a meal keep you satisfied, and explain one.

8. (10 pts)

Calculation: a 20-ounce bottle of sweet tea lists 52 g of added sugars. About how many teaspoons is that ($4\text{ g} \approx 1\text{ teaspoon}$)? The Daily Value for added sugars is 50 g. What percent of the Daily Value is it?

9. (10 pts)

Calculation: a recipe uses $\frac{1}{2}$ cup of sugar. You step it down by 25% for the next batch and another 25% of the original for the batch after that. How much sugar is in each batch, in cups and tablespoons (1 cup = 16 tablespoons)?

10. (8 pts)

What did the Monell salt and sugar studies show about taste preferences?

11. (8 pts)

Why does the stomach's 20-minute signal matter for how fast you eat?

12. (8 pts)

Short answer: In four or five sentences, explain how a Christian might think about treats, cravings and self-control, using what you learned in this unit.

ANSWER KEY

1. The amount of an ingredient such as sugar or salt at which people like a food most. He had many versions of a food made with different amounts, had ordinary people taste and rate them, and graphed liking against the amount; the peak of the curve is the bliss point.
2. They combine sugar, salt and fat near their bliss points, often with textures that melt away quickly so the mouth does not tire, and little fiber or protein to bring satisfaction, so it is easy to keep eating before fullness signals arrive.
3. That when a tiny signal reached a certain area of a rat's brain, the rat would press a lever again and again to get it, revealing a brain system that motivates seeking rewards (the reward system).
4. Dopamine is a messenger chemical tied to wanting, motivation and learning what is rewarding; it rises especially when we expect something good. Wanting is the pull toward a reward; liking is the enjoyment when we get it. They are different, and dopamine is mainly about wanting.
5. Examples: a snack bag on the counter (put fruit there instead); an advertisement (turn it off or notice it); walking past a bakery (take another route or plan a snack); boredom (do something active, drink water first). Other reasonable answers accepted.
6. Foods given in equal-energy portions differed greatly in how long they kept people satisfied; foods with more protein, fiber and water and less fat were most filling. Boiled potatoes were most satisfying; croissants, cake and doughnuts were among the least.
7. Protein, fiber, water (and time, eating slowly). Example: fiber adds bulk, holds water and slows digestion so energy is released steadily.
8. $52 \div 4 = 13$ teaspoons. $52 \div 50 \times 100 = 104\%$ of the Daily Value.
9. Original: $\frac{1}{2}$ cup = 8 tablespoons. 25% of 8 = 2 tablespoons. Second batch: 6 tablespoons ($\frac{3}{8}$ cup). Third batch: 4 tablespoons ($\frac{1}{4}$ cup).
10. After several weeks to a few months of eating less salt (1982) or sugar (2016), people's taste adjusted: lower amounts tasted stronger, and they came to prefer less salty or less sweet foods.
11. Fullness signals take about 20 minutes to reach the brain, so eating very fast can mean eating past full before you notice; eating slowly gives the signals time to arrive.

12. Food, including treats and feasts, is a good gift from God to be enjoyed with thanks. Our brains were made to want good-tasting food, and knowing how cues and designed foods work helps us choose wisely instead of being pulled along. Temperance is a fruit of the Spirit, grown with God's help and practice, not a joyless rule. Planning treats, eating slowly, building satisfying meals and changing habits gradually are practical ways to enjoy food in its right place.

UNIT CHALLENGE: A TWO-WEEK DRINKS AND SNACKS SWAP

Plan and carry out a two-week swap for one drink or snack habit: for example, water or sparkling water with fruit instead of a sweet drink at lunch, or a homemade snack (hummus and vegetables, baked oatmeal, popcorn you season yourself) instead of a packaged one. Cook at least two homemade snacks during the two weeks.

Keep a daily log of what you chose, how it tasted (1–5), your hunger and energy, and any cravings and their cues. At the end, write a one-page reflection on what your taste buds noticed, which cues mattered most, and what habit you will keep. Do not record weight or body measurements; this challenge is about taste, habits and cooking.

LOOK FOR	WHAT IT MEANS
Plan	A clear, specific swap with a step-by-step plan for both weeks.
Cooking	At least two homemade snacks cooked safely and recorded, with recipes in your own words.
Daily log	Fourteen honest entries with taste ratings, hunger and energy, cravings and cues.
Reflection	Uses the ideas of taste adaptation, cues, satiety and temperance correctly and honestly.
Next step	Names a habit to keep and how; a swap that was hard and honestly recorded earns full credit.

UNIT 7

FIRE, THE GRILL & SPICE

This is the fun unit, and the one where your skills come together. You will cook with live fire and with the spices that once moved empires. You will learn how a tiny nutmeg seed from a handful of islands in the East Indies changed the map of the world, how Americans built their great regional barbecue traditions, how smoke flavors food, and how scientists study why some flavors belong together.

In eighth grade you may cook on the grill yourself, with an adult beside you. An adult always lights the grill, and no one in this course ever uses lighter fluid. Every recipe also has an indoor method with a grill pan or the oven broiler for families without a grill. When the unit ends, you will plan and cook a grilled dinner for your family with your own spice rub, and balance its flavors like a real cook.

PREREQUISITES

- Knows safe internal temperatures and uses a thermometer every time (Unit 1)
- Understands conduction, convection and radiation (Unit 4)
- Knows the five basic tastes and how smell makes flavor (Unit 3)
- Has watched an adult light and run a grill safely, and has reviewed the grill rules with an adult

MASTERY CHECKLIST

- ☐ I can follow every grill rule: outdoors on a flat spot away from the house, adult lights it, no lighter fluid, long tongs, lid for flare-ups, water or extinguisher nearby, never left alone.
- ☐ I can tell the story of the nutmeg trade and use whole spices and freshly ground spices well.
- ☐ I can describe American regional barbecue styles and make and use a dry rub.
- ☐ I can set up and cook over direct and indirect heat, and explain how smoke flavors food.
- ☐ I can balance a dish with salt, acid, fat, sweetness and heat, and explain complementary and contrasting flavors.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **NFPA: Grilling safety:** Free. Grilling safety tips and a printable sheet from the National Fire Protection Association. Read it together before Lesson 7.2.
- **An instant-read food thermometer and long-handled tongs:** Check every piece of chicken and pork in its thickest part. Long tongs keep hands away from the heat; never use a fork to turn meat.
- **For the adult who lights the grill: a chimney starter:** A chimney starter lights charcoal with crumpled newspaper, so no lighter fluid is needed. A gas grill needs neither. Not required: every recipe also works under the oven broiler or in a grill pan.
- **A whole nutmeg and a small grater:** Inexpensive at any grocery store. Freshly grated nutmeg is far more fragrant than ground. Used in Lesson 7.1.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

7.1	Nutmeg and the Banda Islands	2 sessions of 50–60 minutes
7.2	Barbecue Traditions and the Dry Rub	2 sessions of 50–60 minutes
7.3	Smoke, Indirect Heat and Grilled Vegetables	2 sessions of 50–60 minutes
7.4	The Science of Flavor Pairing	2 sessions of 50–60 minutes

UNIT 7 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **10 pts**

List six grill safety rules from this unit.

2. **8 pts**

What happened at the Treaty of Breda in 1667, and why did it matter for nutmeg?

3. 8 pts

Why do whole spices keep their flavor longer than ground spices?

4. 8 pts

Describe the barbecue styles of two of these regions: the Carolinas, Memphis, Kansas City, central Texas.

5. 8 pts

Predict: you grill chicken with a sweet rub over high direct heat the whole time. What will happen, and what should you do instead?

6. 8 pts

Explain the difference between direct and indirect grilling.

7. 8 pts

What part of wood makes the main smoky aroma, and why does cool, moist food absorb more smoke?

8. 8 pts

What did the 2011 flavor-network study find?

9. 8 pts

Give an example of each: salt and sweet, acid and fat, heat and cool.

10. 10 pts

Calculation: your dry rub makes $\frac{1}{3}$ cup. A family barbecue needs 1 cup. By what factor do you multiply, and how much paprika do you need if the recipe uses 1 tablespoon?

11. 8 pts

Calculation: a pork chop comes off the grill at 142 °F and rises 4 °F as it rests. Is it safe? What is its final temperature in °C?

12. 8 pts

Short answer: In three or four sentences, explain how you would fix a salsa that tastes flat, one that is too sour, and one that is too hot.

ANSWER KEY

1. Any six: outdoors only, on a flat spot away from the house, railings, overhangs and dry leaves; only an adult lights the grill; never use lighter fluid; use long tongs, never a fork; close the lid to smother a flare-up; keep a hose or extinguisher nearby; never leave a lit grill alone; let coals cool 24–48 hours before an adult disposes of them in a metal can; students grill only with an adult beside them.
2. The Dutch kept the island of Run, giving them control of the whole nutmeg trade, while the English kept New Amsterdam (Manhattan), which became New York.
3. Most of a spice's aroma is in volatile oils sealed inside the whole seed or bark. Grinding exposes them to air, so they evaporate and fade much faster.
4. Carolinas: smoked pork (often whole hog) with thin vinegar sauce, some tomato in the west. Memphis: pork ribs with a dry rub, served dry or wet. Kansas City: many meats with thick, sweet tomato-molasses sauce. Central Texas: smoked beef brisket and sausage over post oak, often with no sauce.
5. The sugar will burn black and bitter before the chicken is cooked through. Start it over the cooler side (indirect heat) with the lid closed, then finish briefly over direct heat.
6. Direct grilling cooks food right over the fire for fast searing and browning. Indirect grilling cooks food beside the fire with the lid closed, so hot air surrounds it like an oven, cooking gently.
7. Lignin breaks down into guaiacol and related compounds. Smoke compounds stick and dissolve best on cool, moist surfaces, so food takes up most smoke early in cooking.
8. In North American and Western European recipes, ingredients that share aroma compounds are paired more often than chance; in East Asian recipes, cooks often pair ingredients that share few compounds. There is more than one good way to pair flavors.
9. Salt and sweet: salted watermelon, salted caramel. Acid and fat: lime on grilled pork, vinegar on fried fish. Heat and cool: jalapeño with peaches or yogurt. Other correct examples accepted.
10. $1 \div \frac{1}{3} = 3$. Paprika: $3 \times 1 \text{ tablespoon} = 3 \text{ tablespoons}$.
11. It rises to 146 °F, above 145 °F, so it is safe after a 3-minute rest. $(146 - 32) \times \frac{5}{9} = 114 \times \frac{5}{9} \approx 63.3 \text{ }^{\circ}\text{C}$.

12. A flat salsa usually needs salt, and sometimes more acid; add a pinch and taste. If it is too sour, add a little sweetness (honey or more ripe fruit) or a little fat (avocado). If it is too hot, add more fruit or something cool and creamy, and use less pepper next time.

UNIT CHALLENGE: A GRILLED FAMILY DINNER

Plan and cook a grilled (or broiled) dinner for your family with an adult beside you at the grill: a main dish with your own homemade spice rub, a grilled vegetable, and a fresh side that provides contrast (a salsa, a slaw or a fruit salad). Write the grill safety checklist and review it with the adult before you begin.

Make a flavor-pairing chart for the meal, labeling each pairing as shared or contrast, and record every safe internal temperature. Finish with a family rating and a paragraph on what you would change. If you have no grill, use the indoor methods in this unit.

LOOK FOR	WHAT IT MEANS
Safety	Grill checklist completed with the adult; adult lit the grill; long tongs, lid, water or extinguisher ready; never left alone; safe temperatures checked and recorded.
Spice rub	A homemade rub with a clear plan and a name, written as a recipe.
Cooking	Direct and indirect heat used well; foods cooked through but not burnt; clean kitchen and grill area afterward.
Flavor-pairing chart	Every pairing labeled and explained; the dish balanced by tasting.
Reflection	Family ratings and one honest improvement; a dinner that had problems but is well recorded earns full credit.

7.1 NUTMEG AND THE BANDA ISLANDS

OBJECTIVES

- Tell the story of the nutmeg trade: the tiny Banda Islands, the Dutch monopoly, the island of Run and the Treaty of Breda of 1667.
- Explain why whole spices keep their flavor longer than ground ones, and how warm spices pair with sweet vegetables.
- Cut a butternut squash safely with a chef's knife and roast it with nutmeg, maple and sage.

Warm-up. Smell a jar of ground nutmeg. Then, if you can, grate a little whole nutmeg and smell it. Describe the difference in three words. What foods have you eaten that you think contained nutmeg?

WATCH

How to Make Roasted Butternut Squash with Apple

America's Test Kitchen • 5:16

<https://www.youtube.com/watch?v=0i122clOVdE>

WHEN TO WATCH

After the story and before you cook. Watch how the squash is peeled and cut safely, flat side down.

Note: From America's Test Kitchen's Cook's Country. Their recipe adds apple; ours adds nutmeg, sage and brown butter.

KEY TERMS

spice

A dried seed, bark, root, bud or fruit used to flavor food, such as nutmeg (seed), cinnamon (bark), ginger (root) and cloves (flower buds).

mace

The lacy red covering around a nutmeg seed, dried and used as a separate spice with a similar, more delicate flavor.

volatile oils

The fragrant oils in spices that evaporate easily and carry most of their aroma. Grinding exposes them to air, so ground spices fade faster.

monopoly

Complete control of the supply of a product by one seller, which lets the seller set the price.

warm spices

Spices such as nutmeg, cinnamon, cloves, allspice and ginger that give a cozy, sweet-seeming aroma without being hot.

CORE IDEAS

The story. For most of history, every nutmeg in the world came from one tiny group of volcanic islands, the Banda Islands, in what is now eastern Indonesia. Nutmeg passed from hand to hand along the trade routes of Asia and the Middle East, and by the time it reached Europe it was worth a fortune; it was used to flavor food and was believed to be a medicine. The Portuguese reached Banda by sea in 1512. In the early 1600s the Dutch East India Company, a powerful trading company, set out to control the entire nutmeg crop, and by 1621 it had taken the main islands by force.

How they figured it out. One small island, Run, was held for a time by the English, who had made an agreement with its people. The two nations fought over the spice trade for decades. In 1667, at the Treaty of Breda, they settled their claims: the Dutch kept Run, and with it the whole nutmeg trade, while the English kept a Dutch colony across the world that they had seized three years earlier, New Amsterdam on the island of Manhattan, which they had renamed New York. The Dutch monopoly finally broke when Pierre Poivre, a French official, smuggled nutmeg and clove seedlings out of the islands and planted them on the island of Mauritius around 1770. Later the British planted nutmeg in the Caribbean, and the island of Grenada is still called the Spice Isle.

The kitchen science. Nutmeg is the seed of a tropical evergreen tree; its fruit looks like an apricot, and when it splits open it shows a dark seed wrapped in a bright red, lacy net, the **mace**. Most of a spice's aroma comes from **volatile oils** locked inside the seed or bark. Whole spices keep them sealed in for a year or more; grinding exposes them to air, so ground spices fade within months. That is why cooks grate nutmeg

fresh. Warm spices like nutmeg and cinnamon have aromas our brains link with sweetness, so they make sweet vegetables like squash, carrots and sweet potatoes taste even sweeter. Nutmeg is strong: a pinch is enough, and large amounts (spoonfuls) can make a person sick.

