

GRADE 7 COOKING & FOOD

First edition

8 units

32 lessons · one school year

A video for every lesson

FIRST EDITION

COURSE GUIDE

This course follows the same eight strands of cooking and food that run through every year of School Launch, now at a seventh grader's depth: 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 and spice, and meal planning for the family table. Each unit is built around real people and real moments: George Soper tracing a typhoid outbreak to one cook's kitchen, Robert Koch growing bacteria on slices of potato and plates of agar, Casimir Funk naming the "vitamine," Linda Bartoshuk finding the supertasters, Jacob Perkins building the first refrigerating machine, Louis-Camille Maillard heating sugars with amino acids, a twelve-year-old named Edmond Albius discovering how to pollinate vanilla by hand, and Ellen Swallow Richards bringing chemistry into the home kitchen.

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 observed and what they learned. Then **the kitchen science**, explained with real vocabulary and a little arithmetic: temperatures in °F and °C, grams and ounces, scaling a recipe, unit prices and cost per serving. Last, **let's cook**: the student makes a real dish or meal for the family, records it in a cook's notebook, and improves it the next time. Seventh graders use a chef's knife, the stove and the oven with an adult nearby, and grill with an adult beside them. 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 full menu, writes a cooking timeline, shops with a parent, cooks several dishes learned during the year, 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: TED-Ed, BBC science channels, SciShow, America's Test Kitchen, university extension services, the USDA and careful cooking teachers chosen lesson by lesson. Every video was previewed for content, accuracy and modest dress. A few are longer and are best watched together. 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 7 (about ages 12–13) who read independently, work with fractions, ratios and percentages, and can follow a recipe from start to finish. A parent or responsible adult supervises all cooking: nearby for the knife, stove and oven work once the student has shown it can be done safely, and right beside the student at 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 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 7 safety ladder.** Seventh graders use a chef's knife after practicing the claw and bridge grips with an adult (Lessons 1.2 and 1.4). They use the stove and oven with an adult at home and nearby, once that adult has watched them do each job safely; until then, the adult stands beside them. Shallow pan-frying in a thin

layer of oil is done with an adult present; there is **no deep frying** in this course. At the grill, an adult lights it, and the student may cook with the adult right beside. Pot handles turn in, oven mitts go on, lids open away from the face, and a lid and baking soda stay near the stove for a grease fire.

4. **Story, then science, then cooking.** The core ideas are written for the student to read, or to read aloud together. 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, ask the student to explain the science back in his or her own words, with an example from your own kitchen.
5. **Picture study.** Each lesson has one painting or historic photograph of a kitchen, a harvest, a market, a laboratory or a table. Look at it quietly for two minutes. Then put it away and have the student tell everything he or she remembers. 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, copy the recipe in your own words, record what you measured, timed and observed, work any calculations, make a quick sketch of the finished dish, collect a family rating, and write 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. We call foods “nutrient-dense foods” and “treats,” never “good” or “bad.” Calories appear only as a unit of food energy, never as something to count or restrict. 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; a few lessons (steak, salmon, pork tenderloin) cost more and offer a cheaper swap. Read the recipe card a few days ahead and add its ingredients to the shopping list.
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 worth 100 points, including two or three short calculations with the work shown and one or two

written answers, and a unit challenge: something real cooked, served and recorded, such as a kitchen sanitation audit, a planned and cooked day of balanced meals, a family taste-sensitivity survey, a timed cooling and freezing experiment, a sandwich loaf with a rise log, or a one-week menu and budget. Keep the challenge pages and photographs in a folder for the year.

11. **The family feast.** In the last week the student plans a full menu, writes a timeline, shops with a parent, cooks several dishes from the year with an adult nearby, sets the table, and leads or joins in giving thanks.

SCOPE AND SEQUENCE

UNIT 1 • WEEKS 1–4

Kitchen & Food Safety

Typhoid Mary and why a healthy cook's hands matter; Robert Koch, bacteria and sanitizing; food thermometers, the 2011 pork guideline and carryover cooking; and Harry Brearley's stainless steel, honing and sharpening, and the chef's knife.

- 1.1 Typhoid Mary and the Cook's Hands
- 1.2 Robert Koch and the Bacteria You Cannot See
- 1.3 The Thermometer, the 3-Minute Rest and Carryover Cooking
- 1.4 Harry Brearley's Stainless Steel and the Safe, Sharp Knife

UNIT 2 • WEEKS 5–8

Food Groups & the Balanced Meal

Casimir Funk and the vitamins in a roasted vegetable soup; the Dietary Guidelines and a planned day of meals; protein from eggs, beans and fish in a baked salmon dinner; and iron, leafy greens and vitamin C in spinach and bean quesadillas.

- 2.1 Casimir Funk Names the "Vitamine"
- 2.2 The Dietary Guidelines and a Balanced Day
- 2.3 Protein at Every Meal: Eggs, Beans and Fish
- 2.4 Iron, Leafy Greens and Vitamin C

UNIT 3 • WEEKS 9–12

Taste, Smell & Your Taste Buds

Linda Bartoshuk and supertasters; Buck and Axel and the smell receptors behind a fresh basil pesto; how taste and smell change across a lifetime, with a recipe interview of an older relative; and Alina Szczesniak’s science of texture in oven-crisped panko chicken.

- 3.1 Linda Bartoshuk and the Supertasters
- 3.2 Buck, Axel and the Thousand Smells: Basil Pesto
- 3.3 Taste Across a Lifetime: A Recipe from an Older Relative
- 3.4 Alina Szczesniak and the Science of Texture

UNIT 5 • WEEKS 17–20

Food Chemistry

Louis-Camille Maillard and browning in seared steak and mushrooms; Milton Hershey’s caramels and caramelized onions; Pasteur, yeast and fermentation in a sandwich loaf with a rise log; and Abbé Nollet’s osmosis and a brined roast chicken.

- 5.1 Louis-Camille Maillard and the Chemistry of Browning
- 5.2 Milton Hershey’s Caramels and the Chemistry of Caramelization
- 5.3 Pasteur, Yeast and a Sandwich Loaf
- 5.4 Abbé Nollet, Osmosis and a Brined Roast Chicken

UNIT 4 • WEEKS 13–16

Heat & Cold

Jacob Perkins’s 1834 refrigerating machine and cooling food quickly; altitude, air pressure and the boiling point; searing versus steaming and the “seal in the juices” myth; and Frederic Tudor, the Ice King, with a homemade fruit sorbet.

- 4.1 Jacob Perkins and the Machine That Made Cold
- 4.2 Altitude, Air Pressure and the Boiling Point
- 4.3 Searing and Steaming: Testing an Old Kitchen Claim
- 4.4 Frederic Tudor, the Ice King: Fruit Sorbet

UNIT 6 • WEEKS 21–24

Cravings, Reward & a Balanced Diet

Olds and Milner’s 1954 discovery of the brain’s reward pathway; Kent Berridge, dopamine and “wanting” versus “liking”; the history of cane and beet sugar and fruit-sweetened muffins; and self-control as a fruit of the Spirit at a planned family dessert night.

- 6.1 Olds and Milner Find the Brain’s Reward Pathway
- 6.2 Dopamine Means Wanting: Snack Foods and the Bliss Point
- 6.3 Sugar’s History: From Cane to Beets to Everyday Sweetness
- 6.4 Self-Control Is a Fruit of the Spirit: A Planned Dessert Night

UNIT 7 • WEEKS 25–28

Fire, the Grill & Spice

Magellan’s voyage and the clove islands, with clove-and-cinnamon spiced meatballs; Edmond Albius and vanilla in a creamy rice pudding; the two-zone grill and grilled pork tenderloin; and the science of flavor pairing with grilled chicken and mango salsa.

- 7.1 Magellan’s Voyage and the Clove Islands
- 7.2 Edmond Albius and the Secret of Vanilla
- 7.3 The Two-Zone Grill: Pork Tenderloin
- 7.4 Pairing Flavors: Grilled Chicken with Mango Salsa

UNIT 8 • WEEKS 29–32

Meal Planning & the Family Table

Irma Rombauer’s *Joy of Cooking* and a classic chicken pot pie; Ellen Swallow Richards and a weekly menu plan; Hazel Stiebeling’s food plans, unit prices and a budget pasta e fagioli; and the family feast with a full menu and timeline.

- 8.1 Irma Rombauer and *The Joy of Cooking*: Chicken Pot Pie
- 8.2 Ellen Swallow Richards and a Weekly Menu Plan
- 8.3 Hazel Stiebeling’s Food Plans: Eating Well on a Budget
- 8.4 The Family Feast

WEEKLY PACING CALENDAR

WEEK	PLAN
1	- Session 1: Lesson 1.1 Typhoid Mary and the Cook’s Hands: 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 Robert Koch and the Bacteria You Cannot See: 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 The Thermometer, the 3-Minute Rest and Carryover Cooking: 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 Harry Brearley’s Stainless Steel and the Safe, Sharp Knife: 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

WEEK	PLAN
5	• Session 1: Lesson 2.1 Casimir Funk Names the “Vitamine”: warm-up, video, teaching and picture study • Session 2: Lesson 2.1 kitchen project (cook the recipe) and cook’s notebook
6	• Session 1: Lesson 2.2 The Dietary Guidelines and a Balanced Day: 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 Protein at Every Meal: Eggs, Beans and Fish: 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 Iron, Leafy Greens and Vitamin C: 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 Linda Bartoshuk and the Supertasters: 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 Buck, Axel and the Thousand Smells: Basil Pesto: 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 Across a Lifetime: A Recipe from an Older Relative: 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 Alina Szczesniak and the Science of Texture: 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 Jacob Perkins and the Machine That Made Cold: 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 Altitude, Air Pressure and the Boiling Point: 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 Searing and Steaming: Testing an Old Kitchen Claim: 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 Frederic Tudor, the Ice King: Fruit Sorbet: 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 Louis-Camille Maillard and the Chemistry of Browning: 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 Milton Hershey's Caramels and the Chemistry of Caramelization: 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 Pasteur, Yeast and a Sandwich Loaf: 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 Abbé Nollet, Osmosis and a Brined Roast Chicken: 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 Olds and Milner Find the Brain's Reward Pathway: 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 Dopamine Means Wanting: Snack Foods and the Bliss Point: 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 Sugar's History: From Cane to Beets to Everyday Sweetness: 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 Self-Control Is a Fruit of the Spirit: A Planned Dessert Night: 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 Magellan's Voyage and the Clove 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 Edmond Albius and the Secret of Vanilla: 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 The Two-Zone Grill: Pork Tenderloin: 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 Pairing Flavors: Grilled Chicken with Mango Salsa: 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 Irma Rombauer and <i>The Joy of Cooking</i>: Chicken Pot Pie: 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 Ellen Swallow Richards and a Weekly Menu Plan: 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 Hazel Stiebeling's Food Plans: Eating Well on a Budget: 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, measurements and calculations, observations, taste charts, sketches, family ratings and “what I would change next time.”

An instant-read food thermometer

The one tool we strongly recommend. Used in nearly every unit to check chicken, pork, fish, eggs, leftovers and the refrigerator.

A refrigerator thermometer

Optional and inexpensive. Leave it in the fridge to check that it stays at or below 40 °F (4 °C), and in the freezer for 0 °F (−18 °C).

Measuring cups (dry and liquid), measuring spoons and a kitchen scale

Used in every recipe. A scale that reads in grams is very helpful this year for bread, brines and comparing recipes, but not required.

A chef's knife (8 inches), a paring knife, a honing steel if you have one, 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. Lesson 1.4 teaches honing and safe knife care.

A large skillet (cast iron or stainless), a medium and a large pot with lids, a rimmed baking sheet, a loaf pan, a 9×13-inch baking dish and oven mitts

Ordinary kitchen equipment for the stovetop and oven recipes.

Mixing bowls, a whisk, a wooden spoon, a spatula, long tongs, a colander and a steamer basket or a lid that fits a skillet

For mixing, draining, steaming and turning food safely.

Clean dish towels, dish soap, paper towels and unscented household bleach

Cleanup is part of every recipe. Lesson 1.2 shows how an adult mixes a safe sanitizing solution.

A timer, a calculator and a camera or phone

For timing cooking and experiments, working recipe math, 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, measurements, calculations, observations, sketches)	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, check temperatures, observe and record honestly, 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 measurement or calculation, an observation, 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 flat loaf or a scorched pan of onions teaches as much as a perfect one.
- On the unit reviews, give partial credit on calculations for correct setup and clear work even when the arithmetic slips.

- 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 story together, watch the video, and then be the student's kitchen partner. At this age your job shifts from doing to watching: stand beside the student the first time he or she uses the chef's knife, sears in a hot skillet or takes a heavy pan from the oven; once you have seen it done safely, stay nearby rather than at the elbow. Keep asking "What do you think will happen?" and "Why do you think it happened?" Those two questions are most of what a good cooking teacher does. Let the student do the planning, the math and the cleanup.

Expect some flops. Bread will come out dense, onions will scorch, a sorbet will freeze rock-hard. 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. *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. Unit 6 explains how the brain learns to want sweet, salty and rich foods and how some packaged snacks are designed to be easy to keep eating; it teaches self-control and thankfulness, not fear. 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

A good cook is first of all a safe cook. This unit begins with one of the strangest true stories in the history of food: a skilled New York cook named Mary Mallon who never felt sick herself, yet carried typhoid germs from one family's kitchen to the next. You will follow the sanitary engineer who tracked her down, and then go back a generation to Robert Koch, the German country doctor who proved that particular bacteria cause particular diseases and invented the lab methods that let anyone grow and see them.

Then you will put the science to work. You will learn the difference between cleaning and sanitizing, mix a sanitizing solution with an adult, and cook chicken fajitas to 165 °F. You will learn why the USDA lowered the safe temperature for pork chops in 2011, what carryover cooking is, and how to use a thermometer like a professional. Finally you will hear how a Sheffield metallurgist invented stainless steel in 1913, learn why a sharp knife is safer than a dull one, and hone your chef's knife before mincing a fresh herb sauce for pasta. Throughout the course, **a parent or responsible adult supervises all cooking**, and families check every recipe against their own food allergies.

PREREQUISITES

- Can read a recipe all the way through and measure with cups, spoons and a scale
- Knows the four steps Clean, Separate, Cook, Chill from earlier grades (reviewed here)
- Can read a dial or digital thermometer in °F
- Has practiced the claw and bridge grips with a smaller knife, or will practice them with an adult in Lesson 1.2 before using a chef's knife

MASTERY CHECKLIST

- ☐ I can tell the story of Mary Mallon and George Soper and explain what a healthy carrier is.
- ☐ I can explain how Robert Koch proved that a particular germ causes a particular disease, and the difference between cleaning and sanitizing.
- ☐ I can name the USDA safe minimum internal temperatures, use a thermometer correctly, and explain carryover cooking and the 3-minute rest.
- ☐ I can explain why a sharp knife is safer than a dull one, tell honing from sharpening, and use a chef's knife with the claw and bridge grips.
- ☐ I can keep the danger zone (40–140 °F) and the 2-hour rule in mind every time I cook.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **FoodSafety.gov: Safe Minimum Internal Temperatures:** Free. A printable chart to tape inside a cupboard door for Lessons 1.2 and 1.3 and the rest of the year.
- **An instant-read food thermometer:** The most important tool in this course. A digital one that reads in a few seconds is easiest to use. Check it in ice water (32 °F) before Lesson 1.3.
- **A honing steel or ceramic honing rod:** Optional. Many chef's knives come with one. Lesson 1.4 shows how an adult uses it and how you may use it with supervision.

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 Typhoid Mary and the Cook's Hands

2 sessions of 50–60 minutes

1.2 Robert Koch and the Bacteria You Cannot See

2 sessions of 50–60 minutes

1.3 The Thermometer, the 3-Minute Rest and Carryover Cooking

2 sessions of 50–60 minutes

1.4 Harry Brearley's Stainless Steel and the Safe, Sharp Knife

2 sessions of 50–60 minutes

UNIT 1 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

What is a healthy carrier? How did George Soper figure out that Mary Mallon was one?

2. **8 pts**

Why are ready-to-eat foods like cut fruit and ice cream the riskiest foods for a cook with unwashed hands?

3. **8 pts**

How did Robert Koch grow a pure culture of bacteria, and what was Fanny Hesse's contribution?

4. **8 pts**

What is the difference between cleaning and sanitizing? In what order do you do them?

5. **8 pts**

Calculation: bacteria double every 20 minutes. Starting with 10 bacteria on a cutting board, how many will there be after 2 hours? Show your work.

6. **10 pts**

Give the USDA safe minimum internal temperature for each: chicken thighs; ground beef; pork chops; salmon; scrambled eggs; leftover soup.

7. **8 pts**

Why did the USDA lower the safe temperature for whole cuts of pork to 145 °F in 2011, and why does ground pork still need 160 °F?

8. **8 pts**

Calculation: convert 145 °F and 165 °F to °C, using $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5 \div 9$. Round to the nearest degree.

9. **8 pts**

Explain carryover cooking. Would you expect it to be larger in a thin pork chop or a large pork roast? Why?

10. **8 pts**

Why is a sharp knife safer than a dull one? What is the difference between honing and sharpening?

11. **8 pts**

What did Harry Brearley add to steel in 1913, and why did it matter in the kitchen?

12. **10 pts**

Written answer: You are making chicken fajitas. List, in order, at least five things you do to keep the meal safe from the moment you take the chicken out of the fridge until the leftovers are put away.

ANSWER KEY

1. A person who carries and spreads a germ without feeling sick. Soper noticed the banker's family hired Mallon about three weeks before the outbreak, then traced her past jobs and found typhoid in seven of the eight households where she had cooked; tests in 1907 found typhoid bacteria in her.
2. They are not cooked after the cook touches them, so no heat kills germs that are transferred from the hands to the food.
3. He spread bacteria on a solid surface (first a potato slice, then gelatin, then agar) so each single bacterium grew into its own colony of one kind. Fanny Hesse suggested using agar, a seaweed jelly she used in her kitchen, because it stayed firm in warm weather.
4. Cleaning removes dirt, food and grease with soap and water; sanitizing reduces the remaining germs to a safe level with heat or a sanitizer. Clean first, then sanitize.
5. 2 hours = 120 minutes = 6 doublings. $10 \times 2^6 = 10 \times 64 = 640$ bacteria.
6. Chicken 165 °F; ground beef 160 °F; pork chops 145 °F with a 3-minute rest; salmon 145 °F; egg dishes 160 °F; leftovers reheated to 165 °F.
7. Trichinosis had become very rare in farmed pork, and testing showed that 145 °F held for a 3-minute rest kills harmful germs. Grinding mixes surface germs all through the meat, so ground pork must reach 160 °F.
8. 145 °F: $(145 - 32) \times 5 \div 9 = 113 \times 5 \div 9 \approx 63$ °C. 165 °F: $(165 - 32) \times 5 \div 9 = 133 \times 5 \div 9 \approx 74$ °C.
9. After meat leaves the heat, the hot outer layers keep conducting heat into the cooler center, so the center temperature rises. It is larger in a large roast, because there is more hot outer meat and a bigger difference between outside and center.
10. A sharp knife cuts with little pressure and bites into food instead of skidding off, so it slips less. Honing straightens a bent edge without removing much metal; sharpening grinds away metal to make a new edge.
11. About 12.8 percent chromium. The chromium forms a thin protective layer, so the steel resists rust and stains from acidic foods, making knives, forks, sinks and bowls that need no constant polishing.
12. A good answer includes: wash hands; use a separate board and knife for raw chicken; do not wash the chicken; wash hands after touching it; throw away used marinade; cook to 165 °F and check the thickest piece with a thermometer;

use clean tongs and a clean plate for cooked chicken; clean and sanitize surfaces; refrigerate leftovers within 2 hours.

UNIT CHALLENGE: A FAMILY KITCHEN SANITATION AUDIT

Inspect your family's kitchen the way a health inspector would. Make a checklist with at least 15 items under the headings Clean, Separate, Cook and Chill: a refrigerator thermometer reading (40 °F or below) and a freezer reading (0 °F), how raw meat is stored (bottom shelf, in a container), cutting boards, sponge and towel habits, a calibrated food thermometer, the hand-washing station, and leftovers labeled with dates.

Score each item, then fix at least three problems with your parent's permission (for example, moving raw meat to the bottom shelf, labeling leftovers, or setting up a sponge-sanitizing routine). Finish by cooking one meal from this unit for your family using every safety step, and write a one-page report with your scores before and after.

LOOK FOR	WHAT IT MEANS
Checklist	At least 15 clear items under Clean, Separate, Cook and Chill, each scored honestly, with refrigerator and freezer temperatures recorded.
Improvements	At least three real problems fixed, with before-and-after notes or photos.
Safe cooking	One meal from the unit cooked with clean hands, separate boards, a thermometer check and leftovers chilled within 2 hours.
Report	A neat one-page report with scores, what changed, and what the family will keep doing.
Cleanup and attitude	Kitchen left clean; the audit carried out respectfully and helpfully.

1.1 TYPHOID MARY AND THE COOK'S HANDS

OBJECTIVES

- Tell the story of George Soper's 1906–1907 investigation and explain what a healthy carrier is.
- Explain why foods that are not cooked after handling, like cut fruit and salads, depend most on clean hands.
- Wash hands correctly for 20 seconds and prepare a cold peach dessert with clean-hands habits.

Warm-up. Make a list of everything your hands touched since you got up this morning: doorknobs, your phone, the dog, a pencil, your face. Then guess: how many of those things did the next person who touched them also touch? Which of those would you want touching your dessert?

WATCH

The Curious Case Of Typhoid Mary | Earth Science

BBC Earth Science · 3:37

<https://www.youtube.com/watch?v=THLZpWJMK7M>

WHEN TO WATCH

After reading The story and How they figured it out. Watch for the clue that made George Soper suspect the cook, and for the dessert she was known for.

BACKUP VIDEO

What Really Happened with Typhoid Mary?

SciShow · 4:02

<https://www.youtube.com/watch?v=gLbJznLoo80>

A second telling with more about what happened to Mary Mallon afterward and why health officials struggled to explain her condition to her.

KEY TERMS

typhoid fever

A serious illness caused by the bacterium *Salmonella Typhi*, spread through food or water contaminated by an infected person. Today it is rare in the United States and can be treated with antibiotics.

outbreak

A group of people who become sick from the same source at about the same time.

sanitary engineer

An engineer who works on clean water, sewers and the prevention of disease spread through the environment.

healthy carrier

A person who carries and spreads a germ without feeling sick from it.

ready-to-eat food

Food that will not be cooked again before it is eaten, such as cut fruit, salad, sandwiches and ice cream. Hands and surfaces matter most for these foods, because no heat will kill germs that land on them.

CORE IDEAS

The story. In the summer of 1906 a wealthy New York banker rented a large summer house in Oyster Bay, on Long Island, for his family. Late in August, six of the eleven people in the household came down with typhoid fever. Typhoid was usually a disease of crowded city neighborhoods with poor water, not of wealthy summer homes, and the owners of the house worried that no one would ever rent it again. They hired George Soper, a sanitary engineer who had studied typhoid outbreaks, to find the cause.

How they figured it out. Soper tested the water, the milk, the plumbing and the shellfish from the bay, and found nothing. Then he noticed something about the timing: the family had hired a new cook, Mary Mallon, about three weeks before the first person fell ill. She had left soon after the outbreak. Soper traced her work history back ten years and found that in seven of the eight households where she had cooked, people had caught typhoid, 22 cases in all, including one young girl who

died. Mallon herself had never been sick that she knew of. In 1907 the New York City Health Department tested her and found typhoid bacteria. She was the first person in the United States identified as a **healthy carrier**. She was isolated in a cottage on North Brother Island in the East River, released in 1910 after promising never to cook for others again, and then found in 1915 working as a cook at a New York maternity hospital under another name, where 25 people became sick and two died. She spent the rest of her life on the island and died there in 1938.

The kitchen science. Soper noticed that Mallon was known for a particular dessert: ice cream served with fresh cut peaches. Most of what a cook makes is heated, and heat kills typhoid bacteria. But fresh fruit and ice cream are never cooked after the cook's hands touch them. If a few bacteria are on unwashed hands, they go straight to the plate. That is why **ready-to-eat foods** need the cleanest hands of all. Washing with soap and water for at least 20 seconds lifts germs off the skin: soap molecules have one end that clings to water and one end that clings to oils and dirt, so the germs are rinsed down the drain. Scrub the backs of your hands, between your fingers and under your nails, rinse, and dry with a clean towel.

Think it through. Mary Mallon's story is sad as well as important. She did not feel sick, and the idea of a healthy carrier was new and hard to believe. Some historians think the health officials could have explained it to her more clearly and helped her find other work. Others point out that she went back to cooking after promising not to, and more people became ill. Either way, her story changed how health departments think about food workers, and it is the reason restaurants today post signs saying "Employees must wash hands before returning to work."

Let's cook. You will make fresh peach sundaes with a quick raspberry sauce, the kind of cold dessert Mallon was known for, but made the safe way. The one skill to do well is **clean hands at every step**: wash before you begin, wash after you touch your face or phone, wash and dry the peaches under running water, and use clean utensils instead of fingers wherever you can.

PICTURE STUDY



Mary Mallon in Hospital, Unknown newspaper photographer, Published 1909 · Photograph · Originally printed in *The New York American*, June 20, 1909

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

This photograph of Mary Mallon was printed in a New York newspaper in 1909, while she was held on North Brother Island. It is one of the very few photographs of her. Newspapers of the time made her famous, and not always kindly; the name “Typhoid Mary” came from them. Look at her as a real person, a cook who worked hard and did not understand the danger she carried.

Look closely

- Find Mary Mallon in the front bed. Where is she, and how is she lying? Does she look sick?
- Look at the other beds in the room. What kind of place is this?
- Notice how plain and bare the room is. What would a hospital ward of 1909 have done to keep germs from spreading?
- Look at her hands. In your mind, list every food a cook’s hands touch in a single day.

Talk about it

1. How does this photograph show the hardest part of the idea of a healthy carrier?

2. Why do you think newspapers gave her a nickname? Is it fair to remember a person by her illness?
3. What three habits could have kept Mallon's peach dessert from spreading germs?

Safety first. A parent or responsible adult supervises all cooking in this course, and your family should check every recipe and taste test against its own food allergies. Wash hands with soap for at least 20 seconds before cooking and again after touching your face, hair, phone or raw foods; ready-to-eat foods like cut fruit get no heat to kill germs. If you are sick, especially with vomiting or diarrhea, do not cook for others until you have been well for at least two days.

KITCHEN PROJECT

Fresh Peach Sundaes, the Clean-Hands Way

You will make a quick raspberry sauce on the stove, slice fresh peaches with clean hands and clean tools, and serve sundaes to your family. Before you cook, you will run a hand-washing test to see which parts of the hands people miss.

You will need

- A small saucepan, a wooden spoon and a fine strainer (optional)
- A paring knife or small chef's knife and a cutting board with a damp towel underneath
- A vegetable brush, a colander and clean paper towels
- An ice cream scoop, small bowls and spoons
- For the hand test: a teaspoon of cooking oil and a teaspoon of ground cinnamon

FRESH PEACH SUNDAES WITH RASPBERRY SAUCE

Serves 6 • Prep 15 min • Cook 8 min • Cool 10 min

Ingredients

- **Raspberry sauce:** 2 cups (about 250 g) frozen raspberries
- ¼ cup (50 g) sugar
- 2 tablespoons water
- 1 teaspoon lemon juice
- **Sundaes:** 4 ripe peaches (or one 15-ounce can of sliced peaches, drained)
- 1 quart vanilla ice cream or frozen vanilla yogurt
- 2 tablespoons sliced almonds, toasted (optional)

Method

1. Wash your hands with soap for 20 seconds. Wipe the counter and set out clean bowls and tools.
2. With an adult nearby, put the raspberries, sugar and water in the saucepan. Cook over medium heat, stirring, until the berries break

down and the sauce bubbles gently, about 5–6 minutes. Stir in the lemon juice. For a smooth sauce, press it through a strainer with the back of a spoon. Let it cool at least 10 minutes.

3. Rinse the peaches under cool running water, rubbing the fuzzy skin gently with your hands or a soft brush. Dry them with a clean paper towel. Never use soap on produce.
4. On a board with a damp towel under it, use the bridge grip to cut each peach in half around the pit, twist the halves apart, and lift out the pit with a spoon. Lay each half flat and slice it with the claw grip.
5. Scoop ice cream into bowls with a clean scoop. Top with peach slices, a spoonful of raspberry sauce and a few almonds if you like. Serve right away.
6. Put the ice cream back in the freezer immediately. Refrigerate leftover sauce in a covered jar for up to 5 days.

Allergy check: Contains milk (ice cream) and tree nuts (almonds, optional). For a milk-free dessert, use a dairy-free frozen dessert or serve the peaches and sauce over plain sliced bananas; leave off the almonds for a nut-free version.

Steps

1. **The cinnamon test.** Rub $\frac{1}{2}$ teaspoon of oil over your hands, then sprinkle on a little cinnamon and rub it in. This is your “germs.” Wash your hands the way you usually do, quickly. Look: where is cinnamon left? Then wash properly for 20 seconds, scrubbing backs, thumbs, between fingers and under nails. Record what you missed the first time.
2. Draw the outline of your hands in your notebook and shade the places the cinnamon stayed. Ask one family member to try the test and add their results.
3. Make the recipe. Every time you touch your face, hair, phone or a cabinet handle, stop and wash again. Count how many times you had to rewash.
4. **Serve and survey.** Serve the sundaes and ask each person to rate them from 1 to 5. Record whether they liked the sauce strained or with seeds.
5. **Clean up.** Wash the saucepan, board, knife and bowls in hot, soapy water; wipe the counter; put away the ice cream first.

6. **Improve it.** Write one change for next time: a different fruit (nectarines, strawberries), less sugar in the sauce, or a better hand-washing routine.

Tips

- A ripe peach smells sweet and gives slightly when pressed near the stem. Hard peaches will ripen on the counter in a paper bag in a day or two.
- If the pit will not let go, the peach is a “clingstone.” Cut the flesh off the pit in wedges instead of twisting.
- Scoop ice cream with a scoop dipped in warm water and wiped dry; it slides out cleanly.

Check your work

- ☐ I can tell how George Soper traced the Oyster Bay outbreak to Mary Mallon.
- ☐ I can explain why ready-to-eat foods depend most on clean hands.
- ☐ I washed my hands correctly for 20 seconds and made a cold dessert without touching food with dirty hands.

COOK'S NOTEBOOK

1. Draw a timeline of Mary Mallon's story from 1906 to 1938, with at least five dated events.
2. Copy the sundae recipe in your own words and add your cinnamon-test hand drawing beside it.
3. Make a two-column list: foods your family eats that are cooked after handling, and ready-to-eat foods that are not. Circle the ones where clean hands matter most.

From history. Typhoid fever was common in American cities in 1900, causing tens of thousands of deaths a year. Its decline came from clean water and chlorinated city water supplies, the pasteurization of milk, better sewers, and finally antibiotics. Typhoid is still common in parts of the world without clean water.

COMMON MISTAKES

- Washing for only a few seconds, or rinsing without soap. Lather and scrub for 20 seconds, about as long as singing the Doxology twice.
- Thinking a person who feels well cannot spread germs. Healthy carriers and people in the first days of an illness can.

- Washing produce with soap or bleach. Rinse fruit and vegetables under running water and rub or brush them; soap can leave a residue.

Make it a game • Outbreak Detective. Play George Soper. Your parent gives you clues, one at a time, about a household where several people fell ill, and you ask questions to narrow the source. Use the words outbreak, healthy carrier and ready-to-eat food. After the case closes, list five foods that are never cooked after handling and explain why clean hands matter most for them.

1.2 ROBERT KOCH AND THE BACTERIA YOU CANNOT SEE

OBJECTIVES

- Tell how Robert Koch grew bacteria on solid food and proved that one germ causes one disease, and name Koch's postulates in simple words.
- Explain the difference between cleaning and sanitizing, and mix and use a sanitizing solution with an adult.
- Cook chicken fajitas to 165 °F using separate boards and a thermometer.

Warm-up. Bacteria can double in number about every 20 minutes when the conditions are right. Start with 1 bacterium on a damp sponge. How many will there be after 1 hour? After 2 hours? After 4 hours? (Work it out by doubling.)

WATCH

How a few scientists transformed the way we think about disease - Tien Nguyen

TED-Ed · 4:39

<https://www.youtube.com/watch?v=N9LC-3ZKiok>

WHEN TO WATCH

After How they figured it out. The video tells the story of germ theory from the old idea of bad air to John Snow, Pasteur and Koch; listen for what Koch added.

Note: From TED-Ed. A short animated history; it shows a mouse being injected in a cartoon of Koch's experiments.

BACKUP VIDEO

Cleaning and Sanitizing - Foodservice

Health and Human Sciences Extension and Outreach · 10:50

<https://www.youtube.com/watch?v=r0sWf0jf6T4>

Before you sanitize the kitchen. An extension specialist shows the two steps, cleaning and then sanitizing, in a working kitchen.

KEY TERMS

bacteria

Living things made of a single cell, far too small to see without a microscope. Most are harmless or helpful; a few, called pathogens, cause illness.

Koch's postulates

Koch's rules for proving that a germ causes a disease: find it in every sick animal, grow it pure, show that it causes the same disease in a healthy animal, and find it again.

sanitizing

Reducing the germs on an already clean surface to a safe level, with heat or a sanitizer such as a weak bleach solution.

pure culture

A colony of bacteria grown from a single cell, so that every bacterium in it is the same kind.

cleaning

Removing dirt, food and grease from a surface with soap and water. Cleaning lifts away many germs but does not kill them all.

CORE IDEAS

The story. In the 1870s Robert Koch was a country doctor in the small town of Wollstein, in what was then Prussia. His wife gave him a microscope for his birthday, and in a corner of his house he set up a little laboratory. Farm animals in the region were dying of anthrax, and Koch wanted to know why. In 1876 he showed that rod-shaped bacteria found in the blood of sick animals could be grown, could form tough spores that survived in the soil, and could cause the disease again. It was the first time anyone had proved that one particular germ caused one particular disease.

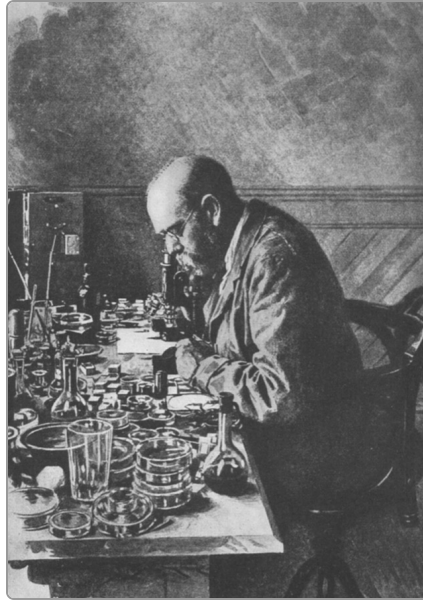
How he figured it out. Koch's great problem was mixtures. A drop of broth teemed with many kinds of bacteria at once. In 1881 he tried growing them on a solid surface instead: a cut slice of boiled potato. Each single bacterium that landed on it grew into its own little spot, a **colony**, all of one kind. Potato was not good for every germ, so he tried gelatin, which melted on warm days. Fanny Hesse, the wife of one of his assistants, suggested agar, a jelly made from seaweed that she used in her

kitchen for jellies because it stayed firm in summer heat. Agar worked, and in 1887 Koch's assistant Julius Petri designed the shallow covered glass dish still called a Petri dish. With these tools Koch announced in 1882 that he had found the bacterium that causes tuberculosis, and he set out his rules, now called **Koch's postulates**. He received the Nobel Prize in 1905.

The kitchen science. Koch's potato slice shows what a kitchen counter can become: a damp, food-smeared surface where bacteria grow into colonies. Kitchens fight back in two steps. **Cleaning** with hot, soapy water removes food and grease and washes many germs away. **Sanitizing** then kills most of what is left. The USDA's home recipe for a sanitizer is 1 tablespoon of unscented liquid chlorine bleach in 1 gallon of water. Wipe it on a clean surface, let it sit for a few minutes, and let it air-dry. Raw chicken often carries *Salmonella* or *Campylobacter*, so boards and counters that touch it get cleaned and sanitized, and the chicken itself is cooked to **165 °F (74 °C)**, which kills them.

Let's cook. You will make chicken fajitas: strips of chicken and peppers seared in a hot skillet. This is your first time slicing raw chicken with a chef's knife, so an adult stands beside you. The skill to do well is **separating**: raw chicken stays on its own board with its own knife, your hands get washed every time they touch it, and the cooked chicken goes onto a clean plate. Then you will clean and sanitize the counter the way a restaurant would.

PICTURE STUDY



Robert Koch in His Laboratory, Unknown photographer, c. 1890s · Illustration made from a photograph · Robert Koch Institute, Berlin (historic photograph)

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

Robert Koch worked for years in a home laboratory before moving to Berlin to lead an institute. This photograph shows him at his workbench. The microscope in front of him let him see what no one in a kitchen could: the tiny living things that grow on food and spread illness.

Look closely

- Find the microscope. How close is Koch to his work?
- Look for glass bottles, dishes and tubes. What might he grow in them?
- Notice how neat and bare the table is. Why would a scientist growing pure cultures keep his bench so clean?
- Look at his clothes. How is a lab bench like a kitchen counter, and how is it different?

Talk about it

1. Why did Koch need a solid surface, like potato or agar, to grow a pure culture?
2. If you could look at your kitchen sponge under Koch's microscope, what do you think you would see?

3. Which of Koch's habits at the lab bench could you use in your kitchen?

Safety first. An adult stands beside you the first time you slice raw chicken with a chef's knife and sear food in a hot skillet. Use a separate board and knife for raw chicken, wash your hands after every touch, and never put cooked food on a plate that held raw chicken; cook chicken to 165 °F. Only an adult mixes bleach sanitizer (never mix bleach with ammonia or any other cleaner), in a well-aired room, and it is never used on food.

KITCHEN PROJECT

Chicken Fajitas and a Sanitized Kitchen

You will slice chicken and peppers, sear them in a hot skillet, and check the chicken with a thermometer. Then you will clean and sanitize every surface the raw chicken touched and test how well you did.

You will need

- Two cutting boards (one marked for raw meat) and a damp towel under each
- A chef's knife and a paring knife
- A large heavy skillet (cast iron or stainless), long tongs and a spatula
- An instant-read food thermometer and two clean plates
- A bowl or zip-top bag for marinating
- For sanitizing: a clean spray bottle or bucket, unscented liquid chlorine bleach, measuring spoon, a gallon of water (adult mixes)

SKILLET CHICKEN FAJITAS

Serves 4–6 (about 12 fajitas) · Prep 25 min · Marinate 15–60 min · Cook 15 min

Ingredients

- 1½ pounds (680 g) boneless, skinless chicken breasts or thighs
- **Marinade:** 2 tablespoons vegetable or olive oil
- 2 tablespoons lime juice (1 lime)
- 1 teaspoon chili powder
- 1 teaspoon ground cumin
- ½ teaspoon garlic powder
- ¾ teaspoon salt and ¼ teaspoon black pepper
- **Vegetables:** 2 bell peppers (any colors), 1 large onion
- 1 more tablespoon oil for the vegetables
- 12 small flour or corn tortillas
- For serving: salsa, sour cream or plain yogurt, grated cheese, lime wedges

Method

1. Wash your hands. Stir the marinade ingredients together in a bowl or bag.
2. With an adult beside you, lay the chicken on the raw-meat board. Using the claw grip, slice it across the grain into strips about $\frac{1}{2}$ inch (1 cm) thick. Put the strips in the marinade and refrigerate 15–60 minutes. Wash your hands, and set the raw board and knife in the sink.
3. On the clean vegetable board, cut the peppers in half, remove the stems and seeds, and slice them into $\frac{1}{2}$ -inch strips. Halve the onion from root to tip, peel it, lay it flat (bridge grip), and slice it into thin wedges.
4. Heat 1 tablespoon oil in the skillet over medium-high heat until it shimmers. Add the vegetables and cook, stirring every minute, until they are tender and browned at the edges, 6–8 minutes. Move them to a clean plate.
5. Lift the chicken out of the marinade with tongs and lay it in the hot skillet in one layer; throw away the used marinade. Cook without stirring for 3 minutes to brown, then turn and cook 3–5 minutes more. Check the thickest strip: it must read 165 °F (74 °C). Wash the tongs in hot, soapy water before using them on cooked food, or use a second pair.
6. Return the vegetables to the skillet, toss for 1 minute, and turn off the heat. Warm the tortillas in a dry skillet or wrapped in a damp towel in the microwave for 30 seconds.
7. Serve with the toppings. Refrigerate leftovers within 2 hours.

Allergy check: Contains wheat (flour tortillas) and milk (cheese, sour cream). Use corn tortillas for a wheat-free meal and skip the dairy toppings for a milk-free one. Check that your chili powder blend fits your family's allergies.

Steps

1. **Warm-up math.** Finish the doubling chart from the warm-up up to 6 hours. Graph it. Why does this chart explain the 2-hour rule?
2. Make the fajitas, keeping a tally of every time you washed your hands.
3. **Thermometer check.** Record the temperature of three strips. If any read below 165 °F, cook them longer and check again.