Let's cook. You will roast butternut squash with brown butter, maple, sage and freshly grated nutmeg. The skill to do well is **cutting a hard, round vegetable with a chef's knife**: softening the skin for 2–3 minutes in the microwave, cutting off the ends to make flat bases, separating the neck from the round bottom, peeling with a peeler, and cutting each piece flat side down using the bridge and claw grips.

PICTURE STUDY



Myristica fragrans (Nutmeg), from Köhler's Medicinal Plants, Franz Eugen Köhler (publisher), botanical illustration, 1887 · Chromolithograph (color print) · From Köhler's Medizinal-Pflanzen, Germany

Image: [Wikimedia Commons](#), public domain

Before photography was common, botanical artists drew plants with scientific precision so doctors, pharmacists and scholars could recognize them. This page from a famous German book of medicinal plants shows every part of the nutmeg tree, from flower to seed.

Look closely

- Find the fruit split open. What color is the mace, and how is it wrapped around the seed?
- Find the seed itself. Which part becomes the nutmeg we grate?
- Look at the numbered small drawings. Why would an artist draw each part separately?
- Look at the leaves. How can you tell this tree grows in a warm, wet climate?

Talk about it

1. Why would one nutmeg tree's seed and its covering become two different spices?
2. Why were spices like this worth so much in Europe four hundred years ago?
3. Today a whole nutmeg costs very little. What changed?

Safety first. Butternut squash is hard and round: microwave it 2–3 minutes to soften the skin, cut off the ends so it sits flat, and always cut with a flat side down, using the bridge and claw grips on a board that cannot slide. Brown butter is very hot; use a long spoon and an adult at home and nearby. Use only a pinch of nutmeg.

KITCHEN PROJECT

A Pinch of History: Roasted Butternut Squash with Nutmeg and Sage

You will compare fresh and pre-ground spices in a smell test, practice cutting a difficult vegetable safely, and roast a squash side dish for a family dinner.

You will need

- A cutting board, a damp towel, a chef's knife and a sturdy vegetable peeler
- A large spoon for scooping seeds
- A rimmed baking sheet and parchment
- A small saucepan for brown butter
- A small grater or microplane
- Measuring cups and spoons

ROASTED BUTTERNUT SQUASH WITH BROWN BUTTER, MAPLE, SAGE AND NUTMEG

Serves 6 (side dish) · Prep 20 min · Roast 30–35 min

Ingredients

- 1 large butternut squash (about 3 pounds, 1.4 kg)
- 2 tablespoons olive oil
- $\frac{3}{4}$ teaspoon salt and $\frac{1}{4}$ teaspoon black pepper
- 3 tablespoons butter
- 8 fresh sage leaves (or $\frac{1}{2}$ teaspoon dried sage)
- 1 tablespoon maple syrup
- $\frac{1}{8}$ teaspoon freshly grated nutmeg (a few strokes on the grater)
- 2 tablespoons toasted pumpkin seeds or chopped pecans (optional)

Method

1. Heat the oven to 425 °F (220 °C). Wash your hands and the squash.
2. Pierce the squash a few times with a fork and microwave it 2–3 minutes to soften the skin. Let it cool a minute.

3. With the chef's knife, cut off the top and bottom so it stands flat. Cut the narrow neck from the round bottom. Peel each piece with the peeler. Stand the bottom on its flat end, cut it in half, and scoop out the seeds.
4. Lay each piece flat side down and cut it into 1-inch cubes using the bridge grip for long cuts and the claw grip for cubes.
5. Toss the cubes with the oil, salt and pepper on the parchment-lined baking sheet. Roast 30–35 minutes, turning once, until tender and browned at the edges.
6. Meanwhile melt the butter in the small saucepan over medium heat. Add the sage and cook, swirling, 3–4 minutes, until the butter smells nutty and turns golden brown and the sage is crisp. Turn off the heat and stir in the maple syrup and nutmeg.
7. Toss the roasted squash with the brown butter and sage, and sprinkle with the seeds or nuts. Serve warm.
8. Clean up: wash the board, knife and pan, and compost or discard the peels and seeds (or rinse and roast the seeds for a snack).

Allergy check: Contains milk (butter). Pecans are a tree nut; pumpkin seeds are not. For milk-free, cook the sage in olive oil instead of butter.

Steps

1. **Smell test.** Smell ground nutmeg from an old jar, ground nutmeg from a new jar if you have one, and freshly grated whole nutmeg. Rate each from 1 to 5 for strength. Explain the results using the words volatile oils.
2. **Knife check.** Ask an adult to watch you cut the squash and note whether every cut was made with a flat side down.
3. **Roast the recipe.** Record the roasting time and when the edges browned.
4. **Pairing test.** Taste one plain roasted cube and one tossed with the brown butter and nutmeg. Which tastes sweeter? Why?
5. **Map it.** On a world map, trace the route a nutmeg might have taken from the Banda Islands to Europe in 1600, and the route it takes to your store today (most nutmeg now comes from Indonesia and Grenada).
6. **Improve it.** Write one change for next time (cinnamon instead of nutmeg, a sprinkle of parmesan, or squash cut smaller for more browning).

7. Clean up: wash, dry and put away everything.

Tips

- Store whole spices in a cool, dark cupboard in closed jars. Write the date on new jars.
- Brown butter goes from golden to burnt quickly. As soon as it smells nutty, take it off the heat.
- Butternut squash seeds roast like pumpkin seeds: rinse, dry, toss with oil and salt, and roast at 325 °F for 15–20 minutes.

Check your work

- ☐ I can tell the story of nutmeg, Run and the Treaty of Breda.
- ☐ I can explain why whole spices last longer and why warm spices make sweet vegetables taste sweeter.
- ☐ I cut a hard, round squash safely with a chef's knife.

COOK'S NOTEBOOK

1. Draw a nutmeg fruit split open, labeling the fruit, the mace and the seed.
2. Draw a simple map of the world and mark the Banda Islands, Run, Manhattan, Mauritius and Grenada, with dates.
3. Copy the recipe in your own words and record your smell-test results.

From history. The Dutch East India Company, founded in 1602, was one of the first companies in the world to sell shares to ordinary investors. At its height it had its own ships, forts and soldiers and controlled much of the trade of the East Indies. The spices it carried, nutmeg, mace, cloves and pepper, are now sold in every grocery store for a few dollars.

COMMON MISTAKES

- Cutting a round vegetable without a flat side. It rolls under the knife; make a flat base first.
- Using a heavy hand with nutmeg. A little is fragrant; a lot is bitter and can make people sick.
- Keeping ground spices for years. They lose most of their aroma within a year.

Make it a game • Sniff and Tell. Close your eyes while your parent holds a whole spice and its ground form under your nose, such as cinnamon stick and ground cinnamon. Say which smells stronger and why: volatile oils. Then take turns adding one sentence at a time to the nutmeg story: Banda Islands, the Dutch, the island of Run and the Treaty of Breda.

7.2 BARBECUE TRADITIONS AND THE DRY RUB

OBJECTIVES

- Describe the history of American barbecue and four regional styles: the Carolinas, Memphis, Kansas City and Texas.
- Explain how salt, sugar and spices in a dry rub season meat and form a crust, and why sugar can burn over direct heat.
- Make a dry rub and grill chicken thighs to a safe temperature with an adult beside you (or broil them indoors).

Warm-up. Write down every kind of barbecue or grilled food you have ever eaten, and what sauce or seasoning it had. Was it sweet, tangy, smoky or spicy? Where do you think that style came from?

WATCH

Setting Up a Two-Zone Charcoal Fire | Weber Grills

Weber Grills • 1:26

<https://www.youtube.com/watch?v=V-21tnf6tHk>

WHEN TO WATCH

Watch together with the adult who will light and set up the grill: this is the two-zone fire you will cook over.

Note: From Weber Grills. Note that the adult lights the coals in a chimney starter with paper, never lighter fluid.

BACKUP VIDEO

Learn Some Grilling Safety Tips from NFPA

National Fire Protection Association • 3:27

<https://www.youtube.com/watch?v=-AYBZzLDO04>

Watch together with the adult who will light the grill, before you cook.

KEY TERMS

barbecue

Meat cooked slowly with smoke and low heat, often for hours; also used loosely for any outdoor grilling and for the gathering itself. The word comes from *barbacoa*, a wooden frame used by the Taíno people of the Caribbean.

direct heat

Cooking food right over the flames or coals, for quick searing and browning.

flare-up

A sudden burst of flame when fat drips onto hot coals or burners. Close the lid to smother it and move the food to the cooler side.

dry rub

A mixture of salt, sugar, spices and herbs rubbed onto meat before cooking to season it and help form a flavorful crust.

indirect heat

Cooking food beside the fire, not over it, with the lid closed, so heat surrounds the food like an oven.

CORE IDEAS

The story. When Spanish explorers reached the Caribbean in the early 1500s, they saw the Taíno people cooking meat and fish on a raised frame of green sticks over a slow fire. The Spanish called it *barbacoa*, and the word came into English as barbecue. In the American South, barbecue became the food of big outdoor gatherings: church suppers, community picnics, harvest celebrations and Fourth of July feasts, where whole hogs or sides of beef cooked slowly over pits of coals while the community gathered.

How they figured it out. Each region worked with what it had, and four great styles grew up. In **the Carolinas**, cooks smoked pork, often a whole hog, and served it with a thin, peppery vinegar sauce (with some tomato added in the western part of North Carolina). In **Memphis**, pork ribs were seasoned with a dry rub of spices, served “dry” or “wet” with sauce. In **Kansas City**, a cook named Henry Perry began selling smoked meats from an old streetcar barn in the early 1900s, and the city became known for many meats and a thick, sweet tomato-and-molasses sauce. In **central**

Texas, German and Czech families who had settled there and ran meat markets smoked beef brisket and sausages over post oak and served them on brown paper with crackers or bread, often with no sauce at all.

The kitchen science. A **dry rub** does three jobs. Salt seasons the meat and, given time, draws out a little moisture, dissolves in it and soaks back in, helping the meat stay juicy. Sugar and spices like paprika form a flavorful crust as they brown in the Maillard reaction and caramelize. But sugar burns at grill temperatures: above about 350 °F it quickly turns from brown to black and bitter. So a sweet rub is best cooked over medium or **indirect heat**, with only a short time over **direct heat** to finish. Chicken thighs are forgiving: they have more fat and connective tissue than breasts and stay juicy even at 175 °F, though they are safe at 165 °F.

Let's cook. You will mix a barbecue dry rub and grill chicken thighs. In eighth grade, you may do the grilling yourself **with an adult beside you**. The adult lights the grill (a chimney starter or a gas grill; never lighter fluid). The skill to do well is **managing a two-zone fire**: starting the chicken over the cooler side with the lid closed, then moving it to the hot side for a minute or two per side to crisp, turning with long tongs, and closing the lid if fat flares up.

PICTURE STUDY



Serving Up the Barbecue at the Pie Town, New Mexico, Fair, Russell Lee, for the Farm Security Administration, 1940 · Photograph · Library of Congress, Washington, D.C.

Image: [Wikimedia Commons](#), public domain

Pie Town was a small homesteading community in the high country of New Mexico. In 1940 the photographer Russell Lee recorded its yearly fair, where the families of the area gathered for a free barbecue dinner, along with beans, bread and the pies that gave the town its name.

Look closely

- Find the people serving. What are they using to serve the meat?
- Look at the people in line. What are they holding?
- Look at the clothes and the setting. What kind of work do you think these families did?
- Look for anything that shows how the meat was cooked or kept warm.

Talk about it

1. Why do you think barbecue became the food of big community gatherings?
2. How would the cooks keep so much meat safe for a crowd on a warm day?
3. What foods does your family or church serve when everyone gathers?

Safety first. Grill outdoors only, on a flat spot away from the house, railings, overhangs and dry leaves. Only an adult lights the grill, never with lighter fluid. You may grill with an adult beside you, using long tongs (never a fork); close the lid to smother a flare-up; keep a hose or extinguisher nearby; never leave a lit grill alone. Cook chicken to 165 °F (74 °C), and wash hands, boards and tongs after touching raw chicken.

KITCHEN PROJECT

Your Own Rub: Dry-Rubbed Grilled Chicken Thighs

You will create and test your own dry rub, then grill chicken thighs over a two-zone fire with an adult beside you (or under the broiler indoors). You will record temperatures and compare a piece cooked only over direct heat with pieces started over indirect heat.

You will need

- A small bowl and measuring spoons for the rub
- A raw-meat cutting board and a large plate or tray
- Long-handled tongs and a clean platter for cooked chicken
- An instant-read food thermometer
- A grill (charcoal set up for two zones by the adult, or gas with one side on low), or a broiler pan and the oven
- A hose or fire extinguisher nearby

BARBECUE DRY RUB AND GRILLED CHICKEN THIGHS

Serves 6 • Prep 15 min • Rest 30 min–4 hr • Grill 25–30 min

Ingredients

- **Dry rub (makes about $\frac{1}{3}$ cup):** 2 tablespoons brown sugar
- 1 tablespoon smoked or sweet paprika
- 2 teaspoons kosher salt
- 1 teaspoon garlic powder and 1 teaspoon onion powder
- 1 teaspoon chili powder
- $\frac{1}{2}$ teaspoon ground cumin and $\frac{1}{2}$ teaspoon black pepper
- $\frac{1}{4}$ teaspoon cayenne pepper (optional)
- **Chicken:** 3 pounds (1.4 kg) bone-in, skin-on chicken thighs (8–10), or $2\frac{1}{2}$ pounds boneless thighs
- 1 tablespoon vegetable oil
- **To serve:** barbecue sauce on the side (optional), coleslaw, corn and bread

Method

1. Wash your hands. Stir all the rub ingredients together in the small bowl, breaking up any lumps of sugar.
2. On the raw-meat board, pat the chicken dry, rub it with the oil, and sprinkle the rub all over, pressing it in. Use about 3 tablespoons of rub; save the rest in a jar. Refrigerate the chicken 30 minutes to 4 hours. Wash your hands and the board.
3. **Grill:** An adult lights the grill and sets it up with a hot side and a cooler side, about 350–400 °F with the lid closed.
4. With the adult beside you, use long tongs to lay the chicken skin side up on the cooler side. Close the lid and cook 15–20 minutes (boneless: 8–10 minutes), until the thighs read about 155 °F.
5. Move the chicken skin side down to the hot side for 1–2 minutes until crisp and browned, watching for flare-ups (close the lid and move the chicken back to the cooler side if flames jump up). Turn and cook until the thickest part reads at least 165 °F (74 °C); thighs are juiciest at 170–175 °F.
6. **Indoor way:** Bake the chicken skin side up on a rack in a foil-lined pan at 400 °F (200 °C) for 30–35 minutes, then an adult moves the rack 6 inches below the broiler and broils it 2–3 minutes to crisp the skin, watching closely.
7. Put the cooked chicken on a *clean* platter and rest 5 minutes. Serve with sauce on the side, coleslaw and corn.
8. **Clean up:** wash the tongs, board and plates in hot, soapy water. The adult turns off the gas or closes the vents on the charcoal grill and lets it cool completely; coals must cool 24–48 hours before an adult empties them into a metal can.

Allergy check: The rub and chicken contain none of the nine major allergens. Check spice blends and barbecue sauce labels. Coleslaw dressing often contains eggs (mayonnaise).

Steps

1. **Design your rub.** Before mixing, decide whether your rub will lean Memphis (heavy on paprika and spice), Kansas City (sweeter) or Texas (mostly salt and pepper). Write your changes to the base recipe and why.

2. **Safety walk-through.** With the adult, check the grill's location, the lid, the long tongs, the thermometer, the hose or extinguisher, and the plan for flare-ups. Write a checklist and tick each item.
3. **Direct vs. indirect test.** Cook one thigh only over direct heat while the rest start on the cooler side. Compare the color of the crust and the time each took to reach 165 °F.
4. **Temperature log.** Record the grill temperature and each thigh's final temperature.
5. **Taste test.** Ask your family to rate the chicken from 1 to 5 for crust, juiciness and seasoning, with and without sauce.
6. **Improve it.** Write one change to your rub (more or less sugar, more heat, a little cinnamon or mustard powder).
7. **Clean up:** wash, dry and put away everything, and label the jar of leftover rub.

Tips

- Rub that has touched raw chicken must not go back in the jar. Sprinkle from a small dish, not your hand.
- If the rub is browning too fast, the fire is too hot; move the chicken to the cooler side.
- Never brush sauce that touched raw meat onto cooked meat. Use clean sauce at the end, or serve it on the side.

Check your work

- ☐ I can describe four American barbecue styles and where they came from.
- ☐ I can explain what a dry rub does and why sugar needs gentle heat.
- ☐ I grilled chicken to a safe temperature over a two-zone fire with an adult beside me, following every grill rule.

COOK'S NOTEBOOK

1. Draw a map of the United States and mark the four barbecue regions with a sketch of each one's signature meat and sauce.
2. Draw a two-zone grill from above and from the side, showing the coals, the hot side, the cooler side and the lid.

3. Write your custom rub recipe on a label for the jar, with its name and the date.

From history. Henry Perry, born in Tennessee, sold smoked meats wrapped in newspaper from a stand in Kansas City's Garment District and later from an old trolley barn, starting around 1908. Several of the city's most famous barbecue restaurants were started by men who learned the craft in his kitchen.

COMMON MISTAKES

- Putting sugary rubbed meat over high direct heat the whole time. The sugar burns before the meat is done.
- Turning meat with a fork. Piercing it lets juices drip and cause flare-ups; use long tongs.
- Using the same platter for raw and cooked chicken. Take a clean platter to the grill for the cooked meat.

Make it a game • Four Corners BBQ. Label four corners of a room: Carolinas, Memphis, Kansas City and Texas. Your parent calls a feature of barbecue and you race to the right corner and give one more fact there. Then design a dry rub on paper using salt, sugar and spices, and explain why the sugar might burn over direct heat.

Scripture. "As soon then as they were come to land, they saw a fire of coals there, and fish laid thereon, and bread." (John 21:9, KJV)

After His resurrection, Jesus Himself cooked breakfast over a fire of coals for His tired disciples. Cooking over a fire for others is an old and loving kind of hospitality.

7.3 SMOKE, INDIRECT HEAT AND GRILLED VEGETABLES

OBJECTIVES

- Explain how smokehouses preserved meat in early America and what chemistry gives smoke its flavor.
- Explain why moist, cool surfaces absorb more smoke, and how indirect heat cooks food gently.
- Grill a platter of vegetables over indirect heat with a wood-chip smoke packet, with an adult beside you (or roast them indoors).

Warm-up. Think of three foods that taste smoky (bacon, smoked cheese, barbecue, smoked paprika, even some teas). What do they have in common? Do you think smoke adds a taste, a smell, or both?

WATCH

Part 2 - Science of Smoking Wood Lignin How-To by BBQ Champion Harry Soo SlapYoDaddyBBQ.com

Harry Soo • 5:21

<https://www.youtube.com/watch?v=X8Xwcj5feDg>

WHEN TO WATCH

After the kitchen-science paragraph. Listen for what happens to the lignin, cellulose and hemicellulose in wood as it burns.

Note: From a competition barbecue cook who teaches the science of smoke. Parents may wish to preview.

KEY TERMS

smokehouse

A small building where salted meat was hung for days or weeks over a smoldering fire to dry and flavor it, before refrigerators.

lignin

The tough material that holds wood fibers together. When it smolders it makes the compounds that give smoke its spicy, smoky aroma.

guaiacol

One of the main aroma compounds in wood smoke, with a smoky, spicy smell. Say it “GWY-uh-col.”

smoldering

Burning slowly with smoke but little or no flame. Smoldering wood makes more flavorful smoke than a roaring fire.

indirect grilling

Cooking food on the side of the grill away from the fire with the lid closed, so it roasts gently in hot, smoky air.

CORE IDEAS

The story. Before refrigerators, most farms and plantations in early America had a smokehouse, a small, windowless building of brick, stone or logs. Many still stand. At Woodlawn, an estate near Mount Vernon in northern Virginia, built in the early 1800s for Martha Washington’s granddaughter Nelly Custis Lewis, the brick smokehouse still stands behind the house. In the winter, after the hams and bacon from the farm’s hogs had been salted for weeks, the meat was hung from the rafters of the smokehouse while a low, smoky fire of hickory or other hardwood smoldered on the dirt floor for days or weeks.

How they figured it out. Generations of farm families learned by experience that salt, drying and smoke together kept meat for months and gave it a deep flavor. Much later, chemists learned why. Salt and drying take away the water microbes need. Smoke adds compounds that slow spoilage on the surface and keep fat from going rancid. And the smell of smoke comes from specific molecules made when wood smolders. The Historic American Buildings Survey, begun by the National Park Service in 1933, photographed and measured old buildings across the country, including many smokehouses, so that we still know how they were built.

The kitchen science. Wood is made of three main materials. Cellulose and hemicellulose, the long sugar chains of the wood fibers, break down in heat into compounds with sweet, caramel-like, toasty smells. **Lignin**, the glue that holds the fibers together, breaks down into **guaiacol** and related compounds with the smoky, spicy aroma we know as smoke. Wood that **smolders** at a moderate temperature makes the best-tasting smoke; wood that burns hot and fast makes harsh, bitter smoke. Smoke sticks best to food that is cool and moist on the surface, so food

absorbs most of its smoke flavor early in cooking. Today we smoke mainly for flavor, not preservation: smoked food still needs to be cooked to safe temperatures and refrigerated.

Let's cook. You will grill a big platter of summer vegetables over indirect heat with a foil packet of wood chips for smoke, then finish them with a lemon-herb dressing. The skill to do well is **indirect grilling**, with an adult beside you: arranging the vegetables away from the fire, closing the lid, and checking them with tongs without letting all the heat and smoke escape.

PICTURE STUDY



Smokehouse at Woodlawn, Fairfax County, Virginia, Historic American Buildings Survey photographer, 1930s · Photograph · Library of Congress, Washington, D.C.

Image: [Wikimedia Commons](#), public domain

This small brick building is the smokehouse at Woodlawn, an estate built in the early 1800s near Mount Vernon. Photographers for the Historic American Buildings Survey recorded it so that future generations could see how food was preserved before refrigerators.

Look closely

- Look at the walls. What are they made of, and why would that be good for a building with a fire inside?
- Find the small arched opening high in the wall. What might it have been for?
- Look at the roof. Where might smoke escape?
- Compare the size of the building with the trees. How much meat could hang inside?

Talk about it

1. Why would a smokehouse be built apart from the main house?
2. Smoke, salt and drying worked together to keep meat. Which one do you think did the most work, and why?
3. Today we smoke food for flavor. What do we use instead for preservation?

Safety first. Only an adult lights the grill and handles the hot wood-chip packet; never use lighter fluid. Grill outdoors on a flat spot away from the house and dry leaves, keep the lid ready for flare-ups and a hose or extinguisher nearby, use long tongs, and never leave the grill alone. Smoke can bother the eyes and lungs; stand upwind and do not lean over the grill when the lid opens.

KITCHEN PROJECT

Low and Smoky: Grilled Vegetable Platter over Indirect Heat

You will grill a platter of vegetables over indirect heat with a smoke packet, and test whether smoke flavor is stronger on vegetables that start cool and moist.

You will also compare grilled vegetables with oven-roasted ones.

You will need

- A grill set up by an adult for indirect heat (or the oven)
- A handful of hardwood chips (hickory, apple or oak), soaked 30 minutes, wrapped in a foil packet with holes poked in the top
- A grill basket or perforated grill pan (helpful for small pieces), long tongs and a large platter
- A cutting board, a damp towel and a chef's knife
- A large bowl and a jar for the dressing
- Oven mitts and a timer

SMOKY GRILLED VEGETABLE PLATTER WITH LEMON-HERB DRESSING

Serves 6 • Prep 25 min • Grill 25–35 min

Ingredients

- 2 zucchini and 2 yellow squash, cut lengthwise into ½-inch planks
- 2 bell peppers (red, yellow or orange), cut into wide strips
- 1 red onion, cut into ½-inch rounds (keep the rings together; a toothpick through the side helps)
- 1 small eggplant, cut into ½-inch rounds (optional)
- 3 ears corn, husked
- 8 ounces (225 g) whole mushrooms or 2 portobello caps
- ¼ cup (60 mL) olive oil, 1 teaspoon salt and ½ teaspoon pepper
- **Lemon-herb dressing:** ¼ cup (60 mL) olive oil
- 2 tablespoons lemon juice and 1 teaspoon zest
- 1 clove garlic, minced

- 2 tablespoons chopped fresh herbs (parsley, basil, mint or oregano)
- ¼ teaspoon salt
- Crumbled feta or goat cheese, to serve (optional)

Method

1. Wash your hands and all the vegetables. Cut them as listed, using flat sides down and the bridge and claw grips.
2. Toss the vegetables with the oil, salt and pepper in the large bowl.
3. **Grill:** An adult lights the grill, sets up a hot side and a cooler side, and sets the wood-chip packet directly on the coals or over a lit burner. Close the lid until smoke appears, about 5 minutes.
4. With an adult beside you, arrange the vegetables on the cooler side (use a grill basket for mushrooms and small pieces). Close the lid and cook 15–20 minutes, turning once with tongs.
5. For color, move the vegetables to the hot side for 1–2 minutes per side, until they have grill marks and are tender. Corn may take 8–10 minutes in all, turned every few minutes.
6. **Indoor way:** Roast the vegetables in a single layer on two baking sheets at 450 °F (230 °C) for 20–25 minutes, turning once. Toss them with ½ teaspoon smoked paprika for a smoky taste.
7. Shake the dressing in the jar. Arrange the vegetables on the platter, cut the corn into pieces, drizzle with dressing, and sprinkle with cheese.
8. **Clean up:** wash the bowl, board and tongs. The adult closes the grill vents or turns off the gas and lets the grill and the foil packet cool completely before disposal.

Allergy check: Contains none of the nine major allergens unless you add cheese (milk). Check any spice blend labels.

Steps

1. **Smoke test.** Before grilling, put two zucchini planks in the refrigerator for 30 minutes and leave two at room temperature, patted very dry. Grill them side by side. Which tastes smokier? Explain using what you learned about cool, moist surfaces.

2. **Grill vs. oven.** If you can, roast a few pieces of the same vegetables in the oven. Compare color, texture and flavor.
3. **Log.** Record the grill temperature, the time each vegetable took, and which ones browned best.
4. **Taste test.** Ask your family to rate each vegetable from 1 to 5 and choose a favorite.
5. **Improve it.** Write one change (a different wood, a different dressing, or adding halloumi or chicken sausages).
6. Clean up: wash, dry and put away everything.

Tips

- Cut vegetables in large pieces so they do not fall through the grates. Slice them into bite-size pieces after grilling.
- Every time you open the lid, heat and smoke escape. Check only when you need to.
- A little smoke goes a long way. One small packet of chips is plenty for vegetables.

Check your work

- ☐ I can explain how smokehouses preserved meat and what makes smoke smell smoky.
- ☐ I can explain why cool, moist food absorbs more smoke and how indirect heat works.
- ☐ I grilled vegetables over indirect heat with an adult beside me, following every grill rule.

COOK'S NOTEBOOK

1. Draw a cross-section of a smokehouse with hanging hams, the smoldering fire and the path of the smoke.
2. Draw a grill set up for indirect cooking with a smoke packet, labeling the hot side, the cooler side, the vegetables and the lid.
3. Record your smoke-test and grill-vs.-oven results in a chart.

From history. Virginia hams became famous across the colonies and in England. In 1926 the Virginia General Assembly passed a law saying that only hams cured within the town of Smithfield could be sold as “genuine Smithfield hams,” one of the earliest laws in America protecting a regional food name.

COMMON MISTAKES

- Putting vegetables directly over high heat the whole time. They char outside before they soften inside; start them on the cooler side.
- Cutting vegetables too small. They fall through the grates; cut big and slice after.
- Lifting the lid again and again. Heat and smoke escape and cooking slows down.

Make it a game • Smoke Riddles. Write five riddles about smokehouse, lignin, guaiacol, smoldering and indirect grilling, each with three clues and no giveaway word. Read them to your parent, who has to guess each term. Then switch: your parent reads one riddle and you guess. Add a bonus point for explaining why a cool, damp surface takes up more smoke.

7.4 THE SCIENCE OF FLAVOR PAIRING

OBJECTIVES

- Tell how scientists in 2011 used a “flavor network” of recipes and aroma compounds to study why some ingredients pair well.
- Explain complementary and contrasting pairings (salt and sweet, acid and fat, heat and cool, herb and citrus) and how to balance a dish.
- Grill pork chops to 145 °F with a 3-minute rest and make a grilled peach salsa, with an adult beside you (or using a grill pan or broiler).

Warm-up. Taste a slice of ripe peach or a piece of watermelon. Then taste another with a few grains of salt, and another with a squeeze of lime. (Check for allergies first.) Which did you like best? Why do you think salt and lime changed the fruit?

WATCH

Exploring the HIDDEN Science Behind Flavor Pairings

Abbey the Food Scientist · 8:32

<https://www.youtube.com/watch?v=qV4t8nWbeiM>

WHEN TO WATCH

After the story. Listen for the idea of shared aroma compounds and when it does and does not work.

Note: From a food scientist who teaches flavor chemistry. Parents may wish to preview.