4. **Clean, then sanitize.** Wash the raw-meat board, knife, sink and counter with hot, soapy water and rinse. Then the adult mixes 1 tablespoon unscented bleach in 1 gallon of cool water. Wipe or spray it on the clean surfaces, wait at least 1 minute (several minutes is better), and let them air-dry.
5. **Sponge check.** With the adult, sanitize your kitchen sponge too: soak it in the bleach solution for 1 minute or wash it in the dishwasher on a hot cycle with a drying cycle. Write down how often your family replaces sponges.
6. **Taste and rate.** Ask your family to rate the fajitas from 1 to 5 for flavor and for how well the chicken and vegetables browned.
7. **Improve it.** Write one change: thinner strips, a hotter pan, a longer marinade, or a different spice.

Tips

- Pat the chicken strips with a paper towel before they go in the pan; wet meat steams instead of browning. Throw the paper towel away and wash your hands.
- Do not crowd the skillet. If the strips do not fit in one layer, cook them in two batches.
- Partly frozen chicken (20 minutes in the freezer) is firmer and easier to slice evenly.

Check your work

- ☐ I can explain how Koch grew a pure culture and what his postulates proved.
- ☐ I can explain the difference between cleaning and sanitizing.
- ☐ I kept raw chicken separate, cooked it to 165 °F, and cleaned and sanitized every surface it touched.

COOK'S NOTEBOOK

1. Draw Koch's potato slice with a few separate colonies on it, and label why each colony is a pure culture.
2. Copy your doubling chart and graph. Write two sentences explaining what the graph says about leaving food out.
3. Draw a map of your kitchen from above. Mark the raw-meat zone, the ready-to-eat zone, and the path raw chicken takes from the fridge to the pan.

From history. Koch and Louis Pasteur were rivals as well as fellow pioneers of germ theory. Pasteur showed that germs cause fermentation and spoiling and found ways to protect people and animals from several diseases; Koch developed the methods for growing, staining and photographing bacteria that microbiologists still use. Between them, in about twenty years, they changed medicine, food safety and the kitchen.

COMMON MISTAKES

- Washing raw chicken in the sink. It does not remove bacteria; it splashes them up to two feet around the sink. Cooking to 165 °F is what makes chicken safe.
- Sanitizing a dirty surface. Sanitizer cannot reach germs hidden under grease and crumbs; always clean first.
- Using the same tongs or plate for raw and cooked chicken. Use clean ones for cooked food.

Make it a game • Koch's Three Questions. State Koch's postulates in plain words on three index cards, then shuffle them and rebuild the order from memory. Your parent quizzes you with a sneaky wrong version. Next, explain the difference between cleaning and sanitizing, and write the order for sanitizing a cutting board. Beat your own time on a second round.

1.3 THE THERMOMETER, THE 3-MINUTE REST AND CARRYOVER COOKING

OBJECTIVES

- Tell why the USDA lowered the safe temperature for whole cuts of pork from 160 °F to 145 °F in 2011.
- Use and calibrate an instant-read thermometer, and name the USDA safe minimum internal temperatures.
- Explain carryover cooking and the 3-minute rest, and cook pork chops to 145 °F.

Warm-up. Fill a tall glass with ice, then add cold water and stir for a minute. Put your thermometer in the middle of the glass, not touching the sides. What does it read? What should it read? If it is off, how could you correct for it?

WATCH

Super Quick Video Tips: Is Pink Pork Safe to Eat?

America's Test Kitchen • 1:05

<https://www.youtube.com/watch?v=DAMF0Xanw1Y>

WHEN TO WATCH

After The story. A test cook explains why pork cooked to 145 °F can look slightly pink and still be safe. Watch it twice; it is short.

Note: From America's Test Kitchen. Short, so pair it with the reading.

BACKUP VIDEO

The Right Way to Use a Meat Thermometer

J. Kenji López-Alt • 1:19

<https://www.youtube.com/watch?v=eF3sdtY5H2w>

Before the project. Watch exactly where the thermometer tip goes in a thick piece of meat.

KEY TERMS

safe minimum internal temperature

The lowest temperature, measured in the thickest part of a food, at which harmful germs are killed. Set by the USDA.

carryover cooking

The rise in a food's inside temperature after it leaves the heat, as hot outer layers keep sending heat toward the cooler center.

trichinosis

An illness caused by a tiny worm once common in pork. Thanks to better farming and feeding rules, it is now very rare in American pork.

calibrate

To check a measuring tool against a known standard (ice water is 32 °F, or 0 °C) and correct it.

rest time

The time cooked meat sits before it is cut or eaten. For whole cuts of beef, pork, veal and lamb the USDA requires 3 minutes at or above 145 °F.

CORE IDEAS

The story. For decades American cookbooks told cooks to cook pork until it was gray all the way through, and the USDA's recommended temperature was 160 °F. The reason was a parasite that causes trichinosis, which was once common in pigs. In the late 1940s there were hundreds of reported cases a year in the United States. Over the next sixty years, laws against feeding raw food scraps to pigs, cleaner barns and inspections made the parasite extremely rare in farmed pork. On May 24, 2011, the USDA announced a change: whole cuts of pork, like chops and roasts, are safe at 145 °F (63 °C), the same as beef, veal and lamb, as long as the meat **rests for 3 minutes** before it is cut or eaten.

How they figured it out. Food scientists did not guess. Killing germs depends on two things together: how hot and for how long. At 160 °F, *Salmonella* dies almost instantly. At 145 °F it takes a little time, and the 3-minute rest provides it, because the meat stays hot while it sits. The USDA weighed the testing on how germs die at different temperatures and times, and what pigs now carry, and concluded that 145

°F plus a 3-minute rest was safe for whole cuts. Ground pork still needs 160 °F, because grinding mixes surface germs all through the meat.

The kitchen science. Heat moves from the hot outside of a piece of meat toward the cooler center by conduction. When you take a chop off the heat, the outer layers are much hotter than the middle, so heat keeps flowing inward: the center temperature keeps rising for a few minutes. That is **carryover cooking**. A thin chop may rise 2–5 °F; a big roast can rise 5–10 °F or more. Cooks use carryover to keep meat juicy. For safety, we take the chop off the heat when the thickest part reads **at least 145 °F**, then let it rest; carryover adds a few degrees and the rest provides the time. The full USDA list: poultry 165 °F; ground beef, pork and lamb 160 °F; egg dishes 160 °F; whole cuts of beef, pork, veal and lamb 145 °F with a 3-minute rest; fish 145 °F; leftovers reheated to 165 °F.

Let's cook. You will pan-sear pork chops and track their temperature every minute, then watch carryover cooking happen on the cutting board. The skill is **using the thermometer like a professional**: insert it sideways into the thickest part, not touching bone or fat, wait for the number to settle, and wash the probe between raw and cooked checks.

PICTURE STUDY



A Cooking Class in a Washington, D.C., School, Frances Benjamin Johnston, c. 1899 · Photograph · Library of Congress, Washington, D.C.
Image: [Wikimedia Commons](#), public domain

Around 1899 the photographer Frances Benjamin Johnston photographed classrooms in the public schools of Washington, D.C. Cooking classes were new then. Students learned to measure carefully, keep their stations clean and cook food safely, the same habits you are learning now. In 1899 there were no instant-read thermometers in home kitchens; cooks judged doneness by color, feel and time.

Look closely

- Count the students. What are they all wearing, and why?
- Find the stoves or burners. How is each student's station arranged?
- Look for bowls, pans and spoons. What do you think they are cooking?
- Find the teacher. What might she be checking?

Talk about it

1. How would these students have known whether a piece of meat was cooked through?
2. What is one food-safety rule from this lesson you would teach this class if you could visit?

3. Which of their habits (aprons, caps, clean tables) do cooks still keep today, and why?

Safety first. Sear the pork with an adult beside you the first time; after that, an adult stays at home and nearby. Pork chops are done when the thickest part reads at least 145 °F; then rest them 3 minutes. Wash the thermometer probe in hot, soapy water after it touches raw or undercooked meat, and use a clean plate for the cooked chops.

KITCHEN PROJECT

Pork Chops and the Carryover Curve

You will calibrate your thermometer, sear pork chops, and record their temperature every minute on the stove and every minute while they rest. Your data will show carryover cooking as a curve.

You will need

- An instant-read food thermometer, a tall glass of ice water
- A large heavy skillet, long tongs and a spatter screen if you have one
- A cutting board for raw meat and a clean plate for cooked meat
- A timer and graph paper

PAN-SEARED PORK CHOPS WITH PAN SAUCE

Serves 4 • Prep 10 min • Cook 12–15 min • Rest 3–5 min

Ingredients

- 4 boneless or bone-in pork chops, about 1 inch (2.5 cm) thick (about 2 pounds / 900 g)
- 1 teaspoon salt and ½ teaspoon black pepper
- ½ teaspoon paprika and ½ teaspoon garlic powder
- 1 tablespoon vegetable oil
- **Pan sauce:** ½ cup (120 mL) chicken broth
- ½ cup (120 mL) apple juice
- 1 teaspoon Dijon mustard
- 1 tablespoon butter

Method

1. Take the chops out of the fridge 15 minutes before cooking. Pat them dry with paper towels, then season both sides with salt, pepper, paprika and garlic powder. Wash your hands.
2. Heat the oil in the skillet over medium-high heat until it shimmers. With tongs, lay the chops in the pan, placing each one away from you so the oil does not splash toward you.

3. Cook without moving them until deeply browned, 4–5 minutes. Turn them and lower the heat to medium. Begin checking the temperature of the thickest chop every minute.
4. When the thickest part reads at least 145 °F (63 °C), usually 4–7 minutes after turning, move the chops to a clean plate. Let them rest 3–5 minutes.
5. While they rest, make the sauce: pour the broth and apple juice into the hot skillet (stand back from the steam) and scrape up the browned bits with a wooden spoon. Simmer until reduced by half, about 4 minutes. Turn off the heat and stir in the mustard and butter.
6. Spoon the sauce over the chops and serve. Refrigerate leftovers within 2 hours and reheat to 165 °F.

Allergy check: Contains milk (butter). For a milk-free version, leave out the butter or use olive oil. Most chicken broth contains no major allergens, but check the label; some brands contain soy or wheat.

Steps

1. **Calibrate.** Test your thermometer in ice water (32 °F). Then, with an adult, test it in water at a full boil (212 °F at sea level; lower at higher altitude). Record any error.
2. Cook the chops. Starting when you turn them, record the center temperature of one chop every minute. Keep going after it comes off the heat: record it every minute for 5 minutes of rest.
3. **Graph it.** Plot temperature (up) against time (across). Mark the moment the chop left the pan. How many degrees did it rise after leaving the heat? When did it start to fall?
4. **Check them all.** Record the final temperature of every chop. Were they all the same? Why might thick and thin chops differ?
5. **Taste test.** Rate juiciness and browning from 1 to 5. Compare with any memory of overcooked, dry pork.
6. Clean up: wash the raw-meat board, tongs and thermometer probe in hot, soapy water; wipe the stovetop once it is cool.
7. **Improve it.** Write one change: thicker chops, a hotter sear, a different seasoning, or brining them next time (Lesson 5.4).

Tips

- Insert the thermometer from the side of the chop, so the tip sits in the very center of the thickest part.
- If the chops curl as they cook, cut two small slits through the fat on the edge before cooking.
- Boneless chops cook faster than bone-in chops of the same thickness. Start checking early.

Check your work

- ☐ I can explain why the safe temperature for pork changed in 2011.
- ☐ I can calibrate a thermometer and name the USDA safe minimum internal temperatures.
- ☐ I cooked pork chops to at least 145 °F, rested them 3 minutes, and graphed carryover cooking.

COOK'S NOTEBOOK

1. Make a neat card of the USDA safe minimum internal temperatures in °F and °C and tape it inside a cupboard door. (Use $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5 \div 9$.)
2. Paste or draw your carryover graph and write three sentences explaining it.
3. Copy the pork chop recipe in your own words, with your family rating and one improvement.

From history. Daniel Gabriel Fahrenheit made the first reliable mercury thermometers and his temperature scale in the early 1700s, and Anders Celsius proposed his scale in 1742. Thermometers for meat came much later; the quick digital instant-read thermometer became common in home kitchens only in the 1990s and 2000s.

COMMON MISTAKES

- Judging meat by its color. Pork at a safe 145 °F may be slightly pink, and some meat looks done before it is. Only a thermometer tells you.
- Pushing the thermometer all the way through, or into bone. The tip must rest in the center of the thickest part.
- Cutting into meat the moment it leaves the pan. The 3-minute rest is part of the safety rule, and it keeps the juices in the meat.

Make it a game · Pork Temperature Pop Quiz. Your parent names a food, and you call out its safe minimum temperature within five seconds: poultry, ground meat, pork, fish, leftovers. Miss one and start over. Then explain carryover cooking and the three-minute rest. Walk through the steps of calibrating a thermometer in ice water, and why the USDA lowered pork to 145 in 2011.

1.4 HARRY BREARLEY'S STAINLESS STEEL AND THE SAFE, SHARP KNIFE

OBJECTIVES

- Tell how Harry Brearley discovered stainless steel in Sheffield in 1913 and why it changed kitchen knives.
- Explain why a sharp knife is safer than a dull one, and the difference between honing and sharpening.
- Use a chef's knife with the claw and bridge grips to chop, slice and mince, and make a fresh herb sauce for pasta.

Warm-up. With an adult watching, try to slice a ripe tomato with a butter knife, then with a sharp serrated or chef's knife. Which one needed more pressure? Which one slipped on the skin? Which do you think is more likely to cut a finger?

WATCH

Equipment Review: Honing Rods

America's Test Kitchen • 7:17

<https://www.youtube.com/watch?v=KCh4iKDYAC0>

WHEN TO WATCH

After The kitchen science. Watch how the tester holds the rod and the knife, and listen for the difference between honing and sharpening.

BACKUP VIDEO

How to Hone a Kitchen Knife | Keep Your Knives Sharp Longer | HENCKELS

ZWILLING USA • 2:22

<https://www.youtube.com/watch?v=-hbTSfNDE5g>

A short, clear lesson on honing a chef's knife with the steel pointed down onto a towel.

KEY TERMS

stainless steel

Steel with at least about 10.5 percent chromium, which forms a thin, invisible layer on the surface that keeps the metal from rusting and staining.

sharpening

Grinding away a little metal with a stone or sharpener to make a new, keen edge. Done a few times a year.

mince

To cut food into very tiny pieces, smaller than a dice, by rocking a chef's knife back and forth over it.

honing

Straightening the thin edge of a knife, which bends over with use, by drawing it along a steel or ceramic rod. Honing removes almost no metal.

the claw

Holding food with fingertips curled under and knuckles forward, so the side of the blade rests against the knuckles and fingertips stay out of the way.

CORE IDEAS

The story. Sheffield, in northern England, had made knives and cutlery for hundreds of years. The best steel cut well but had one great fault: it rusted and stained, especially when it touched acidic foods like lemons, vinegar or tomatoes. Kitchen knives had to be dried and polished by hand after every use. In 1913 Harry Brearley, a Sheffield metallurgist who had started work at twelve as a laboratory bottle washer, was trying to find a steel for rifle barrels that would not wear away so quickly. On August 13, 1913, he cast a steel containing about 12.8 percent chromium.

How he figured it out. To study steel, metallurgists polish a sample and dip it in acid, which etches the surface so the crystal grains show under a microscope. Brearley's new steel would hardly etch at all. Then he noticed that samples he had thrown aside in the yard had not rusted. Instead of a disappointment, he saw a new use: cutlery. A Sheffield cutler, Ernest Stuart, made knives from it and called the steel "stainless." Within a few years stainless knives, forks and spoons were sold around the world. Today almost every kitchen knife, sink and mixing bowl is stainless steel.

The kitchen science. A knife edge is a very thin wedge of metal. Under a microscope a sharp edge looks smooth and straight; with use, the thin edge rolls and bends over to one side, and the knife feels dull even though most of the metal is still there.

Honing with a steel rod pushes the bent edge back into line; good cooks hone often, even every time they cook. When the edge is truly worn down, **sharpening** grinds away a little metal to make a new one. A sharp knife is safer because it cuts with little pressure and bites into food instead of skidding off a tomato skin or an onion and into a finger. A dull knife needs force, and force makes slips.

Let's cook. You will watch an adult hone your family's chef's knife, then practice the claw and the bridge on soft foods before you cut anything hard. You will mince parsley, basil and garlic and make a bright green herb sauce for pasta. The skill is **controlled cutting**: board steady on a damp towel, knuckles guiding the blade, tip of the knife on the board when you mince, and the knife laid flat at the back of the counter, never in a sink full of water.

PICTURE STUDY



The Turnip Scraper (La Ratisseuse), Bernard Lépicié, engraved after a painting by Jean-Siméon Chardin, 1742 · Etching and engraving · National Gallery of Art, Washington, D.C.

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

Jean-Siméon Chardin painted ordinary kitchen work with great respect. In this picture, made into a print so many people could own a copy, a young woman has paused while peeling turnips for the family pot. Her knife is the most important tool in the kitchen. Long before stainless steel, she would have had to dry and polish it so it would not rust.

Look closely

- Find the knife. How is she holding it? Where is her other hand?
- Find the turnips: the ones still to peel, the ones finished, and the peelings.
- Look for the chopping block and the pot. What will happen to the turnips next?
- Look at her face. Is she rushing or working steadily?

Talk about it

1. Peeling toward your thumb with a small knife was common in Chardin's day. Why do we teach peeling away from the body and cutting on a board instead?
2. How would a dull knife make her work slower and less safe?
3. What does Chardin seem to think about ordinary kitchen work?

Safety first. Practice the claw and bridge grips with an adult beside you before using a chef's knife on your own, and always cut on a board with a damp towel underneath. Only an adult sharpens knives on a stone or sharpener; you may hone with supervision, with the steel's tip resting on a towel on the counter. Never try to catch a falling knife, never leave a knife in a sink of soapy water, and carry a knife point-down beside your leg.

KITCHEN PROJECT

Knife Skills and Green Herb Sauce Pasta

You will compare a dull and a honed knife on paper and tomatoes, practice four cuts, and mince the herbs and garlic for a fresh green sauce tossed with hot pasta.

You will need

- A chef's knife and, if you have one, a honing steel
- A large cutting board with a damp towel underneath
- A sheet of printer paper and two ripe tomatoes
- A large pot, a colander, a liquid measuring cup, a grater (for lemon zest and cheese) and a mixing bowl

PASTA WITH GREEN HERB SAUCE

Serves 4–6 • Prep 20 min • Cook 12 min

Ingredients

- 1 pound (450 g) spaghetti, linguine or short pasta
- 1 tablespoon salt for the pasta water
- 1 large bunch flat-leaf parsley (about 1½ cups leaves, packed)
- 1 cup fresh basil leaves, packed (or more parsley)
- 2 cloves garlic
- 1 lemon (zest and 2 tablespoons juice)
- ½ cup (120 mL) extra-virgin olive oil
- ½ teaspoon salt and ¼ teaspoon black pepper
- Pinch of red pepper flakes (optional)
- ½ cup (45 g) grated Parmesan cheese, plus more for serving
- 1 cup cherry tomatoes, halved (optional)

Method

1. With an adult nearby, fill the large pot with about 4 quarts of water and bring it to a boil with the lid on. Add 1 tablespoon salt.

2. Wash and dry the herbs. Pick the parsley and basil leaves off the thick stems. Gather the leaves in a tight pile, hold them with the claw, and slice them thinly. Then rock the knife over the pile, tip on the board, gathering and re-chopping until the herbs are finely minced.
3. Crush each garlic clove under the flat of the knife, peel it, slice it thinly, and mince it. Sprinkle a pinch of salt over the garlic and press it with the flat of the blade into a paste.
4. In the mixing bowl, stir together the herbs, garlic, lemon zest, lemon juice, olive oil, salt, pepper and red pepper flakes.
5. Add the pasta to the boiling water, stir, and cook according to the package until just tender. Before draining, dip out $\frac{1}{2}$ cup of the cooking water with a measuring cup. An adult or you (with the adult nearby) carries the pot to the sink and pours it slowly into the colander, steam rising away from your face.
6. Toss the hot pasta with the herb sauce, the Parmesan and a few spoonfuls of the cooking water until glossy. Add the tomatoes and serve with more cheese.

Allergy check: Contains wheat (pasta) and milk (Parmesan). Use gluten-free pasta for a wheat-free meal, and leave out the cheese or use a dairy-free alternative for a milk-free one.

Steps

1. **Paper test.** Before honing, the adult holds a sheet of paper by one corner and you slice down through it slowly. Does the knife cut cleanly or snag? Then the adult hones the knife (or you hone it with the adult beside you) with 5–6 light strokes on each side, steel tip on a towel. Test again. Record what changed.
2. **Tomato test.** Slice one tomato with the knife before honing and one after (or compare with a knife you know is dull). Which crushed the tomato? Which slid off the skin?
3. **Four cuts.** Practice on vegetables for the sauce or a salad: a slice (claw), a halving cut (bridge), a dice and a mince. Ask the adult to watch each and check your grips.
4. Make the pasta and sauce.

5. **Taste test.** Taste the sauce before and after adding the lemon juice. Describe the difference in one sentence.
6. **Clean up:** wash the knife by hand, blade away from you, dry it at once and put it away. Wash and dry the board.
7. **Improve it.** Write one change: more lemon, a different herb (mint, cilantro, chives), toasted nuts, or chopping the herbs more finely.

Tips

- Herbs must be completely dry before chopping, or they bruise and turn dark.
- Use the back of the knife, not the sharp edge, to scrape chopped food across the board.
- Hone a knife at about a 15–20 degree angle: imagine halving a right angle, then halving it again.

Check your work

- ☐ I can tell how Harry Brearley discovered stainless steel.
- ☐ I can explain why a sharp knife is safer and the difference between honing and sharpening.
- ☐ I used the claw and bridge grips with a chef's knife and minced herbs and garlic for a sauce.

COOK'S NOTEBOOK

1. Draw a knife edge as it would look under a microscope: sharp, rolled over, and honed straight again. Label each.
2. Draw the claw and the bridge grips from the side, showing where the blade and fingertips are.
3. Copy the herb sauce recipe in your own words. Rate it and write one improvement.

COMMON MISTAKES

- Thinking a dull knife is safer for beginners. Dull knives need force and skid off food; a sharp knife used with the claw is safer.
- Lifting the whole knife high off the board to chop. Keep the tip down and rock the blade for mincing.

- Putting good knives in the dishwasher or a drawer loose with other tools. Hand-wash, dry and store them with the edge covered or in a block.

Make it a game • Honing or Sharpening. Trade riddles about knives with your parent. For example, I straighten the edge but remove no metal. Answer honing or sharpening. Then argue, in sixty seconds, why a sharp knife is safer than a dull one, mentioning the claw. Finish by telling how Harry Brearley discovered stainless steel in Sheffield in 1913, with no actual knives out.

Scripture. “Iron sharpeneth iron; so a man sharpeneth the countenance of his friend.” (Proverbs 27:17, KJV)

A steel hones a knife by rubbing against it; a good friend sharpens us by honest words and good example. In the kitchen, as in life, we grow sharper working beside others.

UNIT 1

KITCHEN & FOOD SAFETY

A good cook is first of all a safe cook. This unit begins with one of the strangest true stories in the history of food: a skilled New York cook named Mary Mallon who never felt sick herself, yet carried typhoid germs from one family's kitchen to the next. You will follow the sanitary engineer who tracked her down, and then go back a generation to Robert Koch, the German country doctor who proved that particular bacteria cause particular diseases and invented the lab methods that let anyone grow and see them.

Then you will put the science to work. You will learn the difference between cleaning and sanitizing, mix a sanitizing solution with an adult, and cook chicken fajitas to 165 °F. You will learn why the USDA lowered the safe temperature for pork chops in 2011, what carryover cooking is, and how to use a thermometer like a professional. Finally you will hear how a Sheffield metallurgist invented stainless steel in 1913, learn why a sharp knife is safer than a dull one, and hone your chef's knife before mincing a fresh herb sauce for pasta. Throughout the course, **a parent or responsible adult supervises all cooking**, and families check every recipe against their own food allergies.

PREREQUISITES

- Can read a recipe all the way through and measure with cups, spoons and a scale
- Knows the four steps Clean, Separate, Cook, Chill from earlier grades (reviewed here)
- Can read a dial or digital thermometer in °F
- Has practiced the claw and bridge grips with a smaller knife, or will practice them with an adult in Lesson 1.2 before using a chef's knife

MASTERY CHECKLIST

- ☐ I can tell the story of Mary Mallon and George Soper and explain what a healthy carrier is.
- ☐ I can explain how Robert Koch proved that a particular germ causes a particular disease, and the difference between cleaning and sanitizing.
- ☐ I can name the USDA safe minimum internal temperatures, use a thermometer correctly, and explain carryover cooking and the 3-minute rest.
- ☐ I can explain why a sharp knife is safer than a dull one, tell honing from sharpening, and use a chef's knife with the claw and bridge grips.
- ☐ I can keep the danger zone (40–140 °F) and the 2-hour rule in mind every time I cook.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **FoodSafety.gov: Safe Minimum Internal Temperatures:** Free. A printable chart to tape inside a cupboard door for Lessons 1.2 and 1.3 and the rest of the year.
- **An instant-read food thermometer:** The most important tool in this course. A digital one that reads in a few seconds is easiest to use. Check it in ice water (32 °F) before Lesson 1.3.
- **A honing steel or ceramic honing rod:** Optional. Many chef's knives come with one. Lesson 1.4 shows how an adult uses it and how you may use it with supervision.

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 Typhoid Mary and the Cook's Hands

2 sessions of 50–60 minutes

1.2 Robert Koch and the Bacteria You Cannot See

2 sessions of 50–60 minutes

1.3 The Thermometer, the 3-Minute Rest and Carryover Cooking

2 sessions of 50–60 minutes

1.4 Harry Brearley's Stainless Steel and the Safe, Sharp Knife

2 sessions of 50–60 minutes

UNIT 1 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

What is a healthy carrier? How did George Soper figure out that Mary Mallon was one?

2. **8 pts**

Why are ready-to-eat foods like cut fruit and ice cream the riskiest foods for a cook with unwashed hands?

3. **8 pts**

How did Robert Koch grow a pure culture of bacteria, and what was Fanny Hesse's contribution?

4. **8 pts**

What is the difference between cleaning and sanitizing? In what order do you do them?

5. **8 pts**

Calculation: bacteria double every 20 minutes. Starting with 10 bacteria on a cutting board, how many will there be after 2 hours? Show your work.

6. **10 pts**

Give the USDA safe minimum internal temperature for each: chicken thighs; ground beef; pork chops; salmon; scrambled eggs; leftover soup.

7. **8 pts**

Why did the USDA lower the safe temperature for whole cuts of pork to 145 °F in 2011, and why does ground pork still need 160 °F?

8. **8 pts**

Calculation: convert 145 °F and 165 °F to °C, using $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5 \div 9$. Round to the nearest degree.

9. **8 pts**

Explain carryover cooking. Would you expect it to be larger in a thin pork chop or a large pork roast? Why?

10. **8 pts**

Why is a sharp knife safer than a dull one? What is the difference between honing and sharpening?

11. **8 pts**

What did Harry Brearley add to steel in 1913, and why did it matter in the kitchen?

12. **10 pts**

Written answer: You are making chicken fajitas. List, in order, at least five things you do to keep the meal safe from the moment you take the chicken out of the fridge until the leftovers are put away.

ANSWER KEY

1. A person who carries and spreads a germ without feeling sick. Soper noticed the banker's family hired Mallon about three weeks before the outbreak, then traced her past jobs and found typhoid in seven of the eight households where she had cooked; tests in 1907 found typhoid bacteria in her.
2. They are not cooked after the cook touches them, so no heat kills germs that are transferred from the hands to the food.
3. He spread bacteria on a solid surface (first a potato slice, then gelatin, then agar) so each single bacterium grew into its own colony of one kind. Fanny Hesse suggested using agar, a seaweed jelly she used in her kitchen, because it stayed firm in warm weather.
4. Cleaning removes dirt, food and grease with soap and water; sanitizing reduces the remaining germs to a safe level with heat or a sanitizer. Clean first, then sanitize.
5. 2 hours = 120 minutes = 6 doublings. $10 \times 2^6 = 10 \times 64 = 640$ bacteria.
6. Chicken 165 °F; ground beef 160 °F; pork chops 145 °F with a 3-minute rest; salmon 145 °F; egg dishes 160 °F; leftovers reheated to 165 °F.
7. Trichinosis had become very rare in farmed pork, and testing showed that 145 °F held for a 3-minute rest kills harmful germs. Grinding mixes surface germs all through the meat, so ground pork must reach 160 °F.
8. 145 °F: $(145 - 32) \times 5 \div 9 = 113 \times 5 \div 9 \approx 63$ °C. 165 °F: $(165 - 32) \times 5 \div 9 = 133 \times 5 \div 9 \approx 74$ °C.
9. After meat leaves the heat, the hot outer layers keep conducting heat into the cooler center, so the center temperature rises. It is larger in a large roast, because there is more hot outer meat and a bigger difference between outside and center.
10. A sharp knife cuts with little pressure and bites into food instead of skidding off, so it slips less. Honing straightens a bent edge without removing much metal; sharpening grinds away metal to make a new edge.
11. About 12.8 percent chromium. The chromium forms a thin protective layer, so the steel resists rust and stains from acidic foods, making knives, forks, sinks and bowls that need no constant polishing.
12. A good answer includes: wash hands; use a separate board and knife for raw chicken; do not wash the chicken; wash hands after touching it; throw away used marinade; cook to 165 °F and check the thickest piece with a thermometer;

use clean tongs and a clean plate for cooked chicken; clean and sanitize surfaces; refrigerate leftovers within 2 hours.

UNIT CHALLENGE: A FAMILY KITCHEN SANITATION AUDIT

Inspect your family's kitchen the way a health inspector would. Make a checklist with at least 15 items under the headings Clean, Separate, Cook and Chill: a refrigerator thermometer reading (40 °F or below) and a freezer reading (0 °F), how raw meat is stored (bottom shelf, in a container), cutting boards, sponge and towel habits, a calibrated food thermometer, the hand-washing station, and leftovers labeled with dates.

Score each item, then fix at least three problems with your parent's permission (for example, moving raw meat to the bottom shelf, labeling leftovers, or setting up a sponge-sanitizing routine). Finish by cooking one meal from this unit for your family using every safety step, and write a one-page report with your scores before and after.

LOOK FOR	WHAT IT MEANS
Checklist	At least 15 clear items under Clean, Separate, Cook and Chill, each scored honestly, with refrigerator and freezer temperatures recorded.
Improvements	At least three real problems fixed, with before-and-after notes or photos.
Safe cooking	One meal from the unit cooked with clean hands, separate boards, a thermometer check and leftovers chilled within 2 hours.
Report	A neat one-page report with scores, what changed, and what the family will keep doing.
Cleanup and attitude	Kitchen left clean; the audit carried out respectfully and helpfully.

UNIT 2

FOOD GROUPS & THE BALANCED MEAL

God made a world full of good things to eat, and He made our bodies to be nourished by them. In this unit you will look inside the food groups at the nutrients that do the work: the vitamins that a Polish chemist named in 1912, the proteins built from amino acids, and minerals like iron that carry oxygen in your blood. You will see how scientists discovered each one, often by noticing what went wrong when people went without.

You will also learn how the *Dietary Guidelines for Americans* turn that science into everyday advice, and you will plan and cook a full day of balanced meals. Along the way you will make a roasted vegetable soup, whole-grain pancakes, baked salmon with black beans, and spinach and bean quesadillas. This unit is about nourishment and stewardship, never about body size: a balanced way of eating gives a growing body what it needs to work, learn, play and serve.

PREREQUISITES

- Knows the five MyPlate food groups (fruits, vegetables, grains, protein, dairy) from earlier grades
- Can measure dry and liquid ingredients and use a chef's knife with the claw and bridge (Unit 1)
- Knows the safe temperature for fish (145 °F) and how to use a thermometer (Unit 1)
- Can multiply and divide fractions and work with percentages

MASTERY CHECKLIST

- ☐ I can tell how Casimir Funk named vitamins and explain the difference between fat-soluble and water-soluble vitamins.

- ☐ I can explain what the *Di* are and plan a balanced day of *eta* meals with MyPlate.

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- ☐ I can explain what proteins and amino acids are, and name protein foods from plants and animals.
- ☐ I can explain what iron does in the body and how vitamin C helps the body absorb iron from plant foods.
- ☐ I can use calories correctly as a unit of food energy (carbohydrate and protein about 4 per gram, fat about 9), not as something to count or restrict.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **MyPlate.gov:** Free. The USDA’s MyPlate site, with the food groups, serving ideas and printable planning sheets. Useful for Lesson 2.2 and the unit challenge.
- **Dietary Guidelines for Americans:** Free. The official site for the Guidelines. Parents may want to read the short executive summary before Lesson 2.2.
- **An immersion (stick) blender:** Optional. Makes blending hot soup safer and easier in Lesson 2.1. A regular blender works if it is filled only halfway and the lid is vented.

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	Casimir Funk Names the “Vitamine”	2 sessions of 50–60 minutes
2.2	The Dietary Guidelines and a Balanced Day	2 sessions of 50–60 minutes
2.3	Protein at Every Meal: Eggs, Beans and Fish	2 sessions of 50–60 minutes
2.4	Iron, Leafy Greens and Vitamin C	2 sessions of 50–60 minutes

UNIT 2 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. 8 pts

Who was Casimir Funk, and why did he call the substances he studied “vitamines”?

2. 8 pts

Name the fat-soluble vitamins. Why is a little olive oil helpful when you roast carrots?

3. (8 pts)

Why do long-boiled vegetables lose more vitamin C than roasted vegetables or soup?

4. (8 pts)

What are the *Dietary Guidelines for Americans*, and how often are they updated?

5. (10 pts)

Calculation: one serving of oatmeal has 27 grams of carbohydrate, 5 grams of protein and 3 grams of fat. How much food energy does it give? Show your work.

6. (8 pts)

Describe the MyPlate plate.

7. (8 pts)

What are amino acids, and what does “essential” mean?

8. (8 pts)

Why are rice and beans a good pair? Name two other traditional meals that pair grains and beans.

9. (6 pts)

What is the safe internal temperature of salmon, and how else can you tell it is done?

10. (8 pts)

What did Vincenzo Menghini do with a magnet, and what does iron do in the blood?

11. (10 pts)

Calculation: a recipe for 4 people calls for 1 can (15 ounces) of black beans and 5 ounces of spinach. How much of each do you need for 10 people? Show your work.

12. (10 pts)

Written answer: Plan a balanced dinner that includes an iron-rich food and a vitamin C food, and covers at least four MyPlate groups. Explain your choices.

ANSWER KEY

1. A Polish chemist working in London who in 1912 argued that diseases like beriberi and scurvy were caused by missing substances in food. He thought they were amines vital to life, so he named them vitamines (vita + amine); the e was later dropped.
2. Vitamins A, D, E and K. The beta-carotene in carrots, which the body turns into vitamin A, dissolves in fat, so cooking or eating carrots with a little fat helps the body absorb it.
3. Vitamin C dissolves in water and is damaged by long heating; it leaches into the cooking water, which is often poured away. Roasting uses no water, and in soup you eat the liquid.
4. Advice on healthy eating published by the USDA and the Department of Health and Human Services, first in 1980, based on reviews of nutrition research. They are updated every five years.
5. $27 \times 4 = 108$; $5 \times 4 = 20$; $3 \times 9 = 27$. Total = $108 + 20 + 27 = 155$ calories.
6. Half the plate fruits and vegetables (a little more vegetables than fruit), about a quarter grains with at least half of them whole, about a quarter protein, and a serving of dairy on the side.
7. Amino acids are the 20 building blocks of proteins. Nine are essential, which means the body cannot make them, so they must come from food.
8. Beans are low in one essential amino acid and grains are low in another, so together they complement each other. Examples: bean burritos in tortillas, lentils with bread, hummus with pita, Ezekiel bread, peanut butter on whole-wheat bread.
9. 145 °F. The flesh turns from translucent to opaque and flakes easily with a fork.
10. He burned dried blood to ash and showed that a magnet picked up particles from it, proving blood contains iron. Iron is part of hemoglobin, which carries oxygen from the lungs to the body's cells.
11. Scale factor = $10 \div 4 = 2.5$. Beans: $15 \times 2.5 = 37.5$ ounces, about $2\frac{1}{2}$ cans. Spinach: $5 \times 2.5 = 12.5$ ounces.
12. Answers vary. Example: beef and pepper stir-fry over brown rice with orange slices and a glass of milk: beef (protein, heme iron), peppers and oranges (vegetables, fruit, vitamin C to help absorb iron), brown rice (whole grain), milk (dairy).

UNIT CHALLENGE: A BALANCED DAY, PLANNED AND COOKED

Plan one full day of balanced meals and two snacks for your family using a MyPlate chart, with at least one iron-plus-vitamin-C pairing and protein at every meal. Write a shopping list for the day.

Then cook at least two of the day's three meals yourself, with an adult nearby, and help with the third. Photograph each plate, check it against MyPlate, and ask your family to rate each meal. Finish with a one-page reflection: what went well, which food groups were easiest and hardest to include, and what you would change.

LOOK FOR	WHAT IT MEANS
Planning	A complete day on a MyPlate chart, all five groups represented, with a shopping list.
Nutrition thinking	Protein at each meal, at least half the grains whole, and an iron-plus-vitamin-C pairing, each explained.
Cooking and safety	Two meals cooked with clean hands, safe knife and stove work, and correct temperatures.
Record	Photos or sketches of each plate, family ratings, and a one-page reflection.
Cleanup and service	Kitchen left clean after each meal; meals served with thanks.

2.1 CASIMIR FUNK NAMES THE “VITAMINE”

OBJECTIVES

- Tell how Casimir Funk named vitamins in 1912, building on the work on beriberi and polished rice.
- Explain the difference between fat-soluble and water-soluble vitamins and how cooking affects each.
- Roast vegetables and blend them safely into a soup, choosing methods that keep the most vitamins.

Warm-up. Look at three foods in your kitchen: a carrot, an orange and a slice of bread. Guess one vitamin each one gives you. Then check the Nutrition Facts label on any package that has one. Which vitamins and minerals are listed?

WATCH

[Introduction to vitamins and minerals](#) | [Biology foundations](#) | [High school biology](#) | [Khan Academy](#)

[Khan Academy](#) · 6:11

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

WHEN TO WATCH

After How he figured it out. Watch for the difference between vitamins and minerals and the two kinds of vitamins.

Note: From Khan Academy. A clear introduction at a high-school level; pause to write down the names of the vitamins.

BACKUP VIDEO

[Vitamins and Minerals for Kids](#) | [Learn the difference and why they're important](#)

[Learn Bright](#) · 7:05

<https://www.youtube.com/watch?v=LG3LjykAa4k>

A simpler review of vitamins and minerals and the foods they come from, good for younger siblings too.

KEY TERMS

vitamin

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

fat-soluble vitamins

Vitamins A, D, E and K, which dissolve in fat. The body absorbs them best when they are eaten with a little fat, and it can store them.

nutrient-dense food

A food that gives many vitamins, minerals and other nutrients for its amount of food energy, such as vegetables, fruit, beans and whole grains.

deficiency disease

An illness caused by not getting enough of a particular nutrient, such as scurvy (vitamin C) or beriberi (thiamine, vitamin B₁).

water-soluble vitamins

Vitamin C and the B vitamins, which dissolve in water. They can leach into cooking water and are easily damaged by long heating.

CORE IDEAS

The story. By 1900 scientists knew that food gave the body energy and building material, but some diseases still made no sense. On long voyages sailors got scurvy. In Asia, people who ate mostly white, polished rice got beriberi, a disease of weak nerves and heart. In the 1890s the Dutch doctor Christiaan Eijkman, working in Java, noticed that chickens fed polished rice became sick and recovered when they were fed rice with its brown outer layer. Something in that layer protected them. In London, at the Lister Institute, a young Polish chemist named Casimir Funk set out to find it.

How he figured it out. Funk worked to pull the protective substance out of rice polishings. He believed it was a kind of chemical called an amine, and that it was vital to life. In 1912 he published a paper arguing that beriberi, scurvy, pellagra and rickets were all caused by missing substances in food, and he gave them a name: “vitamines,” from *vita* (life) and amine. He was right about the big idea, and wrong about one detail: not all of them are amines. In 1920 the British biochemist Jack

Drummond suggested dropping the final *e*, and the word became “vitamin.” Over the next thirty years scientists identified and named the vitamins one by one, often by letters: A, B, C, D, E and K.

The kitchen science. Vitamins come in two families. **Fat-soluble** vitamins (A, D, E and K) dissolve in fat. The orange beta-carotene in carrots and sweet potatoes, which the body turns into vitamin A, is absorbed far better when the vegetables are cooked with a little oil. **Water-soluble** vitamins (C and the B vitamins) dissolve in water and are fragile. Boiling vegetables for a long time and pouring the water down the drain throws some of them away. Roasting, steaming, microwaving and making soup, where you eat the liquid too, keep more of them. A balanced way of eating, with many colors of vegetables and fruit, gives you the whole set; that is why MyPlate fills half the plate with them.

Let’s cook. You will roast tomatoes, red peppers, carrots and onions until they are sweet and browned, then simmer and blend them into a bright soup. Roasting adds flavor, a little olive oil helps you absorb vitamin A, and because you eat the broth, the water-soluble vitamins stay in the bowl. The skill is **blending hot soup safely**.