BACKUP VIDEO

How to Grill Pork Chops the Right Way | Grilling Fridays | Serious Eats

Serious Eats · 2:14

<https://www.youtube.com/watch?v=akvc12gflM4>

Before you cook, for the two-zone method for thick pork chops.

KEY TERMS

aroma compound

A molecule that gives a food part of its smell. A strawberry has hundreds of them.

shared-compound pairing

The idea that foods sharing many aroma compounds may taste good together, such as tomato and basil.

contrast pairing

Pairing foods with opposite qualities that balance each other: sweet with salty, rich with acidic, hot with cool, soft with crisp.

balance

A dish in which no one taste overwhelms the rest: salt, acid, sweetness, bitterness, heat and richness each in proportion.

carryover cooking

The rise in temperature after meat leaves the heat. A thick chop may rise 3–5 °F as it rests.

CORE IDEAS

The story. Cooks have always known that some foods belong together: tomato and basil, apple and cinnamon, pork and apple, lime and chili. But why? In 2011 four scientists, Yong-Yeol Ahn, Sebastian Ahnert, James Bagrow and Albert-László Barabási, who study networks (the way people, websites or molecules connect), decided to look at recipes the way they would look at a social network.

How they figured it out. The team gathered more than 56,000 recipes from cooking websites around the world and a list of the aroma compounds found in hundreds of ingredients. They built a huge map, a “flavor network,” connecting ingredients that share aroma compounds. Then they asked: do cooks tend to combine ingredients that share many compounds? In North American and Western European recipes, the answer was yes: ingredients that share flavor compounds (like butter, cream, eggs and vanilla, or tomato, cheese and herbs) appeared together more often than chance would predict. But in East Asian recipes the opposite was true: cooks often combined ingredients that share *few* compounds, for contrast. The study showed that there is more than one good way to pair flavors.

The kitchen science. Cooks use two kinds of pairing. **Shared pairings** echo each other: grilled pork and grilled peaches both have toasty, caramel and fruity notes after browning. **Contrast pairings** balance each other: *salt and sweet* (salt makes sweetness taste fuller and less flat); *acid and fat* (lime or vinegar cuts through rich meat so each bite tastes fresh); *heat and cool* (a jalapeño’s capsaicin against cool fruit or yogurt); *herb and citrus* (cilantro or mint with lime brightens everything); and *fat and bitter* (a little butter or oil softens bitter greens). A balanced dish has each taste

in proportion; when something tastes flat, it usually needs salt or acid, and when it tastes harsh, a little fat or sweetness can round it out.

Let's cook. You will grill thick pork chops and serve them with a fresh salsa of grilled peaches, red onion, jalapeño, lime and cilantro. The skill to do well is **balancing a dish by taste**: taste the salsa, decide whether it needs salt, acid, sweetness or heat, adjust a little at a time, and taste again. Pork chops are safe at 145 °F (63 °C) with a 3-minute rest, which keeps them juicy and slightly pink.

PICTURE STUDY



Still Life with Cherries and Peaches, Paul Cézanne, 1885–1887 · Oil on canvas · Los Angeles County Museum of Art

Image: [Wikimedia Commons](#), public domain

Paul Cézanne painted fruit again and again, studying how color and shape work together. Here, round golden peaches and deep red cherries sit side by side, their colors balancing and contrasting the way flavors do on a well-planned plate.

Look closely

- Find the peaches and the cherries. How do their colors contrast?
- Look at the white cloth. What does it do for the colors of the fruit?
- Look at the shapes. Which are round, which are angled?
- Find a spot where Cézanne used a cool color next to a warm one.

Talk about it

1. Cézanne balanced warm and cool colors. How is that like balancing sweet fruit with sour lime or salty meat?
2. Peaches and cherries share some aroma compounds. Would you pair them in a dish? What would you add for contrast?
3. Why might an artist paint the same kind of fruit many times?

Safety first. Only an adult lights the grill; never use lighter fluid. You may grill with an adult beside you, using long tongs; close the lid to smother flare-ups and keep a hose or extinguisher nearby. Cook pork chops to 145 °F (63 °C) and rest 3 minutes. Wear gloves or wash hands well after cutting a jalapeño, and never touch your eyes.

KITCHEN PROJECT

Sweet, Salty, Sour, Hot: Grilled Pork Chops with Grilled Peach Salsa

You will grill pork chops and peaches, build a salsa by balancing its tastes step by step, and keep a pairing chart of which combinations your family likes best.

You will need

- A grill set up by an adult with a hot side and a cooler side (or a grill pan on the stove, or the broiler)
- Long-handled tongs, a raw-meat board and a clean platter
- A cutting board, a damp towel and a chef's knife
- A medium bowl for the salsa and small tasting spoons
- Disposable gloves for the jalapeño
- An instant-read food thermometer

GRILLED PORK CHOPS WITH GRILLED PEACH SALSA

Serves 4–6 • Prep 25 min • Brine 30 min (optional) • Grill 15–20 min

Ingredients

- 4–6 bone-in or boneless pork chops, about 1 inch thick (2–2½ pounds, 900 g–1.1 kg)
- **Quick brine (optional):** 4 cups cold water and 2 tablespoons kosher salt
- 1 tablespoon vegetable oil
- 1 teaspoon salt (½ teaspoon if brined), ½ teaspoon black pepper, 1 teaspoon smoked paprika
- **Peach salsa:** 3 ripe but firm peaches, halved and pitted
- ½ small red onion, finely diced
- 1 jalapeño, seeds and ribs removed, finely diced (or less, to taste)
- 2 tablespoons lime juice (1 lime)
- 2 tablespoons chopped cilantro or mint
- ¼ teaspoon salt, and 1 teaspoon honey if the peaches are not very sweet

Method

1. Wash your hands. **Brine (optional):** Stir the salt into the cold water, add the chops, and refrigerate 30 minutes. Remove and pat dry. Wash your hands.
2. Rub the chops with oil and season with salt, pepper and paprika. Brush the cut sides of the peaches with a little oil.
3. **Grill:** An adult lights the grill and sets up a hot side and a cooler side. With the adult beside you, sear the chops over the hot side 2–3 minutes per side, then move them to the cooler side, close the lid and cook 4–8 minutes more, until the thickest part reads 145 °F (63 °C).
4. Grill the peaches cut side down over the hot side 2–3 minutes, until marked and slightly soft.
5. **Indoor way:** Heat a grill pan or heavy skillet over medium-high heat with an adult present and cook the chops 4–5 minutes per side to 145 °F, or an adult broils them 5 inches below the heat, 5–6 minutes per side. Cook the peaches in the same pan.
6. Move the chops to a clean platter and rest at least 3 minutes. Meanwhile dice the peaches and stir them with the onion, jalapeño, lime juice, cilantro and salt.
7. Taste the salsa and balance it: more salt if flat, more lime if heavy, honey if too sour, more jalapeño if mild. Spoon it over the chops.
8. Clean up: wash the boards, knife and tongs in hot, soapy water. The adult shuts down the grill and lets it cool completely.

Allergy check: Contains none of the nine major allergens. Honey is never given to babies under one year.

Steps

1. **Balance log.** Before adding salt, lime or honey to the salsa, taste it and write what it needs. After each addition, taste again and record the change.
2. **Pairing chart.** Set out small bites for a family tasting: grilled peach plain, with salt, with lime, with jalapeño, and with a bite of pork. Each person rates each pairing from 1 to 5. Mark each pairing as “shared” or “contrast.”
3. **Temperature log.** Record each chop’s temperature when it came off and after a 3-minute rest. How much carryover did you see?

4. **Taste test.** Ask your family to rate the dinner from 1 to 5 for juiciness and balance.
5. **Improve it.** Write one change (mango or pineapple instead of peach, a spice rub from Lesson 7.2, or chicken instead of pork).
6. Clean up: wash, dry and put away everything.

Tips

- Thick chops (1 inch or more) stay juicier on the grill than thin ones, which overcook before they brown.
- Firm peaches hold their shape on the grill. Very soft ones fall apart; use them raw in the salsa instead.
- Most of a jalapeño's heat is in the white ribs and seeds. Remove them for a mild salsa.

Check your work

- ☐ I can tell what the 2011 flavor-network study found.
- ☐ I can name and give examples of complementary and contrasting pairings.
- ☐ I grilled pork to 145 °F with a rest and balanced a salsa by tasting.

COOK'S NOTEBOOK

1. Draw a small flavor network: circles for six ingredients you like, with lines connecting those that pair well. Label each line "shared" or "contrast."
2. Copy your pairing chart with the family's ratings.
3. Write your salsa balance log and the final recipe in your own words.

From history. For many years the USDA advised cooking pork to 160 °F. In 2011 it lowered the safe temperature for whole cuts of pork to 145 °F with a 3-minute rest, after research showed that was safe. Many cooks who grew up with dry pork chops have been surprised at how juicy pork can be.

COMMON MISTAKES

- Cooking pork until it is white and dry. Pork is safe at 145 °F with a 3-minute rest; it may be slightly pink.
- Adding all the salt or lime at once. Add a little, taste, and repeat.
- Touching your face after cutting hot peppers. Wear gloves or wash your hands well.

Make it a game • Pairing Duel. Your parent names an ingredient from the kitchen, such as peach. Take turns offering a partner and saying whether it is complementary or contrasting: salt and sweet, acid and fat, heat and cool, herb and citrus. No repeats, and ten seconds per answer. The first to stall loses. Mention the 2011 flavor network once.

Scripture. “Let your speech be alway with grace, seasoned with salt, that ye may know how ye ought to answer every man.” (Colossians 4:6, KJV)

Paul compares good words to well-seasoned food: not bland, not harsh, but balanced and pleasant. A good cook and a good speaker both pay attention to the people they serve.

UNIT 7

FIRE, THE GRILL & SPICE

This is the fun unit, and the one where your skills come together. You will cook with live fire and with the spices that once moved empires. You will learn how a tiny nutmeg seed from a handful of islands in the East Indies changed the map of the world, how Americans built their great regional barbecue traditions, how smoke flavors food, and how scientists study why some flavors belong together.

In eighth grade you may cook on the grill yourself, with an adult beside you. An adult always lights the grill, and no one in this course ever uses lighter fluid. Every recipe also has an indoor method with a grill pan or the oven broiler for families without a grill. When the unit ends, you will plan and cook a grilled dinner for your family with your own spice rub, and balance its flavors like a real cook.

PREREQUISITES

- Knows safe internal temperatures and uses a thermometer every time (Unit 1)
- Understands conduction, convection and radiation (Unit 4)
- Knows the five basic tastes and how smell makes flavor (Unit 3)
- Has watched an adult light and run a grill safely, and has reviewed the grill rules with an adult

MASTERY CHECKLIST

- ☐ I can follow every grill rule: outdoors on a flat spot away from the house, adult lights it, no lighter fluid, long tongs, lid for flare-ups, water or extinguisher nearby, never left alone.
- ☐ I can tell the story of the nutmeg trade and use whole spices and freshly ground spices well.
- ☐ I can describe American regional barbecue styles and make and use a dry rub.
- ☐ I can set up and cook over direct and indirect heat, and explain how smoke flavors food.
- ☐ I can balance a dish with salt, acid, fat, sweetness and heat, and explain complementary and contrasting flavors.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **NFPA: Grilling safety:** Free. Grilling safety tips and a printable sheet from the National Fire Protection Association. Read it together before Lesson 7.2.
- **An instant-read food thermometer and long-handled tongs:** Check every piece of chicken and pork in its thickest part. Long tongs keep hands away from the heat; never use a fork to turn meat.
- **For the adult who lights the grill: a chimney starter:** A chimney starter lights charcoal with crumpled newspaper, so no lighter fluid is needed. A gas grill needs neither. Not required: every recipe also works under the oven broiler or in a grill pan.
- **A whole nutmeg and a small grater:** Inexpensive at any grocery store. Freshly grated nutmeg is far more fragrant than ground. Used in Lesson 7.1.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

7.1	Nutmeg and the Banda Islands	2 sessions of 50–60 minutes
7.2	Barbecue Traditions and the Dry Rub	2 sessions of 50–60 minutes
7.3	Smoke, Indirect Heat and Grilled Vegetables	2 sessions of 50–60 minutes
7.4	The Science of Flavor Pairing	2 sessions of 50–60 minutes

UNIT 7 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. 10 pts

List six grill safety rules from this unit.

2. 8 pts

What happened at the Treaty of Breda in 1667, and why did it matter for nutmeg?

3. 8 pts

Why do whole spices keep their flavor longer than ground spices?

4. 8 pts

Describe the barbecue styles of two of these regions: the Carolinas, Memphis, Kansas City, central Texas.

5. 8 pts

Predict: you grill chicken with a sweet rub over high direct heat the whole time. What will happen, and what should you do instead?

6. 8 pts

Explain the difference between direct and indirect grilling.

7. 8 pts

What part of wood makes the main smoky aroma, and why does cool, moist food absorb more smoke?

8. 8 pts

What did the 2011 flavor-network study find?

9. 8 pts

Give an example of each: salt and sweet, acid and fat, heat and cool.

10. 10 pts

Calculation: your dry rub makes $\frac{1}{3}$ cup. A family barbecue needs 1 cup. By what factor do you multiply, and how much paprika do you need if the recipe uses 1 tablespoon?

11. 8 pts

Calculation: a pork chop comes off the grill at 142 °F and rises 4 °F as it rests. Is it safe? What is its final temperature in °C?

12. 8 pts

Short answer: In three or four sentences, explain how you would fix a salsa that tastes flat, one that is too sour, and one that is too hot.

ANSWER KEY

1. Any six: outdoors only, on a flat spot away from the house, railings, overhangs and dry leaves; only an adult lights the grill; never use lighter fluid; use long tongs, never a fork; close the lid to smother a flare-up; keep a hose or extinguisher nearby; never leave a lit grill alone; let coals cool 24–48 hours before an adult disposes of them in a metal can; students grill only with an adult beside them.
2. The Dutch kept the island of Run, giving them control of the whole nutmeg trade, while the English kept New Amsterdam (Manhattan), which became New York.
3. Most of a spice's aroma is in volatile oils sealed inside the whole seed or bark. Grinding exposes them to air, so they evaporate and fade much faster.
4. Carolinas: smoked pork (often whole hog) with thin vinegar sauce, some tomato in the west. Memphis: pork ribs with a dry rub, served dry or wet. Kansas City: many meats with thick, sweet tomato-molasses sauce. Central Texas: smoked beef brisket and sausage over post oak, often with no sauce.
5. The sugar will burn black and bitter before the chicken is cooked through. Start it over the cooler side (indirect heat) with the lid closed, then finish briefly over direct heat.
6. Direct grilling cooks food right over the fire for fast searing and browning. Indirect grilling cooks food beside the fire with the lid closed, so hot air surrounds it like an oven, cooking gently.
7. Lignin breaks down into guaiacol and related compounds. Smoke compounds stick and dissolve best on cool, moist surfaces, so food takes up most smoke early in cooking.
8. In North American and Western European recipes, ingredients that share aroma compounds are paired more often than chance; in East Asian recipes, cooks often pair ingredients that share few compounds. There is more than one good way to pair flavors.
9. Salt and sweet: salted watermelon, salted caramel. Acid and fat: lime on grilled pork, vinegar on fried fish. Heat and cool: jalapeño with peaches or yogurt. Other correct examples accepted.
10. $1 \div \frac{1}{3} = 3$. Paprika: $3 \times 1 \text{ tablespoon} = 3 \text{ tablespoons}$.
11. It rises to 146 °F, above 145 °F, so it is safe after a 3-minute rest. $(146 - 32) \times \frac{5}{9} = 114 \times \frac{5}{9} \approx 63.3 \text{ }^{\circ}\text{C}$.