PICTURE STUDY



Vegetable Seller, Joachim Beuckelaer, 1565 · Oil on panel · Museum collection (see source)

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

Joachim Beuckelaer of Antwerp was famous for market scenes crowded with real food. Sixteenth-century buyers loved to look at his paintings and name every vegetable. Four hundred years before anyone knew the word “vitamin,” the people of Antwerp were buying exactly the foods that would supply them.

Look closely

- Name as many vegetables as you can. Which ones do you recognize from your own grocery store?
- Find something orange. What vitamin would it give?
- Find something dark green or leafy. What might it give?
- Look at how the vegetables are stored: baskets, piles, cloths. How would this market keep them fresh without a refrigerator?

Talk about it

1. If you could buy six vegetables from this stall for a roasted soup, which would you choose and why?
2. Why do you think Beuckelaer painted the food so large and the woman so small?
3. Which vegetables here would lose the most vitamin C if boiled for an hour?

Safety first. Use oven mitts for the hot pan and stand back when you open the oven door. Blend hot soup only with an adult nearby: an immersion blender kept deep in the pot, or a regular blender filled no more than halfway with the lid's center cap removed and a folded towel held over the opening, pulsing at first. Steam can blow the lid off a sealed blender.

KITCHEN PROJECT

Roasted Vegetable Soup and the Vitamin Hunt

You will roast a sheet pan of vegetables, turn them into a smooth soup, and make a chart showing which vitamins each vegetable brings and how your cooking method protected them.

You will need

- A chef's knife, a cutting board with a damp towel underneath
- A large rimmed baking sheet and oven mitts
- A large pot with a lid and a wooden spoon
- An immersion blender or a regular blender, a ladle and a liquid measuring cup

ROASTED TOMATO AND RED PEPPER SOUP

Serves 6 (about 8 cups) · Prep 20 min · Roast 35–40 min · Simmer 15 min

Ingredients

- 2 pounds (900 g) ripe Roma tomatoes (about 10), halved lengthwise
- 2 red bell peppers, seeded and cut into wide strips
- 3 medium carrots, peeled and cut into 1-inch pieces
- 1 large onion, cut into 8 wedges
- 4 cloves garlic, peeled
- 3 tablespoons olive oil
- 1 teaspoon salt and ½ teaspoon black pepper
- 1 teaspoon dried thyme or Italian seasoning
- 4 cups (950 mL) low-sodium chicken or vegetable broth
- 1 tablespoon lemon juice
- For serving: plain yogurt or grated Parmesan, chopped fresh basil, whole-grain bread

Method

1. With an adult nearby, heat the oven to 425 °F (220 °C).

2. Wash the vegetables. Cut them as listed, using the claw and bridge grips. Spread them on the baking sheet with the garlic. Drizzle with the oil, sprinkle with salt, pepper and thyme, and toss with clean hands until coated.
3. Roast 35–40 minutes, stirring once halfway, until the vegetables are soft and browned at the edges. Use oven mitts and open the door away from your face.
4. Scrape the vegetables and all the browned juices into the pot. Add the broth. Bring to a simmer over medium heat and cook 15 minutes.
5. Turn off the heat. Blend with an immersion blender until smooth, keeping the blade under the surface. (Or ladle half the soup into a blender, no more than half full, remove the center cap, cover with a folded towel, and blend; repeat.)
6. Stir in the lemon juice. Taste and add salt if needed. Serve with a swirl of yogurt or Parmesan, basil and bread. Refrigerate leftovers within 2 hours; reheat to 165 °F.

Allergy check: Contains none of the nine major allergens as written (check your broth label). Yogurt or Parmesan adds milk; bread adds wheat. Serve with rice crackers or leave off toppings for a milk-free, wheat-free meal.

Steps

1. **Vitamin chart.** Before cooking, make a table with each vegetable in a row and columns for vitamin A, vitamin C, B vitamins and fiber. Use the MyPlate site or a nutrition reference to put a check in each box.
2. Roast the vegetables. Every 10 minutes, look and write down the color and smell. What changed?
3. Finish and blend the soup safely with the adult.
4. **Method comparison.** In your notebook, explain why roasting and eating the broth keeps more vitamins than boiling carrots and draining them. Name which vitamins and why.
5. **Taste test.** Taste the soup before and after the lemon juice. Ask your family to rate it from 1 to 5.

6. Clean up: soak the baking sheet, wash the blender (an adult handles the blade), wipe the counter.
7. **Improve it.** Write one change: add a sweet potato, roast a little longer for deeper color, more garlic, or a pinch of smoked paprika.

Tips

- Give the vegetables room on the pan. Crowded vegetables steam instead of browning.
- If the soup is too thick, add broth or water $\frac{1}{4}$ cup at a time.
- This soup freezes well for 3 months; leave an inch of space in the container for expansion.

Check your work

- ☐ I can tell how Casimir Funk named vitamins.
- ☐ I can explain fat-soluble and water-soluble vitamins and how cooking affects them.
- ☐ I roasted vegetables and blended hot soup safely with an adult nearby.

COOK'S NOTEBOOK

1. Copy your vitamin chart neatly and add one sentence for each vitamin saying what it does in the body.
2. Draw the soup in a bowl and label each ingredient with the vitamin it brings.
3. Write the recipe in your own words with your family's rating and one improvement.

From history. Christiaan Eijkman and Frederick Gowland Hopkins shared the 1929 Nobel Prize in Physiology or Medicine for their discoveries about vitamins. Funk never won the prize, but his word is the one the whole world uses.

COMMON MISTAKES

- Thinking vitamins come mainly from pills. Nutrient-dense foods supply vitamins along with fiber and many other good things; vitamin pills are a matter for your family and your doctor.
- Boiling vegetables until they are soft and gray and pouring away the water. Cook them just until tender, or keep the liquid in a soup.

- Sealing a blender full of hot soup. Steam pressure can blow the lid off; fill it halfway and vent the lid.

Make it a game • Vitamin Sort. Write twelve vitamins or foods on slips and sort them into fat-soluble and water-soluble piles against a two-minute timer. Check your answers. Then tell how Casimir Funk coined vitamine in 1912 and how it connects to beriberi and polished rice. Name how cooking affects each group, and which foods are nutrient-dense.

Scripture. “And God said, Behold, I have given you every herb bearing seed, which is upon the face of all the earth, and every tree, in the which is the fruit of a tree yielding seed; to you it shall be for meat.” (Genesis 1:29, KJV)

Long before anyone could name a vitamin, God had already filled the plants of the earth with what our bodies need. Science discovers what the Creator has given.

2.2 THE DIETARY GUIDELINES AND A BALANCED DAY

OBJECTIVES

- Explain what the *Dietary Guidelines for Americans* are, who writes them, and how MyPlate puts them on a plate.
- Use calories correctly as a unit of food energy and calculate the energy in a food from its grams of carbohydrate, protein and fat.
- Plan a balanced day of meals and snacks and cook its breakfast: whole-grain pancakes with fruit and yogurt.

Warm-up. Write down everything you ate and drank yesterday. Next to each item, write which MyPlate group it belongs to (some foods belong to more than one). Which group showed up most? Which was missing?

WATCH

Planning Meals with MyPlate

Neva Cochran · 4:14

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

WHEN TO WATCH

After The kitchen science, before you plan your day. Watch how a registered dietitian builds each meal from the food groups.

Note: A local TV segment; it begins with a short show introduction.

KEY TERMS

Dietary Guidelines for Americans

Advice on healthy eating published by the U.S. Departments of Agriculture and of Health and Human Services, first in 1980 and updated every five years.

calorie

A unit of food energy. Carbohydrate and protein give about 4 calories per gram, and fat about 9. It measures energy, the way a gallon measures fuel.

macronutrients

The nutrients we need in large amounts: carbohydrate, protein and fat.

eating pattern

Everything a person eats and drinks over days and weeks, taken together. The Guidelines focus on the whole pattern, not on single foods.

added sugars

Sugars and syrups added to foods when they are made or prepared, as opposed to the sugars found naturally in fruit and milk.

CORE IDEAS

The story. For most of history, advice about eating came from mothers, grandmothers and cookbooks. In the twentieth century the U.S. government began publishing food guides, starting with a 1916 booklet called *Food for Young Children* and the “Basic Seven” of 1943. In 1980 the U.S. Department of Agriculture and the Department of Health and Human Services published the first *Dietary Guidelines for Americans*. Since 1990 the law has required a new edition every five years, written after scientists review the latest research. The 2020–2025 edition was the first to give advice for every stage of life, from babies to older adults.

How they figured it out. The Guidelines are made by gathering many studies, not one. A committee of nutrition scientists reviews research on what people eat and how they grow and stay well over years. Then the two departments write the advice in plain words. The 2020–2025 Guidelines say four main things: follow a healthy eating pattern at every stage of life; enjoy nutrient-dense foods and drinks that fit your family’s traditions and budget; fill up mostly on vegetables, fruits, whole grains, protein foods and dairy; and limit added sugars, saturated fat and sodium. MyPlate, introduced in 2011, turns that advice into a picture: half the plate fruits and vegetables, about a quarter grains (at least half of them whole), a quarter protein, and dairy on the side.

The kitchen science. Food gives the body energy, measured in **calories**. A gram of carbohydrate or protein gives about 4 calories; a gram of fat gives about 9. So a slice of bread with 15 grams of carbohydrate, 3 grams of protein and 1 gram of fat has about $15 \times 4 + 3 \times 4 + 1 \times 9 = 81$ calories of energy. The number tells you how much

fuel is in the food, not whether the food is good or bad. Growing bodies need plenty of energy, and also protein, vitamins, minerals and fiber. A balanced day spreads those across meals: something from three or four groups at each meal, and snacks that fill the gaps.

Let's cook. You will plan a whole day of meals and snacks for your family on a MyPlate chart, then cook the breakfast: whole-wheat banana-oat pancakes with berries and yogurt. That one meal covers grains, fruit and dairy, and an egg brings protein. The skill is **planning before cooking**: reading the whole day's menu, listing what you need, and checking each meal against the plate.

PICTURE STUDY



A Woman Preparing Bread and Butter for a Boy, Pieter de Hooch, c. 1660–1663 · Oil on canvas · J. Paul Getty Museum, Los Angeles

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

Pieter de Hooch painted quiet Dutch homes full of light. Here a mother prepares a simple meal of bread and butter for her son, who is about to go out, perhaps to school. The boy holds his hat, and many viewers think he has paused to say grace. It is an ordinary moment of a mother feeding her child, painted as something worth remembering.

Look closely

- Find the loaf, the knife and the butter. How is the mother holding the knife?
- Look at the boy. What is he holding, and why do you think he is standing so still?
- Follow the light through the doorway into the courtyard. Where is the boy going next?
- Look at the room: floor, chair, bed cupboard. Is this a rich home or an ordinary one?

Talk about it

1. Bread and butter gives grains and a little fat. What could you add from other food groups to make this a balanced breakfast?
2. Why does a breakfast before school matter for learning?

3. What does this painting suggest about the care that goes into everyday meals?

Safety first. Cook pancakes with an adult nearby, keeping the handle of the skillet turned in and using a spatula, not fingers, to lift the edges. Do not taste the raw batter, which contains uncooked egg and flour. If your family plans meals for a child with food allergies or special medical needs, follow your doctor's guidance.

KITCHEN PROJECT

Plan a Balanced Day and Cook Its Breakfast

You will plan breakfast, lunch, dinner and two snacks for your family for one day, check each against MyPlate, and calculate the food energy in one meal. Then you will cook the breakfast.

You will need

- A large bowl, a medium bowl, a whisk and a fork
- Measuring cups and spoons
- A large nonstick skillet or griddle and a wide spatula
- A $\frac{1}{4}$ -cup measure or ladle for pouring batter
- Paper for a meal-plan chart

WHOLE-WHEAT BANANA OAT PANCAKES

Serves 4–5 (about 14 pancakes) · Prep 10 min · Rest 5 min · Cook 15–20 min

Ingredients

- 1 cup (120 g) whole-wheat flour
- $\frac{1}{2}$ cup (45 g) quick or old-fashioned rolled oats
- 1 tablespoon sugar
- 2 teaspoons baking powder
- $\frac{1}{2}$ teaspoon ground cinnamon
- $\frac{1}{4}$ teaspoon salt
- 1 very ripe banana
- 1 large egg
- $1\frac{1}{4}$ cups (300 mL) milk
- 2 tablespoons melted butter or vegetable oil, plus a little for the pan
- 1 teaspoon vanilla extract
- For serving: fresh berries or sliced fruit, plain or vanilla yogurt, a little maple syrup

Method

1. Wash your hands. In the large bowl, whisk together the flour, oats, sugar, baking powder, cinnamon and salt.
2. In the medium bowl, mash the banana with a fork until almost smooth. Whisk in the egg, milk, melted butter and vanilla. Wash your hands after cracking the egg.
3. Pour the wet mixture into the dry and stir gently just until no dry flour shows; a few lumps are fine. Let the batter rest 5 minutes so the oats soften.
4. With an adult nearby, heat the skillet over medium heat and brush it lightly with oil. Pour $\frac{1}{4}$ cup batter for each pancake, leaving space between them.
5. Cook until bubbles form on top and the edges look dry, 2–3 minutes. Flip with the spatula and cook 1–2 minutes more, until golden and cooked through. Lower the heat if they brown too fast.
6. Serve with fruit, a spoonful of yogurt and a small drizzle of syrup. Refrigerate leftover pancakes within 2 hours; they freeze well for quick breakfasts.

Allergy check: Contains wheat, eggs and milk. For an egg-free version, use 3 tablespoons unsweetened applesauce instead of the egg. For milk-free, use oat or soy milk (soy is an allergen) and oil instead of butter, and serve with a dairy-free yogurt.

Steps

1. **Plan the day.** Make a chart with rows for breakfast, a snack, lunch, a snack and dinner, and columns for the five food groups. Plan meals your family will really eat. Aim for three or four groups at each meal and all five over the day.
2. **Check it.** Shade each box you filled. Is half of the day's food from fruits and vegetables? Are at least half the grains whole grains? Fix any gaps.
3. Cook the pancakes and serve them as part of your planned breakfast.
4. **Energy math.** Using the Nutrition Facts labels for your flour, oats and milk, or a nutrition reference, find the grams of carbohydrate, protein and fat in one serving of your breakfast. Calculate its food energy using 4, 4 and 9 calories per gram. Show your work.

5. **Rate it.** Ask your family to rate the breakfast and say which food group they enjoyed most.
6. **Clean up:** wash bowls and skillet, wipe the counter, put the milk and eggs away right away.
7. **Improve it.** Cook one other meal from your plan later in the week. Write what you would change in the plan.

Tips

- Overmixing makes tough pancakes: the more you stir, the more gluten forms. Stir just until combined.
- The first pancake is a test. If it is pale, turn the heat up a little; if it is dark outside and raw inside, turn it down.
- Keep finished pancakes warm on a plate in a 200 °F oven.

Check your work

- ☐ I can explain what the

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- ☐ I can calculate food energy from grams of carbohydrate, protein and fat.
- ☐ I planned a balanced day of meals and cooked its breakfast.

COOK'S NOTEBOOK

1. Paste or copy your day's meal plan with the MyPlate chart shaded.
2. Draw a MyPlate plate and fill it with one meal from your plan, labeled.
3. Write your food energy calculation neatly, and one sentence explaining what a calorie measures.

From history. In 1894 the USDA published its first nutrition advice for farmers, written by the chemist Wilbur Atwater, who measured the energy in hundreds of foods. His numbers, about 4 calories per gram of carbohydrate and protein and 9 per gram of fat, are still the ones printed on food labels today.

COMMON MISTAKES

- Thinking a food with more calories is a bad food. Calories measure energy; nuts and olive oil have many and are nutrient-dense.
- Planning meals with only one or two food groups. Most balanced meals include three or four.
- Tasting raw pancake batter. Uncooked flour and egg can carry germs; taste the cooked pancake instead.

Make it a game • Calorie Calculator Duel. Your parent reads a label's grams of carbohydrate, protein and fat. Race each other to calculate Calories using four, four and nine per gram. Write the working on paper. The closest, fastest correct answer wins a point. Then explain what the Dietary Guidelines for Americans are and how MyPlate puts them on a plate.

2.3 PROTEIN AT EVERY MEAL: EGGS, BEANS AND FISH

OBJECTIVES

- Tell how protein got its name in 1838 and explain what proteins and amino acids do in the body.
- Name protein foods from animals and plants, and explain how beans and grains complement each other.
- Bake salmon to 145 °F and serve it with a black bean and corn salad.

Warm-up. Name ten foods that you think have a lot of protein. Sort them into two groups: from animals and from plants. Which group was easier to fill?

WATCH

Protein in the diet | Health | Biology | FuseSchool

FuseSchool - Global Education · 4:15

<https://www.youtube.com/watch?v=Fe5wHw3pnmY>

WHEN TO WATCH

After How they figured it out. Listen for what amino acids are and why the body needs protein every day.

Note: From FuseSchool, a free science-teaching channel. It shows an illustration of a child with severe protein malnutrition (kwashiorkor), explained calmly.

BACKUP VIDEO

How To Make Slow-Roasted Salmon with Chives and Lemon

America's Test Kitchen · 6:37

<https://www.youtube.com/watch?v=T7hMBDUI4JM>

Before you cook. Watch how the cook checks salmon for doneness and why a gentle oven keeps it moist.

KEY TERMS

protein

A large molecule made of a long chain of amino acids. Proteins build and repair muscles, skin, blood and organs, and do much of the body's chemical work.

complete protein

A food with all nine essential amino acids in good amounts, such as eggs, fish, meat, milk and soybeans.

omega-3 fats

Special fats found in fish like salmon and in walnuts and flaxseed, which the body uses for the brain, eyes and heart.

amino acids

The 20 small building blocks of proteins. Nine are essential: the body cannot make them, so they must come from food.

complementary proteins

Two plant foods, such as beans and grains, whose amino acids fill each other's gaps when eaten over the same day.

CORE IDEAS

The story. In the 1830s the Dutch chemist Gerardus Johannes Mulder was studying substances from egg whites, milk, blood and wheat. He found that they all contained the same elements, carbon, hydrogen, oxygen and nitrogen, in nearly the same proportions, and he thought they were built around one common core. He wrote to the famous Swedish chemist Jöns Jacob Berzelius about it, and in a letter of 1838 Berzelius suggested a name: *protein*, from a Greek word meaning “first” or “of the first rank.” Mulder used the word in print that same year, and it stuck.

How they figured it out. Mulder's single-core idea turned out to be wrong, but his name was right: proteins really are of the first rank. Over the next hundred years chemists learned that every protein is a long chain of smaller pieces called **amino acids**, folded into a particular shape. There are 20 amino acids, and the body can make eleven of them. The other nine are **essential**: they must come from food. Your body takes the protein you eat apart into amino acids and rebuilds them into the proteins it needs: muscle, skin, hair, the hemoglobin in your blood, and the enzymes that digest your food.

The kitchen science. Eggs, fish, meat, milk and soybeans are **complete proteins**, with all nine essential amino acids. Most beans are low in one amino acid (methionine) and most grains are low in another (lysine), so beans and grains eaten over the same day **complement** each other. That is why so many traditional meals pair them: rice and beans, tortillas and beans, lentils and bread. Even the bread recipe in Ezekiel 4:9 mixes wheat, barley, beans, lentils, millet and spelt. Because the body does not store extra protein the way it stores fat, it helps to have some protein at each meal. Fish like salmon add omega-3 fats, and salmon cooks quickly: it is safe at 145 °F (63 °C), when the flesh turns opaque and flakes with a fork.

Let's cook. You will bake salmon fillets with lemon and herbs and serve them with a black bean, corn and pepper salad and brown rice, a meal with protein from both fish and beans. The skill is **cooking fish to temperature without drying it out**: a hot oven, a thermometer in the thickest part, and taking it out the moment it reaches 145 °F.

PICTURE STUDY



The Herring Net, Winslow Homer, 1885 · Oil on canvas · Art Institute of Chicago

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

Winslow Homer lived on the rocky coast of Maine and painted the men who made their living from the sea. In this painting two fishermen haul a net heavy with herring into their small boat. Herring, like salmon, is an oily fish full of protein and omega-3 fats, and for centuries it fed families all around the North Atlantic.

Look closely

- Find the herring in the net and in the bottom of the boat. How do you know they are fresh from the water?
- Look at the two men. What is each one doing? Why does it take two?
- Find the larger ships in the mist. Why might the dory have left them?
- Look at the waves and sky. What kind of day is it for fishing?

Talk about it

1. What has to happen between this net and a fish fillet on your table? Name at least three steps, including keeping it cold.
2. Fish was an everyday protein for coastal families. What protein foods are everyday foods in your family?
3. How does this painting show that food is a gift that comes with work?

Safety first. Cook fish to 145 °F, checking the thickest part with a thermometer, and keep raw fish on its own plate and board. Use oven mitts for the hot pan. Fish is one of the nine major allergens; if anyone in your family is allergic to fish, make the bean and rice part of the meal with eggs or chicken (cooked to 160 °F or 165 °F) instead.

KITCHEN PROJECT

Baked Salmon with Black Bean and Corn Salad

You will bake salmon, check it with a thermometer, and build a bean and corn salad that turns rice into a complementary-protein side. Then you will compare the protein in each part of the meal.

You will need

- A rimmed baking sheet lined with foil or parchment
- A chef's knife and two cutting boards (one for raw fish)
- A colander, a large bowl and a small jar with a lid
- An instant-read thermometer, oven mitts and a thin spatula
- A pot with a lid for brown rice

LEMON-HERB BAKED SALMON WITH BLACK BEAN AND CORN SALAD

Serves 4 • Prep 25 min • Bake 12–15 min (rice 40 min)

Ingredients

- **Salmon:** 4 salmon fillets, about 5–6 ounces (150 g) each, 1 inch thick
- 1 tablespoon olive oil
- ½ teaspoon salt and ¼ teaspoon black pepper
- 1 lemon (zest and slices)
- 1 tablespoon chopped fresh dill or parsley (or 1 teaspoon dried)
- **Salad:** one 15-ounce can (425 g) black beans, rinsed and drained
- 1½ cups corn (frozen and thawed, or canned and drained)
- 1 red bell pepper, diced
- ¼ cup finely chopped red onion
- ¼ cup chopped cilantro or parsley
- **Dressing:** 3 tablespoons lime juice (2 limes), 2 tablespoons olive oil, ½ teaspoon ground cumin, ½ teaspoon salt
- **Rice:** 1 cup brown rice cooked in 2¼ cups water with a pinch of salt (about 3 cups cooked)

Method

1. Start the rice: with an adult nearby, bring the rice, water and salt to a boil, cover, turn the heat to low and simmer 40–45 minutes until the water is absorbed. Let it stand covered 10 minutes.
2. Make the salad: on the clean board, dice the pepper and onion. In the large bowl, combine the beans, corn, pepper, onion and cilantro. Shake the dressing ingredients in the jar and pour over. Refrigerate while you cook the fish.
3. Heat the oven to 425 °F (220 °C). Set the salmon, skin side down, on the lined pan. Pat dry with a paper towel. Brush with oil, sprinkle with salt, pepper, lemon zest and dill, and lay a lemon slice on each. Wash your hands and the raw-fish plate.
4. Bake 12–15 minutes. Check the thickest part of the thickest fillet: it should read 145 °F (63 °C), and the flesh should be opaque and flake easily with a fork.
5. Slide a thin spatula between the flesh and the skin to lift the fillets onto a clean platter. Serve each fillet with rice and a big spoonful of the salad.
6. Refrigerate leftovers within 2 hours. Leftover salad makes a good lunch the next day.

Allergy check: Contains fish. The salad and rice contain none of the nine major allergens. For a fish-free meal, top the rice and beans with scrambled or fried eggs (cooked until firm, 160 °F) or grilled chicken (165 °F).

Steps

1. **Protein survey.** Before cooking, read the labels or a nutrition reference to find the grams of protein in one serving of salmon (about 4 ounces cooked), ½ cup black beans, ½ cup brown rice and ½ cup corn. Record them in a table.
2. Make the meal, keeping raw fish separate and washing your hands after handling it.
3. **Doneness test.** Record the temperature of two fillets at 10 minutes and again when you take them out. Gently press one with a fork at each check: what changes when fish reaches 145 °F?

4. **Add it up.** Total the protein on one plate. Which food gave the most? How much came from plants?
5. **Rate it.** Ask your family to rate the salmon and the salad from 1 to 5.
6. **Clean up:** wrap and throw away the pan liner, wash the boards and knife, and take the trash out if it holds fish scraps.
7. **Improve it.** Write one change: a different fish (cod, trout), a different herb, or adding avocado to the salad.

Tips

- Thin ends of a fillet cook faster. Fold the thin tail under so the fillet is an even thickness.
- Frozen salmon works well. Thaw it overnight in the refrigerator, never on the counter.
- Rinsing canned beans removes some of the salt and the thick canning liquid.

Check your work

- ☐ I can explain what proteins and amino acids are and how protein got its name.
- ☐ I can explain complementary proteins and name protein foods from plants and animals.
- ☐ I baked salmon to 145 °F and served a meal with protein from both fish and beans.

COOK'S NOTEBOOK

1. Draw a protein as a chain of beads (amino acids) folding into a shape. Label it.
2. Copy your protein table and total, and write two sentences about what you learned.
3. Write the recipe in your own words with your family's rating and one improvement.

COMMON MISTAKES

- Cooking fish until it is dry and chalky. Take it out as soon as the thickest part reads 145 °F.
- Thinking only meat has protein. Beans, lentils, nuts, seeds, eggs, milk, yogurt and whole grains all add protein.

- Thawing fish on the counter. Thaw it in the refrigerator, or sealed in a bag in cold water.

Make it a game • Protein Name Origins. Tell your parent how protein got its name in 1838 from a Greek word. Then play a rapid list: name as many protein foods as you can in sixty seconds, sorting them into animal and plant. Say which are complete proteins. Pair beans with grains on paper to show complementary proteins. Add one food with omega-3 fats.

Scripture. “And they gave him a piece of a broiled fish, and of an honeycomb.” (Luke 24:42, KJV)

After His resurrection, Jesus ate broiled fish with His disciples, showing them He had a real body. Fish was everyday food at the Sea of Galilee, as it still is for families around the world.

2.4 IRON, LEAFY GREENS AND VITAMIN C

OBJECTIVES

- Tell how Vincenzo Menghini showed in the 1740s that blood contains iron, and explain what iron does in the body.
- Explain the difference between iron from animal foods and from plant foods, and how vitamin C helps the body absorb plant iron.
- Make spinach and bean quesadillas with a fresh tomato salsa, pairing iron-rich foods with vitamin C.

Warm-up. Hold a strong magnet near a spoonful of iron-fortified breakfast cereal crushed into a fine powder in a zip-top bag with a little water. (Squish it for a minute, then slowly drag the magnet across the outside of the bag.) What do you see? What is it?

WATCH

Iron Deficiency | Cells | Biology | FuseSchool

FuseSchool - Global Education · 4:15

<https://www.youtube.com/watch?v=H-IY53XBORo>

WHEN TO WATCH

After How they figured it out. Watch what hemoglobin does in red blood cells and why iron matters.

Note: From FuseSchool, a free science-teaching channel. It names a few kinds of anemia; stop after the part on iron.

KEY TERMS

iron

A mineral the body uses to build hemoglobin, which carries oxygen from the lungs to every cell.

hemoglobin

The iron-containing protein in red blood cells that picks up oxygen and gives blood its red color.

heme iron

Iron from animal foods such as beef, chicken, turkey and fish. The body absorbs it fairly easily.

non-heme iron

Iron from plant foods and fortified grains, such as beans, lentils, spinach and iron-fortified cereal. The body absorbs less of it, but vitamin C helps a great deal.

fortified

Having vitamins or minerals added during processing, such as iron added to breakfast cereals and flour.

CORE IDEAS

The story. In the 1740s an Italian physician in Bologna, Vincenzo Menghini, wanted to know whether the iron in some medicines actually reached the blood. He dried blood from animals and people, burned it to ash, and held a magnet over the ash. Tiny particles jumped up and clung to the magnet. They were iron. It was the first clear proof that blood contains iron, and Menghini showed that the red part of the blood held more of it than the clear part.

How they figured it out. Over the next two hundred years scientists learned why. Inside your red blood cells is a protein called **hemoglobin**. Each molecule holds four atoms of iron, and each iron atom can grab a molecule of oxygen in your lungs and let it go in your muscles and brain. That iron is what makes blood red. When people do not get enough iron, their bodies make less hemoglobin, and they can feel tired and weak and find it hard to concentrate. Iron needs are high for everyone who is growing, which is why the *Dietary Guidelines* pay special attention to iron for teenagers.

The kitchen science. Food gives two kinds of iron. **Heme iron**, in meat, poultry and fish, is absorbed fairly easily. **Non-heme iron**, in beans, lentils, leafy greens, whole grains and fortified cereal, is absorbed less well, but **vitamin C** eaten at the same meal can raise absorption several times, because it changes the iron into a form the gut takes in more easily. That is why a squeeze of lemon on greens, salsa with beans, or orange slices with fortified cereal is smart cooking. Spinach is a good food, but it also contains oxalic acid, which binds much of its iron; the old cartoon idea that

spinach is the best source of iron is an exaggeration. Beans, lentils and lean meats are better sources, and cooking in a cast-iron skillet can add a little iron too.

Let's cook. You will make spinach and black bean quesadillas, crisped in a skillet, with a fresh tomato salsa full of vitamin C. The skill is **wilting greens and building a balanced quesadilla**: cooking the spinach down so it fits, draining it so the tortilla stays crisp, and flipping safely with a wide spatula.

PICTURE STUDY



The Grocer's Shop, Gerrit Dou, 1647 · Oil on panel · Musée du Louvre, Paris

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

Gerrit Dou of Leiden painted with such tiny brushstrokes that he sometimes worked with a magnifying glass. He often painted shops and kitchens through a stone window frame. In this little shop a young woman grocer weighs out goods for her customers, and the shelves and ledge are filled with the vegetables and staples a Dutch family cooked with every day.

Look closely

- Find the scale. What is being weighed? Why does a grocer weigh food?
- Look along the window ledge. Which foods can you name?
- Find any greens, eggs or grains. Which of them would give iron?
- Look at the faces of the grocer and the customer. Are they hurried or friendly?

Talk about it

1. If you were planning an iron-rich meal from this shop, what would you buy, and what would you add for vitamin C?
2. Why do you think Dou painted the scene through a window?
3. How is shopping at a small grocer different from a modern supermarket?

Safety first. Cook quesadillas with an adult nearby, keeping the skillet handle turned in and using a wide spatula to flip; the filling and melted cheese are very hot inside. Cut tomatoes and onions with the claw grip on a steady board. Keep the cereal-iron magnet experiment away from small children, and do not eat the cereal afterward.

Spinach and Bean Quesadillas with Fresh Salsa

You will pull iron out of cereal with a magnet, make a fresh salsa, wilt spinach, and build crisp quesadillas. Then you will plan a week of iron-plus-vitamin-C pairings.

You will need

- A strong magnet, a zip-top bag and 1 cup iron-fortified flake cereal (for the warm-up)
- A chef's knife, cutting board with damp towel, and a medium bowl
- A large skillet (cast iron if you have one), a wide spatula and a colander
- A fork or potato masher and a cutting board for slicing the finished quesadillas

SPINACH AND BLACK BEAN QUESADILLAS WITH FRESH TOMATO SALSA

Serves 4 (4 large quesadillas, 16 wedges) • Prep 20 min • Cook 20 min

Ingredients

- **Salsa:** 3 ripe tomatoes, diced
- ¼ cup finely chopped onion
- ¼ cup chopped cilantro
- 2 tablespoons lime juice (1 lime)
- ¼ teaspoon salt
- **Quesadillas:** 1 teaspoon olive oil
- 5 ounces (140 g) fresh baby spinach (about 5 packed cups)
- One 15-ounce can (425 g) black beans, rinsed and drained
- ½ teaspoon ground cumin and ½ teaspoon chili powder
- 8 medium (8-inch) flour or whole-wheat tortillas
- 1½ cups (170 g) grated Monterey Jack or cheddar cheese
- A little oil or butter for the skillet

Method

1. Make the salsa: dice the tomatoes and onion with the claw grip, chop the cilantro, and stir everything together in the bowl. Let it stand while you cook.
2. With an adult nearby, heat 1 teaspoon oil in the skillet over medium heat. Add the spinach a handful at a time, stirring until it wilts, about 2 minutes. Tip it into the colander and press out the liquid with a spoon. Chop it roughly.
3. In a bowl, mash the beans lightly with the cumin and chili powder, leaving some whole.
4. Lay out 4 tortillas. Spread each with a quarter of the beans, a quarter of the spinach and a handful of cheese. Top with the remaining tortillas.
5. Wipe the skillet, brush it lightly with oil, and heat over medium. Cook one quesadilla at a time, 2–3 minutes per side, until golden and the cheese has melted. To flip, slide the spatula all the way under, hold the top with a second spatula or your free hand on a clean plate, and turn it in one smooth motion away from you.
6. Let each rest 1 minute, then cut into wedges on the board. Serve with the salsa.

Allergy check: Contains wheat (tortillas) and milk (cheese). Use corn tortillas for wheat-free; use a dairy-free grated cheese or skip the cheese and add mashed avocado for milk-free.

Steps

1. **Iron from cereal.** Do the warm-up experiment with the magnet. Photograph or sketch the iron you pulled out. Why is iron added to cereal?
2. **Label hunt.** Read the iron line (in milligrams and % Daily Value) on three foods in your kitchen. Record them.
3. Make the salsa and quesadillas.
4. **Pairing plan.** Make a chart of seven iron-rich foods your family eats and a vitamin C food to pair with each (beans + salsa, cereal + strawberries, lentil soup + lemon, beef + peppers).
5. **Rate it.** Ask your family to rate the quesadillas and the salsa from 1 to 5.

6. Clean up: wash the skillet (a cast-iron pan is rinsed, dried on low heat, and wiped with a few drops of oil), the board and the bowls.
7. **Improve it.** Write one change: add sautéed mushrooms or peppers, use leftover chicken, or try a different green such as kale.

Tips

- Five cups of spinach cook down to about half a cup. That is why the leaves seem to disappear.
- Squeeze the cooked spinach well; water makes a soggy quesadilla.
- If the outside browns before the cheese melts, lower the heat and cover the pan for a minute.

Check your work

- ☐ I can tell how Menghini found iron in blood and what iron does in the body.
- ☐ I can explain heme and non-heme iron and why vitamin C helps.
- ☐ I made quesadillas that pair iron-rich foods with vitamin C, and flipped them safely.

COOK'S NOTEBOOK

1. Draw a red blood cell with hemoglobin molecules inside, each holding iron and oxygen. Label the path of oxygen from lungs to muscle.
2. Copy your iron-plus-vitamin-C pairing chart.
3. Write the recipe in your own words with your family's rating and one improvement.

From history. The cartoon sailor Popeye began eating spinach for strength in 1932, and spinach sales in America rose. In 1937 spinach growers in Crystal City, Texas, put up a statue of Popeye. Spinach is a fine, nutrient-dense vegetable full of vitamins A and K and folate, even if its iron is not as easy to absorb as Popeye fans believed.

COMMON MISTAKES

- Believing spinach is the best source of iron. It has iron, but much of it is bound up; beans, lentils, lean meats and fortified cereals are better sources.
- Drinking tea or milk with an iron-rich meal and expecting the same absorption. Some compounds in tea and the calcium in milk can reduce iron absorption; vitamin C helps it.

- Flipping a full quesadilla toward yourself. Turn it away from your body so hot filling cannot spill on you.

Make it a game • Iron Pairing Match. Make cards of iron-rich foods, such as beef, spinach, lentils and fortified cereal, and cards of vitamin C foods, such as peppers, oranges and tomatoes. Lay them face down and play memory match, pairing each iron food with a helper. Say the difference between heme and non-heme iron. Tell what Menghini found in the 1740s.

UNIT 2

FOOD GROUPS & THE BALANCED MEAL

God made a world full of good things to eat, and He made our bodies to be nourished by them. In this unit you will look inside the food groups at the nutrients that do the work: the vitamins that a Polish chemist named in 1912, the proteins built from amino acids, and minerals like iron that carry oxygen in your blood. You will see how scientists discovered each one, often by noticing what went wrong when people went without.

You will also learn how the *Dietary Guidelines for Americans* turn that science into everyday advice, and you will plan and cook a full day of balanced meals. Along the way you will make a roasted vegetable soup, whole-grain pancakes, baked salmon with black beans, and spinach and bean quesadillas. This unit is about nourishment and stewardship, never about body size: a balanced way of eating gives a growing body what it needs to work, learn, play and serve.

PREREQUISITES

- Knows the five MyPlate food groups (fruits, vegetables, grains, protein, dairy) from earlier grades
- Can measure dry and liquid ingredients and use a chef's knife with the claw and bridge (Unit 1)
- Knows the safe temperature for fish (145 °F) and how to use a thermometer (Unit 1)
- Can multiply and divide fractions and work with percentages

MASTERY CHECKLIST

- ☐ I can tell how Casimir Funk named vitamins and explain the difference between fat-soluble and water-soluble vitamins.

- ☐ I can explain what the *Di* are and plan a balanced day of *eta* meals with MyPlate.

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- ☐ I can explain what proteins and amino acids are, and name protein foods from plants and animals.
- ☐ I can explain what iron does in the body and how vitamin C helps the body absorb iron from plant foods.
- ☐ I can use calories correctly as a unit of food energy (carbohydrate and protein about 4 per gram, fat about 9), not as something to count or restrict.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **MyPlate.gov:** Free. The USDA’s MyPlate site, with the food groups, serving ideas and printable planning sheets. Useful for Lesson 2.2 and the unit challenge.
- **Dietary Guidelines for Americans:** Free. The official site for the Guidelines. Parents may want to read the short executive summary before Lesson 2.2.
- **An immersion (stick) blender:** Optional. Makes blending hot soup safer and easier in Lesson 2.1. A regular blender works if it is filled only halfway and the lid is vented.

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	Casimir Funk Names the “Vitamine”	2 sessions of 50–60 minutes
2.2	The Dietary Guidelines and a Balanced Day	2 sessions of 50–60 minutes
2.3	Protein at Every Meal: Eggs, Beans and Fish	2 sessions of 50–60 minutes
2.4	Iron, Leafy Greens and Vitamin C	2 sessions of 50–60 minutes

UNIT 2 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. 8 pts

Who was Casimir Funk, and why did he call the substances he studied “vitamines”?

2. 8 pts

Name the fat-soluble vitamins. Why is a little olive oil helpful when you roast carrots?

3. (8 pts)

Why do long-boiled vegetables lose more vitamin C than roasted vegetables or soup?

4. (8 pts)

What are the *Dietary Guidelines for Americans*, and how often are they updated?

5. (10 pts)

Calculation: one serving of oatmeal has 27 grams of carbohydrate, 5 grams of protein and 3 grams of fat. How much food energy does it give? Show your work.

6. (8 pts)

Describe the MyPlate plate.

7. (8 pts)

What are amino acids, and what does “essential” mean?

8. (8 pts)

Why are rice and beans a good pair? Name two other traditional meals that pair grains and beans.

9. (6 pts)

What is the safe internal temperature of salmon, and how else can you tell it is done?

10. (8 pts)

What did Vincenzo Menghini do with a magnet, and what does iron do in the blood?

11. (10 pts)

Calculation: a recipe for 4 people calls for 1 can (15 ounces) of black beans and 5 ounces of spinach. How much of each do you need for 10 people? Show your work.

12. (10 pts)

Written answer: Plan a balanced dinner that includes an iron-rich food and a vitamin C food, and covers at least four MyPlate groups. Explain your choices.

ANSWER KEY

1. A Polish chemist working in London who in 1912 argued that diseases like beriberi and scurvy were caused by missing substances in food. He thought they were amines vital to life, so he named them vitamines (vita + amine); the e was later dropped.
2. Vitamins A, D, E and K. The beta-carotene in carrots, which the body turns into vitamin A, dissolves in fat, so cooking or eating carrots with a little fat helps the body absorb it.
3. Vitamin C dissolves in water and is damaged by long heating; it leaches into the cooking water, which is often poured away. Roasting uses no water, and in soup you eat the liquid.
4. Advice on healthy eating published by the USDA and the Department of Health and Human Services, first in 1980, based on reviews of nutrition research. They are updated every five years.
5. $27 \times 4 = 108$; $5 \times 4 = 20$; $3 \times 9 = 27$. Total = $108 + 20 + 27 = 155$ calories.
6. Half the plate fruits and vegetables (a little more vegetables than fruit), about a quarter grains with at least half of them whole, about a quarter protein, and a serving of dairy on the side.
7. Amino acids are the 20 building blocks of proteins. Nine are essential, which means the body cannot make them, so they must come from food.
8. Beans are low in one essential amino acid and grains are low in another, so together they complement each other. Examples: bean burritos in tortillas, lentils with bread, hummus with pita, Ezekiel bread, peanut butter on whole-wheat bread.
9. 145 °F. The flesh turns from translucent to opaque and flakes easily with a fork.
10. He burned dried blood to ash and showed that a magnet picked up particles from it, proving blood contains iron. Iron is part of hemoglobin, which carries oxygen from the lungs to the body's cells.
11. Scale factor = $10 \div 4 = 2.5$. Beans: $15 \times 2.5 = 37.5$ ounces, about $2\frac{1}{2}$ cans. Spinach: $5 \times 2.5 = 12.5$ ounces.
12. Answers vary. Example: beef and pepper stir-fry over brown rice with orange slices and a glass of milk: beef (protein, heme iron), peppers and oranges (vegetables, fruit, vitamin C to help absorb iron), brown rice (whole grain), milk (dairy).