12. A flat salsa usually needs salt, and sometimes more acid; add a pinch and taste. If it is too sour, add a little sweetness (honey or more ripe fruit) or a little fat (avocado). If it is too hot, add more fruit or something cool and creamy, and use less pepper next time.

UNIT CHALLENGE: A GRILLED FAMILY DINNER

Plan and cook a grilled (or broiled) dinner for your family with an adult beside you at the grill: a main dish with your own homemade spice rub, a grilled vegetable, and a fresh side that provides contrast (a salsa, a slaw or a fruit salad). Write the grill safety checklist and review it with the adult before you begin.

Make a flavor-pairing chart for the meal, labeling each pairing as shared or contrast, and record every safe internal temperature. Finish with a family rating and a paragraph on what you would change. If you have no grill, use the indoor methods in this unit.

LOOK FOR	WHAT IT MEANS
Safety	Grill checklist completed with the adult; adult lit the grill; long tongs, lid, water or extinguisher ready; never left alone; safe temperatures checked and recorded.
Spice rub	A homemade rub with a clear plan and a name, written as a recipe.
Cooking	Direct and indirect heat used well; foods cooked through but not burnt; clean kitchen and grill area afterward.
Flavor-pairing chart	Every pairing labeled and explained; the dish balanced by tasting.
Reflection	Family ratings and one honest improvement; a dinner that had problems but is well recorded earns full credit.

MEAL PLANNING & THE FAMILY TABLE

A good cook does more than follow a recipe. A good cook plans: what the family will eat this week and this month, what it will cost, how tonight's roast becomes tomorrow's soup, how to cook for twelve as calmly as for four, and how to bring everyone to the table with joy. In this unit you will learn those skills from a USDA economist who planned food budgets for American families, from Jesus' command to gather up the fragments, from Fred Harvey's railroad dining rooms, and from Abraham, who ran to welcome three strangers to a meal.

Everything you have learned this year comes together here. You will price a month of groceries, roast a chicken that feeds the family twice, scale a pot of chili for a crowd, and finally plan, budget, shop for and cook a three-course family feast, set the table, and give thanks. "Whether therefore ye eat, or drink, or whatsoever ye do, do all to the glory of God" (1 Corinthians 10:31).

PREREQUISITES

- Can plan a balanced meal with MyPlate (Unit 2)
- Cooks safely on the stove and in the oven with an adult at home and nearby (Unit 1)
- Knows safe internal temperatures and leftover rules (Unit 1)
- Can multiply and divide fractions and decimals and calculate percentages

MASTERY CHECKLIST

- ☐ I can plan a month of family meals within a grocery budget, using unit prices and cost per serving.
- ☐ I can plan a roast that becomes two or more meals and store leftovers safely.
- ☐ I can scale a recipe up for a crowd, adjust pans and cooking times, and hold food at safe temperatures for serving.
- ☐ I can write a timeline for a multi-course meal so everything is ready at once.
- ☐ I can plan, budget, shop for, cook and serve a three-course family feast, set the table and lead or join in giving thanks.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA Food Plans: Monthly Cost of Food Reports:** Free. The USDA's monthly estimates of what nutritious, balanced meals cost for families of different sizes, at four cost levels. Used in Lesson 8.1.
- **MyPlate Kitchen (on MyPlate.gov):** Free. Hundreds of balanced, budget-friendly recipes from the USDA, many with cost information. Helpful for planning the unit challenge.
- **FoodKeeper app (USDA, on FoodSafety.gov):** Free. Tells how long foods and leftovers keep in the refrigerator, freezer and pantry. Used in Lesson 8.2.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

8.1 Budgeting a Month of Groceries

2 sessions of 50–60 minutes

8.2 Planning for Leftovers: Gather Up the Fragments

2 sessions of 60–90 minutes (on two days)

8.3 Cooking for a Crowd: The Harvey Houses

2 sessions of 50–60 minutes (plus cooking time)

8.4 The Family Feast

2 sessions of 60–90 minutes (plus shopping and the feast itself)

UNIT 8 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**

What did Hazel Stiebeling's 1933 food plans show, and how does the USDA still use the idea?

2. **10 pts**

Calculation: a 24-ounce jar of pasta sauce costs \$3.36 and a 45-ounce jar costs \$5.85. Find each unit price. Which is the better buy?

3. **10 pts**

Calculation: a baked ziti uses ingredients costing \$3.10 (pasta and sauce), \$4.50 (beef), \$3.20 (ricotta and egg) and \$3.60 (other cheese). It serves 8. What is the cost per serving?

4. **8 pts**

Name four ways to lower a family's grocery bill without giving up balanced meals.

5. **8 pts**

What did Jesus command after feeding the five thousand, and how does it apply to a kitchen?

6. **8 pts**

Give four rules for storing and reheating leftovers safely.

7. **8 pts**

How did the Harvey Houses serve a whole trainload of passengers in about 30 minutes?

8. **10 pts**

Calculation: a recipe for 6 uses $1\frac{1}{2}$ pounds of beef and 2 tablespoons of chili powder. What is the scaling factor for 15 servings? How much beef and chili powder do you need?

9. **8 pts**

Why should salt and strong spices not always be multiplied straight up when scaling a recipe?

10. **8 pts**

What is hot holding, and what temperature must food stay at?

11. **6 pts**

Calculation: dinner is at 6:00 p.m. The pork roasts 75 minutes and rests 15 minutes, and you need 20 minutes to prep it first. When must you start prepping?

12. **8 pts**

Short answer: In four or five sentences, explain what Abraham's feast in Genesis 18 teaches about hospitality, and how you will practice it.

ANSWER KEY

1. They showed the amounts of each kind of food a family needed for balanced meals at four cost levels, proving a family could eat well on little money with careful planning and home cooking. The USDA still publishes four food plans and updates their costs every month.
2. $\$3.36 \div 24 = \$0.14$ per ounce. $\$5.85 \div 45 = \$0.13$ per ounce. The 45-ounce jar is the better buy, if the family will use it before it spoils.
3. Total = $\$3.10 + \$4.50 + \$3.20 + \$3.60 = \$14.40$. $\$14.40 \div 8 = \$1.80$ per serving.
4. Any four: plan meals and shop with a list; compare unit prices; build meals around staples like beans, rice, oats, eggs and potatoes; use meat as part of a dish; buy produce in season or frozen; cook at home; use planned leftovers; avoid waste; buy store brands.
5. “Gather up the fragments that remain, that nothing be lost” (John 6:12). In the kitchen it means planning and using leftovers, saving bones for broth and scraps for stock, and not wasting food.
6. Refrigerate within 2 hours (1 hour above 90 °F); use shallow containers; label and date; eat within 3–4 days or freeze; reheat to 165 °F.
7. The train crew telegraphed ahead with the number of passengers, so the kitchen cooked exactly enough and had the first course on the table when they arrived. Trained Harvey Girls served quickly, and every step was planned.
8. $15 \div 6 = 2.5$. Beef: $1.5 \times 2.5 = 3.75$ pounds (3¾ pounds). Chili powder: $2 \times 2.5 = 5$ tablespoons (add about three-quarters first, then taste).
9. In large batches they can taste too strong, and big pots lose less liquid; adding about three-quarters and then tasting and adjusting gives better control.
10. Keeping cooked food hot until it is served, at 140 °F (60 °C) or above, so bacteria cannot grow.
11. $75 + 15 + 20 = 110$ minutes = 1 hour 50 minutes. 6:00 p.m. – 1:50 = 4:10 p.m.
12. Abraham ran to welcome strangers, gave them rest, served the best food he had, involved his household in preparing it, served it all together, and stayed with his guests while they ate. Hospitality is about care, preparation and presence more than fancy food. I can practice it by planning ahead, cooking good food, setting a welcoming table, paying attention to my guests, and giving thanks to God together.

UNIT CHALLENGE: THE FAMILY FEAST

The family feast is the unit challenge and the capstone of the year. Assemble a feast portfolio: the menu card; the budget and shopping list with prices and the cost per person; the timeline with planned and actual times; the recipes in your own words; temperature records for the main dish and any reheated dishes; and photographs or sketches of each course and the table.

Finish with a thank-you note to someone who helped and a one-page reflection on the feast and the year: what you can cook now that you could not cook in September, what you learned about food and about hospitality, and one dish you will keep cooking for your family.

LOOK FOR	WHAT IT MEANS
Planning	A balanced three-course menu with at least three dishes from the year, a budget kept within limits, a complete shopping list and a realistic timeline.
Cooking and safety	Every dish cooked safely with temperatures checked and recorded; kitchen cleaned as you went; leftovers stored correctly.
The table	The table set properly, guests welcomed, food served together and thanks given.
Records	Menu card, budget, timeline, recipes, temperatures and photographs or sketches gathered neatly in the portfolio.
Reflection and thanks	An honest reflection on the feast and the year and a thank-you note; a feast that had problems but is well recorded and graciously served earns full credit.

8.1 BUDGETING A MONTH OF GROCERIES

OBJECTIVES

- Tell how Hazel Stiebeling created the USDA's family food plans at different cost levels in the 1930s, and how the USDA still uses them.
- Calculate unit prices and cost per serving, and plan a month of family dinners within a budget.
- Cook a budget-friendly baked ziti and calculate its cost per serving.

Warm-up. Guess how much your family spends on groceries in a week. Then ask a parent (if they are willing to share) or look at one grocery receipt. How close was your guess? Which item on the receipt cost the most?

WATCH

How Can I Save Money on Groceries?

Two Cents • 6:31

https://www.youtube.com/watch?v=1VAZmcJ6_50

WHEN TO WATCH

After the kitchen-science paragraph. Listen for the tips about planning, unit prices and food that goes to waste.

Note: From PBS's personal-finance series.

BACKUP VIDEO

Unit pricing helps you save money at the grocery store | Consumer Reports

Consumer Reports • 1:48

<https://www.youtube.com/watch?v=KMe85qahPbk>

Before your store visit, to review how to read a shelf tag's unit price.

KEY TERMS

budget

A plan for how much money will be spent on something over a period of time, such as groceries for a month.

cost per serving

The total cost of a recipe divided by the number of servings it makes.

food plan

A list of the kinds and amounts of food a family needs for balanced meals over a period of time, with its cost.

unit price

The price per ounce, pound, count or other unit, printed on most shelf tags. It lets you compare packages of different sizes.

staple

A basic food a household uses often and keeps on hand, such as rice, flour, oats, beans, eggs, milk and onions.

CORE IDEAS

The story. In the early 1930s, during the Great Depression, millions of American families had very little money for food. Hazel Stiebeling, an economist and nutrition scientist at the U.S. Department of Agriculture's Bureau of Home Economics, asked a practical question: what is the least a family can spend and still eat balanced, nourishing meals? And what could a family eat with a little more money?

How they figured it out. In 1933 Stiebeling and her colleague Medora Ward published food plans at four cost levels. They worked out how many pounds of milk, grains, potatoes, beans, vegetables, fruit, eggs, meat and fats a family needed each week to meet its nutrient needs, then priced those amounts at the stores. The cheaper plans used more grains, beans, potatoes and milk and less meat; the more generous ones added more variety. Their work showed that a family could eat well on very little if it planned carefully and cooked at home. The USDA still publishes four food plans and updates their cost every month, for families of different sizes and ages.

The kitchen science. Planning is the cook's best money-saver. Plan the week's dinners first, then write a list from the recipes and check what is already in the pantry. Compare **unit prices**: a 32-ounce jar for \$4.80 costs 15¢ an ounce, while a 24-

ounce jar for \$3.84 costs 16¢ an ounce, so the larger one is the better buy if you will use it. Build meals around inexpensive, nutrient-dense **staples**: dried beans, rice, oats, pasta, eggs, potatoes, carrots, cabbage, onions, bananas and frozen vegetables. Use meat as one part of a dish rather than the whole plate. Buy produce in season. Most of all, use what you buy: food thrown away is money thrown away. To find a recipe's **cost per serving**, add up the cost of the amount of each ingredient you actually used (not the whole package), then divide by the number of servings.

Let's cook. You will make a family-size baked ziti with meat sauce and calculate exactly what each serving cost. The skill to do well is **pricing a recipe**: finding the cost of the part of each package you used, and keeping careful records.

PICTURE STUDY



Canned Goods in a Company Store, Gary, West Virginia, Russell Lee, for the U.S. Department of the Interior, 1946 · Photograph · National Archives, College Park, Maryland

Image: [Wikimedia Commons](#), public domain

In many coal-mining towns, families bought their groceries at a store owned by the mining company. The photographer Russell Lee recorded this store in Gary, West Virginia, in 1946, when canned foods had become an everyday part of American cooking. Notice how many choices a shopper had, and how few prices are easy to compare at a glance.

Look closely

- Find the different kinds of cans. Which foods can you identify?
- Look for any price signs. How would a shopper compare the cost of two brands?
- Look at how the shelves are arranged. Which items are easiest to reach?
- Compare this store with your grocery store. What is the same and what is different?

Talk about it

1. Canned foods are often inexpensive and keep a long time. How could a family use them in a budget meal plan?
2. Shelf tags with unit prices were not common until the 1970s. How do they help you shop today?

3. If a family could shop at only one store, why would careful planning matter even more?

Safety first. Cook ground meat to 160 °F (71 °C). The baked ziti contains egg and should reach 165 °F (74 °C) in the center. Use oven mitts for the heavy, hot baking dish, with an adult at home and nearby. Refrigerate leftovers within 2 hours.

Count the Cost: Budget Baked Ziti

You will cook a family dinner and price it to the penny, then plan four weeks of family dinners within a budget your parent sets, using the USDA food plans as a guide.