UNIT CHALLENGE: A BALANCED DAY, PLANNED AND COOKED

Plan one full day of balanced meals and two snacks for your family using a MyPlate chart, with at least one iron-plus-vitamin-C pairing and protein at every meal. Write a shopping list for the day.

Then cook at least two of the day's three meals yourself, with an adult nearby, and help with the third. Photograph each plate, check it against MyPlate, and ask your family to rate each meal. Finish with a one-page reflection: what went well, which food groups were easiest and hardest to include, and what you would change.

LOOK FOR	WHAT IT MEANS
Planning	A complete day on a MyPlate chart, all five groups represented, with a shopping list.
Nutrition thinking	Protein at each meal, at least half the grains whole, and an iron-plus-vitamin-C pairing, each explained.
Cooking and safety	Two meals cooked with clean hands, safe knife and stove work, and correct temperatures.
Record	Photos or sketches of each plate, family ratings, and a one-page reflection.
Cleanup and service	Kitchen left clean after each meal; meals served with thanks.

TASTE, SMELL & YOUR TASTE BUDS

Why does broccoli taste harsh to one person and mild to another? Why does food taste flat when you have a cold? Why do grandparents sometimes salt their food more than you do? This unit looks at the science behind those everyday puzzles. You will meet Linda Bartoshuk, who discovered that some people are “supertasters,” and Linda Buck and Richard Axel, who won the Nobel Prize for finding the receptors that let your nose recognize thousands of smells.

Then you will look across a whole lifetime of tasting, from a baby’s love of sweetness to an older adult’s fading sense of smell, and interview an older relative about a family recipe. Last you will study texture, the crisp, chewy and creamy feel of food, as food scientists measure it. Along the way you will make a cocoa tasting, a fresh basil pesto, a family stew and oven-crisped panko chicken. As always, “O taste and see”: tasting is a gift to be received with thanks, and a new food deserves several honest tries.

PREREQUISITES

- Knows the five basic tastes (sweet, salty, sour, bitter, umami) and that the tongue map is a myth (earlier grades)
- Knows that most of flavor comes from smell
- Can use a chef’s knife, the stove and the oven with an adult nearby (Unit 1)
- Knows the safe temperature for chicken (165 °F) and beef stew meat cooked until tender (Unit 1)

MASTERY CHECKLIST

- ☐ I can explain what a supertaster is, how Linda Bartoshuk studied them, and why bitter tastes differ from person to person.
- ☐ I can explain how smell receptors work, the difference between sniffing and retronasal smell, and why flavor is mostly smell.
- ☐ I can describe how taste and smell change from childhood to old age, and why repeated tasting helps us learn to like new foods.
- ☐ I can name and describe textures the way a food scientist does, and explain what makes food crisp.
- ☐ I can run a fair taste test and record the results in a chart.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **NIDCD: Taste Disorders and Smell Disorders**: Free. Clear pages from the National Institutes of Health on how taste and smell work and how they change with age. Good background for Lessons 3.1–3.3.
- **Blue food coloring and a hand lens**: Optional. For counting the taste papillae on the tip of your tongue in Lesson 3.1.

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

3.1 Linda Bartoshuk and the Supertasters	2 sessions of 50–60 minutes
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3.2 Buck, Axel and the Thousand Smells: Basil Pesto	2 sessions of 50–60 minutes
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3.3 Taste Across a Lifetime: A Recipe from an Older Relative

2 sessions of 60–90 minutes

3.4 Alina Szczesniak and the Science of Texture	2 sessions of 50–60 minutes
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UNIT 3 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

What happened in Arthur Fox’s laboratory in 1931, and why was it important?

2. **8 pts**

How did Linda Bartoshuk identify supertasters, and what did she find on their tongues?

3. **8 pts**

Name three ways a cook can balance a bitter food.

4. (8 pts)

What did Linda Buck and Richard Axel discover, and how can about 400 receptors detect thousands of smells?

5. (8 pts)

What is retronasal smell? Why does food taste flat with a stuffy nose?

6. (8 pts)

What did Richard Doty's 1984 study find about smell and age?

7. (8 pts)

About how many friendly tastes does it often take for a child to come to like a new food? What does that mean for your family table?

8. (8 pts)

Calculation: your family stew recipe serves 6 and calls for 2 pounds of beef. How much beef do you need to serve 15? If beef costs \$6.50 a pound, what will it cost? Show your work.

9. (8 pts)

Name four of Szczesniak's texture characteristics and give a food example of each.

10. (8 pts)

Why does panko make a crisper coating than fine bread crumbs, and why should breaded chicken bake on a rack?

11. (10 pts)

Calculation: cocoa recipe A uses 3 tablespoons of sugar for 4 cups of cocoa. A taster wants it one-third less sweet. How much sugar should you use? Write your answer in tablespoons and teaspoons (1 tablespoon = 3 teaspoons).

12. (10 pts)

Written answer: Your younger brother says he hates broccoli. Using what you learned in this unit, write a short, kind plan to help him try it again.

ANSWER KEY

1. PTC dust flew into the air; a coworker found it very bitter while Fox tasted nothing. It showed that people differ in their ability to taste some bitter compounds, which is largely inherited.
2. She had people rate the bitterness of PROP on a careful scale; about a quarter rated it extremely strong. Using blue dye to count papillae, she found supertasters have many more fungiform papillae, and so more taste buds.
3. Any three: add salt; add a little sweetness; add fat (cheese, butter, oil); add acid (lemon, vinegar); pair it with other flavors.
4. In 1991 they discovered the large family of genes for smell receptors. Each odor activates a pattern of several receptors, and the brain reads the pattern, so a few hundred receptors can distinguish many thousands of smells.
5. Smelling the aromas of food in your mouth as they rise from the back of the throat into the nose. With a stuffy or pinched nose, the aromas cannot reach the receptors, so only the five basic tastes remain and most of the flavor is lost.
6. People identify smells best from about their 20s to 40s; the ability declines with age, especially after 60. More than half of people 65–80 and more than three-quarters over 80 had major smell loss, often without realizing it.
7. About 8 to 15. Keep offering small tastes of new foods without pressure, and try them yourself many times before deciding.
8. $15 \div 6 = 2.5$ times the recipe. $2 \times 2.5 = 5$ pounds. $5 \times \$6.50 = \$32.50$.
9. Examples: hardness (raw carrot), cohesiveness (gummy candy holds together), springiness (marshmallow), adhesiveness (peanut butter), brittleness (cracker), chewiness (bagel), gumminess (a thick paste). Other good examples accepted.
10. Panko's large, airy flakes have more surface and air, so they dry, brown and snap; fine crumbs pack densely and absorb more moisture. A rack lets hot dry air reach every side so steam escapes and the bottom does not go soggy.
11. One-third of 3 tablespoons is 1 tablespoon, so use $3 - 1 = 2$ tablespoons (6 teaspoons).
12. Answers vary. A good plan mentions that children taste bitterness strongly, that taste buds renew and likes change with 8–15 tries, cooking broccoli in a way that reduces bitterness (roasting with olive oil and salt, adding cheese or lemon), offering small tastes without pressure, and tasting it together with thanks.

UNIT CHALLENGE: A FAMILY TASTE SURVEY ACROSS THE GENERATIONS

Design and run a taste survey with at least five people of different ages, including at least one child and one older adult (with permission). Prepare one food three ways, for example broccoli steamed, roasted with olive oil and salt, and served with cheese sauce, and let everyone taste each version blind and rate bitterness, flavor and texture.

Record results in a chart and a bar graph, along with each person's age group and, if they agree, their papillae count. Write a one-page report on what you found, connecting it to supertasters, smell and age, and texture, and include a "try it again" plan for one food someone in your family dislikes.

LOOK FOR	WHAT IT MEANS
Fair test	Same food prepared three ways, tasted blind in the same order, with water between tastes, allergies checked first.
Cooking and safety	Each version cooked safely with an adult nearby; kitchen kept clean.
Data	A clear chart and graph with ratings for bitterness, flavor and texture by age group.
Explanation	A one-page report that uses at least three ideas from the unit to explain the results.
Kindness and follow-up	Tasters treated respectfully; a realistic "try it again" plan written and begun.

3.1 LINDA BARTOSHUK AND THE SUPERTASTERS

OBJECTIVES

- Tell how Arthur Fox discovered taste blindness in 1931 and how Linda Bartoshuk named supertasters in the 1990s.
- Explain why people taste bitterness differently, including genes, papillae and age.
- Run a bitter-and-sweet tasting chart and make a homemade cocoa, adjusting sweetness to balance bitterness.

Warm-up. Put a pinch of unsweetened cocoa powder on your tongue. (Check for allergies first.) Describe it in three words. Then ask someone else in your family to try it and describe it. Did you use the same words?

WATCH

Are You A Supertaster | Test Your Tongue

ABC Science · 2:23

<https://www.youtube.com/watch?v=jExqPBLgf-o>

WHEN TO WATCH

After How they figured it out, before your own tasting. Watch how the tester uses blue dye to count taste papillae, the same test you will do.

Note: From ABC Science (Australian Broadcasting Corporation).

KEY TERMS

supertaster

A person who tastes bitterness, and often other tastes, much more strongly than most people. Linda Bartoshuk named them in the 1990s.

taste bud

A cluster of 50 to 150 taste receptor cells inside the papillae. The cells are replaced about every one to two weeks.

papillae

The small bumps on the tongue. The mushroom-shaped ones (fungiform papillae) on the tip and sides hold taste buds.

PROP

A harmless bitter chemical used in research to sort people into nontasters, medium tasters and supertasters.

gene

A section of DNA that carries instructions for one part of the body, such as a bitter-taste receptor.

CORE IDEAS

The story. In 1931 a chemist named Arthur Fox at the DuPont company was pouring a powdered chemical called PTC into a bottle when some of it flew into the air. A coworker near him complained that the dust tasted terribly bitter. Fox, who was closer, tasted nothing at all. Puzzled, he had friends and family taste the crystals: some found them intensely bitter, others tasted nothing. People do not all live in the same world of taste. Sixty years later, at Yale University, the psychologist Linda Bartoshuk took the question further.

How they figured it out. Bartoshuk used a similar harmless bitter chemical, PROP, and asked people to rate how strong it tasted on a carefully designed scale. Most people were “medium tasters,” about a quarter tasted little or nothing, and about a quarter rated it as one of the strongest tastes they had ever experienced. She called these people **supertasters**. Then she looked at their tongues. She painted the tip of the tongue with blue food coloring, which stains the tongue but not the mushroom-shaped **fungiform papillae**, so the papillae stand out as pink dots, and she counted them through a lens. Supertasters had many more papillae, packed closely together, and so more taste buds. Later geneticists found that much of the difference in tasting PTC and PROP comes from one bitter-taste receptor gene.

The kitchen science. Bitterness is the body’s caution signal, because many harmful plants taste bitter. But many wholesome foods are bitter too: dark greens, broccoli, Brussels sprouts, grapefruit, cocoa. A supertaster may find them harsh, and children taste bitterness more strongly than adults. Cooks balance bitterness by adding **salt** (which blocks some bitterness), a little **sweetness**, **fat** (which coats the tongue) or **acid**. That is why we put cheese on broccoli, sugar in cocoa and lemon on greens. Unsweetened cocoa is very bitter; a good cup of cocoa is a lesson in balancing tastes.

Let’s cook. You will make a tasting chart of bitter and sweet foods, count your tongue papillae, and make homemade cocoa from unsweetened cocoa powder, adjusting the sugar spoon by spoon. The skill is **tasting and adjusting**: changing one thing at a time and tasting again.

PICTURE STUDY



Still Life with Chocolate Service, Luis Egidio Meléndez, 1770 · Oil on canvas · Museo del Prado, Madrid

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

In eighteenth-century Spain, chocolate was a hot drink, made by melting tablets of chocolate in water or milk in a tall pot and frothing it with a wooden whisk called a *molinillo*. Luis Meléndez painted the whole chocolate service with such care that you can almost feel the cold copper and smell the cocoa. Spanish chocolate was often flavored with cinnamon and sweetened with sugar to balance its natural bitterness.

Look closely

- Find the chocolate pot and the wooden whisk standing in it. How would the whisk be used?
- Find the chocolate tablets. How are they wrapped?
- Find the cup and the sweet buns. Why serve something sweet and soft with chocolate?
- Look at the copper. How has Meléndez shown that it is shiny and hard?

Talk about it

1. Chocolate comes from bitter cocoa beans. What would a cook in 1770 add to make it pleasant to drink?
2. Would a supertaster want more or less sugar in this chocolate? Why?

3. What does this painting tell you about how people of that time enjoyed chocolate?

Safety first. Check every tasting item for allergies before you begin, and give each taster a clean spoon. Heat the milk with an adult nearby over medium-low heat, stirring so it does not boil over or scorch; pour hot cocoa carefully and let it cool a little before sipping. Blue food coloring stains clothes and counters, so wear an old shirt.

Taster Survey and Balanced Homemade Cocoa

You will count the papillae on your tongue, rate bitter and sweet foods with your family, and make cocoa that is balanced to each taster's preference.

You will need

- Blue food coloring, cotton swabs, a hole punch, a small piece of wax paper and a hand lens or phone camera
- Small tasting cups or spoons, water for rinsing
- Tasting items: unsweetened cocoa, a square of dark chocolate (70% or more), a piece of milk chocolate, raw broccoli, grapefruit or lemon slice, a sweet apple slice
- A medium saucepan, a whisk and a measuring cup

HOMEMADE HOT COCOA, BALANCED TO TASTE

Serves 4 mugs · Prep 5 min · Cook 8 min

Ingredients

- $\frac{1}{4}$ cup (20 g) unsweetened cocoa powder
- 3–4 tablespoons sugar (start with 3)
- Pinch of salt
- $\frac{1}{2}$ cup (120 mL) hot water
- 3 $\frac{1}{2}$ cups (830 mL) milk
- $\frac{1}{2}$ teaspoon vanilla extract
- Pinch of ground cinnamon (optional)

Method

1. In the saucepan, whisk the cocoa, 3 tablespoons sugar and the salt together so there are no lumps.
2. With an adult nearby, add the hot water and whisk over medium heat until it makes a smooth, glossy syrup and bubbles gently, about 1–2 minutes. This blooms the cocoa and brings out its flavor.

3. Slowly whisk in the milk. Heat over medium-low, whisking often, until steaming but not boiling, 4–5 minutes.
4. Turn off the heat. Stir in the vanilla and cinnamon.
5. Pour a little into a cup, cool, and taste. Add sugar $\frac{1}{2}$ tablespoon at a time if needed, tasting after each, until it is balanced. Record how much you used.
6. Pour into mugs with a ladle. Refrigerate any leftover cocoa and reheat it.

Allergy check: Contains milk. For milk-free cocoa, use oat milk or another non-dairy milk (soy milk contains soy, an allergen). Check chocolate in the tasting for milk, nuts and soy.

Steps

1. **Count your papillae.** Punch a hole in a small piece of wax paper. Dab blue coloring on the tip of your tongue with a swab, swallow, and press the paper on your tongue tip. Use the hand lens or a phone photo to count the pink dots inside the hole. Do the same for willing family members and record the counts.
2. **Rate the tastes.** Each taster rinses with water, then tastes each item and rates its bitterness and sweetness from 0 (none) to 10 (the strongest imaginable). Record in a chart.
3. **Look for a pattern.** Did the people with the most papillae rate bitterness highest? Did children and adults differ?
4. Make the cocoa. Have each taster choose how much sugar they want. Record each person's choice next to their bitterness rating.
5. **Balance test.** Pour two small cups of unsweetened cocoa drink before adding sugar. Add a tiny pinch of salt to one. Which is less bitter?
6. Clean up: wash the saucepan right away (milk sticks as it cools), wipe up any blue coloring, and wash the tasting cups.
7. **Improve it.** Write one change to the cocoa: less sugar, more cinnamon, a pinch of nutmeg or a different milk.

Tips

- Taste in the same order for everyone and rinse with water between items so one taste does not change the next.

- Mixing cocoa with sugar first keeps it from clumping when the liquid goes in.
- Scorched milk tastes burnt. Keep the heat medium-low and whisk often.

Check your work

- ☐ I can tell the stories of Arthur Fox and Linda Bartoshuk.
- ☐ I can explain why bitterness differs between people and how cooks balance it.
- ☐ I ran a fair taste test and made balanced cocoa safely.

COOK'S NOTEBOOK

1. Draw the tip of your tongue as it looked through the lens, with your papillae count.
2. Make a table of your family's ratings and papillae counts, and write two sentences about any pattern you see.
3. Write the cocoa recipe in your own words with the amount of sugar each person chose.

From history. Linda Bartoshuk also helped show that the tongue map, the old diagram that put sweet on the tip and bitter at the back, was wrong. Every area of the tongue with taste buds can sense every taste.

COMMON MISTAKES

- Assuming everyone tastes food the way you do. Tasting differs with genes, age and experience; ask instead of insisting.
- Adding lots of sugar to cover bitterness. A pinch of salt, a little fat or a squeeze of acid often balances it better.
- Calling a food “disgusting” at the table. Say “That one is strong for me,” and try it again another day.

Make it a game • Supertaster Survey. Interview three family members about bitter foods, such as grapefruit, coffee, kale or dark chocolate. Count how many dislike each. Predict who is a supertaster, and explain papillae, genes and age as clues. Retell how Arthur Fox discovered taste blindness in 1931 and how Linda Bartoshuk named supertasters.

3.2 BUCK, AXEL AND THE THOUSAND SMELLS: BASIL PESTO

OBJECTIVES

- Tell how Linda Buck and Richard Axel discovered the family of smell-receptor genes (1991; Nobel Prize 2004).
- Explain orthonasal and retronasal smell and why most of what we call flavor is really smell.
- Make a fresh basil pesto and test how much of its flavor disappears when the nose is pinched.

Warm-up. Close your eyes while someone holds jars of five kitchen herbs or spices under your nose one at a time: for example cinnamon, cumin, basil, oregano and vanilla. Name each by smell alone. How many did you get? Which were hardest?

WATCH

Journey of Smell to the Brain

National Institutes of Health (NIH) • 3:05

https://www.youtube.com/watch?v=_Qyp157Az50

WHEN TO WATCH

After How they figured it out. Follow a smell from the nose to the brain.

Note: From the National Institutes of Health.

BACKUP VIDEO

How do we smell? - Rose Eveleth

TED-Ed • 4:19

<https://www.youtube.com/watch?v=snJnO6OpjCs>

A lively animated lesson on smell receptors and why people smell some things differently.

KEY TERMS

odorant

A molecule light enough to float through the air and be detected by the nose.

olfactory receptor

A protein on a smell nerve cell in the nose that fits certain odorant molecules. Humans have about 400 working kinds.

orthonasal smell

Smelling by sniffing air in through the nostrils.

retronasal smell

Smelling the aromas of food in your mouth, which rise from the back of the mouth up into the nose as you chew and swallow.

flavor

The whole experience of a food: taste from the tongue, smell from the nose, and texture, temperature and even sound.

CORE IDEAS

The story. For most of history no one knew how the nose could tell a rose from a lemon from a loaf of baking bread. In the 1980s, at Columbia University in New York, Richard Axel led a laboratory studying genes, and Linda Buck, a young scientist in his lab, decided to search for the genes that let the nose detect smells. Many scientists thought the search would fail.

How they figured it out. Buck reasoned that smell receptors would be proteins in the membranes of nerve cells in the nose, of a type already known from other senses, and that their genes would be active only in the nose. She designed a clever way to copy and sort genes from the tissue lining the top of the nose. In 1991 Buck and Axel published what she had found: not a handful of smell receptor genes but a huge family, about a thousand in rats and mice, the largest gene family known. Later work showed that humans have about 400 working smell receptors. Each smell nerve cell carries just one kind of receptor, and each odor molecule fits several receptors in different degrees. The brain reads the *pattern* of receptors that fire, the way you read

a word from its pattern of letters, so 400 receptors can tell apart many thousands of smells. Buck and Axel shared the Nobel Prize in Physiology or Medicine in 2004.

The kitchen science. You smell food two ways. When you sniff, aromas come in through your nostrils: **orthonasal smell**. When you chew, aromas from the food in your mouth rise from the back of your throat into your nose: **retronasal smell**. Your tongue can sense only five basic tastes; nearly everything else you call flavor, basil versus mint, strawberry versus raspberry, comes from retronasal smell. That is why food tastes flat when you have a cold or pinch your nose. Basil is a good example: its flavor comes from aroma molecules held in tiny glands on its leaves, which burst when you chop or crush it. Pesto, from an Italian word meaning “pounded,” releases them all at once.

Let’s cook. You will make a fresh basil pesto in a food processor (or by hand in a mortar or with a chef’s knife), toss it with pasta, and run a nose-pinch test. The skill is **releasing and protecting aroma**: crush the leaves just before serving, and add the pesto to warm, not boiling, food so the aromas do not cook away.

PICTURE STUDY



Fruits of the Midi, Pierre-Auguste Renoir, 1881 · Oil on canvas · Art Institute of Chicago

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

Renoir painted this still life after a trip to the south of France and Italy, where the markets overflow with peppers, tomatoes, eggplants and citrus. The colors are so warm and bright that many people say they can almost smell the painting: the green scent of peppers, the sharp oil of lemon peel, the sweetness of a ripe melon.

Look closely

- Name every fruit and vegetable you can find.
- Find the lemons. Where does most of their smell come from: the juice or the peel?
- Find the ripest-looking fruit. How can you tell it is ripe?
- Look at how Renoir paints with soft, feathery strokes. How does that make the fruit feel?

Talk about it

1. If you could smell this painting, which three smells would be strongest?
2. Which of these foods would you add to a pesto or a sauce to bring out more aroma?
3. Why do you think ripe fruit smells stronger than unripe fruit?

Safety first. Pine nuts are tree nuts for allergy purposes; check for allergies and use sunflower seeds if needed. A food-processor blade is very sharp: an adult removes and washes it, and the machine is unplugged before you scrape the bowl. Drain hot pasta with an adult nearby, pouring away from you.

KITCHEN PROJECT

Fresh Basil Pesto and the Nose-Pinch Test

You will smell-test herbs blind, make pesto, and then taste it with your nose pinched and unpinched to measure how much of flavor is smell.

You will need

- A food processor or blender (or a mortar and pestle, or a chef's knife and board)
- A small dry skillet for toasting nuts
- A large pot and colander for pasta
- A rubber spatula and a measuring cup
- Clean spoons for tasting

FRESH BASIL PESTO WITH PASTA

Serves 4–6 (about $\frac{3}{4}$ cup pesto) · Prep 15 min · Cook 12 min

Ingredients

- 2 cups (about 50 g) fresh basil leaves, packed, washed and dried
- $\frac{1}{4}$ cup (35 g) pine nuts, or sunflower seeds for a nut-free version
- 1 small clove garlic
- $\frac{1}{2}$ cup (45 g) grated Parmesan cheese
- $\frac{1}{2}$ cup (120 mL) extra-virgin olive oil
- $\frac{1}{4}$ teaspoon salt
- 1 teaspoon lemon juice
- 1 pound (450 g) pasta, such as trofie, fusilli or spaghetti
- 1 tablespoon salt for the pasta water

Method

1. With an adult nearby, toast the pine nuts in the dry skillet over medium-low heat, shaking the pan, until golden and fragrant, 3–4 minutes. Tip them onto a plate at once; they burn quickly.
2. Bring a large pot of water to a boil and add 1 tablespoon salt.

3. In the food processor, pulse the garlic and nuts until finely chopped. Add the basil and salt and pulse until chopped. With the machine running, pour in the olive oil in a thin stream. Unplug the machine, scrape down the bowl with the spatula, add the Parmesan and lemon juice, and pulse just to mix.
4. Cook the pasta until just tender. Dip out ½ cup of cooking water before draining.
5. Return the pasta to the pot off the heat. Add the pesto and a few spoonfuls of cooking water and toss until glossy. Serve right away.
6. Store leftover pesto in a jar with a thin layer of oil on top, refrigerated, up to 4 days.

Allergy check: Contains tree nuts (pine nuts), milk (Parmesan) and wheat (pasta). For nut-free pesto use toasted sunflower or pumpkin seeds; for milk-free, leave out the cheese and add a little more salt; use gluten-free pasta for wheat-free.

Steps

1. **Blind sniff.** Do the warm-up herb test with your family and record each person's score.
2. **Leaf test.** Smell a whole basil leaf. Then tear it and smell again. Then crush it between your fingers. Rate the aroma each time from 1 to 10.
3. Make the pesto and pasta.
4. **Nose-pinch test.** Each taster pinches the nose, puts a forkful of pesto pasta in the mouth, chews three times and describes the taste. Then lets go and keeps chewing. Record what changed. Which of the five basic tastes could they sense with the nose pinched?
5. **Rate it.** Ask your family to rate the pesto pasta from 1 to 5.
6. Clean up: the adult washes the processor blade; wash the bowl, pot and colander; wipe the counter.
7. **Improve it.** Write one change: more lemon, half parsley and half basil, more cheese or another nut or seed.

Tips

- Basil bruises and turns black when wet or crushed too early. Dry the leaves well and make the pesto just before you need it.

- A thin layer of oil on top of stored pesto keeps air away and helps it stay green.
- Pesto is also good on sandwiches, stirred into soup or spread on roasted vegetables.

Check your work

- ☐ I can tell how Buck and Axel found the smell receptor genes.
- ☐ I can explain retronasal smell and why food tastes flat when my nose is pinched.
- ☐ I made pesto safely and recorded a nose-pinch test.

COOK'S NOTEBOOK

1. Draw a side view of the head showing the path of aroma from a fork of pasta in the mouth, up the back of the throat, to the smell receptors at the top of the nose.
2. Copy your nose-pinch results in a table.
3. Write the pesto recipe in your own words with your family's rating and one improvement.

COMMON MISTAKES

- Thinking the tongue tastes basil or strawberry. The tongue tastes only sweet, salty, sour, bitter and umami; herbs and fruit flavors are smelled.
- Cooking pesto in a hot pan. Heat drives off the fresh aromas and darkens the basil; toss it with warm pasta off the heat.
- Opening a food processor while it is plugged in. Always unplug it before you reach inside.

Make it a game • A Thousand Smells. Gather six safe things to smell, such as basil, lemon, cinnamon, coffee, vanilla and garlic. Close your eyes and name each. Score a point per correct answer, then swap. Then explain what olfactory receptors do and how Buck and Axel found the gene family in 1991. Explain orthonasal and retronasal smell.

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

God made our senses of taste and smell to enjoy His gifts. The psalmist uses tasting to describe knowing God's goodness for ourselves, not just hearing about it.

3.3 TASTE ACROSS A LIFETIME: A RECIPE FROM AN OLDER RELATIVE

OBJECTIVES

- Describe how taste and smell change from infancy through childhood to old age, using Richard Doty's 1984 study of smell and age.
- Explain why repeated tasting (often 8–15 tries) helps people come to like new foods.
- Interview an older relative or friend about a family recipe and cook it together or from their instructions.

Warm-up. Think of a food you disliked when you were small but like now, or one you still dislike. Write it down. When did your opinion change, or what would it take to change it?

WATCH

Aging and the loss of smell, taste

CBS News • 4:16

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

WHEN TO WATCH

After How they figured it out. Watch for what changes first as people age, taste or smell, and what a scratch-and-sniff test shows.

Note: A news feature from CBS News.

KEY TERMS

olfactory decline

The gradual loss of the sense of smell that many people experience as they grow older, usually after about age 60.

repeated exposure

Tasting a new food many times. Research shows that liking often grows after about 8 to 15 small tastes.

food memory

The strong link between a food's smell and taste and the people, places and events we connect with it.

braise

To brown food and then cook it slowly, covered, in a small amount of liquid until tender.

CORE IDEAS

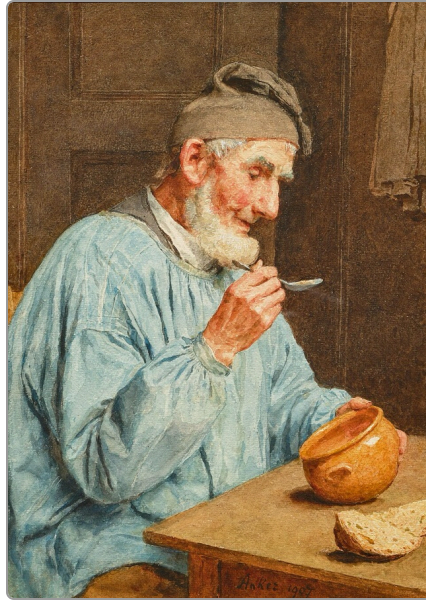
The story. In the early 1980s Richard Doty and his colleagues at the University of Pennsylvania created a scratch-and-sniff test with 40 everyday smells, like pizza, lemon, licorice and smoke, each with four multiple-choice answers. In 1984 they published the results of testing nearly two thousand people from age 5 to 99 in the journal *Science*. It was one of the first large, careful measurements of how the sense of smell changes over a lifetime.

How they figured it out. Doty's team found that people identify smells best between about their 20s and 40s. After that, scores fall slowly, and then more quickly after about 60. More than half of the people between 65 and 80 had a major loss of smell, and more than three-quarters of those over 80, though many of them did not realize it. Taste itself (sweet, salty, sour, bitter) changes much less. So when an older person says food does not taste the way it used to, it is mostly smell, and therefore flavor, that has faded. Older adults sometimes add more salt or prefer stronger flavors for this reason.

The kitchen science. At the other end of life, babies are born liking sweetness and disliking bitterness, and children stay more sensitive to bitter tastes than adults. Taste buds are replaced about every one to two weeks all through life, and the brain keeps learning. Studies of children show that a new vegetable often becomes liked after about **8 to 15 small, friendly tastes**. Your own likes are not fixed; they grow with practice and with good company at the table. Food memories are also strong because smell signals travel to the parts of the brain that handle emotion and memory. That is why a grandmother's stew can bring back a whole childhood.

Let's cook. You will interview an older relative or family friend about a recipe from their childhood, write it down exactly, and cook it, with them if you can. If your family does not have a recipe to share, use the model recipe here, an old-fashioned beef and vegetable stew. The skill is **browning and braising**: searing the meat in batches and then simmering it slowly until it is fork-tender.

PICTURE STUDY



Farmer Eating Soup, Albert Anker, 1907 · Watercolor · Private collection, Switzerland

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

Albert Anker spent his life painting the people of his village in Switzerland, especially children and the old. Near the end of his life he painted this old farmer eating a bowl of soup with a piece of bread. It is a simple meal, eaten slowly. Perhaps it is a soup he has eaten since he was a boy.

Look closely

- Look at the farmer's face. How is he eating: quickly or slowly?
- Find the bowl and the bread. What kind of meal is this?
- Look at his hands and clothes. What kind of work has he done all his life?
- Look at the colors. How did Anker make the scene feel warm and quiet?

Talk about it

1. As people grow older, smell and flavor often fade. Why might a warm, well-seasoned soup be a good meal for an older person?
2. What foods do you think this farmer loved as a boy? How could you find out from an older person you know?
3. What does this picture say about the dignity of an ordinary meal?

Safety first. Brown meat with an adult nearby: pat it dry, add it to the hot pan by laying each piece away from you, and do not crowd the pan, which causes spattering and steaming. Keep the pot handle turned in and lift the lid away from your face to let steam escape. Beef stew is safe when the meat is fork-tender after long simmering; reheat leftovers to 165 °F.

The Family Recipe Interview

You will interview an older relative or friend about food in their childhood and a recipe they love, write the recipe in clear modern form, and cook it. Then you will run a taste test across the generations at your table.

You will need

- Your notebook and a list of interview questions (or a phone to record, with permission)
- A large heavy pot or Dutch oven with a lid
- A chef's knife, cutting boards (one for raw meat), tongs and a wooden spoon
- Measuring cups and spoons

MODEL RECIPE: OLD-FASHIONED BEEF AND VEGETABLE STEW

Serves 6 • Prep 30 min • Cook 2–2½ hr

Ingredients

- 2 pounds (900 g) beef chuck roast, cut into 1½-inch cubes
- 1 teaspoon salt and ½ teaspoon black pepper
- 3 tablespoons all-purpose flour
- 2 tablespoons vegetable oil
- 1 large onion, chopped
- 2 cloves garlic, minced
- 2 tablespoons tomato paste
- 4 cups (950 mL) low-sodium beef broth
- 1 teaspoon dried thyme and 1 bay leaf
- 4 carrots, cut into 1-inch pieces
- 1½ pounds (680 g) potatoes, cut into 1½-inch chunks
- 1 cup frozen peas
- 2 tablespoons chopped parsley

Method

1. Pat the beef dry with paper towels. Sprinkle with salt and pepper, then toss with the flour. Wash your hands and the raw-meat board.
2. With an adult nearby, heat 1 tablespoon oil in the pot over medium-high heat. Add half the beef in one layer and brown well on two or three sides, about 6–8 minutes. Move it to a clean bowl. Add the rest of the oil and brown the second batch.
3. Lower the heat to medium. Add the onion and cook, stirring, 5 minutes, scraping up the browned bits. Add the garlic and tomato paste and stir 1 minute.
4. Pour in the broth slowly (stand back from the steam), add the thyme, bay leaf and browned beef with its juices. Bring to a simmer, cover, and turn the heat to low. Simmer gently 1½ hours, stirring now and then.
5. Add the carrots and potatoes. Cover and simmer 30–40 minutes more, until the beef and vegetables are fork-tender.
6. Stir in the peas and cook 5 minutes. Remove the bay leaf. Taste and add salt if needed. Sprinkle with parsley and serve with bread. Refrigerate leftovers within 2 hours; reheat to 165 °F.

Allergy check: Contains wheat (flour). For a wheat-free stew, skip the flour and thicken at the end with 1 tablespoon cornstarch stirred into 2 tablespoons cold water. Check the broth label.

Steps

1. **Prepare questions.** Write at least eight, such as: What did your family eat on an ordinary weeknight? What was a special-occasion food? Who taught you to cook? Is there a food you disliked as a child and like now? Has the taste of any food changed for you over the years?
2. **Interview.** Visit, call or video-chat. Ask your questions and listen. Ask them to tell you one recipe step by step, including the little tricks that are not written down.
3. **Write it out.** Turn the recipe into a modern card: name, servings, time, ingredient list with measurements, numbered steps and safety notes (temperatures, handling raw meat). Check any “a handful” or “a pinch” with them.

4. Cook the recipe, together if possible, with an adult nearby.
5. **Generations taste test.** At the meal, ask each person to rate the dish from 1 to 5 and say whether they would add salt, herbs or anything else. Do the youngest and oldest tasters differ?
6. Clean up together: wash the pot, boards and knives; wipe the stove.
7. **Thank you.** Write a thank-you note to the person you interviewed, with a photo of the finished dish.

Tips

- Brown the meat in batches. If the pot is crowded, the meat steams gray instead of browning.
- Chuck roast is a tough, inexpensive cut that becomes tender with long, gentle cooking. Do not hurry it.
- Stew often tastes even better the next day, after the flavors have blended.

Check your work

- ☐ I can explain how taste and smell change across a lifetime and what Doty's study found.
- ☐ I can explain why repeated tasting helps people learn to like new foods.
- ☐ I interviewed an older person, wrote a family recipe clearly, and cooked it safely.

COOK'S NOTEBOOK

1. Write a one-page summary of your interview, with the person's name, when and where they grew up, and their favorite food memory.
2. Copy the family recipe in your best handwriting as a card to keep.
3. Make a chart of your "try it again" plan: one disliked food, with ten dates to taste it a little, and a rating each time.

COMMON MISTAKES

- Deciding a food is disliked forever after one taste. Most people need many friendly tries.
- Writing down a family recipe with vague amounts. Ask, measure while you watch, and write exact quantities.

- Boiling a stew hard. A gentle simmer, with small bubbles, keeps the meat tender; a hard boil makes it tough and stringy.

Make it a game • Older Relative Interview. Ask an older relative about a food they love, a food they disliked as a child, and what tastes different now. Write down three answers. Then explain Richard Doty's study of smell and age, olfactory decline, and why repeated tasting of eight to fifteen tries helps people like new foods. Share your interview with the family.

Scripture. “I am this day fourscore years old: and can I discern between good and evil? can thy servant taste what I eat or what I drink?” (2 Samuel 19:35, KJV)

Old Barzillai, at eighty, told King the king he could no longer taste his food as he once had. The Bible noticed what scientists measure today, and it honors the old for their wisdom and faithfulness.

3.4 ALINA SZCZESNIAK AND THE SCIENCE OF TEXTURE

OBJECTIVES

- Tell how Alina Szczesniak and her team at General Foods built a scientific vocabulary for food texture in the 1960s.
- Describe textures with precise words and explain what makes a food crisp and what makes it go soggy.
- Make oven-crisped panko chicken to 165 °F and compare it with a batch made with ordinary bread crumbs.

Warm-up. Gather four foods: a cracker, a slice of bread, a banana and a raw carrot. Bite each and describe its texture in at least two words each, without using the words “good” or “yummy.” How hard is it to describe texture?

WATCH

The Difference Between Crispy and Crunchy Foods

America's Test Kitchen · 1:14

<https://www.youtube.com/watch?v=oturA007Jpo>

WHEN TO WATCH

After The kitchen science. Listen for the difference between crispy and crunchy.

Note: From America’s Test Kitchen. Short; pair it with the reading.

KEY TERMS

texture

How food feels in the mouth and hands: hard or soft, crisp or chewy, smooth or grainy, and how it changes as you chew.

Texture Profile

A method developed at General Foods in the 1960s in which trained tasters rate textures like hardness, chewiness and crispness on set scales.

crisp

Breaking cleanly and easily with a light, high sound, like a thin cracker or a well-baked crust.

panko

Japanese-style bread crumbs made from crustless bread, coarsely flaked and dried. Their large, airy flakes brown and stay crisp.

sogginess

The loss of crispness when a dry, brittle food absorbs water from steam, sauce or the air.

CORE IDEAS

The story. Food companies in the 1950s could measure the sugar, fat and color of a food, but texture was a puzzle. Customers would say a cracker was “stale” or a cake was “too heavy,” and no one had exact words or numbers for what they meant. At General Foods in New York, a Polish-born food scientist named Alina Surmacka Szczesniak set out to give texture a science of its own.

How she figured it out. Szczesniak and her colleagues collected the words people use for how food feels and sorted them. In 1963 she published a classification of texture that named the main characteristics: **hardness** (how much force it takes to bite), **cohesiveness** (how well it holds together), **springiness**, **adhesiveness** (stickiness), and the qualities that grow from them, like **brittleness**, **chewiness** and **gumminess**. Her team trained tasters to rate each one on fixed scales using reference foods, and built a machine to measure some of them by squeezing a sample twice like a pair of teeth. Their method, the Texture Profile, is still used by food scientists around the world. She also found in surveys that people notice texture most when it goes wrong: soggy cereal, stale chips, tough meat.

The kitchen science. Crispness comes from a dry, brittle structure full of tiny air pockets that snap when you bite. When a crisp food absorbs water, its starches and proteins soften and bend instead of snapping, and it goes soggy. A crisp coating on chicken needs three things: a **dry surface** so the coating sticks and browns; a coating with lots of **surface and air**, like panko’s large flakes; and **hot, dry air** all around so moisture escapes. A wire rack on the pan lets hot air reach the bottom. Steam is the enemy of crunch, so cooked chicken should not be covered while hot.

Let's cook. You will bread chicken tenders in two batches, one with panko and one with fine dry bread crumbs, bake them on a rack, and compare their textures with a tasting scale. The skill is **the three-step breading station**, flour, egg, crumbs, using one dry hand and one wet hand, then checking the chicken to 165 °F.

PICTURE STUDY



Girl Eating Soup, Albert Anker, 1898 · Oil on canvas · Private collection, Switzerland

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

Albert Anker painted children doing ordinary things with great tenderness. Here a little girl concentrates on her bowl of soup. Next to her lies a crusty piece of bread. In many homes, bread was dipped into soup, changing from crisp and hard to soft and soaked in a few seconds: a lesson in texture at every supper.

Look closely

- Find the bread. Which part is crust and which part is soft crumb?
- Look at the soup and spoon. How carefully is she eating?
- Find the glass of water. What else is on the table?
- Look at her face. What is she paying attention to?

Talk about it

1. Describe the bread crust and the soup with texture words: hardness, crispness, chewiness, smoothness.
2. What would happen to the bread's crust if she dipped it in the soup? Explain with the word sogginess.
3. Why do cooks often serve something crisp with something soft?

Safety first. Keep raw chicken on its own board and plate, use one hand for the wet (egg) step and one for the dry steps, and wash hands and tools afterward; throw away leftover flour, egg and crumbs that touched raw chicken. Bake to 165 °F in the thickest piece. Use oven mitts for the hot rack and pan.

KITCHEN PROJECT

Panko Chicken and the Crunch Test

You will bread chicken two ways, bake it, and run a texture test with a scale, including how the crunch holds up after 15 minutes.

You will need

- Three shallow dishes for a breading station
- A rimmed baking sheet with a wire cooling rack set inside it, and nonstick spray
- A raw-meat cutting board, a chef's knife and a clean platter
- An instant-read thermometer, tongs and oven mitts
- A small dry skillet for toasting the panko

OVEN-CRISPED PANKO CHICKEN TENDERS

Serves 4–6 • Prep 25 min • Bake 15–20 min

Ingredients

- 1½ pounds (680 g) chicken tenderloins, or boneless breasts cut into ¾-inch strips
- ¾ teaspoon salt and ¼ teaspoon black pepper
- ½ cup (60 g) all-purpose flour
- 2 large eggs beaten with 1 tablespoon water
- 1½ cups (75 g) panko bread crumbs
- 2 tablespoons olive or vegetable oil
- ½ teaspoon paprika and ½ teaspoon garlic powder
- ¼ cup (25 g) grated Parmesan (optional)
- **For the comparison batch:** ¾ cup fine dry bread crumbs
- For serving: lemon wedges, honey-mustard or another dipping sauce

Method

1. With an adult nearby, heat the oven to 425 °F (220 °C). Set the rack in the baking sheet and coat it with nonstick spray.

2. Toast the panko: stir the panko and oil in the dry skillet over medium heat until light golden, 3–4 minutes. Tip into a shallow dish and stir in the paprika, garlic powder and Parmesan. (Toasting first makes the oven coating golden and crisp.)
3. Set up the station: flour in the first dish, egg in the second, crumbs in the third. Put a fine-crumb dish beside it for the comparison batch.
4. Pat the chicken dry and season with salt and pepper. With your dry hand, coat a strip in flour and shake off the extra. Drop it into the egg; with your wet hand, turn it and let the extra drip off. Drop it into the crumbs; with your dry hand, press crumbs on all sides. Lay it on the rack. Bread about two-thirds with panko and one-third with fine crumbs (toast a little of those with oil too). Wash your hands.
5. Bake 15–20 minutes, until golden. Check the thickest strip of each batch: it must read 165 °F (74 °C).
6. Serve right away with lemon and dipping sauce. Throw away all leftover breading that touched raw chicken. Refrigerate leftovers within 2 hours; reheat on a rack in the oven to keep them crisp.

Allergy check: Contains wheat (flour, panko, bread crumbs), eggs and milk (Parmesan). For egg-free, dip in plain yogurt or mayonnaise instead of egg (milk or egg may be in these; check). For wheat-free, use gluten-free flour and crushed rice cereal or gluten-free panko. Leave out the Parmesan for milk-free.

Steps

1. **Texture words.** Before cooking, make a list of at least ten texture words using Szczesniak's categories. Use it in the tests below.
2. Bread and bake both batches, keeping raw chicken separate.
3. **Crunch test.** Each taster rates one panko piece and one fine-crumb piece for hardness, crispness, and juiciness of the chicken inside, from 1 to 5. Listen to the sound of the bite, too.
4. **Soggy test.** Put one piece of each kind on a plate and cover it with a bowl for 15 minutes. Taste again. What happened, and why?
5. **Rate it.** Ask your family which batch they prefer and why, using texture words.

6. Clean up: throw away used breading, wash the dishes, rack and boards in hot soapy water, and sanitize the counter.
7. **Improve it.** Write one change: add crushed cornflakes, more seasoning, a different dip, or try fish fillets.

Tips

- The dry-hand, wet-hand method keeps your fingers from becoming clumps of breading.
- Leave space between pieces on the rack so hot air can circulate.
- Chicken breasts are often uneven. Cut thick parts in half so all pieces cook in the same time.

Check your work

- ☐ I can tell how Alina Szczesniak gave texture a scientific vocabulary.
- ☐ I can explain what makes food crisp and what makes it soggy.
- ☐ I breaded chicken safely, baked it to 165 °F, and compared textures with a scale.

COOK'S NOTEBOOK

1. Make a texture chart of ten foods in your kitchen, each rated for hardness, crispness and chewiness.
2. Draw a magnified panko flake and a fine crumb side by side and explain why one stays crisper.
3. Write the recipe in your own words with your family's rating and one improvement.

From history. Texture matters in every culture's cooking. Japanese cooks prize the crisp lightness of tempura and the springy chew of noodles, Italians speak of pasta cooked *al dente*, "to the tooth," and French bakers judge bread by the crackle of its crust.

COMMON MISTAKES

- Breading wet chicken. The coating slides off and steams; pat the chicken dry first.
- Piling hot breaded chicken on a plate or covering it with foil. Steam softens the coating; serve it from the rack.
- Reusing breading that touched raw chicken. Throw it away.

Make it a game • Crisp or Soggy. Set out two crackers, one dipped in water for a moment and one dry, plus cereal in milk. Describe each with exact texture words from the Texture Profile. Set a timer to see how fast each goes soggy. Then explain what makes a food crisp, why panko stays crunchy, and what Alina Szczesniak built at General Foods.

TASTE, SMELL & YOUR TASTE BUDS

Why does broccoli taste harsh to one person and mild to another? Why does food taste flat when you have a cold? Why do grandparents sometimes salt their food more than you do? This unit looks at the science behind those everyday puzzles. You will meet Linda Bartoshuk, who discovered that some people are “supertasters,” and Linda Buck and Richard Axel, who won the Nobel Prize for finding the receptors that let your nose recognize thousands of smells.

Then you will look across a whole lifetime of tasting, from a baby’s love of sweetness to an older adult’s fading sense of smell, and interview an older relative about a family recipe. Last you will study texture, the crisp, chewy and creamy feel of food, as food scientists measure it. Along the way you will make a cocoa tasting, a fresh basil pesto, a family stew and oven-crisped panko chicken. As always, “O taste and see”: tasting is a gift to be received with thanks, and a new food deserves several honest tries.

PREREQUISITES

- Knows the five basic tastes (sweet, salty, sour, bitter, umami) and that the tongue map is a myth (earlier grades)
- Knows that most of flavor comes from smell
- Can use a chef’s knife, the stove and the oven with an adult nearby (Unit 1)
- Knows the safe temperature for chicken (165 °F) and beef stew meat cooked until tender (Unit 1)

MASTERY CHECKLIST

- ☐ I can explain what a supertaster is, how Linda Bartoshuk studied them, and why bitter tastes differ from person to person.
- ☐ I can explain how smell receptors work, the difference between sniffing and retronasal smell, and why flavor is mostly smell.
- ☐ I can describe how taste and smell change from childhood to old age, and why repeated tasting helps us learn to like new foods.
- ☐ I can name and describe textures the way a food scientist does, and explain what makes food crisp.
- ☐ I can run a fair taste test and record the results in a chart.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **NIDCD: Taste Disorders and Smell Disorders**: Free. Clear pages from the National Institutes of Health on how taste and smell work and how they change with age. Good background for Lessons 3.1–3.3.
- **Blue food coloring and a hand lens**: Optional. For counting the taste papillae on the tip of your tongue in Lesson 3.1.

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

3.1 Linda Bartoshuk and the Supertasters

2 sessions of 50–60 minutes

3.2 Buck, Axel and the Thousand Smells: Basil Pesto

2 sessions of 50–60 minutes

3.3 Taste Across a Lifetime: A Recipe from an Older Relative

2 sessions of 60–90 minutes

3.4 Alina Szczesniak and the Science of Texture

2 sessions of 50–60 minutes

UNIT 3 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

What happened in Arthur Fox’s laboratory in 1931, and why was it important?

2. **8 pts**

How did Linda Bartoshuk identify supertasters, and what did she find on their tongues?

3. **8 pts**

Name three ways a cook can balance a bitter food.

4. (8 pts)

What did Linda Buck and Richard Axel discover, and how can about 400 receptors detect thousands of smells?

5. (8 pts)

What is retronasal smell? Why does food taste flat with a stuffy nose?

6. (8 pts)

What did Richard Doty's 1984 study find about smell and age?

7. (8 pts)

About how many friendly tastes does it often take for a child to come to like a new food? What does that mean for your family table?

8. (8 pts)

Calculation: your family stew recipe serves 6 and calls for 2 pounds of beef. How much beef do you need to serve 15? If beef costs \$6.50 a pound, what will it cost? Show your work.

9. (8 pts)

Name four of Szczesniak's texture characteristics and give a food example of each.

10. (8 pts)

Why does panko make a crisper coating than fine bread crumbs, and why should breaded chicken bake on a rack?

11. (10 pts)

Calculation: cocoa recipe A uses 3 tablespoons of sugar for 4 cups of cocoa. A taster wants it one-third less sweet. How much sugar should you use? Write your answer in tablespoons and teaspoons (1 tablespoon = 3 teaspoons).

12. (10 pts)

Written answer: Your younger brother says he hates broccoli. Using what you learned in this unit, write a short, kind plan to help him try it again.

ANSWER KEY

1. PTC dust flew into the air; a coworker found it very bitter while Fox tasted nothing. It showed that people differ in their ability to taste some bitter compounds, which is largely inherited.
2. She had people rate the bitterness of PROP on a careful scale; about a quarter rated it extremely strong. Using blue dye to count papillae, she found supertasters have many more fungiform papillae, and so more taste buds.
3. Any three: add salt; add a little sweetness; add fat (cheese, butter, oil); add acid (lemon, vinegar); pair it with other flavors.
4. In 1991 they discovered the large family of genes for smell receptors. Each odor activates a pattern of several receptors, and the brain reads the pattern, so a few hundred receptors can distinguish many thousands of smells.
5. Smelling the aromas of food in your mouth as they rise from the back of the throat into the nose. With a stuffy or pinched nose, the aromas cannot reach the receptors, so only the five basic tastes remain and most of the flavor is lost.
6. People identify smells best from about their 20s to 40s; the ability declines with age, especially after 60. More than half of people 65–80 and more than three-quarters over 80 had major smell loss, often without realizing it.
7. About 8 to 15. Keep offering small tastes of new foods without pressure, and try them yourself many times before deciding.
8. $15 \div 6 = 2.5$ times the recipe. $2 \times 2.5 = 5$ pounds. $5 \times \$6.50 = \$32.50$.
9. Examples: hardness (raw carrot), cohesiveness (gummy candy holds together), springiness (marshmallow), adhesiveness (peanut butter), brittleness (cracker), chewiness (bagel), gumminess (a thick paste). Other good examples accepted.
10. Panko's large, airy flakes have more surface and air, so they dry, brown and snap; fine crumbs pack densely and absorb more moisture. A rack lets hot dry air reach every side so steam escapes and the bottom does not go soggy.
11. One-third of 3 tablespoons is 1 tablespoon, so use $3 - 1 = 2$ tablespoons (6 teaspoons).
12. Answers vary. A good plan mentions that children taste bitterness strongly, that taste buds renew and likes change with 8–15 tries, cooking broccoli in a way that reduces bitterness (roasting with olive oil and salt, adding cheese or lemon), offering small tastes without pressure, and tasting it together with thanks.

UNIT CHALLENGE: A FAMILY TASTE SURVEY ACROSS THE GENERATIONS

Design and run a taste survey with at least five people of different ages, including at least one child and one older adult (with permission). Prepare one food three ways, for example broccoli steamed, roasted with olive oil and salt, and served with cheese sauce, and let everyone taste each version blind and rate bitterness, flavor and texture.

Record results in a chart and a bar graph, along with each person's age group and, if they agree, their papillae count. Write a one-page report on what you found, connecting it to supertasters, smell and age, and texture, and include a "try it again" plan for one food someone in your family dislikes.

LOOK FOR	WHAT IT MEANS
Fair test	Same food prepared three ways, tasted blind in the same order, with water between tastes, allergies checked first.
Cooking and safety	Each version cooked safely with an adult nearby; kitchen kept clean.
Data	A clear chart and graph with ratings for bitterness, flavor and texture by age group.
Explanation	A one-page report that uses at least three ideas from the unit to explain the results.
Kindness and follow-up	Tasters treated respectfully; a realistic "try it again" plan written and begun.

UNIT 4

HEAT & COLD

Every recipe is a story about heat moving in or out of food. In this unit you will see heat at work in four ways. First you will meet Jacob Perkins, an American inventor in London who patented the first machine that made cold with a compressed vapor in 1834, the ancestor of the refrigerator in your kitchen, and you will learn how to cool cooked food quickly and safely. Then you will climb a mountain with a pot of water and discover why it boils at a lower temperature the higher you go.

Next you will test an old kitchen claim, that searing meat “seals in the juices,” and cook fish two ways, seared in a hot pan and steamed. Finally you will sail with Frederic Tudor, the Boston merchant who shipped New England ice to the tropics, and use what you have learned about freezing to make a smooth fruit sorbet. You will do a good deal of arithmetic in this unit: temperature conversions, cooling rates and altitude math.

PREREQUISITES

- Knows conduction, convection and radiation (earlier grades)
- Knows the danger zone (40–140 °F) and the 2-hour rule (Unit 1)
- Can use a thermometer and convert between °F and °C (Unit 1)
- Can use the stove and oven with an adult nearby

MASTERY CHECKLIST

- ☐ I can tell how Jacob Perkins’s 1834 machine made cold, and explain how evaporation and compression move heat out of a refrigerator.
- ☐ I can cool cooked food quickly and safely, and explain why shallow containers cool faster.
- ☐ I can explain why water boils at a lower temperature at high altitude and calculate the approximate boiling point for a given elevation.
- ☐ I can explain the difference between searing and steaming, and why searing does not “seal in the juices.”
- ☐ I can tell the story of Frederic Tudor and explain how sugar affects freezing in a sorbet.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA FSIS: Leftovers and Food Safety:** Free. How to cool, store and reheat leftovers safely. Good background for Lesson 4.1.
- **National Center for Home Food Preservation: High Altitude:** Free. University of Georgia's guide to food preservation, including how altitude changes boiling and processing times.
- **A refrigerator and freezer thermometer:** Optional and inexpensive. Used in Lesson 4.1 to check that your refrigerator stays at or below 40 °F and your freezer at 0 °F.

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 Jacob Perkins and the Machine That Made Cold	2 sessions of 50–60 minutes
4.2 Altitude, Air Pressure and the Boiling Point	2 sessions of 50–60 minutes
4.3 Searing and Steaming: Testing an Old Kitchen Claim	2 sessions of 50–60 minutes
4.4 Frederic Tudor, the Ice King: Fruit Sorbet	2 sessions of 50–60 minutes

UNIT 4 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

Name the four main parts of the refrigeration cycle in Jacob Perkins's machine and in a modern refrigerator.

2. **8 pts**

Why is the back or bottom of a refrigerator warm?

3. **8 pts**

Describe two ways to cool a large pot of chili quickly and safely.

4. (8 pts)

Why does water boil at a lower temperature on a mountain?

5. (10 pts)

Calculation: using the rule that water boils about 1 °F lower for every 500 feet, find the boiling point at 7,500 feet. Then convert it to °C. Show your work.

6. (8 pts)

How does a pressure cooker cook beans faster?

7. (8 pts)

What did Justus von Liebig claim about searing meat? What did later experiments show?

8. (10 pts)

Calculation: a raw fillet weighs 170 g. After searing it weighs 136 g. What percent of its weight did it lose? Show your work.

9. (8 pts)

Steam is only about 212 °F, but it cooks quickly and burns badly. Why?

10. (8 pts)

How did Frederic Tudor solve the problem of ice melting on long voyages?

11. (8 pts)

Predict: you make sorbet with almost no sugar. What will happen, and why?

12. (8 pts)

Written answer: Explain to a younger child why a refrigerator does not “make cold” but “moves heat.” Use an example.

ANSWER KEY

1. An evaporator coil inside the cold space (refrigerant evaporates and absorbs heat), a compressor (squeezes the vapor, making it hot), a condenser coil outside (vapor gives off heat and turns back to liquid), and an expansion valve (lets the liquid back into the evaporator).
2. The heat taken out of the food is carried by the refrigerant to the condenser coils outside the cold box, where it is released into the room.
3. Any two: divide it into shallow containers; set the pot in an ice-water bath and stir; stir often to release heat; refrigerate uncovered until cool, then cover. It must be in the refrigerator within 2 hours.
4. Water boils when its vapor pressure equals the air pressure. Higher up there is less air above, so the pressure is lower, and water reaches that point at a lower temperature.
5. $7,500 \div 500 = 15$. $212 - 15 = 197$ °F. $(197 - 32) \times 5 \div 9 = 165 \times 5 \div 9 \approx 92$ °C.
6. It traps steam, raising the pressure inside, so water boils at a higher temperature (about 250 °F); the hotter water cooks food faster.
7. He claimed searing set the surface and sealed in the juices. Experiments that weighed seared and unseared meat found seared meat lost as much juice or slightly more; searing adds flavor and color, not moisture.
8. $170 - 136 = 34$ g lost. $34 \div 170 = 0.20$. $0.20 \times 100 = 20\%$.
9. When steam touches a cooler surface it condenses into water and releases its latent heat, a large amount of energy, all at once.
10. He packed the ice in sawdust, a cheap insulator that slowed heat flow, built insulated icehouses at his ports, and used tightly packed, evenly cut blocks.
11. It will freeze into a hard, icy block, because without dissolved sugar to lower the freezing point, nearly all the water freezes into large crystals.
12. Answers vary. A good answer explains that cold is just less heat; the fridge pulls heat out of the food with an evaporating liquid and carries it outside the box, like sweat cooling skin, so the food gets colder and the room behind the fridge gets a little warmer.

UNIT CHALLENGE: HEAT IN, HEAT OUT: A KITCHEN TEMPERATURE INVESTIGATION

Design and carry out three short experiments with food and heat, each with a prediction, a measurement and a result: (1) a cooling race comparing two ways to cool the same hot food; (2) the boiling point of water in your kitchen compared with your calculated prediction; and (3) the same food cooked two ways (for example, seared and steamed vegetables, or roasted and boiled carrots), with weights and temperatures recorded.

Present your results as a short lab report with tables, at least one graph, photographs or sketches, and a conclusion for each experiment. End by cooking a family meal that uses at least two of the heat methods from this unit, and explain to your family what is happening to the food as you serve it.

LOOK FOR	WHAT IT MEANS
Experiments	Three experiments, each with a clear prediction, fair method and measured results.
Calculations and graph	Temperature conversions, boiling-point or percent calculations done correctly, with at least one clear graph.
Safety	Hot liquids, steam and hot pans handled safely with an adult nearby; food cooled and stored correctly.
Family meal	A meal using two heat methods, cooked and served, with the science explained.
Report and cleanup	A neat, honest report; the kitchen left clean after each experiment.

4.1 JACOB PERKINS AND THE MACHINE THAT MADE COLD

OBJECTIVES

- Tell how Jacob Perkins patented a vapor-compression machine for making cold in 1834.
- Explain how evaporation absorbs heat and how a refrigerator moves heat from inside to outside.
- Cook and cool a pasta salad quickly and safely, measuring how fast food cools in shallow and deep containers.

Warm-up. Wet the back of one hand with water and leave the other dry. Blow gently across both hands. Which feels colder? Now fan the wet hand for a minute. Why do you think water evaporating from your skin makes it feel cold?

WATCH

History of the refrigerator

History Class • 7:30

<https://www.youtube.com/watch?v=TwUoUQWzBT0>

WHEN TO WATCH

After The story. Watch for Jacob Perkins and the inventors who came before and after him.

KEY TERMS

evaporation

A liquid changing into a gas.
Evaporation absorbs heat from its surroundings, which is why sweat cools your skin.

compressor

A pump that squeezes the refrigerant vapor so that it becomes hot and can give up its heat to the room and turn back into a liquid.

refrigerant

The fluid in a refrigerator that evaporates inside the cold box (absorbing heat) and condenses outside (releasing heat).

condensation

A gas changing back into a liquid, which releases heat.

two-stage cooling

The food-service rule for cooling
cooked food: from 135 °F to 70 °F
within 2 hours, and from 70 °F to 41 °F
or below within 4 more hours.

CORE IDEAS

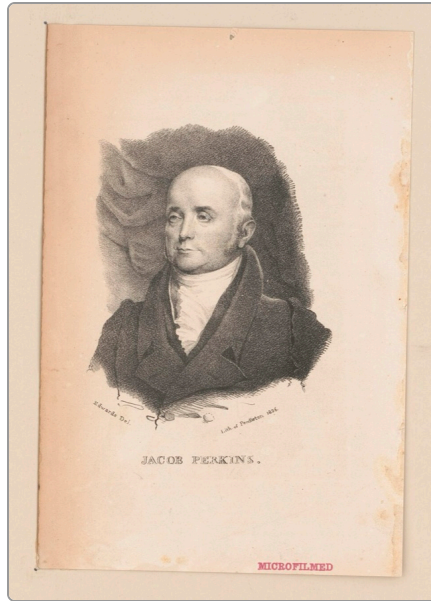
The story. For thousands of years the only way to keep food cold was with natural ice and snow, cool cellars, springhouses or evaporation from damp cloths and clay jars. Scientists in the 1700s noticed that liquids like ether chill whatever they evaporate from. In 1755 the Scottish professor William Cullen made a little ice in a laboratory by letting ether evaporate under a vacuum, but no one could make it useful. Jacob Perkins, an inventor from Newburyport, Massachusetts, who had moved to London, had a better idea: use the same fluid over and over in a closed loop. In 1834 he received a British patent for a machine that did exactly that.

How he figured it out. Perkins's machine had the four parts that every refrigerator still has. Liquid ether flowed into a coil where it **evaporated**, pulling heat from the water around the coil until the water froze. A hand-cranked **compressor** then pumped the ether vapor out and squeezed it until it was hot. In a second coil, outside the cold box, the hot vapor gave off its heat and **condensed** back into a liquid. The liquid passed through a narrow valve back to the cold coil, and the cycle began again. A mechanic named John Hague built a working model, and it made ice. Perkins's machine was never sold widely, but later inventors used the same cycle, and by the 1920s and 1930s electric home refrigerators were replacing iceboxes in American kitchens.

The kitchen science. A refrigerator does not make cold; it moves heat. The refrigerant evaporates in coils inside the fridge, soaking up heat from your food, and the compressor carries that heat to coils outside, which is why the back or bottom of a refrigerator feels warm. Your job is to help it. Hot food takes time to cool, and the center of a big pot of pasta or soup can sit in the danger zone (40–140 °F) for hours if it goes into the fridge in one deep container. Food-service kitchens follow **two-stage cooling**: down to 70 °F within 2 hours and to 41 °F within 4 more. At home, cool food fast by spreading it in **shallow containers**, stirring it, rinsing cooked pasta with cold water, or setting the pot in an ice-water bath, and get it into the refrigerator within 2 hours. Keep your refrigerator at or below 40 °F (4 °C) and your freezer at 0 °F (–18 °C).

Let's cook. You will cook pasta and turn it into a chilled pasta salad with vegetables and a vinaigrette, cooling the pasta quickly and measuring the temperature as it falls. The skill is **fast, safe cooling**.

PICTURE STUDY



Jacob Perkins, Lithograph by Pendleton after a drawing by Edwards, 1826 · Lithograph · Library of Congress, Washington, D.C.

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

Jacob Perkins was a remarkable American inventor. Before he ever thought about cold, he had invented machines for making nails, new ways to engrave banknotes so they were hard to counterfeit, and improvements to steam engines. This portrait was published in 1826, a few years after he moved to London, where he patented his refrigerating machine in 1834.

Look closely

- Look at his face and expression. What kind of man does he seem to be?
- Look at his clothes. What do they tell you about when he lived?
- Notice how the engraver used tiny lines to make light and shadow. Perkins himself was an expert in engraving.
- Imagine the kitchen of his day. What would it have had instead of a refrigerator?

Talk about it

1. Why do you think it took nearly a century for Perkins's idea to reach ordinary kitchens?
2. How would your family's cooking and shopping change if you had no refrigerator?

3. What qualities does an inventor need to keep working on an idea that does not succeed at first?

Safety first. Drain pasta with an adult nearby, pouring the pot away from you so steam rises away from your face. Cool cooked food quickly in shallow containers and refrigerate it within 2 hours (1 hour if the room is above 90 °F); do not leave a big pot of food to cool on the stove overnight.

KITCHEN PROJECT

Chilled Pasta Salad and the Cooling Race

You will cook pasta, then race two batches to see how fast each cools: one left in a deep bowl, one rinsed and spread on a sheet pan. Then you will turn the cooled pasta into a salad.

You will need

- A large pot, a colander and a liquid measuring cup
- A deep bowl and a rimmed baking sheet
- An instant-read thermometer and a timer
- A chef's knife, cutting board and a large serving bowl
- A jar with a lid for the dressing

CHILLED ITALIAN PASTA SALAD

Serves 6–8 • Prep 25 min • Cook 10 min • Chill 1 hr

Ingredients

- 1 pound (450 g) short pasta, such as rotini or bow ties
- 1 tablespoon salt for the pasta water
- 1 cup cherry tomatoes, halved
- 1 cucumber, diced
- 1 bell pepper, diced
- ½ cup sliced black olives
- ¼ small red onion, finely chopped
- 1 cup (115 g) small mozzarella balls or cubed mozzarella
- ¼ cup chopped fresh parsley or basil
- **Vinaigrette:** ½ cup (120 mL) olive oil
- ¼ cup (60 mL) apple cider vinegar or white vinegar
- 1 teaspoon Dijon mustard
- 1 teaspoon dried oregano
- 1 small clove garlic, minced

- $\frac{3}{4}$ teaspoon salt and $\frac{1}{4}$ teaspoon black pepper

Method

1. With an adult nearby, bring a large pot of water to a boil and add 1 tablespoon salt. Cook the pasta according to the package until just tender.
2. Drain in the colander. For the cooling race (see project steps), put one cup of hot pasta in the deep bowl. Rinse the rest under cold running water, shake well, and spread it on the baking sheet.
3. While the pasta cools, make the vinaigrette: put all the dressing ingredients in the jar, close the lid tightly, and shake hard for 20 seconds.
4. Cut the vegetables with the claw and bridge grips.
5. When the spread pasta is cool, put it in the serving bowl with the vegetables, mozzarella and herbs. Shake the dressing again, pour it over, and toss.
6. Cover and refrigerate at least 1 hour. Keep the salad cold, and if you take it on a picnic, pack it in a cooler with ice packs; do not leave it out more than 2 hours (1 hour above 90 °F).

Allergy check: Contains wheat (pasta) and milk (mozzarella). Use gluten-free pasta for wheat-free; leave out the cheese or add chickpeas instead for milk-free.

Steps

1. **Fridge check.** Put a thermometer in a glass of water in the middle of your refrigerator overnight. Read it in the morning. Is it at or below 40 °F? Do the same in the freezer (no water) for 0 °F.
2. **Cooling race.** Right after draining, record the temperature in the center of the deep-bowl pasta and the spread, rinsed pasta. Record both every 5 minutes for 30 minutes (put the deep bowl in the refrigerator after the first reading, as many people would).
3. **Graph it.** Plot both batches on one graph. How long did each take to fall below 70 °F? Which method would pass two-stage cooling?
4. Make the pasta salad.
5. **Rate it.** Ask your family to rate the salad from 1 to 5.

6. Clean up: wash the pot, colander, board and knife; wipe the counter; label the leftovers with the date.
7. **Improve it.** Write one change: add salami or chicken, a different vinegar, more herbs, or less onion.

Tips

- Do not crowd the refrigerator. Cold air needs room to move around containers.
- Pasta salad soaks up dressing as it sits. Save a little dressing to add just before serving.
- Divide a big pot of soup or chili into several small, shallow containers to chill it quickly.

Check your work

- ☐ I can tell how Jacob Perkins's machine made cold.
- ☐ I can explain how a refrigerator moves heat, and how to cool food quickly.
- ☐ I made a pasta salad, measured a cooling race, and refrigerated food within 2 hours.

COOK'S NOTEBOOK

1. Draw the refrigeration cycle as a loop: cold coil (evaporation), compressor, warm coil (condensation), valve. Show where heat goes in and out.
2. Paste or draw your cooling-race graph and write two sentences about it.
3. Write the recipe in your own words with your family's rating and one improvement.

From history. Before electric refrigerators, many American homes had an "icebox," a wooden cabinet lined with tin or zinc, with a block of ice in the top compartment. An iceman delivered fresh blocks several times a week, and families put a card in the window showing how many pounds they needed.

COMMON MISTAKES

- Letting a large pot of food cool on the counter for hours before refrigerating it. Divide it into shallow containers and refrigerate within 2 hours.
- Thinking a refrigerator kills germs. Cold only slows most germs; some, like *Listeria*, can grow slowly in the fridge.

- Setting the refrigerator too warm to save energy. Keep it at or below 40 °F.

Make it a game · Heat Mover Diagram. Draw a refrigerator on paper and show how heat moves from inside to outside. Label the evaporator, compressor, condenser and refrigerant. Cover your labels and have your parent point to each part while you name it and say what it does. Then tell how Jacob Perkins patented his machine for making cold in 1834.

4.2 ALTITUDE, AIR PRESSURE AND THE BOILING POINT

OBJECTIVES

- Explain why water boils at a lower temperature at higher altitude, and how explorers used this to estimate elevation.
- Calculate the approximate boiling point of water at a given altitude and convert it to °C.
- Cook hard-cooked eggs with timing adjusted for altitude and make stuffed eggs.

Warm-up. Look up the elevation of your town in feet above sea level. Then predict: at what temperature will water boil in your kitchen? Write your guess, then measure it with an adult during the project.

WATCH

Water Boiling at Everest - Periodic Table of Videos

Periodic Videos • 9:28

<https://www.youtube.com/watch?v=JTL4dj3Gx1o>

WHEN TO WATCH

After How they figured it out. A chemist and his team carry a thermometer up toward Mount Everest; write down the boiling point at each stop.

BACKUP VIDEO

Boiling Water On Mount Everest! | Earth Science

BBC Earth Science • 3:28

<https://www.youtube.com/watch?v=8lyqFkFsH28>

A short field test: a thermometer in boiling water at different heights in the Himalayas.

KEY TERMS

boiling point

The temperature at which a liquid's vapor pressure equals the air pressure on it, so bubbles of vapor form throughout the liquid.

air pressure

The weight of the air above pressing down. It is greatest at sea level and decreases as you go higher.

altitude

Height above sea level, usually measured in feet or meters.

hypsonometer

An instrument explorers used to estimate altitude by measuring the exact temperature at which water boils.

pressure cooker

A sealed pot that traps steam, raising the pressure inside so water boils at a higher temperature (about 250 °F) and food cooks faster.

CORE IDEAS

The story. In 1724 Daniel Gabriel Fahrenheit, the maker of the first reliable mercury thermometers, reported something odd: water did not always boil at exactly the same temperature. It depended on the weather, rising and falling with the reading of the barometer, the instrument that measures air pressure. A century later explorers turned this into a tool. Climbing in the mountains of South America and Asia, scientists like the botanist Joseph Hooker in the Himalayas in the 1840s carried delicate thermometers and little stoves, boiled water at each camp, and used the boiling point to estimate how high they had climbed.

How they figured it out. Water molecules are always escaping from the surface as vapor. As water heats up, its vapor pushes harder and harder. Water **boils** when the push of its vapor equals the push of the air pressing down on it; then bubbles of steam can form all through the liquid. At sea level the air presses hard, and water must reach 212 °F (100 °C). On a mountain there is less air above you, so the pressure is lower, and water boils at a lower temperature. A handy rule: water boils about 1 °F **lower for every 500 feet** of altitude. In Denver, at about 5,280 feet, water boils at about 202 °F (94 °C). On the summit of Mount Everest, at 29,032 feet, it boils at only about 160 °F (71 °C).

The kitchen science. Boiling water can never get hotter than its boiling point; extra heat only makes it boil faster. So at high altitude, “boiling” water is cooler, and food in it cooks more slowly: pasta, rice, beans and eggs all take longer. High-altitude cooks add time, add water (more evaporates), and in baking adjust leavening, sugar and oven temperature. A **pressure cooker** does the opposite of a mountain: it traps

steam, raises the pressure, and lets water reach about 250 °F, so tough beans and stews cook quickly. That is also why home canning of low-acid foods like green beans must use a pressure canner: only the higher temperature is safe.

Let's cook. You will measure the boiling point of water in your kitchen, calculate what it should be from your altitude, and cook hard-cooked eggs with a timing test, then make stuffed eggs. The skill is **timing and cooling eggs precisely**: a gentle boil, a covered rest, and an ice bath to stop the cooking.

PICTURE STUDY



Denis Papin Shows His Steam Digester to Robert Boyle, Unknown engraver, 19th century · Wood engraving · From a nineteenth-century illustrated history of science

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

In the 1670s the young French scientist Denis Papin worked in London as an assistant to Robert Boyle, the great experimenter who studied the pressure of air. In 1679 Papin invented the steam digester, a sealed iron pot that trapped steam so water could get hotter than its usual boiling point. This engraving, made long afterward, imagines the two men in their laboratory.

Look closely

- Find the two scientists. Which one seems to be explaining something?
- Look around the room. What instruments and vessels can you find?
- Look for a furnace or fire. Why would a laboratory of the 1670s need one?
- Look at their clothes and wigs. When did these men live?

Talk about it

1. Boyle studied air pressure. How does air pressure decide the temperature at which water boils?
2. Papin's digester raised the pressure. What happens to the boiling point inside a sealed pot?

3. Which is more like Papin's digester: a pot on top of a mountain, or a pressure cooker? Why?

Safety first. Boiling water and steam cause serious burns: keep the pot handle turned in, lower eggs into the water with a spoon (never drop them), and lift the lid away from your face. An adult should be nearby whenever water is boiling. Use only a thermometer rated for boiling water, and hold it with an oven mitt, not touching the bottom of the pot.

Boiling-Point Lab and Stuffed Eggs

You will measure your kitchen's boiling point, compare it with your calculation, and test how different cooking times change a hard-cooked egg. Then you will make stuffed eggs.

You will need

- A medium saucepan with a lid and a slotted spoon
- An instant-read thermometer that reads to at least 220 °F
- A large bowl of ice water and a timer
- A mixing bowl, a fork and a small spoon or piping bag

HARD-COOKED EGGS AND CLASSIC STUFFED EGGS

Serves 6 (12 stuffed egg halves) · Cook 12–17 min · Cool 10 min · Prep 15 min

Ingredients

- 8 large eggs (6 for stuffing, 2 extra for the timing test)
- ¼ cup (55 g) mayonnaise
- 1 teaspoon Dijon or yellow mustard
- 1 teaspoon white vinegar or pickle juice
- ⅛ teaspoon salt and a pinch of black pepper
- Paprika and chopped chives or parsley for garnish

Method

1. Put the eggs in the saucepan in one layer and cover with cold water by 1 inch. With an adult nearby, bring to a full boil over medium-high heat.
2. As soon as it boils, cover the pot and turn off the heat. Let the eggs stand in the hot water: 12 minutes at sea level, 14 minutes at about 3,000 feet, and 16–17 minutes at 5,000 feet or higher.
3. With the slotted spoon, move the eggs into the ice water. Cool at least 10 minutes. (For the timing test, take out one extra egg at 8 minutes and one at 20 minutes.)

4. Tap each egg all over on the counter, roll it gently, and peel under a little running water.
5. Halve 6 eggs lengthwise and pop the yolks into the mixing bowl. Mash with a fork. Stir in the mayonnaise, mustard, vinegar, salt and pepper until smooth.
6. Spoon or pipe the filling into the whites. Sprinkle with paprika and herbs. Refrigerate until serving; keep stuffed eggs cold and do not leave them out more than 2 hours.

Allergy check: Contains eggs. Most mayonnaise contains eggs and some contains soy; check the label. For a family that cannot eat eggs, make the boiling-point lab with water only and serve a white-bean dip instead.

Steps

1. **Calculate.** Use the rule: boiling point $\approx 212 - (\text{altitude in feet} \div 500)$ °F. Convert to °C. Write your prediction.
2. **Measure.** With an adult, bring a pot of water to a full rolling boil. Hold the thermometer (with an oven mitt) in the center of the water, not touching the pot. Record the steady reading. How close was your prediction? (If it is off, check your thermometer in ice water; it should read 32 °F.)
3. Cook the eggs, taking out test eggs at 8 minutes and 20 minutes as well as the main batch.
4. **Egg comparison.** Cut each test egg in half. Sketch the yolks. Describe the color and texture: runny, fudgy, firm, chalky? Is there a gray-green ring? (The ring forms when sulfur from the white meets iron in the yolk after too much heat.)
5. Make the stuffed eggs and serve them.
6. Clean up: compost or throw away the shells, wash the pot and bowl, wipe the counter.
7. **Improve it.** Write the perfect time for your altitude and one change to the filling: more mustard, a little relish, or smoked paprika.

Tips

- Eggs a week or more old peel more easily than very fresh eggs.
- The ice bath stops carryover cooking and helps prevent the green ring.
- For neat halves, wipe the knife clean between cuts.

Check your work

- ☐ I can explain why water boils at a lower temperature on a mountain.
- ☐ I calculated and measured the boiling point in my kitchen.
- ☐ I cooked hard-cooked eggs with the right timing for my altitude and made stuffed eggs.

COOK'S NOTEBOOK

1. Draw a mountain with five altitudes marked (sea level, 2,500, 5,000, 10,000 feet and the top of Everest) and the boiling point of water at each in °F and °C.
2. Sketch your three test-egg yolks side by side with their times.
3. Write the recipe in your own words with the best time for your kitchen.

From history. Denis Papin, a French scientist working in London, invented the “steam digester” in 1679, a heavy sealed pot that trapped steam to cook food at a higher temperature and soften bones. He also designed a safety valve to keep it from bursting, an idea used on pressure cookers and steam engines ever since.

COMMON MISTAKES

- Turning the heat up to make boiling water hotter. Once water boils, it stays at its boiling point; more heat only makes more steam.
- Following sea-level times at high altitude. Pasta, rice, beans and eggs need more time; cakes and breads need recipe changes.
- Leaving hard-cooked eggs in the hot water too long, which makes rubbery whites and green rings.

Make it a game • Boil at Altitude. Your parent names an altitude, such as five thousand feet or ten thousand feet. Estimate the boiling point, subtracting about one degree Fahrenheit for every five hundred feet. Then convert to Celsius. Closest and quickest wins a point. Explain why air pressure matters and how a hypsometer helps explorers, and how a pressure cooker changes things.

4.3 SEARING AND STEAMING: TESTING AN OLD KITCHEN CLAIM

OBJECTIVES

- Tell how Justus von Liebig's claim that searing "seals in the juices" spread, and how later testing showed it was wrong.
- Compare how searing and steaming move heat into food, and what each does to color, texture and moisture.
- Cook white fish two ways, seared and steamed, to 145 °F, and measure the moisture each loses.

Warm-up. Hold your hand (carefully!) 6 inches above a pot of boiling water for one second, then near (not in) the steam coming out of a kettle spout with an adult watching. Which feels hotter? Why do you think steam burns are so serious, even though steam is only at 212 °F?

WATCH

Searing Meat Is A Delicious Lie

SciShow · 3:13

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

WHEN TO WATCH

After How they figured it out. Watch for who first claimed searing seals in juices, and what the experiment found.

Note: From SciShow. It begins with a short sponsor message.

BACKUP VIDEO

Harold McGee Debunks the "Sealing in the Juices" Meat Myth - CHOW Tip

Chowhound · 0:40

<https://www.youtube.com/watch?v=GjfdW-kcX5E>

A 40-second tip from food-science writer Harold McGee on the "sealing in the juices" myth.

KEY TERMS

searing

Cooking the surface of food quickly over very high, dry heat until it browns deeply.

steaming

Cooking food in the hot vapor above boiling water, often in a covered basket or pan.

latent heat

The large amount of heat that steam gives up when it condenses back into water on a cooler surface. This is why steam cooks fast and burns badly.

browning

The deep color and rich flavor that form on the surface of foods heated above about 300 °F, mostly from the Maillard reaction (Unit 5).

moisture loss

The water and juices a food gives up as its proteins tighten in the heat, measured by weighing before and after cooking.

CORE IDEAS

The story. In 1847 the famous German chemist Justus von Liebig published a book on the chemistry of food. In it he wrote that meat should be plunged into very hot water or seared over high heat first, so that the outer layer would set quickly and seal the juices inside. Liebig was one of the most respected scientists in Europe, and cookbooks and chefs repeated his advice for a hundred years. Many cooks still say it today.

How they figured it out. But no one had tested it. In the twentieth century food scientists did. They cooked pieces of meat with and without an initial sear, weighed each piece before and after, and compared. The seared meat did not lose less juice; in several studies it lost a little more, because the very hot surface squeezed out more water. You can also see it with your own eyes: a seared steak keeps sizzling in the pan, and the sizzle is juice turning to steam. Liebig's idea was simply wrong. Yet cooks keep searing, for a different and better reason: **flavor**. The deep brown crust is full of new flavor molecules.

The kitchen science. Searing and steaming move heat in different ways. A hot, dry pan at 400 °F or more transfers heat by **conduction**; the surface of the food dries and

climbs above 300 °F, and it browns. **Steam** is only about 212 °F, but when it touches cooler food it condenses and releases its **latent heat**, a great deal of energy, all at once. Steam cooks quickly and gently, keeps food moist and pale, and does not brown it. Because the surface stays wet, steamed food can never get hotter than about 212 °F. Delicate fish is a good test, because it cooks fast and dries out easily; either way, it is done at **145 °F (63 °C)**.

Let's cook. You will cook fillets of cod or another white fish two ways: seared in a hot skillet with a little oil, and steamed in a covered pan over simmering water with ginger and green onions. You will weigh them before and after, check each to 145 °F, and compare. The skill is **controlling high heat**: a dry fish, a hot pan, no crowding, and no moving the fish until it releases.

PICTURE STUDY



Still Life with Mackerels, Lemons and Tomatoes, Vincent van Gogh, 1886 · Oil on canvas · Oskar Reinhart Collection “Am Römerholz,” Winterthur, Switzerland
Image: [Wikimedia Commons](#), public domain

Van Gogh painted this still life in Paris, where he was experimenting with brighter colors. The cool, shining fish sit beside warm lemons and tomatoes. Cooks still pair fish with lemon and tomato today: the acid brightens the rich, oily flesh of fish like mackerel.