You will need

- A large pot and a colander
- A large skillet and a wooden spoon
- A 9 × 13-inch baking dish and foil
- A medium bowl, measuring cups and spoons
- An instant-read food thermometer
- Grocery receipts or a store's website, a calculator and your cook's notebook

BUDGET BAKED ZITI WITH MEAT SAUCE

Serves 8 · Prep 20 min · Cook 15 min · Bake 35 min

Ingredients

- 1 pound (450 g) ziti or penne
- 1 pound (450 g) ground beef or bulk Italian sausage
- 1 onion, chopped
- 3 cloves garlic, minced
- 1 can (28 ounces) crushed tomatoes
- 1 can (15 ounces) tomato sauce
- 2 teaspoons dried Italian seasoning
- 1 teaspoon salt and $\frac{1}{4}$ teaspoon pepper
- 1 container (15 ounces) ricotta cheese
- 1 large egg
- $\frac{1}{2}$ cup (40 g) grated parmesan, divided
- 2 cups (8 ounces, 225 g) shredded mozzarella

- 2 cups frozen spinach, thawed and squeezed dry (optional)

Method

1. Heat the oven to 375 °F (190 °C). Wash your hands. Cook the pasta in salted boiling water for 2 minutes less than the package says. Drain.
2. In the skillet over medium heat, cook the meat and onion, breaking up the meat, 8–10 minutes, until no pink remains and the meat reads 160 °F (71 °C). Spoon off excess fat into a can. Add the garlic for 30 seconds.
3. Stir in the crushed tomatoes, tomato sauce, Italian seasoning, salt and pepper. Simmer 10 minutes.
4. In the bowl, stir together the ricotta, egg, $\frac{1}{4}$ cup parmesan and the spinach.
5. Toss the drained pasta with about two-thirds of the sauce. Spread half in the baking dish. Dot with the ricotta mixture and sprinkle with half the mozzarella. Add the rest of the pasta, then the remaining sauce, mozzarella and parmesan.
6. Cover with foil and bake 20 minutes. Uncover and bake 15 minutes more, until bubbly and golden and the center reads 165 °F (74 °C).
7. Rest 10 minutes, then serve with a green salad. Refrigerate leftovers within 2 hours; they make good lunches.
8. Clean up: soak the baking dish and wash the pot, skillet and bowl.

Allergy check: Contains wheat (pasta), milk (ricotta, mozzarella, parmesan) and eggs. For wheat-free, use gluten-free pasta. For egg-free, leave the egg out of the ricotta. For milk-free, skip the cheeses and add a layer of sautéed vegetables.

Steps

1. **Price the recipe.** Make a table: Ingredient · Package size · Package price · Amount used · Cost of amount used. For each ingredient, divide the package price by the package size to get the unit price, then multiply by the amount used. Add the column for the total cost, then divide by 8 for the cost per serving.
2. **Unit-price hunt.** At the store or on a store's website, compare unit prices for three items in two sizes or two brands (for example, pasta, shredded cheese and canned tomatoes). Which is the better buy each time?

3. Cook the recipe and serve it. Record the family's ratings from 1 to 5.
4. **Plan a month.** Ask a parent to set a dinner budget for four weeks. Look up the current USDA food plan cost for a family your size. Plan 20 dinners (five a week), estimate each one's cost, and keep the total within the budget. Use at least three dinners from this year's lessons.
5. **Improve it.** Write one way to lower the cost of the ziti without losing flavor (half the meat with more vegetables, store-brand cheese, or dried herbs bought in bulk).
6. Clean up: wash, dry and put away everything.

Tips

- The unit price on a shelf tag is often in small print in a corner. Check that both tags use the same unit (ounces, not ounces and pounds).
- Bigger is not always cheaper per ounce. Compare.
- Baked ziti freezes well. Assemble a second pan, wrap it well, and freeze it for a busy night; bake it from frozen for about 1 hour 15 minutes, covered, until it reaches 165 °F.

Check your work

- ☐ I can tell how Stiebeling's food plans helped families eat well on a budget.
- ☐ I can calculate unit prices and cost per serving.
- ☐ I priced a recipe to the penny and planned a month of dinners within a budget.

COOK'S NOTEBOOK

1. Copy your recipe-cost table neatly with the total and cost per serving.
2. Write your 20-dinner plan as a calendar, with the estimated cost of each dinner and the total.
3. List ten inexpensive, nutrient-dense staples and one dinner you could make from each.

From history. Hazel Stiebeling later led the USDA's Bureau of Human Nutrition and Home Economics and helped plan the first national surveys of what American families actually ate. The USDA's four food plans, from thrifty to generous, are still updated every month and are used by families, schools and courts to estimate the cost of feeding a household.

COMMON MISTAKES

- Pricing the whole package instead of the amount used. Divide to find the cost of just what the recipe needs.
- Buying the biggest package without checking whether you will use it before it spoils.
- Shopping without a list. Plan meals first, write the list, and stick to it.

Make it a game • Price Is Close. Pick four pantry items and have your parent invent a price for each. In sixty seconds, work out each unit price and the cost per serving. Then decide which is the better buy and why. Tell how Hazel Stiebeling made family food plans at different costs. Keep a running score across weeks.

Scripture. “For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it?” (Luke 14:28, KJV)

Jesus used ordinary planning as an example of wisdom. Counting the cost before you shop is part of caring well for a household.

8.2 PLANNING FOR LEFTOVERS: GATHER UP THE FRAGMENTS

OBJECTIVES

- Explain Jesus’ command to “gather up the fragments” in John 6 and how planned leftovers save money and food.
- Plan a roast chicken that becomes two meals, and store, label and reheat leftovers safely.
- Roast a whole chicken to 165 °F, carve it, make broth from the bones, and cook a chicken and rice soup the next day.

Warm-up. Open the refrigerator with a parent and list every leftover in it. For each, write when it was made (ask if you are not sure). Which ones should be eaten today, which can wait, and which should be thrown away?

WATCH

How to Make the Perfect Roast Chicken in One Hour

America's Test Kitchen • 8:44

<https://www.youtube.com/watch?v=A7jwsYPnrSk>

WHEN TO WATCH

Before you roast the chicken. Watch where the thermometer goes in each part.

Note: From America’s Test Kitchen. Their method starts the chicken in a preheated skillet; our recipe uses a simple roasting pan.

KEY TERMS

planned leftovers

Food cooked on purpose in a larger amount so part of it becomes a different meal later.

carcass

The bones and frame of a roasted bird left after the meat is removed. It makes excellent broth.

stock or broth

A flavorful liquid made by simmering bones, meat or vegetables in water. Stock is usually made mostly from bones; broth more from meat.

carving

Cutting cooked meat into serving pieces, following the joints and slicing across the grain.

label and date

Writing what a container holds and the date it was made, so the family knows what to eat first.

CORE IDEAS

The story. On a hillside by the Sea of Galilee, a crowd of about five thousand men, besides women and children, had followed Jesus far from any town, and they were hungry. A boy had five barley loaves and two small fishes. Jesus gave thanks, and the disciples handed out the food until everyone had eaten as much as they wanted. Then Jesus said, “Gather up the fragments that remain, that nothing be lost.” The disciples filled twelve baskets with the pieces that were left (John 6:9-13).

How they figured it out. Jesus had just made food out of almost nothing, yet He did not let even the crumbs go to waste. Careful households have always lived by that rule. Families of the past roasted a large joint of meat on Sunday, ate it cold on Monday, minced it into hash on Tuesday and boiled the bones for soup. During World War I, the U.S. Food Administration printed posters asking families to buy food with thought, serve just enough, and “use what is left.” The USDA estimates today that between 30 and 40 percent of the food supply in the United States goes uneaten. A cook who plans leftovers on purpose wastes less, spends less and works less.

The kitchen science. A whole chicken is one of the best values in the store. Roasted, it gives a family dinner; its leftover meat becomes sandwiches, salads, tacos or soup; and its **carcass**, simmered in water, gives broth, because long simmering pulls gelatin from the bones and connective tissue and flavor from the meat and vegetables. Safety makes planned leftovers work: chill cooked meat within 2 hours in shallow containers, **label and date** everything, eat refrigerated leftovers within 3–4 days or freeze them, and reheat them to 165 °F (74 °C). Broth must be cooled quickly

too: divide it into small containers, or set the pot in a sink of ice water and stir. Fat that rises and hardens on chilled broth can be lifted off easily.

Let's cook. On day one you will roast a whole chicken with vegetables, carve it, and save the bones and extra meat. On day two you will turn the carcass into broth and the meat into chicken and rice soup. The skill to do well is **carving a whole bird:** cutting through the joints, not the bones, to separate the legs, thighs and wings, then slicing the breast across the grain.

PICTURE STUDY



The Gleaners, Jean-François Millet, 1857 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

Gleaning was the old custom, commanded in the law of Moses (Leviticus 19:9-10), of letting the poor gather the grain left behind after the harvest. Millet shows three women carefully picking up what would otherwise be wasted. Every stalk they gather will become bread for their families.

Look closely

- Find the three women. What is each one doing with her hands?
- Look at the great stacks of grain in the distance. How do they compare with what the women gather?
- Look at the women's bodies. How long do you think they have been working?
- Find the man on horseback in the distance. Who do you think he is?

Talk about it

1. How is gleaning like Jesus' command to gather up the fragments?
2. What "gleanings" are left in your kitchen after a meal? How could they become another meal?
3. Millet painted poor workers with great dignity. What do you think he wanted people to notice?

Safety first. Do not wash raw chicken; it splashes germs. Keep raw chicken on its own board and wash hands after handling it. Cook the chicken to 165 °F (74 °C) in the thickest part of the breast and thigh, not touching bone. Carve with an adult nearby. Chill leftovers and broth within 2 hours, label and date them, and reheat to 165 °F.

KITCHEN PROJECT

One Bird, Two Dinners: Roast Chicken and Next-Day Chicken and Rice Soup

You will plan and cook two family dinners from one chicken, keep a leftover log, and calculate how much the second meal cost compared with buying everything new.

You will need

- A roasting pan or large oven-safe skillet
- Two cutting boards (one for raw chicken, one for carving), a damp towel, a chef's knife and a carving fork
- Kitchen twine (optional)
- An instant-read food thermometer and oven mitts
- A large stockpot, a strainer and a large bowl
- Shallow containers with lids, masking tape and a marker for labels

HERB-ROASTED CHICKEN WITH VEGETABLES, AND NEXT-DAY CHICKEN AND RICE SOUP

Serves 6 for each dinner • Day 1: Prep 20 min • Roast 1¼–1½ hr • Rest 15 min. Day 2: Broth 2 hr • Soup 30 min

Ingredients

- **Day 1, roast chicken:** 1 whole chicken, 5–6 pounds (2.3–2.7 kg)
- 2 tablespoons softened butter or olive oil
- 1½ teaspoons salt and ½ teaspoon pepper
- 1 teaspoon dried thyme and 1 teaspoon dried rosemary (or 1 tablespoon each fresh)
- 1 lemon, halved, and 4 cloves garlic, smashed
- 2 pounds (900 g) potatoes and 1 pound (450 g) carrots, cut in 1½-inch chunks, tossed with 1 tablespoon oil and ½ teaspoon salt
- **Day 2, broth:** the chicken carcass and any bones
- 1 onion (quartered), 1 carrot and 1 celery rib (in chunks), 1 bay leaf, 10 cups (2.4 L) water

- **Day 2, soup:** 1 tablespoon olive oil, 1 onion, 2 carrots and 2 celery ribs, diced
- 8 cups (2 L) of your homemade broth (add store broth if you have less)
- $\frac{3}{4}$ cup (140 g) long-grain white rice
- 2–3 cups shredded leftover chicken
- 2 tablespoons chopped parsley and 1 tablespoon lemon juice; salt and pepper to taste

Method

1. **Day 1.** Heat the oven to 425 °F (220 °C). Wash your hands. Take the chicken from the package (do not rinse it), remove any giblets, and pat it dry with paper towels. Wash your hands.
2. Rub the chicken all over with the butter, salt, pepper and herbs. Put the lemon and garlic inside. Tie the legs together if you like. Set the chicken breast side up in the pan and arrange the potatoes and carrots around it. Wash your hands and the raw-meat board.
3. Roast $1\frac{1}{4}$ – $1\frac{1}{2}$ hours, until the thickest part of the breast and the thigh (not touching bone) both read at least 165 °F (74 °C) and the juices run clear. Stir the vegetables once halfway.
4. Rest the chicken 15 minutes on a clean board. With an adult nearby, carve: cut through the skin between leg and body, bend the leg out and cut through the joint; separate thigh and drumstick at their joint; remove the wings; then slice each breast off the bone and cut it across the grain. Serve with the vegetables.
5. Within 2 hours, pull the leftover meat off the bones into a shallow container. Put the carcass in a bag. Label and date both and refrigerate.
6. **Day 2, broth.** Put the carcass, onion, carrot, celery, bay leaf and water in the stockpot. Bring to a boil, then simmer gently, uncovered, $1\frac{1}{2}$ –2 hours. Strain into a large bowl and discard the solids. Skim off fat.
7. **Soup.** In the stockpot, warm the oil over medium heat and cook the diced onion, carrots and celery 6–8 minutes. Add 8 cups broth and bring to a boil. Stir in the rice, cover and simmer 15–18 minutes until tender. Add the chicken and heat until the soup reads 165 °F. Stir in parsley and lemon juice, and season to taste.

8. Cool any extra broth or soup quickly in shallow containers, label, and refrigerate (3–4 days) or freeze (2–3 months). Clean up: wash boards, knife, pans and pot in hot, soapy water.

Allergy check: Contains milk if you use butter (use oil instead for milk-free). Celery is not one of the nine major U.S. allergens. No wheat, eggs or nuts.

Steps

1. **Plan.** Before shopping, write both dinners on one plan with a single shopping list.
2. **Temperature log.** Record the breast and thigh temperatures and where you placed the thermometer.
3. **Yield.** Weigh or measure the meat left after dinner one. How many cups did you save for day two?
4. **Leftover log.** Make labels for every container with contents and date. Keep a log of when each leftover was eaten, frozen or thrown away over the next week.
5. **Cost check.** Divide the cost of the chicken across the two dinners. Then estimate what the soup would have cost if you had bought fresh chicken and boxed broth. How much did planned leftovers save?
6. **Taste test and improve it.** Ask your family to rate both dinners from 1 to 5. Write one change (a different third meal, such as chicken salad or tacos, or noodles instead of rice).
7. Clean up: wash, dry and put away everything.

Tips

- Drying the chicken well and roasting at high heat gives crisp, golden skin.
- Save onion ends, carrot peels and celery leaves in a freezer bag through the week; add them to the broth pot.
- Cook the rice in the soup just before serving; rice left in soup overnight soaks up the broth.

Check your work

- ☐ I can explain how planned leftovers follow Jesus' command to waste nothing.

- ☐ I roasted and carved a chicken safely, made broth and turned leftovers into a second dinner.
- ☐ I labeled, dated and stored leftovers correctly.

COOK'S NOTEBOOK

1. Draw a diagram of a roast chicken and mark the joints you cut to carve it and where the thermometer goes.
2. Draw a flow chart: one chicken → dinner one → leftover meat and bones → broth → soup → more meals.
3. Write your cost-check calculation and your leftover log.

From history. During World War I, the U.S. Food Administration asked Americans to observe “wheatless” and “meatless” days so more food could be shipped to soldiers and to hungry people in Europe. Its posters taught a generation of cooks to use every scrap. Many grandmothers’ thrifty kitchen habits began there and during the hard years of the 1930s.