Look closely

- Look at the two fish. How has Van Gogh shown their shiny, silvery skin?
- Find the lemons and the tomatoes. Why might a cook put them beside fish?
- Look at the brushstrokes. Are they smooth or thick and lively?
- Find the warmest and coolest colors in the picture.

Talk about it

1. Would you sear or steam these mackerel? Why?
2. How do you know these fish are fresh? What signs of freshness would you look for at the store?
3. Why do you think artists have painted fish so often?

Safety first. Do not put your hand or face in steam; even brief contact can cause a serious burn. Sear with an adult nearby, laying the fish in the pan away from you, and keep a lid nearby; a grease fire is smothered with a lid or baking soda, never water. Cook fish to 145 °F and keep raw fish on its own plate and board.

KITCHEN PROJECT

Seared and Steamed Fish, Side by Side

You will weigh fish fillets raw, cook half by searing and half by steaming, check each to 145 °F, weigh them again, and taste the difference.

You will need

- A kitchen scale (grams if possible)
- A large heavy skillet and a thin, wide spatula (a fish spatula is ideal)
- A second wide pan with a lid, or a steamer basket in a pot
- An instant-read thermometer, paper towels and two clean plates
- A cutting board for raw fish

SEARED AND GINGER-STEAMED COD

Serves 4 • Prep 15 min • Cook 8–12 min

Ingredients

- 4 cod, haddock or other firm white fish fillets, about 6 ounces (170 g) each and 1 inch thick
- 1 teaspoon salt and ¼ teaspoon pepper, divided
- **For searing:** 1 tablespoon vegetable oil, 1 tablespoon butter, 1 lemon cut in wedges
- **For steaming:** a 2-inch piece of fresh ginger, peeled and cut into thin matchsticks
- 3 green onions, cut into thin 2-inch strips
- 1 tablespoon soy sauce mixed with 1 teaspoon sesame oil and 1 teaspoon water
- Cooked rice and steamed green beans or broccoli for serving

Method

1. Pat all the fillets very dry. Weigh each and record. Season with salt and pepper. Wash your hands.
2. **Steamed fillets:** Pour 1 inch of water into the second pan (or a pot with a steamer basket) and bring it to a simmer with an adult nearby. Lay 2

fillets on a heatproof plate or in the basket and scatter half the ginger and green onions on top. Set it over the simmering water, cover, and steam 7–10 minutes. Lift the lid away from you to check.

3. **Seared fillets:** Meanwhile heat the oil in the skillet over medium-high heat until it shimmers. Lay 2 fillets in the pan, away from you. Cook without moving them until a golden crust forms and they release easily, 3–4 minutes. Turn carefully with the spatula, add the butter, and cook 2–4 minutes more, spooning the butter over the fish.
4. Check the thickest part of each fillet: 145 °F (63 °C), opaque and flaking easily.
5. Move the fillets to clean plates. Weigh each again (after it cools for 2 minutes) and record.
6. Drizzle the steamed fish with the soy mixture and top with the rest of the ginger and onions. Serve the seared fish with lemon wedges. Serve both with rice and vegetables.

Allergy check: Contains fish, soy (soy sauce) and milk (butter); soy sauce usually contains wheat. Use tamari labeled gluten-free for wheat-free, and oil instead of butter for milk-free. If anyone is allergic to fish, run the same experiment with boneless chicken breast cut thin (cook to 165 °F).

Steps

1. **Weigh.** Record each raw fillet's weight.
2. Cook both batches as the recipe describes.
3. **Moisture loss.** Weigh each cooked fillet. Calculate the percent lost: $(\text{raw} - \text{cooked}) \div \text{raw} \times 100$. Which method lost more?
4. **Look and taste.** Compare color, crust, flakiness and juiciness. Ask your family to rate each method from 1 to 5.
5. **Conclusion.** Write a paragraph: did searing seal in juices? What is searing really good for?
6. Clean up: wash the raw-fish board and plates in hot, soapy water; wipe the stove once it is cool.
7. **Improve it.** Write one change: a different fish, a thinner fillet, a sauce, or a different steaming flavor (lemon and dill).

Tips

- A wet fillet will not brown. Pat it dry and do not crowd the pan.
- If the fish sticks when you try to turn it, wait another minute; it releases when the crust forms.
- Thick fillets steam evenly; tuck thin ends under.

Check your work

- ☐ I can explain Liebig's claim and why it was wrong.
- ☐ I can explain how searing and steaming transfer heat and what each does to food.
- ☐ I cooked fish two ways to 145 °F and calculated the moisture each lost.

COOK'S NOTEBOOK

1. Draw two pans side by side, one searing and one steaming, with arrows showing how heat reaches the fish in each.
2. Copy your weight table and percent-loss calculations.
3. Write both methods in your own words with your family's ratings.

From history. Steaming is one of the oldest cooking methods in China, where bamboo steamer baskets stacked over a wok have been used for many centuries to cook fish, dumplings and buns. Cantonese cooks are especially famous for whole steamed fish with ginger and green onion.

COMMON MISTAKES

- Believing searing seals in juices. Sear for flavor and color, not to keep juice in.
- Moving fish around in the pan too soon. It tears and sticks; let the crust form first.
- Opening a steamer lid toward your face. Lift it away from you so the steam escapes on the far side.

Make it a game • Myth Court. Put the claim that searing seals in juices on trial. You are the prosecutor, and your parent defends Justus von Liebig. Present evidence from your kitchen: color, texture and moisture loss in seared and steamed food. Make your case in two minutes, then let the judge decide. Mention latent heat and browning.

4.4 FREDERIC TUDOR, THE ICE KING: FRUIT SORBET

OBJECTIVES

- Tell how Frederic Tudor built a business shipping New England ice to the tropics, beginning in 1806.
- Explain how insulation slows melting and how sugar lowers the freezing point and keeps sorbet scoopable.
- Make a strawberry-lemon sorbet without an ice cream machine and compare batches with different amounts of sugar.

Warm-up. Put two ice cubes on two plates. Wrap one plate loosely in a thick towel and leave the other bare. Predict which will melt first. Check every 10 minutes during the lesson.

WATCH

The Trick to Making the Perfect Sorbet - Kitchen Conundrums with Thomas Joseph

Everyday Food · 3:57

<https://www.youtube.com/watch?v=MBIEbMZdMI8>

WHEN TO WATCH

After The kitchen science, before you cook. Watch the three test batches and notice how the amount of sugar changes the texture.

Note: From Martha Stewart's Everyday Food channel. The cook shows an ice cream machine at the end; our recipe needs none.

KEY TERMS

insulation

A material, like sawdust, straw or foam, that slows the movement of heat. Insulation keeps cold things cold and hot things hot.

freezing point depression

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

sorbet

A frozen dessert made from fruit juice or purée and sugar syrup, without milk or cream.

ice crystals

The tiny solid pieces of frozen water in a frozen dessert. Small crystals feel smooth; large ones feel icy and coarse.

simple syrup

Sugar dissolved in an equal amount of water, usually by heating.

CORE IDEAS

The story. In 1806 a 22-year-old Boston merchant named Frederic Tudor had an idea that made people laugh. Every winter the ponds of New England froze thick with clear ice. In the hot islands of the Caribbean there was no ice at all. Why not cut the ice, load it on a ship and sell it in the tropics? That winter he sent a ship with about 130 tons of ice to the island of Martinique. The ice arrived, but no one there knew what to do with it, much of it melted, and Tudor lost money. For years his ice business struggled; at one point he was jailed for debt. He kept going.

How he figured it out. Tudor attacked the problem of melting. He tried different packing materials and found that **sawdust**, a cheap waste product of New England sawmills, insulated the ice very well. He built well-insulated icehouses at the ports where he sold it. He taught customers how to use ice: to chill drinks, keep butter firm and make ice cream. In the 1820s his supplier Nathaniel Wyeth invented a horse-drawn ice cutter that cut ponds into neat, uniform blocks that packed tightly. By the 1830s Tudor was shipping ice as far as Calcutta, India, a voyage of four months, and much of it arrived. He became known as “the Ice King,” and ice became an everyday good in American kitchens until the refrigerator replaced it.

The kitchen science. Ice melts when heat flows into it. **Insulation** like sawdust traps still air and slows that flow, so a big block packed in sawdust melts only slowly. In a frozen dessert, cooks want the opposite of a solid block: they want many **tiny ice crystals**, so it feels smooth. Two things help. **Sugar** dissolved in the fruit lowers the freezing point, so part of the water stays unfrozen and the sorbet stays soft enough to scoop; too little sugar makes a rock-hard block, too much makes slush. And **stirring** while it freezes breaks up large crystals and works in a little air. Most sorbets have roughly 20 to 30 percent sugar by weight.

Let's cook. You will make simple syrup, blend it with strawberries and lemon, and freeze it in a shallow pan, stirring every 30 minutes. A second, smaller batch with half the sugar will show what sugar does. The skill is **measuring by weight** and controlling texture.

PICTURE STUDY



Ice Harvesting: Sawing, Illustration from *The New Student's Reference Work*, 1914 · Photograph printed as a halftone illustration · *The New Student's Reference Work*, Chicago, 1914

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

This picture comes from a children's encyclopedia of 1914. It shows men harvesting ice on a frozen lake, the same work that supplied Frederic Tudor's ships a century earlier. Ice was cut into blocks, floated along channels to an icehouse, packed in sawdust, and sold through the summer.

Look closely

- Find the saws. How big are they? Why so long?
- Find the open channel of water. What is it for?
- Look at how the ice is cut. Why would neat, even blocks be important?
- Look at the workers' clothing. What was this work like?

Talk about it

1. How would you keep these blocks from melting all summer? Use the word *insulation*.
2. What would a family in 1900 use a block of ice for?
3. Why do you think Tudor kept trying after his first shipment failed?

Safety first. Make the syrup with an adult nearby: sugar syrup is much hotter than boiling water and sticks to skin, so stir gently and let it cool before blending. Never blend hot liquids in a sealed blender. Check for allergies before serving; strawberries and lemons are not major allergens, but some people react to them.

Strawberry-Lemon Sorbet and the Sugar Test

You will measure ingredients by weight, make two batches of sorbet with different amounts of sugar, and test which freezes smoother and scoops more easily.

You will need

- A kitchen scale
- A small saucepan and a heatproof measuring cup
- A blender or food processor
- Two shallow metal or glass pans (an 8-inch square pan and a loaf pan) and a fork
- A timer and a thermometer

STRAWBERRY-LEMON SORBET

Serves 6 (about 1 quart) • Prep 15 min • Freeze 3–4 hr (stirring every 30 min)

Ingredients

- **Simple syrup:** $\frac{3}{4}$ cup (150 g) sugar
- $\frac{3}{4}$ cup (180 mL) water
- 1½ pounds (680 g) fresh strawberries, hulled, or frozen strawberries, thawed
- 3 tablespoons lemon juice (1–2 lemons) and 1 teaspoon grated lemon zest
- Pinch of salt

Method

1. With an adult nearby, stir the sugar and water in the saucepan over medium heat until the sugar dissolves completely and the syrup is clear, about 3 minutes. Do not boil it hard. Pour it into the measuring cup and let it cool to room temperature.
2. Wash and hull the strawberries. Blend them with the lemon juice, zest and salt until very smooth.

3. Blend in the cooled syrup. (For the sugar test, first pour 1 cup of purée into a separate container and mix it with only 2 tablespoons of the syrup instead.)
4. Pour the main batch into the square pan and the test batch into the loaf pan. Cover and freeze.
5. Every 30 minutes, take the pans out and stir and mash the mixture hard with a fork, breaking up the ice crystals, especially at the edges. Do this 5–6 times, until the sorbet is firm and smooth.
6. If the sorbet freezes too hard, let it stand 10 minutes before scooping, or break it into chunks and pulse briefly in the food processor. Store covered in the freezer up to 1 week.

Allergy check: Contains none of the nine major allergens.

Steps

1. **Ice-cube race.** Record the results of the warm-up. How much longer did the towel-wrapped cube last?
2. **Weigh and calculate.** Weigh your purée and syrup. Calculate the percent of sugar by weight in each batch: $\text{sugar} \div \text{total weight} \times 100$. Record both.
3. Make the sorbet and stir it every 30 minutes. Each time, record the temperature and texture of both batches.
4. **Scoop test.** After 4 hours, try to scoop each. Which is smoother? Which is harder? Explain with the words freezing point and ice crystals.
5. **Rate it.** Ask your family to rate both batches for smoothness and flavor.
6. Clean up: wash the blender jar (an adult handles the blade), the pans and the saucepan.
7. **Improve it.** Write one change: a different fruit (mango, peach, watermelon), more lemon, or mint.

Tips

- Metal pans conduct heat well, so the sorbet freezes faster than in glass or plastic.
- Taste the mixture before freezing. Cold dulls sweetness, so it should taste a little sweeter than you want the finished sorbet to be.

- A tablespoon of corn syrup in place of some of the sugar makes an even smoother sorbet.

Check your work

- ☐ I can tell the story of Frederic Tudor and how he kept ice from melting.
- ☐ I can explain how sugar and stirring make sorbet smooth.
- ☐ I made sorbet, calculated the sugar percentage, and compared two batches.

COOK'S NOTEBOOK

1. Draw a ship's hold packed with ice and sawdust, and label how heat is slowed.
2. Draw what you imagine the ice crystals look like in a smooth sorbet and an icy one.
3. Write the recipe in your own words with your sugar percentages and your family's ratings.

COMMON MISTAKES

- Cutting the sugar way down to make a "lighter" sorbet. Without enough sugar it freezes into a hard, icy block.
- Freezing sorbet in a deep container without stirring. Large crystals form; use a shallow pan and stir often.
- Blending hot syrup. Cool it first.

Make it a game • Ice King Insulation. Wrap one ice cube in a towel and put another on a plate, and predict which will melt first. Check after ten minutes. Then tell Frederic Tudor's story of shipping New England ice to the tropics. Explain how insulation works and why sugar lowers the freezing point, so a sorbet stays scoopable.

Scripture. "As the cold of snow in the time of harvest, so is a faithful messenger to them that send him: for he refresheth the soul of his masters." (Proverbs 25:13, KJV)

In the heat of harvest, something cold was a rare gift. Solomon compares it to a faithful messenger, someone who can be trusted to do what he was sent to do. Tudor's ships were faithful messengers of cold.

UNIT 4

HEAT & COLD

Every recipe is a story about heat moving in or out of food. In this unit you will see heat at work in four ways. First you will meet Jacob Perkins, an American inventor in London who patented the first machine that made cold with a compressed vapor in 1834, the ancestor of the refrigerator in your kitchen, and you will learn how to cool cooked food quickly and safely. Then you will climb a mountain with a pot of water and discover why it boils at a lower temperature the higher you go.

Next you will test an old kitchen claim, that searing meat “seals in the juices,” and cook fish two ways, seared in a hot pan and steamed. Finally you will sail with Frederic Tudor, the Boston merchant who shipped New England ice to the tropics, and use what you have learned about freezing to make a smooth fruit sorbet. You will do a good deal of arithmetic in this unit: temperature conversions, cooling rates and altitude math.

PREREQUISITES

- Knows conduction, convection and radiation (earlier grades)
- Knows the danger zone (40–140 °F) and the 2-hour rule (Unit 1)
- Can use a thermometer and convert between °F and °C (Unit 1)
- Can use the stove and oven with an adult nearby

MASTERY CHECKLIST

- ☐ I can tell how Jacob Perkins’s 1834 machine made cold, and explain how evaporation and compression move heat out of a refrigerator.
- ☐ I can cool cooked food quickly and safely, and explain why shallow containers cool faster.
- ☐ I can explain why water boils at a lower temperature at high altitude and calculate the approximate boiling point for a given elevation.
- ☐ I can explain the difference between searing and steaming, and why searing does not “seal in the juices.”
- ☐ I can tell the story of Frederic Tudor and explain how sugar affects freezing in a sorbet.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA FSIS: Leftovers and Food Safety:** Free. How to cool, store and reheat leftovers safely. Good background for Lesson 4.1.
- **National Center for Home Food Preservation: High Altitude:** Free. University of Georgia's guide to food preservation, including how altitude changes boiling and processing times.
- **A refrigerator and freezer thermometer:** Optional and inexpensive. Used in Lesson 4.1 to check that your refrigerator stays at or below 40 °F and your freezer at 0 °F.

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 Jacob Perkins and the Machine That Made Cold	2 sessions of 50–60 minutes
4.2 Altitude, Air Pressure and the Boiling Point	2 sessions of 50–60 minutes
4.3 Searing and Steaming: Testing an Old Kitchen Claim	2 sessions of 50–60 minutes
4.4 Frederic Tudor, the Ice King: Fruit Sorbet	2 sessions of 50–60 minutes

UNIT 4 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

Name the four main parts of the refrigeration cycle in Jacob Perkins's machine and in a modern refrigerator.

2. **8 pts**

Why is the back or bottom of a refrigerator warm?

3. **8 pts**

Describe two ways to cool a large pot of chili quickly and safely.

4. (8 pts)

Why does water boil at a lower temperature on a mountain?

5. (10 pts)

Calculation: using the rule that water boils about 1 °F lower for every 500 feet, find the boiling point at 7,500 feet. Then convert it to °C. Show your work.

6. (8 pts)

How does a pressure cooker cook beans faster?

7. (8 pts)

What did Justus von Liebig claim about searing meat? What did later experiments show?

8. (10 pts)

Calculation: a raw fillet weighs 170 g. After searing it weighs 136 g. What percent of its weight did it lose? Show your work.

9. (8 pts)

Steam is only about 212 °F, but it cooks quickly and burns badly. Why?

10. (8 pts)

How did Frederic Tudor solve the problem of ice melting on long voyages?

11. (8 pts)

Predict: you make sorbet with almost no sugar. What will happen, and why?

12. (8 pts)

Written answer: Explain to a younger child why a refrigerator does not “make cold” but “moves heat.” Use an example.

ANSWER KEY

1. An evaporator coil inside the cold space (refrigerant evaporates and absorbs heat), a compressor (squeezes the vapor, making it hot), a condenser coil outside (vapor gives off heat and turns back to liquid), and an expansion valve (lets the liquid back into the evaporator).
2. The heat taken out of the food is carried by the refrigerant to the condenser coils outside the cold box, where it is released into the room.
3. Any two: divide it into shallow containers; set the pot in an ice-water bath and stir; stir often to release heat; refrigerate uncovered until cool, then cover. It must be in the refrigerator within 2 hours.
4. Water boils when its vapor pressure equals the air pressure. Higher up there is less air above, so the pressure is lower, and water reaches that point at a lower temperature.
5. $7,500 \div 500 = 15$. $212 - 15 = 197$ °F. $(197 - 32) \times 5 \div 9 = 165 \times 5 \div 9 \approx 92$ °C.
6. It traps steam, raising the pressure inside, so water boils at a higher temperature (about 250 °F); the hotter water cooks food faster.
7. He claimed searing set the surface and sealed in the juices. Experiments that weighed seared and unseared meat found seared meat lost as much juice or slightly more; searing adds flavor and color, not moisture.
8. $170 - 136 = 34$ g lost. $34 \div 170 = 0.20$. $0.20 \times 100 = 20\%$.
9. When steam touches a cooler surface it condenses into water and releases its latent heat, a large amount of energy, all at once.
10. He packed the ice in sawdust, a cheap insulator that slowed heat flow, built insulated icehouses at his ports, and used tightly packed, evenly cut blocks.
11. It will freeze into a hard, icy block, because without dissolved sugar to lower the freezing point, nearly all the water freezes into large crystals.
12. Answers vary. A good answer explains that cold is just less heat; the fridge pulls heat out of the food with an evaporating liquid and carries it outside the box, like sweat cooling skin, so the food gets colder and the room behind the fridge gets a little warmer.

UNIT CHALLENGE: HEAT IN, HEAT OUT: A KITCHEN TEMPERATURE INVESTIGATION

Design and carry out three short experiments with food and heat, each with a prediction, a measurement and a result: (1) a cooling race comparing two ways to cool the same hot food; (2) the boiling point of water in your kitchen compared with your calculated prediction; and (3) the same food cooked two ways (for example, seared and steamed vegetables, or roasted and boiled carrots), with weights and temperatures recorded.

Present your results as a short lab report with tables, at least one graph, photographs or sketches, and a conclusion for each experiment. End by cooking a family meal that uses at least two of the heat methods from this unit, and explain to your family what is happening to the food as you serve it.

LOOK FOR	WHAT IT MEANS
Experiments	Three experiments, each with a clear prediction, fair method and measured results.
Calculations and graph	Temperature conversions, boiling-point or percent calculations done correctly, with at least one clear graph.
Safety	Hot liquids, steam and hot pans handled safely with an adult nearby; food cooled and stored correctly.
Family meal	A meal using two heat methods, cooked and served, with the science explained.
Report and cleanup	A neat, honest report; the kitchen left clean after each experiment.

UNIT 5

FOOD CHEMISTRY

Cooking is chemistry you can eat. In this unit you will look closely at four kinds of change that happen every day in a kitchen. You will meet Louis-Camille Maillard, the French chemist who in 1912 discovered why seared meat, toast and roasted coffee beans turn brown and savory, and then learn the difference between that reaction and caramelization, the browning of sugar alone, through the story of Milton Hershey and his caramels.

Next you will return to Louis Pasteur and the living yeast that makes bread rise, and bake a sandwich loaf with a rise log. Finally you will study moisture and salt: how a French priest and scientist discovered osmosis in 1748, why salt draws water out of vegetables but helps meat hold on to its juices, and how to brine and roast a chicken. Starch, fats, protein, moisture and yeast, the five ingredients-in-action of this unit, will appear in every lesson.

PREREQUISITES

- Knows the safe temperatures for beef steak (145 °F with a 3-minute rest) and chicken (165 °F) (Unit 1)
- Knows how searing and steaming move heat (Unit 4)
- Can measure by weight with a kitchen scale (Unit 4)
- Knows that proteins are chains of amino acids (Unit 2)

MASTERY CHECKLIST

- ☐ I can explain the Maillard reaction and why food must be dry and hot (above about 300 °F) to brown.
- ☐ I can tell caramelization from the Maillard reaction and caramelize onions slowly without burning them.
- ☐ I can explain how yeast ferments sugar into carbon dioxide and how gluten traps the gas, and bake a loaf to 190 °F.
- ☐ I can explain osmosis and diffusion and how a brine helps meat stay juicy.
- ☐ I can name starch, fat, protein, moisture and yeast at work in a recipe I cook.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **King Arthur Baking: Yeast Bread Baking Guide**: Free. King Arthur's site has clear guides to kneading, rising and shaping bread, with photographs. Helpful for Lesson 5.3.
- **A kitchen scale and an instant-read thermometer**: Used throughout the unit: weighing flour and brine, and checking steak, bread and chicken.
- **A 9×5-inch or 8½×4½-inch loaf pan**: Needed for the sandwich loaf in Lesson 5.3. A baking sheet works for a free-form round loaf instead.

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 Louis-Camille Maillard and the Chemistry of Browning

2 sessions of 50–60 minutes

5.2 Milton Hershey's Caramels and the Chemistry of Caramelization

2 sessions of 50–60 minutes

5.3 Pasteur, Yeast and a Sandwich Loaf

2 sessions of 60–90 minutes

5.4 Abbé Nollet, Osmosis and a Brined Roast Chicken

2 sessions of 60–90 minutes

UNIT 5 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

What did Louis-Camille Maillard discover in 1912?

2. **8 pts**

Why won't a wet steak brown? Name three things a cook does to get a good sear.

3. 8 pts

How is caramelization different from the Maillard reaction? Give one food for each.

4. 8 pts

Why do caramelized onions take 30–45 minutes? What happens if you use high heat to hurry them?

5. 8 pts

What did Louis Pasteur prove about fermentation?

6. 8 pts

Explain the jobs of yeast, gluten and steam in making bread rise.

7. 8 pts

Predict: you mix bread dough with milk heated to 150 °F. What will happen, and why?

8. 10 pts

Calculation: a bread recipe makes 1 loaf with 430 g flour, 300 mL milk and 9 g salt. How much of each do you need for 3 loaves? What percent of the flour's weight is the salt? Show your work.

9. 8 pts

What did Abbé Nollet observe in 1748? Define osmosis.

10. 8 pts

Salt draws water out of cucumber slices. Why, then, does brining make chicken juicier?

11. 10 pts

Calculation: a chicken thigh weighed 180 g raw, 189 g after brining, and 144 g after roasting. What percent did it gain in the brine? What percent of its brined weight did it lose in roasting? Show your work.

12. 8 pts

Written answer: Choose any recipe from this unit and explain where you see at least three of these at work: starch, fat, protein, moisture, yeast.

ANSWER KEY

1. That amino acids and certain sugars react with each other when heated, producing brown color and new compounds. This browning reaction, now called the Maillard reaction, gives flavor to seared meat, bread crust, toast and roasted foods.
2. Water cannot get hotter than 212 °F, and browning needs about 300 °F or more, so the surface steams until it dries. Pat the meat dry, use a very hot pan with a little oil, and do not crowd the pan (also: do not move it too soon).
3. Caramelization is the breakdown of sugar alone by heat (about 320 °F for table sugar); the Maillard reaction needs amino acids from protein plus sugar. Caramelization: caramel candy, brittle. Maillard: seared steak, bread crust, toast. Caramelized onions use both.
4. The onions must first release their water, then their sugars brown slowly. On high heat the outside burns and turns bitter before the inside softens and sweetens.
5. That fermentation is the work of living yeast cells: the yeast grows and multiplies during fermentation, it stops when the yeast is killed or removed, and it starts again when living yeast is added.
6. Yeast eats sugars and gives off carbon dioxide gas; gluten, a stretchy protein network made by kneading wheat flour with water, traps the gas so the dough rises; in the oven the gas expands and water turns to steam, causing oven spring before the crust sets.
7. The dough will hardly rise, because temperatures above about 140 °F kill the yeast, so no carbon dioxide is produced.
8. 3 loaves: $430 \times 3 = 1,290$ g flour; $300 \times 3 = 900$ mL milk; $9 \times 3 = 27$ g salt. Salt percent: $9 \div 430 \times 100 \approx 2.09$, or about 2 percent.
9. He sealed a liquid in a piece of animal bladder and set it in water; the bladder swelled as water passed into it. Osmosis is the movement of water through a membrane toward the side with more dissolved material.
10. Salt diffuses into the meat and partly dissolves and loosens muscle proteins like myosin, which then hold more water and squeeze out less during cooking.
11. Gain: $(189 - 180) \div 180 \times 100 = 9 \div 180 \times 100 = 5\%$. Loss: $(189 - 144) \div 189 \times 100 = 45 \div 189 \times 100 \approx 23.8\%$.
12. Answers vary. Example, sandwich loaf: starch (flour gelatinizes and sets the crumb), protein (gluten traps gas; crust browns by Maillard), moisture (milk

hydrates flour; steam gives oven spring), yeast (makes carbon dioxide), fat (butter softens the crumb).

UNIT CHALLENGE: A BREAD LOAF WITH A FULL LAB RECORD

Bake a yeast loaf (the sandwich loaf from Lesson 5.3 or a family bread recipe) twice in the same month. The first time, follow the recipe exactly and keep a complete rise log: dough temperature, room temperature, height every 15 minutes, kneading time, oven spring and the final internal temperature.

The second time, change one variable on purpose, such as half whole-wheat flour, an overnight rise in the refrigerator, honey instead of sugar, or a warmer or cooler rise, and record the same measurements. Photograph a slice of each loaf, have your family rate them blind, and write a one-page lab report explaining the differences using what you learned about yeast, gluten, starch and moisture.

LOOK FOR	WHAT IT MEANS
Baking skill	Two loaves mixed, kneaded to the windowpane, shaped and baked to 190 °F.
Rise log	Complete, neat measurements for both bakes, with a graph comparing them.
Fair test	Exactly one variable changed on purpose, and the blind tasting done fairly.
Explanation	A one-page report that explains the results with yeast, gluten, starch and moisture.
Cleanup and safety	No unbaked dough tasted; oven used safely; kitchen left clean.

5.1 LOUIS-CAMILLE MAILLARD AND THE CHEMISTRY OF BROWNING

OBJECTIVES

- Tell how Louis-Camille Maillard discovered in 1912 that sugars and amino acids react to form brown color and new flavors.
- Explain why browning needs a dry surface and temperatures above about 300 °F (150 °C).
- Sear steak and mushrooms, cooking the steak to 145 °F with a 3-minute rest.

Warm-up. Toast one slice of bread lightly and one until golden brown. Smell and taste each. Then try a raw (untoasted) slice. Describe the three in flavor words. Where did the new flavors come from?

WATCH

I FINALLY understand the Maillard reaction

MinuteFood · 6:35

https://www.youtube.com/watch?v=5lKzZc_O07U

WHEN TO WATCH

After How they figured it out. Watch for what reacts with what, why temperature and pH matter, and the kitchen examples.

Note: From MinuteFood, a short food-science channel.

KEY TERMS

Maillard reaction

A set of chemical reactions between amino acids (from protein) and certain sugars, in heat, that creates brown color and hundreds of new flavor and aroma molecules.

reducing sugar

A sugar, such as glucose or fructose, that can react with amino acids in the Maillard reaction.

fond

The browned bits stuck to the bottom of a pan after searing, full of flavor. Cooks dissolve them with a liquid to make a sauce.

deglaze

To pour a liquid such as broth into a hot pan and scrape up the fond.

against the grain

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

CORE IDEAS

The story. Louis-Camille Maillard was a French doctor and chemist who, around 1910, was working in Paris on a question about the body: how do amino acids, the building blocks of protein, link together? In his experiments he heated amino acids with different sugars in water. The mixtures did something he had not expected. They turned yellow, then brown, then nearly black, and gave off gases and new smells. In 1912 he reported to the French Academy of Sciences that sugars and amino acids react with each other when heated, and he suggested that the reaction might matter in medicine, in the soil and in food.

How they figured it out. Maillard could not explain all the steps, and the reaction was largely forgotten for decades. During and after the Second World War, food scientists studying why dried and stored foods turned brown and stale came back to it. In 1953 an American chemist at a USDA laboratory in Illinois, John Hodge, mapped out the main pathway in a famous paper. Today we know the Maillard reaction is not one reaction but a whole web of them, producing hundreds of different molecules. Some give the deep brown color; many give the aromas we love in a bread crust, a seared steak, roasted coffee beans, toasted nuts and chocolate.

The kitchen science. The Maillard reaction needs **protein** (amino acids), a little **sugar**, and **high heat**: it goes slowly at lower temperatures and quickly above about 300 °F (150 °C). That explains a basic rule of cooking. Water cannot get hotter than 212 °F, so as long as a food's surface is wet, it will not brown. To sear well, you must **dry the surface**, use a **hot pan**, and **not crowd it**, because crowded food gives off steam. Boiled meat stays gray; seared meat turns brown and savory. Mushrooms are full of water: they first release it, then, once the pan is dry, they brown.

Let's cook. You will pan-sear a steak and a skillet of mushrooms. The steak is a whole cut of beef, safe at **145 °F (63 °C)** with a 3-minute rest. The skill is **reading the pan:** listening for a strong sizzle, waiting for the crust to form before turning, and using the fond to make a quick pan sauce.

PICTURE STUDY



The Baker, Job Berckheyde, c. 1681 · Oil on canvas · Worcester Art Museum, Worcester, Massachusetts

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

In Dutch towns of the 1600s, the baker blew a horn when the bread came out of the oven so the neighbors would know it was fresh. Job Berckheyde of Haarlem painted this baker in the window of his shop, his loaves and pretzels set out on the ledge. Look at the deep brown crusts: that color and flavor come from the Maillard reaction in the heat of the oven.

Look closely

- Find the round loaves. What color is the crust? Where is it darkest?
- Find the pretzels. How are they shaped and displayed?
- Look at the baker. What is he doing, and why?
- Compare the crust of the loaves with the pale inside of a roll. What made the difference?

Talk about it

1. Why does the outside of a loaf brown while the inside stays pale?
2. What would happen to the crust if the oven were too cool?
3. Name three other foods that brown by the Maillard reaction.

Safety first. Sear with an adult nearby, the exhaust fan on, and a lid within reach: lay the steak in the pan away from you, and if oil smokes heavily, turn the heat down. A grease fire is smothered with a lid or baking soda, never water. Cook the steak to at least 145 °F and rest it 3 minutes; keep raw meat on its own board and plate.

Seared Steak and Browned Mushrooms

You will brown mushrooms two ways (crowded and spread out), sear a steak, make a pan sauce from the fond, and compare a seared piece of steak with a piece simmered in water.

You will need

- A large heavy skillet (cast iron or stainless) and a second skillet if you have one
- Long tongs, a wooden spoon and paper towels
- An instant-read thermometer and a clean cutting board for cooked meat
- A raw-meat board and a chef's knife
- A small saucepan of simmering water for the comparison

PAN-SEARED STEAK WITH BROWNED MUSHROOMS

Serves 4 • Prep 15 min • Cook 20 min • Rest 5 min

Ingredients

- 1½ pounds (680 g) boneless sirloin, flat iron or strip steak, about 1 inch thick (one large or two smaller)
- 1 teaspoon salt and ½ teaspoon black pepper
- 2 tablespoons vegetable oil, divided
- 1 pound (450 g) cremini or white mushrooms, cleaned and quartered
- 1 tablespoon butter
- 1 clove garlic, minced
- 1 teaspoon fresh thyme leaves or ½ teaspoon dried
- **Pan sauce:** ½ cup (120 mL) beef broth
- 1 teaspoon Worcestershire sauce
- 1 tablespoon chopped parsley

Method

1. Take the steak out of the refrigerator 20 minutes before cooking. Pat it very dry with paper towels and season both sides with salt and pepper.

Wash your hands and the raw-meat board.

2. **Mushrooms:** With an adult nearby, heat 1 tablespoon oil in the skillet over medium-high heat. Add the mushrooms in one layer (cook in two batches if needed). Let them cook without stirring 3 minutes, then stir every minute until their water has evaporated and they are deeply browned, 8–10 minutes total. Add the butter, garlic and thyme for the last minute. Season with a pinch of salt. Move to a bowl.
3. **Steak:** Wipe out the skillet, add the remaining oil, and heat over medium-high until the oil shimmers and just begins to smoke. Lay the steak in, away from you. Cook without moving it 4 minutes, until a deep brown crust forms.
4. Turn the steak with tongs and cook 3–5 minutes more. Check the center of the thickest part: take it out at 145 °F (63 °C) or higher. Rest it on the clean board 3–5 minutes.
5. **Pan sauce:** Lower the heat to medium. Pour the broth and Worcestershire into the hot skillet (stand back from the steam) and scrape up the fond with the wooden spoon. Simmer until reduced by half, about 2 minutes. Stir in any juices from the resting steak.
6. Slice the steak against the grain into ¼-inch slices. Spoon over the sauce and mushrooms and sprinkle with parsley. Refrigerate leftovers within 2 hours.

Allergy check: Contains milk (butter). Worcestershire sauce usually contains fish (anchovies); leave it out or use a fish-free version if needed. Use oil instead of butter for a milk-free meal. For a cheaper or meatless meal, double the mushrooms and serve them over toast or rice.

Steps

1. **Mushroom test.** Before the main batch, cook a handful of mushrooms piled high in a small pan and a handful spread in one layer, side by side, for 5 minutes. Which browned? Why?
2. **Simmer versus sear.** Cut a small 1-inch cube from the steak. Simmer it in the saucepan of water for 5 minutes (until 145 °F) while you sear the rest. Taste a piece of each. Describe the color, aroma and flavor.
3. Cook the steak, checking and recording its temperature, and make the sauce.

4. **Rate it.** Ask your family to rate the steak, the crust and the mushrooms from 1 to 5.
5. Clean up: wash the raw-meat board, tongs and skillet; wipe up spatters on the stove once cool.
6. **Improve it.** Write one change: a drier surface, a hotter pan, salting the steak an hour ahead, or a different cut.

Tips

- If a crust is not forming, the pan is not hot enough or the steak was wet.
- Do not salt mushrooms at the start; salt draws out water and slows browning. Season at the end.
- To find the grain, look for the lines of muscle fiber running across the steak, and cut across them.

Check your work

- ☐ I can tell how Maillard discovered browning and what reacts in it.
- ☐ I can explain why food must be dry and hot to brown.
- ☐ I seared steak to 145 °F with a rest and browned mushrooms well.

COOK'S NOTEBOOK

1. Write the Maillard reaction as a word equation: amino acid + sugar + heat → brown color + aroma molecules + water. List five foods where it happens.
2. Draw the crowded and spread-out mushroom pans and label what happened to the water in each.
3. Write the recipe in your own words with your family's rating and one improvement.

From history. Browning is not always welcome. The same Maillard reactions slowly darken dried milk, dried eggs and stored fruit juices, which is why food scientists in the 1940s studied them so carefully. Cooks want browning on the outside of a steak, not in a carton of powdered milk on a shelf.

COMMON MISTAKES

- Searing wet meat or crowding the pan. The surface steams at 212 °F and turns gray instead of brown.

- Turning meat over and over. Let it sit until the crust forms and it releases from the pan.
- Washing away the fond. It is the start of a delicious sauce.

Make it a game · Brown or Pale. Set a timer for thirty seconds and list all the foods you can think of that brown, such as toast, seared chicken and roasted coffee. Then explain what the Maillard reaction needs: sugars, amino acids, a dry surface and heat above about 300 degrees. Your parent says why a wet pan will not brown, and you correct it.

5.2 MILTON HERSHEY’S CARAMELS AND THE CHEMISTRY OF CARAMELIZATION

OBJECTIVES

- Tell how Milton Hershey built the Lancaster Caramel Company after early failures.
- Explain how caramelization differs from the Maillard reaction and why it needs high heat or long, gentle cooking.
- Caramelize onions slowly and use them on a flatbread.

Warm-up. With an adult nearby, put 2 tablespoons of sugar in a small dry skillet over medium heat. Do not stir; just tilt the pan gently and watch. Describe each change in color and smell. (Do not touch or taste the melted sugar; it is far hotter than boiling water.) Pour it onto a sheet of parchment to cool and harden.

WATCH

How to Caramelize Onions in Record Time Without Sacrificing One Ounce of Flavor

America's Test Kitchen · 2:28

<https://www.youtube.com/watch?v=Ovqhzil3wJw>

WHEN TO WATCH

Before you cook. Watch the color of the onions at each stage and the trick for speeding them up.

KEY TERMS

caramelization

The breakdown of sugar by heat into hundreds of new compounds that give brown color and nutty, buttery, slightly bitter flavors. It needs only sugar and heat, not protein.

sucrose

Ordinary table sugar, made of one glucose and one fructose joined together. It begins to caramelize at about 320 °F (160 °C).

caramelized onions

Onions cooked slowly until their natural sugars brown and they become soft, sweet and deep brown. Both caramelization and the Maillard reaction take part.

confectioner

A maker of candies and sweets.

CORE IDEAS

The story. Milton Hershey was born in 1857 on a Pennsylvania farm and left school after the fourth grade. At fifteen he was apprenticed to a candy maker in Lancaster, Pennsylvania, and he loved the work. He started his own candy shops in Philadelphia, Chicago and New York, and one after another they failed. In Denver he worked for a caramel maker who used fresh milk, which made caramels smoother and kept them fresh longer. Back in Lancaster in 1886, Hershey founded the Lancaster Caramel Company with that recipe, and this time he succeeded. His milk caramels sold across America and even overseas.

How he figured it out. Hershey learned by trying, failing and trying again. He experimented with recipes and cooking times until his caramels were smooth and chewy. Then, in 1893, he saw German chocolate-making machines at the World's Columbian Exposition in Chicago and bought some. In 1900 he sold his caramel company for one million dollars and turned to milk chocolate, building the town of Hershey, Pennsylvania, around his factory. He and his wife Catherine had no children, and in 1909 they founded a school for orphan boys, which their fortune still supports.

The kitchen science. **Caramelization** happens to sugar alone. When table sugar is heated to about 320 °F (160 °C), its molecules break apart and recombine into hundreds of new compounds: some brown, some with the aroma of butter, nuts or toast, and some bitter. Hershey's milk caramels browned by both caramelization and the **Maillard reaction**, because milk has protein. Onions are about 5 to 10 percent sugar and also have some protein. Cooked slowly, they first soften and release water, then their sugars brown. Caramelized onions take time, often 30 to 45 minutes; too much heat burns the outside before the inside sweetens. A splash of water when the fond darkens dissolves it back onto the onions and prevents scorching.

Let's cook. You will slice onions thinly with a chef's knife and caramelize them, then spread them on a flatbread with cheese and bake it. The skill is **patient heat control**: medium to medium-low heat, regular stirring, and splashes of water to deglaze.

PICTURE STUDY



Onions, Pierre-Auguste Renoir, 1881 · Oil on canvas · Clark Art Institute, Williamstown, Massachusetts

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

Renoir painted these onions in Naples, Italy, in 1881. He took ordinary kitchen onions and made them glow with pink, gold and violet. Onions are one of the humblest foods in the world, but in a cook's hands, as in a painter's, they can become something beautiful and sweet.

Look closely

- Count the onions. What colors can you find in their skins?
- Find the garlic. How is it different from the onions?
- Look at the white cloth. Is it really white? What other colors did Renoir use?
- Notice how the brushstrokes curve around the onions. What does that do?