COMMON MISTAKES

- Rinsing raw chicken in the sink. It spreads germs; pat it dry instead.
- Leaving the carcass and meat out on the counter after dinner. Chill them within 2 hours.
- Cooling a big pot of broth on the stove. Divide it into shallow containers or stir it in an ice bath first.

Make it a game • Second Life Relay. Your parent names a leftover: roast chicken carcass, plain rice, stale bread. In thirty seconds you name two new meals it could become and how to store it: label, date, cool fast. Do eight rounds. Finish by explaining what Jesus meant in John 6 when He said to gather up the fragments.

Scripture. “When they were filled, he said unto his disciples, Gather up the fragments that remain, that nothing be lost.” (John 6:12, KJV)

Even after a miracle of plenty, Jesus cared about the leftovers. Using food well honors the One who gave it.

8.3 COOKING FOR A CROWD: THE HARVEY HOUSES

OBJECTIVES

- Tell how Fred Harvey and the Harvey Girls served fast, excellent meals to railroad travelers across the American West, beginning in 1876.
- Scale a recipe up for 12 with a scaling factor, adjust equipment and cooking times, and keep food at safe temperatures for serving a crowd.
- Cook a big pot of beef and bean chili for 12 with a toppings bar, and serve it safely.

Warm-up. Your church or family is having 12 guests for supper, and you have a recipe for 4. Without looking anything up, write down everything that will be different about cooking for 12 instead of 4. Keep your list to check at the end.

WATCH

Small Wonders: Harvey Houses, The Harvey Girls & Their Legacy of Settlement in the American West

Colorado Railroad Museum • 13:35

<https://www.youtube.com/watch?v=zRBd6jcPOul>

WHEN TO WATCH

After the story. Watch for how the Harvey Houses fed a trainload of passengers in about half an hour.

Note: From the Colorado Railroad Museum. It is long; the first half covers the story in this lesson.

BACKUP VIDEO

Scaling a Recipe

Association of Nutrition & Foodservice Professionals • 1:38

<https://www.youtube.com/watch?v=nTZLHfpvOF0>

Before you scale your recipe. A short lesson on the conversion factor from a food-service professional association.

KEY TERMS

scaling factor

The number you multiply every ingredient by to change a recipe's yield: $\text{new servings} \div \text{original servings}$.

yield

How much a recipe makes, in servings, cups or pieces.

hot holding

Keeping cooked food at 140 °F (60 °C) or above until it is served, so bacteria cannot grow.

mise en place

French for “everything in its place”: having every ingredient measured and every tool ready before you start cooking. Say it “meez ahn PLAHS.”

service

The time when food is being served to guests, and the work of serving it.

CORE IDEAS

The story. In the 1870s, railroads were carrying travelers across the American West, but the food at the stops along the way was often terrible: stale, greasy and overpriced, gulped down in a hurry before the train left. Fred Harvey, an English-born businessman who had come to America as a teenager and worked his way up from washing dishes, made a deal with the Atchison, Topeka and Santa Fe Railway. In 1876 he opened a clean, well-run lunchroom at the depot in Topeka, Kansas. It was such a success that Harvey Houses soon stood all along the Santa Fe line, from Kansas to California.

How they figured it out. The problem was time: a train stopped for only about 30 minutes, and a whole trainload of hungry passengers had to be fed and back on board. The Harvey system solved it with planning. The train crew sent a message ahead by telegraph saying how many passengers wanted meals, so the kitchen knew exactly how much to cook. The first course was on the table when the passengers walked in. Harvey hired young women, the famous Harvey Girls, trained them carefully, and gave them strict standards of courtesy and cleanliness. Fresh food arrived by refrigerated rail car, and Harvey insisted on generous portions: pies, it was said, were cut into four pieces, not six. Every detail was planned so that a crowd could be served quickly, safely and well.

The kitchen science. To scale a recipe, find the **scaling factor**: $\text{new yield} \div \text{old yield}$. Chili for 6 becomes chili for 12 with a factor of 2; a recipe for 4 becomes one for 12 with a factor of 3. Multiply every ingredient. But some things do not scale perfectly. Salt and strong spices can taste too strong when simply multiplied, so add about three-quarters, then taste and adjust. A bigger pot takes longer to heat and to brown meat (brown in batches so it browns instead of steaming). Make sure your pot is big enough: a quarter of the space should stay empty. Food safety matters more with a crowd: keep hot food at 140 °F (60 °C) or above, keep cold food at 40 °F or below, and never leave food in the danger zone for more than 2 hours. Plan your **mise en place** and a timeline, as the Harvey kitchens did.

Let's cook. You will scale a family chili recipe up to 12 servings and serve it with a toppings bar, keeping it hot on the stove or in a slow cooker set to warm. The skill to do well is **browning meat in batches** in a large pot, so it browns well, then building a big pot of chili step by step.

PICTURE STUDY



A Harvey House Lunchroom, Casa del Desierto, Barstow, California, Unknown photographer (historic postcard, copied by the Historic American Buildings Survey), early 1900s · Photograph of a postcard · Library of Congress, Washington, D.C.

Image: [Wikimedia Commons](#), public domain

Casa del Desierto was the Harvey House at the railroad depot in Barstow, California, opened in 1911. Passengers who wanted a quick meal ate at the lunch counter, served by Harvey Girls in crisp white aprons, while the dining room served full dinners. The card's caption says the lunchrooms “admirably take care of those who wish a light repast.”

Look closely

- Find the Harvey Girls. What are they wearing, and what are they doing?
- Look at the long counters. Why would counters with stools help serve many people quickly?
- Find the windows. Where might the trains have been?
- Look at the travelers. Do they look hurried or comfortable?

Talk about it

1. How did a Harvey House kitchen know how much food to cook before a train arrived?
2. What would have to be ready before the travelers walked in? Make a short list.

3. Which ideas from the Harvey Houses could you use when you cook for a crowd at home or church?

Safety first. Brown ground beef to 160 °F (71 °C) in batches, with an adult at home and nearby. A full pot of chili is very heavy and very hot: use two hands and oven mitts, or ask an adult to move it. Hold the chili at 140 °F or above while serving, refrigerate leftovers in shallow containers within 2 hours, and reheat to 165 °F.

The Harvey Way: Big-Batch Chili for 12

You will scale a chili recipe from 6 to 12 servings, write a timeline and a mise en place list, cook and serve it to a crowd (your family plus guests, or a church or neighborhood supper), and keep a serving log of temperatures.

You will need

- A large heavy pot or Dutch oven (at least 8 quarts) with a lid
- A cutting board, a damp towel and a chef's knife
- A wooden spoon and a ladle
- Measuring cups and spoons
- An instant-read food thermometer
- Small bowls for the toppings bar, and a slow cooker (optional) for keeping chili hot

BIG-BATCH BEEF AND BEAN CHILI FOR 12

Serves 12 (about 1½ cups each) • Prep 30 min • Cook 1 hr

Ingredients

- 3 pounds (1.4 kg) ground beef (85% lean)
- 2 tablespoons vegetable oil
- 2 large onions, diced
- 2 bell peppers, diced
- 6 cloves garlic, minced
- ¼ cup chili powder
- 2 tablespoons ground cumin
- 2 teaspoons dried oregano
- 1½ teaspoons smoked paprika
- 2 cans (28 ounces each) crushed tomatoes
- 4 cans (15 ounces each) kidney or pinto beans, drained and rinsed
- 2 cups (480 mL) beef broth or water

- 2 teaspoons salt to start (taste and add more at the end)
- **Toppings bar:** shredded cheddar, sour cream or plain yogurt, chopped green onions, diced avocado, lime wedges, tortilla chips or cornbread

Method

1. Wash your hands and set out every ingredient (mise en place).
2. Heat 1 tablespoon oil in the large pot over medium-high heat. Brown one-third of the beef, breaking it up, until no pink remains, 6–8 minutes. Move it to a bowl with a slotted spoon. Repeat with the rest of the beef in two more batches. Check that it reached 160 °F (71 °C). Spoon off all but 2 tablespoons of fat into a can.
3. Add the remaining oil, the onions and peppers, and cook 8–10 minutes until soft. Add the garlic, chili powder, cumin, oregano and paprika and stir for 1 minute.
4. Return the beef to the pot. Add the tomatoes, beans, broth and salt. Bring to a boil, then lower the heat, partly cover and simmer 45 minutes, stirring every 10 minutes and scraping the bottom.
5. Taste and adjust the salt and spices. Keep the chili at 140 °F or above for serving, over low heat on the stove or in a slow cooker set to warm.
6. Set out the toppings bar in small bowls, with cold toppings kept chilled until serving time.
7. Refrigerate leftovers in shallow containers within 2 hours. Chili freezes well for up to 3 months.
8. Clean up: soak the pot, wash the board, knife and bowls, and wipe every surface.

Allergy check: The chili contains none of the nine major allergens; check broth and spice labels. Toppings may contain milk (cheese, sour cream) and wheat (cornbread often contains wheat and eggs). Label the toppings bar so guests with allergies can choose safely.

Steps

1. **Scale.** Start from a family recipe for 6 (1½ pounds beef, 1 onion, 1 pepper, 3 cloves garlic, 2 tablespoons chili powder, 1 tablespoon cumin, 1 can tomatoes, 2 cans beans, 1 cup broth, 1 teaspoon salt). Write the scaling factor

for 12 and the new amount of each ingredient. Compare your list with the recipe card. Then scale it again for 30 servings.

2. **Timeline.** Working backward from serving time, write when you will shop, prep, brown, simmer, set out toppings and set the table.
3. **Serving log.** Check the chili's temperature when serving starts and every 30 minutes until it is put away. Keep it at 140 °F or above.
4. **Labels.** Make small labels for the toppings bar listing any major allergens.
5. **Taste test.** Ask guests to rate the chili from 1 to 5 and name their favorite topping.
6. **Improve it.** Compare your warm-up list with what really changed. Write two lessons for the next time you cook for a crowd.
7. Clean up: wash, dry and put away everything.

Tips

- Chili tastes even better the next day. Making it a day ahead and reheating it to 165 °F frees you up on the day of the meal.
- Ask helpers to do one job each: chopping, setting the table, filling topping bowls, pouring water.
- If the chili scorches on the bottom, do not scrape the burnt layer up; move the unburnt chili to a clean pot.

Check your work

- ☐ I can tell how the Harvey Houses fed a crowd quickly and well.
- ☐ I can scale a recipe with a scaling factor and adjust seasoning and cooking for a large batch.
- ☐ I cooked and served chili for 12 and kept it at a safe temperature.

COOK'S NOTEBOOK

1. Write your scaling table for 6, 12 and 30 servings.
2. Draw the layout of your serving table: the chili, the toppings bar, bowls, spoons and napkins, in the order guests will use them.
3. Write your serving log and two lessons learned.

From history. Harvey Houses grew into a chain of restaurants, hotels and dining cars that set a new standard for American travel. Thousands of young women worked as Harvey Girls between the 1880s and the 1950s, and many of them settled in the West and raised families there. Some Harvey House buildings still stand as museums and restaurants.

COMMON MISTAKES

- Browning all the meat at once in a crowded pot. It steams and turns gray; brown it in batches.
- Multiplying salt and cayenne straight up. Add about three-quarters, then taste and adjust.
- Leaving chili and toppings out for the whole evening. Keep hot food at 140 °F or above and cold food cold, and put food away within 2 hours.

Make it a game • Train Arriving. Your parent announces, in a grand voice, that a train will arrive in thirty minutes. You are the Harvey House manager. State the scaling factor to take a recipe from 4 servings to 12, convert three ingredients your parent calls out, and name the hot-holding temperature. Fred Harvey would approve. Then swap roles.

8.4 THE FAMILY FEAST

OBJECTIVES

- Tell how Abraham welcomed three strangers with a feast (Genesis 18) and what it teaches about hospitality.
- Plan a balanced three-course family feast with a menu, a budget, a shopping list and a timeline.
- Cook and serve the feast, set the table, welcome the family and lead or join in giving thanks.

Warm-up. Remember the best meal you have ever shared with family or friends. Write down three things that made it special. How many of them were about the food, and how many about the people and the table?

WATCH

How to Set a Table - Life Skills with Griffin Churchill

[GriffinsLifeSkills](https://www.youtube.com/watch?v=hpKYnvcx1Ao) • 1:51

<https://www.youtube.com/watch?v=hpKYnvcx1Ao>

WHEN TO WATCH

Before you set the table for the feast. Watch where the forks, knives, spoons and glass go, then set one place yourself.

Note: A short, simple demonstration of a basic place setting.

KEY TERMS

hospitality

Welcoming guests warmly and caring for their needs, especially with food, rest and kindness.

course

One part of a meal served at a time, such as a starter (soup or salad), a main course and a dessert.

menu

The list of dishes to be served at a meal, in order.

timeline

A schedule that works backward from serving time, listing when each step must start so that every dish is ready at once.

grace

A short prayer of thanks to God before (or after) a meal.

CORE IDEAS

The story. One hot afternoon, as Abraham sat at the door of his tent by the oaks of Mamre, he looked up and saw three men standing nearby. He ran to meet them, bowed, and begged them to stay and rest. Then he hurried into the tent and asked Sarah to quickly make cakes from fine meal. He ran to the herd, chose a tender calf, and had a young man prepare it. Then he brought butter and milk and the meat, set it all before his guests, and stood by them under the tree while they ate (Genesis 18:1-8). Abraham did not yet know that his guests were messengers of the Lord. He simply welcomed strangers with the best he had.

How they figured it out. Notice how Abraham's feast worked: he planned quickly, gave each person a job (Sarah baked, the young man prepared the meat), chose the best ingredients he had, served everything together, and then stayed with his guests while they ate. Good hosts in every age have done the same. Hospitality is not about fancy food; it is about care, preparation and presence. The New Testament reminds us, "Be not forgetful to entertain strangers: for thereby some have entertained angels unawares" (Hebrews 13:2).

The kitchen science. A feast is many recipes cooked at once, and the secret is the **timeline**. Choose a menu that balances your oven, stovetop and refrigerator: a starter that can be made ahead (a soup reheated or a salad dressed at the last minute), a main course that roasts in the oven, sides that cook on the stovetop or share the oven, and a dessert made the day before or one that bakes while you eat. Write down how long each dish takes, then work backward from serving time. Remember that roasts must rest, which frees the oven for rolls or vegetables. Balance the plate with MyPlate, balance the flavors with salt, acid, sweetness and

texture, and keep food safety in every step. Then set the table, welcome everyone, and give thanks.

Let's cook. You will plan and cook a three-course family feast using at least three dishes from this year. A model menu: *starter*, sweet-potato and carrot soup (Lesson 2.2) or a green salad with vinaigrette; *main*, garlic-herb roast pork loin (below) with roasted potatoes and green beans and crusty bread (Lesson 5.4); *dessert*, apple galette (Lesson 5.2) with homemade vanilla ice cream (Lesson 4.4). The skill to do well is **running the whole kitchen**: following your timeline, cleaning as you go, and asking for help when you need it, with an adult at home and nearby.

PICTURE STUDY



Saying Grace (Le Bénédicité), Jean-Siméon Chardin, 1740 · Oil on canvas · Musée du Louvre, Paris

Image: [Wikimedia Commons](#), public domain

Chardin painted this quiet family moment in 1740. A mother is serving the midday meal, and before anyone eats, the youngest child says grace. The French king Louis XV liked this painting so much that it was presented to him and hung in his collection.

Look closely

- Find the soup tureen and the bowls. What is the mother doing?
- Find the youngest child. What is she doing with her hands?
- Look at the faces of the mother and the older sister. How do they feel about the little one's prayer?
- Find the chair, the table and the simple things in the room. Is this a rich home or an ordinary one?

Talk about it

1. How is this simple meal like a feast, even though the food is plain?
2. Why do you think Chardin chose the moment before the meal, rather than the meal itself?
3. Who will say grace at your feast? What will you thank God for?

Safety first. Plan oven space and timing so nothing is rushed. Cook the pork loin to 145 °F (63 °C) and rest it at least 3 minutes; reheat any made-ahead soup to 165 °F. Keep hot dishes hot and cold dishes cold, and put leftovers away within 2 hours. An adult is at home and nearby for all cooking; ask for help moving heavy, hot pans.

The Family Feast

You will plan, budget, shop for and cook a three-course feast for your family, set the table, welcome everyone, and give thanks. Your plan should use at least three dishes from this year's lessons and fill every MyPlate group. Below is the recipe for the model main course.

You will need

- Your cook's notebook with every recipe you will use
- A roasting pan with a rack (or a rimmed baking sheet), a carving board and a sharp knife
- An instant-read food thermometer and oven mitts
- The pans and tools each of your other recipes needs
- A tablecloth or place mats, plates, bowls, glasses, forks, knives, spoons and napkins
- A calculator and the store's prices for your budget

GARLIC-HERB ROAST PORK LOIN WITH ROASTED POTATOES AND GREEN BEANS (FEAST MAIN COURSE)

Serves 6–8 • Prep 25 min • Roast 1–1¼ hr • Rest 15 min

Ingredients

- 1 boneless pork loin roast, 3 pounds (1.4 kg)
- 4 cloves garlic, minced
- 1 tablespoon chopped fresh rosemary (or 1 teaspoon dried)
- 1 tablespoon chopped fresh thyme (or 1 teaspoon dried)
- 2 teaspoons kosher salt and 1 teaspoon black pepper
- 1 tablespoon Dijon mustard
- 3 tablespoons olive oil, divided
- 2½ pounds (1.1 kg) small potatoes, halved, tossed with 1 tablespoon oil and ½ teaspoon salt

- 1 pound (450 g) green beans, trimmed, tossed with 1 teaspoon oil and a pinch of salt
- 1 lemon, cut in wedges

Method

1. Heat the oven to 425 °F (220 °C). Wash your hands. Pat the pork dry on the raw-meat board.
2. Stir together the garlic, rosemary, thyme, salt, pepper, mustard and 2 tablespoons oil. Rub it all over the pork. Wash your hands and the board.
3. Set the pork, fat side up, on the rack in the roasting pan. Spread the potatoes on a separate baking sheet.
4. Roast the pork and potatoes together for 20 minutes. Then lower the oven to 375 °F (190 °C) and keep roasting until the center of the pork reads 145 °F (63 °C), about 40–55 minutes more. Stir the potatoes once.
5. Move the pork to the carving board, cover it loosely with foil and rest 15 minutes. While it rests, raise the oven to 425 °F, add the green beans to the potato pan, and roast 10–12 minutes until the beans are tender and the potatoes golden. (Warm the bread in the oven for the last 5 minutes.)
6. Slice the pork ½ inch thick across the grain. Arrange it on a warm platter with the potatoes, green beans and lemon wedges.
7. Refrigerate leftovers within 2 hours. Clean up as you go, so that after the feast only the plates remain.

Allergy check: The main course contains none of the nine major allergens (Dijon mustard is not one, but check its label). Check every other dish on your menu: the bread contains wheat, the galette contains wheat, milk and eggs, and the ice cream contains milk.

Steps

1. **Menu.** Write your three-course menu on a card, with at least three dishes from this year. Check that it fills every MyPlate group and balances flavors and textures.
2. **Budget and list.** With a parent, set a budget. Write a shopping list from all your recipes, check the pantry, price each item, and keep the total within budget. Calculate the cost per person.

3. **Timeline.** Write a timeline starting the day before (bread, galette, ice cream) and ending at serving time, with oven temperatures and times for each dish. Plan who will help with which job, as Abraham did.
4. **Cook and serve.** Follow your timeline, cleaning as you go. Set the table as the video showed. Welcome your family, and lead or join in saying grace.
5. **Thank-you and record.** After the meal, write a thank-you note to someone who helped, and record the family's ratings for each course.
6. **Reflect.** Write a page about your feast: what went according to plan, what surprised you, what you would change, and what you have learned about cooking and hospitality this year.
7. Clean up together: wash, dry and put away everything, and store leftovers safely.

Tips

- Choose at least one dish that can be completely finished the day before. It is the best gift you can give yourself on feast day.
- Put everything you can on the table before the main course: water, bread, butter, salt and pepper.
- If something goes wrong, keep going. Your family will remember the welcome and the thanks far longer than a burnt roll.

Check your work

- ☐ I can explain what Abraham's feast teaches about hospitality.
- ☐ I planned a balanced three-course menu with a budget, a shopping list and a timeline.
- ☐ I cooked and served a family feast safely, set the table, and gave thanks.

COOK'S NOTEBOOK

1. Write your final menu card neatly, decorated if you like, to keep with the year's notebook.
2. Copy your timeline with the actual times each step happened beside the planned ones.
3. Draw your table setting from above and label each piece.

From history. Feasts mark the great days of the Christian year and of family life: Christmas, Easter, Thanksgiving, weddings and birthdays. In the Old Testament, God commanded His people to hold feasts of thanksgiving at harvest and to invite the stranger, the fatherless and the widow to share them (Deuteronomy 16:14).

COMMON MISTAKES

- Choosing four dishes that all need the oven at different temperatures at the same time. Plan oven space and use the stovetop and refrigerator too.
- Leaving all the dishes until after the meal. Clean as you go.
- Trying a brand-new, difficult recipe for the first time on feast day. Use dishes you have made before, and practice anything new ahead of time.

Make it a game · Abraham's Guests. Say you are hosting three strangers. In five minutes, write a three-course menu with a budget on an index card. Then your parent throws in a twist: no oven, one guest allergic to nuts, or only twenty dollars. Revise on the spot. Close by explaining what hospitality in Genesis 18 teaches.

Scripture. “And Abraham hastened into the tent unto Sarah, and said, Make ready quickly three measures of fine meal, knead it, and make cakes upon the hearth. And Abraham ran unto the herd, and fetcht a calf tender and good, and gave it unto a young man; and he hasted to dress it. And he took butter, and milk, and the calf which he had dressed, and set it before them; and he stood by them under the tree, and they did eat.” (Genesis 18:6-8, KJV)

Abraham gave his guests his best and his full attention. A family feast is a chance to do the same for the people God has given us.

UNIT 8

MEAL PLANNING & THE FAMILY TABLE

A good cook does more than follow a recipe. A good cook plans: what the family will eat this week and this month, what it will cost, how tonight's roast becomes tomorrow's soup, how to cook for twelve as calmly as for four, and how to bring everyone to the table with joy. In this unit you will learn those skills from a USDA economist who planned food budgets for American families, from Jesus' command to gather up the fragments, from Fred Harvey's railroad dining rooms, and from Abraham, who ran to welcome three strangers to a meal.

Everything you have learned this year comes together here. You will price a month of groceries, roast a chicken that feeds the family twice, scale a pot of chili for a crowd, and finally plan, budget, shop for and cook a three-course family feast, set the table, and give thanks. "Whether therefore ye eat, or drink, or whatsoever ye do, do all to the glory of God" (1 Corinthians 10:31).

PREREQUISITES

- Can plan a balanced meal with MyPlate (Unit 2)
- Cooks safely on the stove and in the oven with an adult at home and nearby (Unit 1)
- Knows safe internal temperatures and leftover rules (Unit 1)
- Can multiply and divide fractions and decimals and calculate percentages

MASTERY CHECKLIST

- ☐ I can plan a month of family meals within a grocery budget, using unit prices and cost per serving.
- ☐ I can plan a roast that becomes two or more meals and store leftovers safely.
- ☐ I can scale a recipe up for a crowd, adjust pans and cooking times, and hold food at safe temperatures for serving.
- ☐ I can write a timeline for a multi-course meal so everything is ready at once.
- ☐ I can plan, budget, shop for, cook and serve a three-course family feast, set the table and lead or join in giving thanks.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA Food Plans: Monthly Cost of Food Reports:** Free. The USDA's monthly estimates of what nutritious, balanced meals cost for families of different sizes, at four cost levels. Used in Lesson 8.1.
- **MyPlate Kitchen (on MyPlate.gov):** Free. Hundreds of balanced, budget-friendly recipes from the USDA, many with cost information. Helpful for planning the unit challenge.
- **FoodKeeper app (USDA, on FoodSafety.gov):** Free. Tells how long foods and leftovers keep in the refrigerator, freezer and pantry. Used in Lesson 8.2.

Not required. Every recipe in this unit works in an ordinary home kitchen.

School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

8.1 Budgeting a Month of Groceries

2 sessions of 50–60 minutes

8.2 Planning for Leftovers: Gather Up the Fragments

2 sessions of 60–90 minutes (on two days)

8.3 Cooking for a Crowd: The Harvey Houses

2 sessions of 50–60 minutes (plus cooking time)

8.4 The Family Feast

2 sessions of 60–90 minutes (plus shopping and the feast itself)

UNIT 8 REVIEW

Answer each question. Use complete sentences for explanations, and show your work for every calculation. The review is worth 100 points.

1. **8 pts**

What did Hazel Stiebeling's 1933 food plans show, and how does the USDA still use the idea?

2. **10 pts**

Calculation: a 24-ounce jar of pasta sauce costs \$3.36 and a 45-ounce jar costs \$5.85. Find each unit price. Which is the better buy?

3. **10 pts**

Calculation: a baked ziti uses ingredients costing \$3.10 (pasta and sauce), \$4.50 (beef), \$3.20 (ricotta and egg) and \$3.60 (other cheese). It serves 8. What is the cost per serving?

4. **8 pts**

Name four ways to lower a family's grocery bill without giving up balanced meals.

5. **8 pts**

What did Jesus command after feeding the five thousand, and how does it apply to a kitchen?

6. **8 pts**

Give four rules for storing and reheating leftovers safely.

7. **8 pts**

How did the Harvey Houses serve a whole trainload of passengers in about 30 minutes?

8. **10 pts**

Calculation: a recipe for 6 uses $1\frac{1}{2}$ pounds of beef and 2 tablespoons of chili powder. What is the scaling factor for 15 servings? How much beef and chili powder do you need?

9. **8 pts**

Why should salt and strong spices not always be multiplied straight up when scaling a recipe?

10. **8 pts**

What is hot holding, and what temperature must food stay at?

11. **6 pts**

Calculation: dinner is at 6:00 p.m. The pork roasts 75 minutes and rests 15 minutes, and you need 20 minutes to prep it first. When must you start prepping?

12. **8 pts**

Short answer: In four or five sentences, explain what Abraham's feast in Genesis 18 teaches about hospitality, and how you will practice it.

ANSWER KEY

1. They showed the amounts of each kind of food a family needed for balanced meals at four cost levels, proving a family could eat well on little money with careful planning and home cooking. The USDA still publishes four food plans and updates their costs every month.
2. $\$3.36 \div 24 = \$0.14$ per ounce. $\$5.85 \div 45 = \$0.13$ per ounce. The 45-ounce jar is the better buy, if the family will use it before it spoils.
3. Total = $\$3.10 + \$4.50 + \$3.20 + \$3.60 = \$14.40$. $\$14.40 \div 8 = \$1.80$ per serving.
4. Any four: plan meals and shop with a list; compare unit prices; build meals around staples like beans, rice, oats, eggs and potatoes; use meat as part of a dish; buy produce in season or frozen; cook at home; use planned leftovers; avoid waste; buy store brands.
5. “Gather up the fragments that remain, that nothing be lost” (John 6:12). In the kitchen it means planning and using leftovers, saving bones for broth and scraps for stock, and not wasting food.
6. Refrigerate within 2 hours (1 hour above 90 °F); use shallow containers; label and date; eat within 3–4 days or freeze; reheat to 165 °F.
7. The train crew telegraphed ahead with the number of passengers, so the kitchen cooked exactly enough and had the first course on the table when they arrived. Trained Harvey Girls served quickly, and every step was planned.
8. $15 \div 6 = 2.5$. Beef: $1.5 \times 2.5 = 3.75$ pounds (3¾ pounds). Chili powder: $2 \times 2.5 = 5$ tablespoons (add about three-quarters first, then taste).
9. In large batches they can taste too strong, and big pots lose less liquid; adding about three-quarters and then tasting and adjusting gives better control.
10. Keeping cooked food hot until it is served, at 140 °F (60 °C) or above, so bacteria cannot grow.
11. $75 + 15 + 20 = 110$ minutes = 1 hour 50 minutes. 6:00 p.m. – 1:50 = 4:10 p.m.
12. Abraham ran to welcome strangers, gave them rest, served the best food he had, involved his household in preparing it, served it all together, and stayed with his guests while they ate. Hospitality is about care, preparation and presence more than fancy food. I can practice it by planning ahead, cooking good food, setting a welcoming table, paying attention to my guests, and giving thanks to God together.

UNIT CHALLENGE: THE FAMILY FEAST

The family feast is the unit challenge and the capstone of the year. Assemble a feast portfolio: the menu card; the budget and shopping list with prices and the cost per person; the timeline with planned and actual times; the recipes in your own words; temperature records for the main dish and any reheated dishes; and photographs or sketches of each course and the table.

Finish with a thank-you note to someone who helped and a one-page reflection on the feast and the year: what you can cook now that you could not cook in September, what you learned about food and about hospitality, and one dish you will keep cooking for your family.

LOOK FOR	WHAT IT MEANS
Planning	A balanced three-course menu with at least three dishes from the year, a budget kept within limits, a complete shopping list and a realistic timeline.
Cooking and safety	Every dish cooked safely with temperatures checked and recorded; kitchen cleaned as you went; leftovers stored correctly.
The table	The table set properly, guests welcomed, food served together and thanks given.
Records	Menu card, budget, timeline, recipes, temperatures and photographs or sketches gathered neatly in the portfolio.
Reflection and thanks	An honest reflection on the feast and the year and a thank-you note; a feast that had problems but is well recorded and graciously served earns full credit.