Talk about it

1. How would these onions change in color and taste if you cooked them for 40 minutes?
2. Why do you think Renoir chose such an ordinary subject?
3. What foods in your kitchen are humble but become special when cooked with care?

Safety first. Melted sugar is far hotter than boiling water and sticks to skin; an adult stays beside you for the warm-up, and no one touches or tastes it until it has completely cooled. Cut onions on a steady board with the claw grip; a sharp knife is safer than a dull one on slippery onion layers. Use oven mitts to slide the flatbread in and out of the oven.

KITCHEN PROJECT

Caramelized Onion Flatbread

You will caramelize sugar in the warm-up, slice and caramelize onions, record their color every 10 minutes, and bake them on a flatbread.

You will need

- A chef's knife and cutting board with damp towel
- A large heavy skillet and a wooden spoon
- A small dry skillet and parchment for the warm-up
- A baking sheet, oven mitts and a pizza cutter or knife
- A white index card for a color chart

CARAMELIZED ONION AND CHEESE FLATBREAD

Serves 4–6 · Prep 15 min · Cook onions 35–45 min · Bake 10–12 min

Ingredients

- 3 large yellow onions (about 2 pounds / 900 g)
- 2 tablespoons olive oil
- 1 tablespoon butter
- ½ teaspoon salt
- ¼ teaspoon baking soda (optional, to speed browning)
- Water for deglazing, about ½ cup in all
- 1 teaspoon fresh thyme leaves or ½ teaspoon dried
- 2 large store-bought naan or flatbreads, or 1 pound pizza dough
- 1½ cups (170 g) grated mozzarella or a mix with Gruyère
- Optional: a handful of baby arugula and a squeeze of lemon

Method

1. Cut each onion in half from root to tip, peel it, lay it flat, and slice it thinly from end to end with the claw grip.
2. With an adult nearby, heat the oil and butter in the large skillet over medium-high heat. Add the onions and salt and stir to coat. Cook,

stirring every few minutes, until they soften and release their water, about 10 minutes.

3. Turn the heat to medium-low (and stir in the baking soda if using). Keep cooking, stirring every few minutes and scraping the bottom. Whenever brown fond builds up on the pan, add 1–2 tablespoons water and scrape it up. Continue until the onions are soft, sweet and deep golden brown, 25–35 minutes more. Stir in the thyme.
4. Heat the oven to 450 °F (230 °C). Lay the flatbreads on the baking sheet.
5. Spread the onions over the flatbreads and sprinkle with cheese. Bake until the cheese is melted and the edges are crisp, 8–12 minutes. Use oven mitts.
6. Top with arugula and a squeeze of lemon if you like. Cut into wedges and serve.

Allergy check: Contains wheat (flatbread) and milk (butter, cheese). Use gluten-free flatbread for wheat-free, and olive oil and a dairy-free cheese (or no cheese) for milk-free.

Steps

1. **Sugar warm-up.** Record each color change of the melting sugar and the time it happened. What did it smell like at each stage?
2. **Color chart.** Every 10 minutes, put a tiny spoonful of onions on the index card in a row, labeled with the time. You will end with a chart from white to deep brown.
3. **Taste chart.** Taste a cooled piece of raw onion, onion at 10 minutes and onion at the end. Rate each for sweetness and sharpness.
4. Make and bake the flatbread.
5. **Rate it.** Ask your family to rate the flatbread from 1 to 5.
6. Clean up: soak the skillet in hot water to loosen the fond; wash the board and knife.
7. **Improve it.** Write one change: add mushrooms, apple slices or a drizzle of balsamic vinegar reduction, or try red onions.

Tips

- Cutting onions releases a gas that stings the eyes. A sharp knife crushes fewer cells and makes fewer tears.

- Caramelized onions keep for 5 days in the refrigerator and freeze well. Make a double batch for burgers, eggs and sandwiches.
- Baking soda raises the pH and speeds browning, but too much makes onions mushy and bitter. Use only a pinch.

Check your work

- ☐ I can tell the story of Milton Hershey's caramels.
- ☐ I can explain how caramelization differs from the Maillard reaction.
- ☐ I caramelized onions slowly without burning them and baked a flatbread safely.

COOK'S NOTEBOOK

1. Paste in or redraw your onion color chart with times and taste notes.
2. Make a two-column chart: Maillard reaction and caramelization. Compare what each needs, the temperature, and three foods for each.
3. Write the recipe in your own words with your family's rating and one improvement.

From history. Hershey's first chocolate bar, the milk chocolate bar, went on sale in 1900. Before that, milk chocolate was a luxury made mostly in Switzerland. Hershey's factory made it cheap enough for ordinary American families.

COMMON MISTAKES

- Trying to caramelize onions on high heat in 10 minutes. They burn on the outside and stay sharp inside.
- Leaving the fond to blacken. Deglaze with a splash of water before it burns.
- Touching or tasting melted sugar. It can cause severe burns; let it cool completely.

Make it a game • Caramel or Maillard. Your parent describes a food, such as caramelized onions, toasted bread, or a candy made from sugar alone, and you call out caramelization or Maillard. Defend your answer in one sentence. Then tell how Milton Hershey recovered from early failures to build his caramel company, and why caramelization needs high heat or patience.

5.3 PASTEUR, YEAST AND A SANDWICH LOAF

OBJECTIVES

- Tell how Louis Pasteur showed that fermentation is the work of living yeast cells.
- Explain how yeast makes carbon dioxide, how gluten traps it, and what happens to dough in the oven.
- Knead, shape and bake a sandwich loaf to 190 °F, keeping a rise log.

Warm-up. Stir ½ teaspoon of yeast and 1 teaspoon of sugar into ½ cup of warm water (about 105 °F). Stir ½ teaspoon of yeast into ½ cup of warm water with no sugar, and another into ice water with sugar. Set them side by side. Check after 10 minutes. Which one is foaming, and why?

WATCH

Easy Sandwich Bread Recipe You'll Make Every Week

King Arthur Baking Company · 17:24

<https://www.youtube.com/watch?v=qeeRrLdZ0IE>

WHEN TO WATCH

Watch it in parts alongside the recipe: mixing, kneading and the windowpane test in Session 1; shaping and baking in Session 2.

Note: From King Arthur Baking. Their recipe is a little different from ours; the techniques are the same.

KEY TERMS

yeast

A tiny single-celled fungus. Baker's yeast (*Saccharomyces cerevisiae*) feeds on sugars and gives off carbon dioxide gas.

fermentation

The process by which yeast or bacteria break down sugars without needing oxygen, producing gas, acids and flavor.

gluten

A stretchy network of proteins that forms when wheat flour is mixed with water and kneaded. It traps gas and gives bread its structure.

proofing

Letting shaped dough rise before baking.

oven spring

The quick rise of bread in the first minutes of baking, as gas expands and water turns to steam before the crust sets.

CORE IDEAS

The story. People have baked leavened bread for thousands of years without knowing why it rose. In the 1680s Antonie van Leeuwenhoek saw tiny round globules in fermenting liquid through his microscope, but no one knew they were alive. In the 1850s, at the university in Lille, France, local manufacturers asked a young chemistry professor named Louis Pasteur why their fermentations sometimes spoiled. Many leading chemists of the day believed fermentation was purely a chemical breakdown, and that the yeast was just a by-product.

How he figured it out. Pasteur looked closely through his microscope and saw that healthy fermentations were full of round, budding yeast cells, while spoiled ones contained other, rod-shaped microorganisms. Between 1857 and the early 1860s he showed that yeast cells grow and multiply as fermentation goes on, that fermentation stops when the yeast is killed by heat or filtered out, and that a tiny amount of living yeast added to a sterile sugar solution starts it again. His conclusion: fermentation is the work of **living cells**. In 1868 the Fleischmann brothers began selling compressed yeast in America, so home bakers no longer had to keep their own starter, and bread baking became more reliable.

The kitchen science. Yeast cells eat sugars from the flour (starch broken down by enzymes) and give off **carbon dioxide** gas and flavor compounds. Yeast works best around 75–95 °F; cold slows it down and temperatures above about 140 °F kill it. When you mix and **knead** wheat flour with water, two proteins join into **gluten**, a stretchy web that traps the gas in thousands of little bubbles, and the dough rises. In the oven, the gas expands, water turns to **steam**, and the loaf springs up; then the

yeast dies, the starch sets, and the crust browns by the Maillard reaction. Bread is done when its center reaches about **190 °F** (88 °C).

Let's cook. You will mix, knead and shape a sandwich loaf, recording its rise every 15 minutes, and bake it until the center reads 190 °F. The skill is **kneading to the windowpane**: working the dough until a small piece stretches thin enough to see light through without tearing.

PICTURE STUDY



M. Louis Pasteur in His Laboratory, Engraving after the painting by Albert Edelfelt, Published 1886 (painting 1885) · Wood engraving · *Harper's Weekly*, New York

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

The Finnish painter Albert Edelfelt painted Louis Pasteur in his Paris laboratory in 1885, and an American magazine printed this engraving of the painting so that readers could see the famous scientist at work. Pasteur holds a glass flask up to the light, studying what is growing inside, just as he once studied yeast and the microorganisms of fermentation.

Look closely

- Find the flask in Pasteur's hands. What do you think he is looking for?
- Find other glassware and the microscope on the bench.
- Look at his face. Is he hurried or patient?
- Look at how neat and orderly the bench is. Why would that matter for his experiments?

Talk about it

1. How did Pasteur prove that yeast is alive?
2. What would you see if you looked at a drop of your bread dough under Pasteur's microscope?
3. What habits of a good scientist are also habits of a good baker?

Safety first. Do not taste unbaked dough; raw flour can carry germs. Use oven mitts to take the hot loaf out of the pan and set it on a rack; the pan stays very hot. An adult is nearby for oven work.

KITCHEN PROJECT

A Sandwich Loaf with a Rise Log

You will run the yeast warm-up, bake a sandwich loaf, record its rise and oven spring, and test it with a thermometer.

You will need

- A kitchen scale and measuring spoons
- A large bowl, a wooden spoon and a clean kitchen towel or plastic wrap
- A 9×5-inch loaf pan, lightly greased
- Masking tape, a marker and a ruler for the rise log
- An instant-read thermometer, oven mitts and a cooling rack

SOFT SANDWICH LOAF

Serves 1 loaf (about 16 slices) · Prep 25 min · Rise 1–1½ hr · Proof 45–60 min · Bake 35–40 min

Ingredients

- 3½ cups (430 g) all-purpose or bread flour, plus a little for kneading
- 2¼ teaspoons (1 packet, 7 g) instant or active dry yeast
- 2 tablespoons (25 g) sugar or honey
- 1½ teaspoons (9 g) salt
- 1¼ cups (300 mL) warm milk, about 105–110 °F (40–43 °C)
- 3 tablespoons (40 g) soft butter or vegetable oil

Method

1. In the large bowl, stir together the flour, yeast, sugar and salt. (If using active dry yeast, first stir it with the sugar into the warm milk and let it foam 5 minutes.)
2. Add the warm milk and butter. Stir until a shaggy dough forms.
3. Turn the dough onto a lightly floured counter. Knead by pushing it away with the heels of your hands, folding it back, and turning it a quarter turn, for 8–10 minutes, until smooth and springy and it passes the windowpane test. Add flour only a tablespoon at a time if it is very sticky.

4. Put the dough in a greased bowl, cover, and let it rise in a warm spot until doubled, 1–1½ hours.
5. Press the dough flat into an 8×10-inch rectangle. Roll it up tightly from the short side, pinch the seam closed, and set it seam-side down in the greased pan. Cover and let it rise until it crowns about 1 inch above the rim, 45–60 minutes. Meanwhile, with an adult nearby, heat the oven to 350 °F (175 °C).
6. Bake 35–40 minutes, until golden brown and the center reads 190 °F (88 °C). Turn it out of the pan with oven mitts and cool on a rack at least 1 hour before slicing.

Allergy check: Contains wheat and milk. For milk-free bread, use water instead of milk and oil instead of butter. This recipe has no eggs.

Steps

1. **Yeast warm-up.** Record what happened in each cup and explain it using the words sugar, temperature and carbon dioxide.
2. **Rise log.** After the dough goes into the bowl, mark its top with tape on the outside of the bowl. Every 15 minutes, measure the height above the first mark and record it with the room temperature. Do the same in the pan during proofing.
3. **Windowpane.** Before the first rise, stretch a small piece of dough. Does light show through? Knead more if it tears, and record how many minutes it took.
4. **Oven spring.** Measure the height of the loaf just before it goes in the oven and right after it comes out. How much did it spring?
5. **Crumb study.** When cool, slice the loaf and sketch the bubbles. Are they even? Ask your family to rate the bread.
6. Clean up: scrape dough off the counter with a scraper before wiping (dried dough is hard to clean), wash the bowl and pan.
7. **Improve it.** Write one change: half whole-wheat flour, a longer rise in the refrigerator for more flavor, or a sprinkle of oats on top.

Tips

- Milk hotter than about 120 °F can kill yeast. Check it with the thermometer; it should feel just warm on your wrist.

- A warm spot for rising: the oven with only the light turned on, or near (not on) a warm stove.
- Bread keeps best in a bread bag on the counter for 3 days, or sliced and frozen. The refrigerator makes it stale faster.

Check your work

- ☐ I can tell how Pasteur showed fermentation is the work of living yeast.
- ☐ I can explain how yeast, gluten and steam make bread rise.
- ☐ I kneaded, shaped and baked a loaf to 190 °F and kept a rise log.

COOK'S NOTEBOOK

1. Graph your rise log: height against time for the first rise and the proof.
2. Draw a magnified piece of dough showing the gluten web with gas bubbles inside, and a yeast cell budding.
3. Write the recipe in your own words with your family's rating and one improvement.

COMMON MISTAKES

- Using liquid that is too hot. Above about 140 °F the yeast dies and the bread will not rise.
- Adding too much flour while kneading. A soft, slightly tacky dough makes a softer loaf.
- Slicing bread right out of the oven. It is still setting inside; let it cool at least an hour.

Make it a game • Dough Rise Log. Keep a rise log for a pinch of yeast and sugar in warm water. Write the time, the height of foam and the smell at the start and every ten minutes. Explain what yeast is doing, how gluten holds gas, and what oven spring adds. Tell how Pasteur proved yeast is alive and causes fermentation.

Scripture. “Another parable spake he unto them; The kingdom of heaven is like unto leaven, which a woman took, and hid in three measures of meal, till the whole was leavened.” (Matthew 13:33, KJV)

Every baker knows how a little yeast, hidden in a big bowl of flour, slowly works through it all until the whole dough rises. Jesus used that everyday sight to show how God's kingdom grows quietly until it fills everything.

5.4 ABBÉ NOLLET, OSMOSIS AND A BRINED ROAST CHICKEN

OBJECTIVES

- Tell how Jean-Antoine Nollet discovered osmosis in 1748.
- Explain osmosis and diffusion, why salt draws water out of vegetables, and how a brine helps meat stay juicy.
- Brine and roast chicken pieces to 165 °F, comparing brined and unbrined pieces by weight and taste.

Warm-up. Slice a cucumber thinly and divide the slices into two bowls. Sprinkle one with ½ teaspoon of salt and leave the other plain. After 15 minutes, look at both bowls. Where did the water come from?

WATCH

What Science Says About Brining Your Bird

Reactions · 12:41

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

WHEN TO WATCH

After The kitchen science. Watch for what salt does to the proteins in meat, and the blind taste test.

Note: From the American Chemical Society's Reactions channel. It visits a fried-chicken restaurant; the science is the same for roast chicken.

BACKUP VIDEO

How to Make the Perfect Roast Chicken in One Hour

America's Test Kitchen · 8:44

<https://www.youtube.com/watch?v=A7jwsYPnrSk>

Before you roast. Watch how the cook checks the thickest part of the breast and thigh.

KEY TERMS

osmosis

The movement of water through a membrane from where there is less dissolved material to where there is more.

brine

A solution of salt in water, sometimes with sugar and seasonings, used to season meat and help it stay juicy.

myosin

One of the main proteins in muscle.
Salt partly dissolves and loosens it, so the muscle can hold more water.

diffusion

The spreading of molecules from where they are more concentrated to where they are less concentrated, such as salt moving into meat.

semipermeable membrane

A thin layer, like a cell wall or membrane, that lets water through but blocks some larger molecules.

CORE IDEAS

The story. Jean-Antoine Nollet was a French priest and a famous teacher of physics in the 1700s, known as the Abbé Nollet. He gave public science lectures in Paris and taught the royal children. In 1748, while studying how liquids boil, he sealed a liquid inside a piece of animal bladder, a thin natural membrane, and set it in a container of plain water. Over the next hours the bladder swelled up and grew tight, and when he pricked it, liquid squirted out. Water had passed through the membrane, but only in one direction. Nollet had discovered **osmosis**.

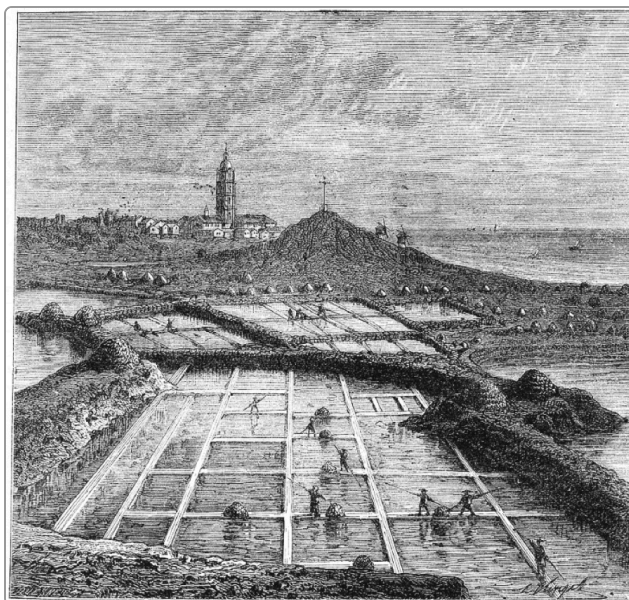
How they figured it out. Nollet could see what happened but not why. In 1877 the German botanist Wilhelm Pfeffer measured the pressure that osmosis creates with a clay pot coated with a membrane, and the Dutch chemist Jacobus van 't Hoff later explained it with mathematics, winning the first Nobel Prize in Chemistry in 1901. Water moves through a membrane toward the side with more dissolved material, trying to even out the concentration. Every living cell, in a cucumber or a chicken, is wrapped in such a membrane.

The kitchen science. Salt a cucumber and water comes *out* of its cells by osmosis; the slices go limp, and the water pools in the bowl. So why does soaking meat in salty water make it *juicier*? Because two things happen. Salt also **diffuses** into the

meat, and once inside, it partly dissolves and loosens the muscle protein **myosin**. The loosened proteins hold on to more water and squeeze out less when they are heated. Brined meat gains a little weight in the brine and loses less juice in the oven, and it is seasoned all the way through. Too long in a strong brine, though, makes meat spongy and too salty.

Let's cook. You will brine half of a batch of chicken pieces and leave the other half plain, weigh them all before and after, roast them to **165 °F (74 °C)**, and taste the difference. The skill is **handling raw chicken safely through a long process**: the brine stays in the refrigerator, the brine is thrown away, and everything it touched is washed and sanitized.

PICTURE STUDY



Salt Evaporation Ponds on the Coast of Brittany, Unknown engraver, c. 1880 · Wood engraving ·
Published in a French illustrated work, about 1880

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

Along the coast of Brittany, in France, salt has been made for more than a thousand years by letting seawater flow into shallow clay ponds. The sun and wind evaporate the water, and the salt crystals that remain are raked into heaps. This engraving from about 1880 shows the salt workers, called *paludiers*, at work.

Look closely

- Find the shallow ponds. Why are they so shallow and wide?
- Find the heaps of salt. How are they shaped?
- Find the workers. What tools are they using?
- Look at the sky and land. What weather would be best for making salt?

Talk about it

1. Explain how sun and wind turn seawater into salt. Is this osmosis, diffusion or evaporation?
2. Before refrigerators, salt was used to preserve meat and fish. How does salt keep germs from growing? (Think about osmosis and germ cells.)
3. Why was salt once so valuable?

Safety first. Brine raw chicken only in the refrigerator, in a covered container, never on the counter; throw away the used brine and wash and sanitize everything it touched. Do not rinse chicken in the sink. Roast to 165 °F in the thickest part of each piece, not touching bone, and use oven mitts for the hot pan.

Brined and Unbrined Roast Chicken

You will run a controlled experiment: the same chicken pieces, the same oven and time, with one difference, the brine. You will weigh, roast, weigh again and taste.

You will need

- A kitchen scale
- A large container or two gallon zip-top bags for brining, and a bowl to hold them
- A rimmed baking sheet with a rack, oven mitts and tongs
- An instant-read thermometer
- Toothpicks or small foil tags to mark brined pieces
- Cleaning supplies for the sanitizing step

BRINED ROAST CHICKEN PIECES WITH LEMON AND HERBS

Serves 4–6 · Brine 1½–3 hr · Prep 10 min · Roast 35–45 min

Ingredients

- 8 bone-in, skin-on chicken pieces (thighs and drumsticks), about 3½ pounds (1.6 kg)
- **Brine:** 2 quarts (1.9 L) cold water
- ¼ cup (72 g) table salt (or ½ cup Diamond Crystal kosher salt)
- 2 tablespoons sugar (optional)
- **To roast:** 1 tablespoon olive oil
- 1 teaspoon dried thyme or rosemary, ½ teaspoon garlic powder, ½ teaspoon paprika
- ¼ teaspoon black pepper (and ¼ teaspoon salt for the unbrined pieces only)
- 1 lemon, cut into wedges

Method

1. Stir the salt and sugar into the cold water until dissolved. Pour it into the container or bag.
2. Weigh each chicken piece and record it. Put 4 pieces (2 thighs, 2 drumsticks) in the brine, seal, and refrigerate 1½–3 hours. Put the other 4 on a plate, cover, and refrigerate. Wash your hands, the scale and the counter.
3. With an adult nearby, heat the oven to 425 °F (220 °C). Set a rack on the baking sheet.
4. Take the brined pieces out of the brine (throw the brine away) and pat them dry. Pat the unbrined pieces dry too. Weigh all pieces again and record. Mark the brined pieces with toothpicks.
5. Rub all the pieces with oil and sprinkle with herbs, garlic, paprika and pepper. Sprinkle only the unbrined pieces with the extra ¼ teaspoon salt. Arrange skin side up on the rack. Wash your hands.
6. Roast 35–45 minutes, until the skin is crisp and brown and every piece reads at least 165 °F in the thickest part. (Thighs and drumsticks are juicier and more tender at 175–185 °F.) Rest 5 minutes and serve with lemon wedges.

Allergy check: Contains none of the nine major allergens.

Steps

1. **Cucumber test.** Record what happened in the warm-up and explain it with the word osmosis.
2. **Weigh before and after brining.** Calculate each brined piece's percent change in weight: $(\text{after} - \text{before}) \div \text{before} \times 100$.
3. Roast all the chicken.
4. **Weigh after roasting.** Weigh each piece after it rests. Calculate the percent of its starting weight lost in cooking. Compare the averages for brined and unbrined.
5. **Blind taste test.** Without telling which is which, serve a brined and an unbrined piece to each taster. Rate juiciness, saltiness and flavor from 1 to 5.
6. Clean up carefully: throw away the brine, wash and then sanitize the container, sink, counter and scale; wash the pan and tongs in hot soapy

water.

7. **Improve it.** Write one change: a longer or shorter brine, adding garlic or peppercorns to the brine, or brining pork chops (Lesson 1.3).

Tips

- Kosher salt and table salt measure differently by volume because of their crystal size. Weighing salt is the most accurate.
- Patting the brined skin very dry helps it crisp and brown.
- Never brine meat that is already labeled “enhanced,” “self-basting” or “kosher”; it has already been salted.

Check your work

- ☐ I can tell how Abbé Nollet discovered osmosis.
- ☐ I can explain how salt draws water out of vegetables but helps meat hold its juices.
- ☐ I ran a controlled brining experiment and roasted chicken to 165 °F safely.

COOK’S NOTEBOOK

1. Draw two cells side by side: a cucumber cell in salt (water moving out) and a muscle fiber in brine (salt moving in, proteins loosening). Label each.
2. Copy your weight table and calculations, and write a conclusion for the experiment.
3. Write the recipe in your own words with your family’s blind-taste results.

COMMON MISTAKES

- Brining chicken on the counter. Raw meat must stay at 40 °F or below.
- Brining too long. Many hours in a strong brine makes meat spongy and salty.
- Salting brined chicken again before roasting. It is already seasoned inside.

Make it a game • Osmosis Race. Salt some cucumber slices and leave a second batch unsalted. After twenty minutes, compare how much water pooled on each plate. Predict first. Say what osmosis and diffusion mean and why a brine keeps meat juicy. Tell how Jean-Antoine Nollet noticed osmosis in 1748 with a pig's bladder.

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)

Salt seasons food all the way through and helps it keep. Paul says our words should be like that: gracious, thoughtful and good for those who hear them.

UNIT 5

FOOD CHEMISTRY

Cooking is chemistry you can eat. In this unit you will look closely at four kinds of change that happen every day in a kitchen. You will meet Louis-Camille Maillard, the French chemist who in 1912 discovered why seared meat, toast and roasted coffee beans turn brown and savory, and then learn the difference between that reaction and caramelization, the browning of sugar alone, through the story of Milton Hershey and his caramels.

Next you will return to Louis Pasteur and the living yeast that makes bread rise, and bake a sandwich loaf with a rise log. Finally you will study moisture and salt: how a French priest and scientist discovered osmosis in 1748, why salt draws water out of vegetables but helps meat hold on to its juices, and how to brine and roast a chicken. Starch, fats, protein, moisture and yeast, the five ingredients-in-action of this unit, will appear in every lesson.

PREREQUISITES

- Knows the safe temperatures for beef steak (145 °F with a 3-minute rest) and chicken (165 °F) (Unit 1)
- Knows how searing and steaming move heat (Unit 4)
- Can measure by weight with a kitchen scale (Unit 4)
- Knows that proteins are chains of amino acids (Unit 2)

MASTERY CHECKLIST

- ☐ I can explain the Maillard reaction and why food must be dry and hot (above about 300 °F) to brown.
- ☐ I can tell caramelization from the Maillard reaction and caramelize onions slowly without burning them.
- ☐ I can explain how yeast ferments sugar into carbon dioxide and how gluten traps the gas, and bake a loaf to 190 °F.
- ☐ I can explain osmosis and diffusion and how a brine helps meat stay juicy.
- ☐ I can name starch, fat, protein, moisture and yeast at work in a recipe I cook.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **King Arthur Baking: Yeast Bread Baking Guide**: Free. King Arthur's site has clear guides to kneading, rising and shaping bread, with photographs. Helpful for Lesson 5.3.
- **A kitchen scale and an instant-read thermometer**: Used throughout the unit: weighing flour and brine, and checking steak, bread and chicken.
- **A 9×5-inch or 8½×4½-inch loaf pan**: Needed for the sandwich loaf in Lesson 5.3. A baking sheet works for a free-form round loaf instead.

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 Louis-Camille Maillard and the Chemistry of Browning

2 sessions of 50–60 minutes

5.2 Milton Hershey's Caramels and the Chemistry of Caramelization

2 sessions of 50–60 minutes

5.3 Pasteur, Yeast and a Sandwich Loaf

2 sessions of 60–90 minutes

5.4 Abbé Nollet, Osmosis and a Brined Roast Chicken

2 sessions of 60–90 minutes

UNIT 5 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

What did Louis-Camille Maillard discover in 1912?

2. **8 pts**

Why won't a wet steak brown? Name three things a cook does to get a good sear.

3. 8 pts

How is caramelization different from the Maillard reaction? Give one food for each.

4. 8 pts

Why do caramelized onions take 30–45 minutes? What happens if you use high heat to hurry them?

5. 8 pts

What did Louis Pasteur prove about fermentation?

6. 8 pts

Explain the jobs of yeast, gluten and steam in making bread rise.

7. 8 pts

Predict: you mix bread dough with milk heated to 150 °F. What will happen, and why?

8. 10 pts

Calculation: a bread recipe makes 1 loaf with 430 g flour, 300 mL milk and 9 g salt. How much of each do you need for 3 loaves? What percent of the flour's weight is the salt? Show your work.

9. 8 pts

What did Abbé Nollet observe in 1748? Define osmosis.

10. 8 pts

Salt draws water out of cucumber slices. Why, then, does brining make chicken juicier?

11. 10 pts

Calculation: a chicken thigh weighed 180 g raw, 189 g after brining, and 144 g after roasting. What percent did it gain in the brine? What percent of its brined weight did it lose in roasting? Show your work.

12. 8 pts

Written answer: Choose any recipe from this unit and explain where you see at least three of these at work: starch, fat, protein, moisture, yeast.

ANSWER KEY

1. That amino acids and certain sugars react with each other when heated, producing brown color and new compounds. This browning reaction, now called the Maillard reaction, gives flavor to seared meat, bread crust, toast and roasted foods.
2. Water cannot get hotter than 212 °F, and browning needs about 300 °F or more, so the surface steams until it dries. Pat the meat dry, use a very hot pan with a little oil, and do not crowd the pan (also: do not move it too soon).
3. Caramelization is the breakdown of sugar alone by heat (about 320 °F for table sugar); the Maillard reaction needs amino acids from protein plus sugar. Caramelization: caramel candy, brittle. Maillard: seared steak, bread crust, toast. Caramelized onions use both.
4. The onions must first release their water, then their sugars brown slowly. On high heat the outside burns and turns bitter before the inside softens and sweetens.
5. That fermentation is the work of living yeast cells: the yeast grows and multiplies during fermentation, it stops when the yeast is killed or removed, and it starts again when living yeast is added.
6. Yeast eats sugars and gives off carbon dioxide gas; gluten, a stretchy protein network made by kneading wheat flour with water, traps the gas so the dough rises; in the oven the gas expands and water turns to steam, causing oven spring before the crust sets.
7. The dough will hardly rise, because temperatures above about 140 °F kill the yeast, so no carbon dioxide is produced.
8. 3 loaves: $430 \times 3 = 1,290$ g flour; $300 \times 3 = 900$ mL milk; $9 \times 3 = 27$ g salt. Salt percent: $9 \div 430 \times 100 \approx 2.09$, or about 2 percent.
9. He sealed a liquid in a piece of animal bladder and set it in water; the bladder swelled as water passed into it. Osmosis is the movement of water through a membrane toward the side with more dissolved material.
10. Salt diffuses into the meat and partly dissolves and loosens muscle proteins like myosin, which then hold more water and squeeze out less during cooking.
11. Gain: $(189 - 180) \div 180 \times 100 = 9 \div 180 \times 100 = 5\%$. Loss: $(189 - 144) \div 189 \times 100 = 45 \div 189 \times 100 \approx 23.8\%$.
12. Answers vary. Example, sandwich loaf: starch (flour gelatinizes and sets the crumb), protein (gluten traps gas; crust browns by Maillard), moisture (milk

hydrates flour; steam gives oven spring), yeast (makes carbon dioxide), fat (butter softens the crumb).

UNIT CHALLENGE: A BREAD LOAF WITH A FULL LAB RECORD

Bake a yeast loaf (the sandwich loaf from Lesson 5.3 or a family bread recipe) twice in the same month. The first time, follow the recipe exactly and keep a complete rise log: dough temperature, room temperature, height every 15 minutes, kneading time, oven spring and the final internal temperature.

The second time, change one variable on purpose, such as half whole-wheat flour, an overnight rise in the refrigerator, honey instead of sugar, or a warmer or cooler rise, and record the same measurements. Photograph a slice of each loaf, have your family rate them blind, and write a one-page lab report explaining the differences using what you learned about yeast, gluten, starch and moisture.

LOOK FOR	WHAT IT MEANS
Baking skill	Two loaves mixed, kneaded to the windowpane, shaped and baked to 190 °F.
Rise log	Complete, neat measurements for both bakes, with a graph comparing them.
Fair test	Exactly one variable changed on purpose, and the blind tasting done fairly.
Explanation	A one-page report that explains the results with yeast, gluten, starch and moisture.
Cleanup and safety	No unbaked dough tasted; oven used safely; kitchen left clean.

CRAVINGS, REWARD & A BALANCED DIET

Why is it so easy to eat a whole bag of chips and so hard to stop at a handful? Why does the smell of fresh cookies make you want one even when you are not hungry? This unit looks at the science of wanting. You will hear how two young scientists in Montreal stumbled onto the brain's reward pathway in 1954, and how later researchers learned that the messenger chemical dopamine is mostly about *wanting* and learning what is rewarding, not about pleasure itself.

You will also trace the history of sugar from a rare spice to an everyday ingredient, and learn how some packaged snack foods are designed to be easy to keep eating. None of this is meant to make you afraid of food. God made us able to enjoy good things, and treats and feasts are gifts in their place. The goal is wisdom: understanding how your appetite works, so that you can practice self-control, eat a balanced diet, enjoy treats with thanks, and share them with others.

PREREQUISITES

- Knows the food groups and how to read a Nutrition Facts label (Unit 2 and earlier grades)
- Knows that calories measure food energy (Unit 2)
- Can bake muffins and use the oven with an adult nearby
- Can convert grams of sugar to teaspoons (4 grams $\approx$ 1 teaspoon)

MASTERY CHECKLIST

- ☐ I can tell how Olds and Milner discovered the brain's reward pathway in 1954.
- ☐ I can explain that dopamine is a messenger tied to wanting and learning, and the difference between wanting and liking.
- ☐ I can explain why sweet, salty and rich foods are appealing, why some snacks are easy to overeat, and what helps us feel full (fiber, protein, water and time).
- ☐ I can tell the history of cane and beet sugar and read the Added Sugars line on a label.
- ☐ I can plan treats in their place and practice self-control with thankfulness.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **FDA: The Nutrition Facts Label:** Free. The FDA's guide to every line of the label, including Added Sugars and % Daily Value. Useful for Lessons 6.2 and 6.3.
- **A food journal (any small notebook):** For the craving journal and the unit challenge. Record what you wanted, when, how hungry you were, and what you chose.

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 Olds and Milner Find the Brain's Reward Pathway

2 sessions of 50–60 minutes

6.2 Dopamine Means Wanting: Snack Foods and the Bliss Point

2 sessions of 50–60 minutes

6.3 Sugar's History: From Cane to Beets to Everyday Sweetness

2 sessions of 50–60 minutes

6.4 Self-Control Is a Fruit of the Spirit: A Planned Dessert Night

2 sessions of 60–90 minutes

UNIT 6 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

What did James Olds and Peter Milner discover in 1954, and how did they discover it?

2. **8 pts**

What is dopamine, and what is it mostly about?

3. **8 pts**

How did Kent Berridge show that wanting and liking are different?

4. (8 pts)

Why can you eat past full when you eat quickly? Name three things that help you feel satisfied.

5. (8 pts)

What is the “bliss point,” and why do some snacks make it easy to keep eating?

6. (10 pts)

Calculation: a drink label says “Includes 36 g Added Sugars.” How many teaspoons is that? If someone needs about 2,000 calories of food energy a day, and the Guidelines advise less than 10 percent from added sugars, how many grams is the daily limit? (Sugar gives 4 calories per gram.) Show your work.

7. (8 pts)

What did Andreas Marggraf discover in 1747, and why did beet sugar matter in the Napoleonic Wars?

8. (8 pts)

Why is the sugar in a whole apple different for your body from the sugar in a soda?

9. (8 pts)

What did Celeste Kidd’s 2012 study add to the marshmallow research?

10. (8 pts)

Why do frozen butter and cold milk make flaky shortcakes?

11. (8 pts)

Calculation: your shortcake recipe serves 8 and uses 2 pounds of strawberries. Strawberries cost \$3.50 per pound, cream \$3.00 per cup, and the biscuit ingredients about \$1.80 total. What is the total cost and the cost per serving? Show your work.

12. (10 pts)

Written answer: Explain how a Christian can enjoy treats and feasts and also practice self-control. Use at least one verse or example from this unit.

ANSWER KEY

1. They discovered the brain's reward pathway. A laboratory rat with a slightly misplaced electrode kept returning to the place where it received a small pulse; when given a lever, it pressed it over and over, and they mapped the brain areas where stimulation was rewarding.
2. A neurotransmitter, a chemical messenger in the reward pathway. It is mostly about wanting, expecting and learning what is rewarding, not about pleasure itself.
3. Rats with greatly reduced dopamine stopped seeking food (no wanting), but still made the same happy "yum" face when sugar was put in their mouths (liking unchanged).
4. It takes about 20 minutes for fullness signals from the stomach and gut to reach the brain. Fiber, protein, water, and eating slowly help.
5. The level of sweetness (or saltiness) at which a food is most appealing, found by testing many versions. Some snacks combine sweet, salty, rich and crunchy, melt quickly and have little fiber, protein or water, so the brain does not register how much has been eaten.
6. $36 \div 4 = 9$ teaspoons. 10% of $2,000 = 200$ calories; $200 \div 4 = 50$ grams of added sugar.
7. He proved that beets contain the same sugar as sugarcane. When Britain's blockade cut France off from cane sugar, Napoleon encouraged beet sugar, which could be grown in Europe's cool climate.
8. The apple's sugar comes with fiber and water (and vitamins) that slow digestion and help you feel full; a soda has sugar with little else, so it is easy to take in a lot quickly.
9. Children who had just seen that an adult was reliable waited about four times longer than those who saw the adult break a promise, showing that trust, not only willpower, affects waiting.
10. Cold butter stays in small pieces in the dough; in the hot oven it melts and gives off steam that pushes the dough into flaky layers. Warm butter blends in and makes flat, dense biscuits.
11. Strawberries $2 \times \$3.50 = \$7.00$; cream $\$3.00$; biscuits $\$1.80$. Total = $\$11.80$. Per serving: $\$11.80 \div 8 = \$1.475 \approx \$1.48$.
12. Answers vary. A good answer says that food and feasts are God's good gifts to be received with thanks (Nehemiah 8:10; 1 Timothy 4:4), that self-control is a fruit

of the Spirit (Galatians 5:22-23), and that wisdom means enjoying sweet things in their place and amount (Proverbs 25:16), often by planning treats ahead and giving some away.

UNIT CHALLENGE: A ONE-WEEK DRINK AND SNACK SWAP

For one week, swap one sweetened drink or packaged snack you usually have for a homemade or nutrient-dense one (for example, fruit-infused water instead of soda, or homemade trail mix instead of candy). Make at least two homemade snacks from this unit or your own recipes, portioned ahead of time.

Keep a daily journal: what you swapped, your hunger and fullness ratings, any cravings and their cues, and how the original food tastes to you if you try it again at the end of the week. Finish with a one-page reflection on what you noticed about wanting, liking, fullness and your taste buds, and one habit you will keep.

LOOK FOR	WHAT IT MEANS
Effort and honesty	The swap attempted every day and recorded honestly, including slips.
Homemade snacks	At least two snacks made and portioned safely, with recipes recorded.
Journal	Daily entries with hunger, fullness, cravings and cues.
Reflection	A thoughtful one-page reflection that uses ideas from the unit (wanting versus liking, satiety, taste-bud change).
Attitude	Treats talked about with thankfulness, not guilt; no comments about anyone's body.

6.1 OLDS AND MILNER FIND THE BRAIN'S REWARD PATHWAY

OBJECTIVES

- Tell how James Olds and Peter Milner discovered the brain's reward pathway at McGill University in 1954.
- Explain in simple terms how the brain learns which foods and actions are rewarding, and why the stomach's fullness signal takes about 20 minutes.
- Make a homemade trail mix, portion it, and record how hungry and satisfied you feel before and after a snack.

Warm-up. Rate how hungry you are right now on a scale from 1 (stuffed) to 10 (starving). Then think of your favorite snack. Picture it, smell it in your mind. Rate how much you *want* it, from 1 to 10. Is your “want” number the same as your “hungry” number?

WATCH

2-Minute Neuroscience: Reward System

Neuroscientifically Challenged • 2:04

<https://www.youtube.com/watch?v=f7E0mTJQ2KM>

WHEN TO WATCH

After How they figured it out. Watch for the names of the reward pathways and why the narrator says dopamine is not the same as pleasure.

Note: From a neuroscience teaching channel. It is short; watch it twice.

KEY TERMS

reward pathway

A set of connected brain areas that help us learn which things are good for us and motivate us to seek them again.

neuron

A nerve cell. Neurons pass signals to each other with electrical pulses and chemical messengers.

neurotransmitter

A chemical messenger that carries a signal from one neuron to the next.

dopamine

A neurotransmitter in the reward pathway. It rises when we expect or get something good and helps us learn to want it and work for it.

satiety

The feeling of being satisfied and full, which tells us to stop eating.

CORE IDEAS

The story. In 1954 James Olds, a young American psychologist, came to McGill University in Montreal to work with Peter Milner, a graduate student who knew how to place very fine wire electrodes in a precise spot in the brain. They were studying alertness in laboratory rats. An electrode in one rat had ended up a little away from its intended place. Olds noticed that whenever the rat received a tiny electrical pulse in one corner of its box, it kept coming back to that corner, as if it wanted more.

How they figured it out. Olds and Milner followed the surprise. They set up a lever the rat could press to give itself the small pulse, and the rat pressed it over and over, sometimes hundreds of times an hour, preferring it to other activities. By testing many brain locations, they mapped a network of areas where stimulation was strongly rewarding. They had found what came to be called the brain's **reward pathway**. Over the next decades, scientists learned that one key messenger in this pathway is **dopamine**, released by neurons deep in the brain whenever we expect or receive something good, such as food when hungry, water when thirsty, or a kind word.

The kitchen science. The reward pathway helps us learn: the brain notices what was good, and next time we see, smell or think of it, we want it. That is useful; it is part of how God made us to seek food when we need it. But wanting and hunger are not the same thing. The sight or smell of a favorite food can make us want it even when we are full. And the stomach is slow: it takes about **20 minutes** after we start eating for signals from the stomach and gut to tell the brain we are satisfied. Eating quickly can carry us past full before the message arrives. Foods with **fiber, protein and water**, eaten slowly, help us feel satisfied.

Let's cook. You will make a trail mix with whole-grain cereal, nuts or seeds, dried fruit and a few chocolate chips, and portion it into small containers. Then you will eat one portion slowly and rate your hunger before, right after and 20 minutes later. The skill is **portioning**: measuring a serving instead of eating from the bag.

PICTURE STUDY



Children Eating Grapes and Melon, Bartolomé Esteban Murillo, c. 1645–1650 · Oil on canvas · Alte Pinakothek, Munich

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

Bartolomé Murillo of Seville often painted the poor children of his city. These two boys have found a feast of grapes and melon, and they are enjoying every bite. Look at their faces: one is chewing and watching his friend, and the other lifts a whole bunch of grapes to his mouth. Murillo shows how good food is when you are hungry.

Look closely

- Find the grapes and the melon. How is each boy eating?
- Look at their faces. What do they seem to feel?
- Look at their clothes and bare feet. What can you tell about their lives?
- Find the basket. How much fruit is left?

Talk about it

1. Are these boys hungry, or just wanting a treat? How can you tell?
2. Fruit is sweet, but it also has water and fiber. How would that help these boys feel satisfied?
3. What does this painting suggest about gratitude for food?

Safety first. Check every ingredient for allergies before mixing; trail mix often contains peanuts, tree nuts, sesame or milk, and a nut-free version is given. Use clean, dry hands or a scoop for portioning, and store the mix in sealed containers. Raisins and nuts can be a choking hazard for very small children.

Trail Mix and the 20-Minute Test

You will make and portion a trail mix, then test how your hunger and fullness change over 20 minutes after eating one portion slowly.

You will need

- A large bowl, a big spoon and measuring cups
- Small containers or bags for portions
- A kitchen scale (optional)
- A timer and your food journal

HOMEMADE TRAIL MIX IN PORTIONS

Serves 12 portions of about $\frac{1}{3}$ cup · Prep 15 min

Ingredients

- $1\frac{1}{2}$ cups whole-grain O-shaped or square cereal
- 1 cup roasted unsalted peanuts or almonds (or roasted sunflower and pumpkin seeds for nut-free)
- $\frac{1}{2}$ cup raisins or dried cranberries
- $\frac{1}{2}$ cup chopped dried apricots
- $\frac{1}{2}$ cup roasted pumpkin seeds
- $\frac{1}{3}$ cup dark chocolate chips
- Optional: $\frac{1}{2}$ teaspoon cinnamon and a pinch of salt

Method

1. Wash your hands. Cut the apricots into small pieces with clean kitchen scissors or a knife.
2. Measure everything into the large bowl and stir well with a big spoon. Sprinkle with cinnamon and salt if using.
3. Scoop $\frac{1}{3}$ -cup portions into small containers or bags. (If you have a scale, weigh one portion and record it.)
4. Seal and store in a cool, dry place up to 2 weeks.

Allergy check: Contains peanuts or tree nuts (as chosen), and chocolate chips often contain milk and soy. For a nut-free mix use sunflower and pumpkin seeds and check that the chocolate and cereal are made in a nut-free facility. Some cereals contain wheat.

Steps

1. **Before.** Rate your hunger (1–10) and how much you want the trail mix (1–10).
2. **Eat slowly.** Eat one portion slowly, with a glass of water, taking at least 10 minutes. Rate your hunger and fullness right after.
3. **After 20 minutes.** Rate them again. Did the numbers change after you stopped eating? Record.
4. **Compare.** On another day, try the same test with a portion eaten quickly. Write down what you notice.
5. **Ingredient math.** Using the labels, estimate the grams of fiber and protein in one portion.
6. **Clean up:** wash the bowl and spoon, wipe the counter, and store the portions.
7. **Improve it.** Write one change: less chocolate, more seeds, a different dried fruit, or toasted coconut.

Tips

- Portions are easier to enjoy than a big bag, because the stopping point is already decided.
- Nuts and seeds bring protein and healthy fats; dried fruit brings fiber and sweetness.
- A small portion of chocolate is a treat in its place.

Check your work

- ☐ I can tell how Olds and Milner discovered the reward pathway.
- ☐ I can explain why wanting and hunger are different and why fullness takes about 20 minutes.
- ☐ I made and portioned trail mix and recorded my hunger and fullness.

COOK'S NOTEBOOK

1. Draw a simple diagram of a neuron passing a dopamine message to another neuron. Label the parts.

2. Make a graph of your hunger and fullness ratings before, right after and 20 minutes after your snack.
3. Write the trail mix recipe in your own words and your family's ratings.

From history. Ivan Pavlov, the Russian scientist who won the 1904 Nobel Prize for his work on digestion, showed in the 1890s and early 1900s that dogs learned to drool at a sound that came before food. It was an early clue that the brain learns to expect and want food from signals around it.

COMMON MISTAKES

- Thinking dopamine is a “pleasure chemical.” It is mostly about wanting, expecting and learning what is rewarding.
- Eating straight from a large bag. It is hard to notice how much you have eaten; portion it first.
- Thinking wanting a treat means you are hungry. Ask yourself whether you are hungry or just reminded by a sight or smell.

Make it a game · Reward Pathway Teach-Back. Teach your parent about the reward pathway using a drawing of neurons and arrows. Include the story of Olds and Milner at McGill in 1954. Explain how the brain learns what is rewarding and why the stomach takes twenty minutes to signal fullness. Your parent sneaks in one false claim. Catch it for the win.

6.2 DOPAMINE MEANS WANTING: SNACK FOODS AND THE BLISS POINT

OBJECTIVES

- Explain Kent Berridge's discovery that wanting and liking are separate in the brain.
- Explain how some packaged snacks are designed to be easy to keep eating, including Howard Moskowitz's "bliss point."
- Make homemade cheddar crackers, compare them with a packaged snack, and keep a three-day craving journal.

Warm-up. Look at the front of a bag or box of a packaged snack. List every word or picture designed to make you want it. Then turn it over and read the ingredients. How many ingredients are there? Which ones are sugars, salts or fats?

WATCH

How does your body know you're full? - Hilary Coller

TED-Ed • 4:33

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

WHEN TO WATCH

After The kitchen science. Watch for the hormones that tell the brain you are full, and the foods that help: water, fiber and protein.

Note: From TED-Ed. It was also used in Grade 5; at this grade, watch for the hormone names and connect them to wanting versus liking.

KEY TERMS

wanting

The drive to seek something out. In the brain, dopamine is closely tied to wanting.

liking

The actual enjoyment we feel while eating something. It depends on different brain chemicals and is not the same as wanting.

bliss point

The amount of sweetness (or saltiness) at which a food is most appealing, neither too little nor too much. Food companies test to find it.

cue

A sight, sound, smell or place that reminds the brain of a reward and sparks wanting.

treat

A food enjoyed for pleasure on occasion, in its place, along with mostly nutrient-dense foods.

CORE IDEAS

The story. In the 1980s and 1990s, at the University of Michigan, the psychologist Kent Berridge was studying how the brain enjoys food. Everyone assumed dopamine was the brain's pleasure chemical. To test it, Berridge watched the faces of laboratory rats as they tasted sugar water. Rats, like human babies, make a small, licking “yum” face when they taste something sweet and a gaping “yuck” face at something bitter.

How he figured it out. When the rats' dopamine was greatly reduced, they stopped seeking out food: they would not walk over to it or work for it. Yet when sugar was placed in their mouths, they still made the same happy “yum” face. Their **liking** was untouched; only their **wanting** was gone. Berridge and his colleague Terry Robinson concluded that dopamine is about wanting, about being drawn toward a reward and its cues, not about pleasure itself. That helps explain why we can want a snack intensely, eat it, and then find we did not enjoy it as much as we expected.

The kitchen science. God made us able to enjoy sweet, salty and rich foods, and in nature those tastes usually come with nourishment: fruit, milk, nuts. Some packaged snacks are designed to combine them in ways that are unusually easy to keep eating. In the 1970s and 1980s the researcher Howard Moskowitz helped food companies test many versions of a product to find the “**bliss point**,” the exact sweetness at which people like it most. Snack makers also tune salt, fat and crunch, and make foods that melt quickly in the mouth, so the brain does not register how much has been eaten. Many such snacks are low in fiber, protein and water, the things that help us feel full. Knowing this is not a reason to fear food; it is a reason to **notice** cues, choose portions ahead of time, and enjoy treats in their place.

Let's cook. You will make homemade whole-wheat cheddar crackers and compare them with a packaged cheese cracker: ingredients, taste, how many you want, and how full you feel. The skill is **rolling dough evenly** so every cracker bakes crisp.

PICTURE STUDY



Sushi (from the series Famous Sushi of Edo), Utagawa Hiroshige, c. 1830s–1840s · Color woodblock print · Museum collections (see source)
Image: [Wikimedia Commons](#), public domain

In the city of Edo, now Tokyo, sushi began as a quick snack sold from street stalls to busy workers in the early 1800s. Utagawa Hiroshige, famous for his landscapes of the Tōkaidō road, also made prints of food. In this one, small pieces of sushi are arranged with care. Each piece is a single, satisfying bite, made by hand and meant to be enjoyed slowly.

Look closely

- Count the pieces of sushi. How many different toppings can you see?
- Look at how the pieces are arranged. Why do you think the maker took such care?
- Look at the colors Hiroshige used. Which colors make the food look fresh?
- Find the writing. Prints like this were sometimes advertisements for a shop.

Talk about it

1. How is a handmade snack sold at a stall different from a packaged snack designed in a factory?
2. If this print was an advertisement, what cues does it use to make you want the food?

3. How could you serve a snack at home so that it is enjoyed slowly and with thanks?

Safety first. Check the cracker ingredients for allergies (wheat and milk) before baking. Use an adult nearby for the oven, and use oven mitts for the hot pans. Do not taste unbaked dough, which contains raw flour.

Homemade Cheddar Crackers and a Craving Journal

You will bake cheese crackers from scratch and compare them with a packaged cracker, then keep a three-day journal of what you want, when, and why.

You will need

- A food processor or a large bowl and a pastry blender
- A rolling pin, a ruler and a pizza cutter or knife
- Two baking sheets lined with parchment, oven mitts and a cooling rack
- A packaged cheese cracker for comparison

WHOLE-WHEAT CHEDDAR CRACKERS

Serves About 80 small crackers · Prep 20 min · Chill 15 min · Bake 12–15 min per pan

Ingredients

- 2 cups (225 g) sharp cheddar cheese, finely grated
- 4 tablespoons (55 g) cold butter, cut into small pieces
- ½ cup (60 g) all-purpose flour
- ½ cup (60 g) whole-wheat flour
- ½ teaspoon salt
- ¼ teaspoon paprika
- 2–3 tablespoons cold water

Method

1. Pulse the cheese, butter, both flours, salt and paprika in the food processor until it looks like coarse sand. (Or rub them together in a bowl with your fingers or a pastry blender.)
2. Add 2 tablespoons water and pulse until the dough clumps into a ball. Add a little more water only if needed. Unplug the processor before removing the dough. Wrap the dough and chill 15 minutes.
3. With an adult nearby, heat the oven to 350 °F (175 °C).

4. Roll the dough between two sheets of parchment to an even $\frac{1}{8}$ -inch thickness. Cut into 1-inch squares with the pizza cutter. Poke a small hole in the center of each with a skewer. Move to the lined baking sheets.
5. Bake 12–15 minutes, until the edges are golden. Watch closely; they brown quickly at the end. Cool on the rack; they crisp as they cool.
6. Store in an airtight container up to 5 days.

Allergy check: Contains milk and wheat. For a wheat-free version, use a gluten-free flour blend. There is no milk-free version of this recipe; choose a different homemade snack, such as roasted chickpeas, if milk is a problem.

Steps

1. **Label comparison.** List the ingredients of the packaged cracker and your homemade cracker side by side. Compare the number of ingredients and the grams of fat, sodium and fiber per serving.
2. Make the crackers.
3. **Taste test.** Taste one homemade and one packaged cracker. Rate liking (how much you enjoy it) and wanting (how much you want another) from 1 to 10.
4. **Portion test.** Put 15 of each kind in two bowls for two family members. Eat slowly. Who wanted more? Who felt full first?
5. **Craving journal.** For three days, write down each time you want a snack: the time, what you wanted, how hungry you were (1–10), what cue you noticed (a smell, an ad, boredom, being tired), and what you chose.
6. Clean up: wash the processor (an adult handles the blade), rolling pin and baking sheets.
7. **Improve it.** Write one change: add herbs, a pinch of cayenne, sesame seeds or a different cheese.

Tips

- Even thickness is the secret to even crisping. Use the ruler.
- If the dough is too sticky to roll, chill it longer.
- Thin crackers at the edge of the pan brown first; pull them out early if needed.

Check your work

- ☐ I can explain the difference between wanting and liking.
- ☐ I can explain how some snacks are designed to be easy to overeat, and what helps me stop.
- ☐ I baked crackers, compared them with a packaged snack, and kept a craving journal.

COOK'S NOTEBOOK

1. Make a two-column chart comparing the homemade and packaged crackers.
2. Summarize your three-day craving journal: your most common cues and one plan for each.
3. Write the cracker recipe in your own words with your family's ratings.

COMMON MISTAKES

- Thinking a strong craving means you need that food. Often it is a cue, not hunger; a glass of water and a short wait help you tell the difference.
- Calling foods good or bad, or the people who eat them good or bad. Describe what the food does, and choose wisely.
- Eating while watching a screen. It is easy to miss the signals of fullness.

Make it a game • Wanting versus Liking. Write wanting on one card and liking on another. Your parent describes a situation, such as reading a menu or enjoying the first bite, and you hold up the right card. Explain Kent Berridge's discovery. Then name three tricks that make snack foods easy to eat and describe the bliss point.

Scripture. “Hast thou found honey? eat so much as is sufficient for thee, lest thou be filled therewith, and vomit it.” (Proverbs 25:16, KJV)

Solomon does not say honey is bad. He says to eat enough and stop. Good things are best enjoyed with self-control.

6.3 SUGAR'S HISTORY: FROM CANE TO BEETS TO EVERYDAY SWEETNESS

OBJECTIVES

- Tell the history of sugar from sugarcane in Asia to the Caribbean plantations and Andreas Marggraf's discovery of sugar in beets.
- Read the Added Sugars line on a label and convert grams of sugar to teaspoons.
- Bake banana-oat muffins sweetened with fruit and compare them with a standard muffin.

Warm-up. Look at the Nutrition Facts label of three drinks or snacks. Find the line "Includes __ g Added Sugars." Divide each number by 4 to find the teaspoons of added sugar. Measure out that many teaspoons of sugar into a small dish for each. Which surprised you?

WATCH

How It's Made: Beet Sugar

Science Channel • 5:24

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

WHEN TO WATCH

After The story. Follow every step from beets in the field to white sugar in the bag.

Note: From the Science Channel's How It's Made series, filmed in a European beet-sugar factory.

BACKUP VIDEO

The History of Sugar Beets

Prairie Public • 5:33

<https://www.youtube.com/watch?v=T1wLUYhwHVM>

The story of sugar beet farming in the Red River Valley of Minnesota and North Dakota.

KEY TERMS

sucrose

Table sugar. The same molecule comes from sugarcane and from sugar beets.

sugarcane

A tall tropical grass whose stalks are full of sweet juice. It was first grown in New Guinea and southern Asia.

sugar beet

A white root crop grown in cooler climates, with about 15–20 percent sugar. Over half of America's sugar comes from beets.

added sugars

Sugars and syrups added to foods during processing or cooking. The *Dietary Guidelines* advise keeping them to less than 10 percent of daily food energy for everyone age 2 and older.

naturally occurring sugars

Sugars that are part of whole foods, like fructose in fruit and lactose in milk, which come packaged with fiber, water, vitamins and protein.

CORE IDEAS

The story. For most of history, sweetness was rare. People had honey, fruit and dates. Sugarcane was first grown in New Guinea and southern Asia, and by about 1,600 years ago cooks in India had learned to boil cane juice into crystals. Arab traders carried sugar to the Mediterranean, and in medieval Europe it was so costly that it was kept with the spices and sold by apothecaries. On his second voyage in 1493, Columbus brought sugarcane to the Caribbean. Over the next three centuries huge plantations grew there and in Brazil, worked by enslaved Africans under cruel conditions, and sugar slowly became cheaper in Europe.

How they figured it out. In 1747 a German chemist in Berlin, Andreas Marggraf, extracted the sweet substance from dried white beets, examined its crystals under a microscope, and proved that they were the very same sugar as cane sugar. His student Franz Karl Achard bred beets with more sugar and in 1801 opened the first beet-sugar factory, in Silesia. When Britain blockaded French ports during the Napoleonic Wars and cane sugar could not get through, Napoleon encouraged French farmers to grow sugar beets. Beet sugar spread across Europe and later to the

United States, where today more than half of our sugar comes from beets grown in states like Minnesota, North Dakota, Idaho and Michigan.

The kitchen science. Cane sugar and beet sugar are the same molecule, sucrose. Your body handles sugar in whole fruit differently from sugar in a soda, because fruit comes with **fiber** and **water** that slow digestion and help you feel full. On a Nutrition Facts label, the **Added Sugars** line (added in 2016) shows sugars that were put in during making; **4 grams** is about **1 teaspoon**. Taste buds adjust: people who cut back on added sugar for a few weeks usually find that sweet foods taste sweeter than before. In baking, sugar does more than sweeten: it keeps muffins moist and tender and helps them brown. Ripe bananas and applesauce can do much of that work, too.

Let's cook. You will bake banana-oat muffins sweetened mostly with very ripe bananas, applesauce and raisins, with no added sugar, and compare them with a standard muffin. The skill is **the muffin method**: mixing wet and dry separately and folding them together just until combined.

PICTURE STUDY



The Mill Yard (Ten Views in the Island of Antigua), William Clark, 1823 · Hand-colored aquatint · British Library, London

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

In 1823 William Clark published a set of pictures of sugar-making on the island of Antigua. This one shows the mill yard, where cut cane was brought to a windmill that crushed the juice out of the stalks. The people doing this hard and dangerous work were enslaved. The picture shows how the sugar on European tables was made, and at what cost. Britain ended slavery in its colonies in the 1830s, after a long campaign led by Christians such as William Wilberforce.

Look closely

- Find the windmill. What do you think it is turning?
- Find the carts and the bundles of cane. How is the cane brought to the mill?
- Look at the workers. What are they doing?
- Look at the land and sky. What tells you this is a tropical island?

Talk about it

1. What steps would the cane juice go through after the mill before it became sugar?
2. Why is it important to know the history of the foods we enjoy?
3. How did beet sugar change where sugar could be grown?

Safety first. Use oven mitts for the hot muffin tin, and an adult is nearby for oven work. Do not taste the raw batter, which contains uncooked egg and flour. If anyone in your family has diabetes or other special medical needs, follow their doctor's advice about sugar.

KITCHEN PROJECT

Fruit-Sweetened Banana Oat Muffins

You will measure the added sugar in common drinks and snacks, then bake muffins sweetened with fruit and compare their label with a store muffin.

You will need

- A 12-cup muffin tin with paper liners
- Two mixing bowls, a whisk, a fork and a rubber spatula
- Measuring cups and spoons and a ¼-cup scoop
- A toothpick, oven mitts and a cooling rack
- Small dishes and a teaspoon for the sugar display

BANANA OAT MUFFINS WITH NO ADDED SUGAR

Serves 12 muffins · Prep 15 min · Bake 20–24 min

Ingredients

- 3 very ripe bananas (about 1½ cups mashed), with brown spots
- ½ cup (120 g) unsweetened applesauce
- 2 large eggs
- ¼ cup (60 mL) vegetable oil or melted butter
- 1 teaspoon vanilla extract
- 1 cup (120 g) whole-wheat flour
- 1 cup (90 g) quick or old-fashioned oats
- 1 teaspoon baking soda and 1 teaspoon baking powder
- 1 teaspoon cinnamon and ¼ teaspoon salt
- ½ cup raisins or chopped dates

Method

1. With an adult nearby, heat the oven to 350 °F (175 °C). Line the muffin tin with paper liners.
2. In one bowl, mash the bananas well with a fork. Whisk in the applesauce, eggs, oil and vanilla. Wash your hands after cracking the

eggs.

3. In the other bowl, whisk together the flour, oats, baking soda, baking powder, cinnamon and salt.
4. Pour the wet mixture into the dry and fold gently with the spatula just until no dry flour shows. Fold in the raisins. Lumps are fine.
5. Scoop the batter into the cups, about $\frac{3}{4}$ full. Bake 20–24 minutes, until a toothpick in the center comes out clean.
6. Cool 5 minutes in the tin, then on the rack. Store covered 3 days, or freeze.

Allergy check: Contains wheat and eggs (and milk if you use butter). For egg-free, use 2 tablespoons ground flaxseed mixed with 6 tablespoons water. Use oil for milk-free, and a gluten-free flour blend and certified gluten-free oats for wheat-free.

Steps

1. **Sugar display.** Do the warm-up and set out the dishes of sugar with labels. Photograph them.
2. Bake the muffins.
3. **Compare.** Read the label of a store-bought muffin. Calculate its added sugar in teaspoons. Our muffins have no added sugar; the sweetness comes from the fruit.
4. **Taste test.** Taste your muffin and, if you have one, a store muffin. Rate sweetness and flavor from 1 to 10. Ask your family.
5. **Taste-bud challenge.** Choose one drink or snack with added sugar to cut back on for two weeks. Write it down and plan to taste it again at the end.
6. Clean up: wash the bowls, spatula and tin; wipe the counter.
7. **Improve it.** Write one change: add walnuts, blueberries, a little peanut butter swirl, or 2 tablespoons maple syrup if you want them a little sweeter.

Tips

- The riper the bananas, the sweeter the muffins. Black-spotted bananas are perfect.
- Overmixing makes muffins tough and full of tunnels. Fold just until combined.

- Freeze ripe bananas in their peels for baking later; thaw them and squeeze out the soft fruit.

Check your work

- ☐ I can tell the history of cane and beet sugar.
- ☐ I can read the Added Sugars line and convert grams to teaspoons.
- ☐ I baked fruit-sweetened muffins and compared them with a standard muffin.

COOK'S NOTEBOOK

1. Draw a timeline of sugar from ancient India to beet sugar in America, with at least six dates or events.
2. Make a chart of the drinks and snacks you measured, with grams and teaspoons of added sugar.
3. Write the muffin recipe in your own words with your family's ratings.

From history. Sugar was once so precious that wealthy households in Tudor England kept it locked in a sugar box. Queen Elizabeth I was known for her love of sweets. Today the average American eats far more added sugar in a week than a medieval family might have seen in a year.

COMMON MISTAKES

- Thinking honey, maple syrup or brown sugar are not added sugars. On a label, they all count as added sugars.
- Treating the sugar in a whole apple the same as the sugar in a soda. Whole fruit brings fiber, water and vitamins.
- Cutting all sugar from a baking recipe without replacing its moisture. Use ripe fruit or applesauce.

Make it a game · Sugar Trail Timeline. Make five cards: sugarcane in Asia, trade to the Caribbean, Marggraf finds sugar in beets, added sugars on a label, and your own kitchen. Shuffle and put them in order. Then pick a label and convert grams of sugar into teaspoons. Name which sugars are naturally occurring and which are added.

6.4 SELF-CONTROL IS A FRUIT OF THE SPIRIT: A PLANNED DESSERT NIGHT

OBJECTIVES

- Explain self-control (temperance) as a virtue and a fruit of the Spirit, and describe Benjamin Franklin's plan to practice it.
- Describe research on waiting for a reward and what helps people wait.
- Plan and make a from-scratch strawberry shortcake for a family dessert night, served as a treat in its place.

Warm-up. Write down one treat you love. When is the best time to enjoy it? With whom? How would it feel different if you ate it every day versus on a special evening with your family?

WATCH

The Science Behind Self-Control

University of Rochester • 2:52

<https://www.youtube.com/watch?v=k1Xk7PPo6TU>

WHEN TO WATCH

After How they figured it out. Listen for what the researchers say about the Rochester study and what helped children wait.

Note: From the University of Rochester. It shows a cigarette for one second as an example of a hard habit.

KEY TERMS

self-control

The ability to choose what is good over what you want right now. Scripture calls it temperance, one of the fruit of the Spirit.

delayed gratification

Waiting for a later or greater good instead of taking a smaller reward now.

virtue

A good habit of character, built by practice, such as patience, honesty and temperance.

shortcake

A tender, biscuit-like cake split and filled with fruit and whipped cream.

CORE IDEAS

The story. In 1726, at age twenty, Benjamin Franklin made a plan to improve his character. He listed thirteen virtues he wanted to practice and put **temperance** first, with a short rule: “Eat not to dulness.” He made a little book with a chart for each week and marked a dot every day he failed at a virtue. He worked on one virtue a week, cycling through all thirteen. Franklin admitted he never became perfect, but he wrote that he was a better and happier man for the effort.

How they figured it out. In the late 1960s and 1970s, the psychologist Walter Mischel at Stanford tested how long young children would wait alone with a marshmallow or cookie if they were promised two when the researcher returned. Some waited; many did not. The children who waited longest often used smart strategies: they looked away, sang, or covered their eyes. In 2012 Celeste Kidd and her colleagues at the University of Rochester added an important discovery. Before the test, children met an adult who either kept a small promise or broke it. Children who had learned the adult was **reliable** waited about four times longer. Waiting depends not only on willpower but on trust and on good habits.

The kitchen science. Self-control with food is not about refusing every treat; it is about enjoying good things in their right place and amount. Some helpful habits: decide on a treat ahead of time instead of in the moment; serve a portion on a plate rather than eating from the package; eat slowly with others at the table; and keep nutrient-dense foods easy to reach. Scripture shows feasts and treats as good gifts: Nehemiah told the people, “Eat the fat, and drink the sweet,” and to send portions to those with nothing, because the day was holy. A planned dessert night shared with the family is a small feast: anticipated, enjoyed and given thanks for.

Let’s cook. You will plan a family dessert night and make strawberry shortcakes from scratch: tender biscuits, sliced strawberries and freshly whipped cream. The skill is **keeping butter cold**, so the biscuits are flaky.

PICTURE STUDY



Cutting the Pies and Cakes at the Barbecue Dinner, Pie Town Fair, Russell Lee, for the Farm Security Administration, 1940 · Photograph · Library of Congress, Washington, D.C.

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

Pie Town, New Mexico, got its name from a café that sold homemade pies to travelers. At the 1940 community fair, the women of the town baked pies and cakes for everyone. Here they are cutting them into slices to share. A dessert made with care and shared at a feast is a very different thing from a snack eaten alone.

Look closely

- Count the pies and cakes. How many people do you think they will serve?
- Find the knives and plates. How are the slices being cut?
- Look at the women's faces and hands. Are they rushed or careful?
- Look at the background. Who is waiting?

Talk about it

1. Why might pie taste better at a community feast than eaten alone?
2. How does cutting a pie into fair slices show both self-control and kindness?
3. What dessert would you bake for a feast in your town?

Safety first. Use oven mitts for the hot baking sheet, with an adult nearby. Keep the cream cold and the whipped cream in the refrigerator until serving. Do not taste raw biscuit dough. Strawberries should be rinsed under running water just before slicing.

Strawberry Shortcake for a Planned Dessert Night

You will plan a family dessert night with a date, a menu, a time and a way to give thanks, then bake strawberry shortcakes and serve them. You will also make a personal plan for treats.

You will need

- A large bowl, a pastry blender or two forks, and a box grater (for frozen butter)
- A baking sheet lined with parchment, oven mitts and a cooling rack
- A 2½-inch round cutter or a glass, and a sharp knife
- A chilled bowl and a whisk or electric mixer for the cream

STRAWBERRY SHORTCAKES

Serves 8 • Prep 30 min • Stand 20 min • Bake 14–16 min

Ingredients

- **Strawberries:** 2 pounds (900 g) fresh strawberries, hulled and sliced
- 2 tablespoons sugar
- **Shortcakes:** 2 cups (240 g) all-purpose flour
- 2 tablespoons sugar, plus 1 tablespoon for sprinkling
- 1 tablespoon baking powder
- ½ teaspoon salt
- 6 tablespoons (85 g) cold butter, frozen for 15 minutes
- ¾ cup (180 mL) cold milk, plus 1 tablespoon for brushing
- **Whipped cream:** 1 cup (240 mL) cold heavy cream
- 1 tablespoon sugar and ½ teaspoon vanilla extract

Method

1. Toss the sliced strawberries with 2 tablespoons sugar. Let them stand 20 minutes to make their own juice.

2. With an adult nearby, heat the oven to 425 °F (220 °C). Line the baking sheet.
3. Whisk the flour, sugar, baking powder and salt in the large bowl. Grate the frozen butter on the large holes of the box grater into the flour (keep your fingers away from the grater; stop when the butter gets short). Toss to coat.
4. Pour in the milk and stir with a fork just until a shaggy dough forms. Turn it onto a floured counter and pat gently into a 1-inch-thick round. Cut 8 rounds with the cutter, pressing straight down without twisting; gently re-pat the scraps.
5. Set the rounds on the sheet, brush the tops with milk, and sprinkle with sugar. Bake 14–16 minutes, until tall and golden. Cool 10 minutes on the rack.
6. Whip the cream with the sugar and vanilla in the chilled bowl until soft peaks form. Split each shortcake with a knife, spoon strawberries and juice on the bottom, add cream, and set the top on. Serve right away; refrigerate leftover cream and berries.

Allergy check: Contains wheat and milk. For milk-free, use cold plant butter and non-dairy milk, and serve with coconut whipped cream. This recipe has no eggs.

Steps

1. **Plan the evening.** Choose a date with your family, write a menu card, plan who sets the table and who reads a short grace or verse.
2. **My treat plan.** Write a simple personal plan: which treats you enjoy, how often and when you will have them (for example, dessert on Sundays and at birthdays), and one habit to help, such as serving treats on a plate.
3. Bake the shortcakes and whip the cream.
4. **Cold butter test.** Break open a shortcake. Sketch the flaky layers. Explain how frozen butter made them (steam from melting butter pushes layers apart).
5. **Serve.** Serve the dessert at the table with thanks. Ask each person to rate it and share one thing they are thankful for.
6. **Clean up together:** wash the bowls, grater and baking sheet; wipe the table.

7. **Improve it.** Write one change: peaches or blueberries, a little lemon zest in the biscuits, or yogurt with the cream.

Tips

- Cold is the secret of flaky biscuits. If the kitchen is warm, chill the bowl and flour too.
- Do not twist the cutter; twisting seals the edges and keeps the shortcakes from rising tall.
- Whip cream only to soft peaks. Overwhipped cream turns grainy and then into butter.

Check your work

- ☐ I can explain self-control as a virtue and a fruit of the Spirit.
- ☐ I can describe what helps people wait for a reward.
- ☐ I planned a family dessert night and baked shortcakes with cold butter.

COOK'S NOTEBOOK

1. Copy Franklin's idea: make a small weekly chart for one virtue you want to practice, and fill it in for a week.
2. Write your treat plan neatly.
3. Write the shortcake recipe in your own words with your family's ratings and thanks.

COMMON MISTAKES

- Thinking self-control means never enjoying treats. Scripture celebrates feasts; self-control enjoys them in their place.
- Letting the butter get warm. Warm butter makes flat, tough shortcakes.
- Whipping cream in a warm bowl. Chill the bowl and whisk first.

Make it a game • Franklin's Virtue Chart. Draw a small weekly chart like Benjamin Franklin's, with one virtue, temperance, and a dot for each day you practice self-control. Choose a concrete goal, such as one dessert eaten slowly, and mark it each night. Explain self-control as a fruit of the Spirit. Describe what research says helps people wait for a reward.

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 in us like fruit on a tree, by the work of God’s Spirit and by daily practice. It sits right beside joy: self-control helps us enjoy good gifts well.

CRAVINGS, REWARD & A BALANCED DIET

Why is it so easy to eat a whole bag of chips and so hard to stop at a handful? Why does the smell of fresh cookies make you want one even when you are not hungry? This unit looks at the science of wanting. You will hear how two young scientists in Montreal stumbled onto the brain's reward pathway in 1954, and how later researchers learned that the messenger chemical dopamine is mostly about *wanting* and learning what is rewarding, not about pleasure itself.

You will also trace the history of sugar from a rare spice to an everyday ingredient, and learn how some packaged snack foods are designed to be easy to keep eating. None of this is meant to make you afraid of food. God made us able to enjoy good things, and treats and feasts are gifts in their place. The goal is wisdom: understanding how your appetite works, so that you can practice self-control, eat a balanced diet, enjoy treats with thanks, and share them with others.

PREREQUISITES

- Knows the food groups and how to read a Nutrition Facts label (Unit 2 and earlier grades)
- Knows that calories measure food energy (Unit 2)
- Can bake muffins and use the oven with an adult nearby
- Can convert grams of sugar to teaspoons (4 grams $\approx$ 1 teaspoon)

MASTERY CHECKLIST

- ☐ I can tell how Olds and Milner discovered the brain's reward pathway in 1954.
- ☐ I can explain that dopamine is a messenger tied to wanting and learning, and the difference between wanting and liking.
- ☐ I can explain why sweet, salty and rich foods are appealing, why some snacks are easy to overeat, and what helps us feel full (fiber, protein, water and time).
- ☐ I can tell the history of cane and beet sugar and read the Added Sugars line on a label.
- ☐ I can plan treats in their place and practice self-control with thankfulness.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **FDA: The Nutrition Facts Label:** Free. The FDA's guide to every line of the label, including Added Sugars and % Daily Value. Useful for Lessons 6.2 and 6.3.
- **A food journal (any small notebook):** For the craving journal and the unit challenge. Record what you wanted, when, how hungry you were, and what you chose.

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 Olds and Milner Find the Brain's Reward Pathway

2 sessions of 50–60 minutes

6.2 Dopamine Means Wanting: Snack Foods and the Bliss Point

2 sessions of 50–60 minutes

6.3 Sugar's History: From Cane to Beets to Everyday Sweetness

2 sessions of 50–60 minutes

6.4 Self-Control Is a Fruit of the Spirit: A Planned Dessert Night

2 sessions of 60–90 minutes

UNIT 6 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

What did James Olds and Peter Milner discover in 1954, and how did they discover it?

2. **8 pts**

What is dopamine, and what is it mostly about?

3. **8 pts**

How did Kent Berridge show that wanting and liking are different?

4. **8 pts**

Why can you eat past full when you eat quickly? Name three things that help you feel satisfied.

5. **8 pts**

What is the “bliss point,” and why do some snacks make it easy to keep eating?

6. **10 pts**

Calculation: a drink label says “Includes 36 g Added Sugars.” How many teaspoons is that? If someone needs about 2,000 calories of food energy a day, and the Guidelines advise less than 10 percent from added sugars, how many grams is the daily limit? (Sugar gives 4 calories per gram.) Show your work.

7. **8 pts**

What did Andreas Marggraf discover in 1747, and why did beet sugar matter in the Napoleonic Wars?

8. **8 pts**

Why is the sugar in a whole apple different for your body from the sugar in a soda?

9. **8 pts**

What did Celeste Kidd’s 2012 study add to the marshmallow research?

10. **8 pts**

Why do frozen butter and cold milk make flaky shortcakes?

11. **8 pts**

Calculation: your shortcake recipe serves 8 and uses 2 pounds of strawberries. Strawberries cost \$3.50 per pound, cream \$3.00 per cup, and the biscuit ingredients about \$1.80 total. What is the total cost and the cost per serving? Show your work.

12. **10 pts**

Written answer: Explain how a Christian can enjoy treats and feasts and also practice self-control. Use at least one verse or example from this unit.

ANSWER KEY

1. They discovered the brain's reward pathway. A laboratory rat with a slightly misplaced electrode kept returning to the place where it received a small pulse; when given a lever, it pressed it over and over, and they mapped the brain areas where stimulation was rewarding.
2. A neurotransmitter, a chemical messenger in the reward pathway. It is mostly about wanting, expecting and learning what is rewarding, not about pleasure itself.
3. Rats with greatly reduced dopamine stopped seeking food (no wanting), but still made the same happy "yum" face when sugar was put in their mouths (liking unchanged).
4. It takes about 20 minutes for fullness signals from the stomach and gut to reach the brain. Fiber, protein, water, and eating slowly help.
5. The level of sweetness (or saltiness) at which a food is most appealing, found by testing many versions. Some snacks combine sweet, salty, rich and crunchy, melt quickly and have little fiber, protein or water, so the brain does not register how much has been eaten.
6. $36 \div 4 = 9$ teaspoons. 10% of $2,000 = 200$ calories; $200 \div 4 = 50$ grams of added sugar.
7. He proved that beets contain the same sugar as sugarcane. When Britain's blockade cut France off from cane sugar, Napoleon encouraged beet sugar, which could be grown in Europe's cool climate.
8. The apple's sugar comes with fiber and water (and vitamins) that slow digestion and help you feel full; a soda has sugar with little else, so it is easy to take in a lot quickly.
9. Children who had just seen that an adult was reliable waited about four times longer than those who saw the adult break a promise, showing that trust, not only willpower, affects waiting.
10. Cold butter stays in small pieces in the dough; in the hot oven it melts and gives off steam that pushes the dough into flaky layers. Warm butter blends in and makes flat, dense biscuits.
11. Strawberries $2 \times \$3.50 = \$7.00$; cream $\$3.00$; biscuits $\$1.80$. Total = $\$11.80$. Per serving: $\$11.80 \div 8 = \$1.475 \approx \$1.48$.
12. Answers vary. A good answer says that food and feasts are God's good gifts to be received with thanks (Nehemiah 8:10; 1 Timothy 4:4), that self-control is a fruit

of the Spirit (Galatians 5:22-23), and that wisdom means enjoying sweet things in their place and amount (Proverbs 25:16), often by planning treats ahead and giving some away.

UNIT CHALLENGE: A ONE-WEEK DRINK AND SNACK SWAP

For one week, swap one sweetened drink or packaged snack you usually have for a homemade or nutrient-dense one (for example, fruit-infused water instead of soda, or homemade trail mix instead of candy). Make at least two homemade snacks from this unit or your own recipes, portioned ahead of time.

Keep a daily journal: what you swapped, your hunger and fullness ratings, any cravings and their cues, and how the original food tastes to you if you try it again at the end of the week. Finish with a one-page reflection on what you noticed about wanting, liking, fullness and your taste buds, and one habit you will keep.

LOOK FOR	WHAT IT MEANS
Effort and honesty	The swap attempted every day and recorded honestly, including slips.
Homemade snacks	At least two snacks made and portioned safely, with recipes recorded.
Journal	Daily entries with hunger, fullness, cravings and cues.
Reflection	A thoughtful one-page reflection that uses ideas from the unit (wanting versus liking, satiety, taste-bud change).
Attitude	Treats talked about with thankfulness, not guilt; no comments about anyone's body.

UNIT 7

FIRE, THE GRILL & SPICE

This is the fun unit, full of smoke, fire and fragrance. You will sail around the world with Magellan's fleet in search of the islands where cloves grow, and meet Edmond Albius, a twelve-year-old boy on the island of Réunion who discovered in 1841 how to pollinate vanilla flowers by hand, making vanilla possible to grow outside Mexico. You will cook a clove-and-cinnamon meatball supper and a creamy vanilla rice pudding.

Then you will step up to the grill. This year, after an adult lights it, **you may grill with an adult right beside you.** You will learn to build a two-zone fire, sear over direct heat and finish over indirect heat, and cook pork tenderloin to 145 °F. Last, you will look at what food scientists have learned about why some flavors go together, and grill chicken with a mango salsa that balances sweet, sour, salty, heat and herb. Every grill recipe has an **indoor way**, with a skillet, grill pan or broiler, for families without a grill.

PREREQUISITES

- Knows the fire triangle and that a grease fire is smothered, never doused with water (earlier grades)
- Knows the safe temperatures: pork 145 °F with a 3-minute rest, ground beef 160 °F, chicken 165 °F (Unit 1)
- Knows the Maillard reaction and searing (Units 4 and 5)
- Can use a chef's knife and the stove and oven with an adult nearby

MASTERY CHECKLIST

- ☐ I can tell the story of Magellan's voyage and the clove islands, and name where common spices come from.
- ☐ I can tell how Edmond Albius discovered hand-pollination of vanilla and why it mattered.
- ☐ I can set up a two-zone grill with an adult, explain direct and indirect heat, and follow every grill safety rule.
- ☐ I can grill or broil meat to its safe temperature with an adult beside me.
- ☐ I can balance a dish using complementary and contrasting flavors.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **NFPA: Grilling safety:** Free. Grilling safety tips and a printable tip sheet from the National Fire Protection Association. Read together before Lesson 7.3.
- **For the adult griller: a chimney starter and long-handled tongs:** A chimney starter lights charcoal with crumpled newspaper, so no liquid starter is ever needed. A gas grill needs neither. Not required: every recipe also works indoors.
- **Whole spices: cloves, cinnamon sticks, black peppercorns, nutmeg:** Optional but fun for the smell tests in Lesson 7.1. Many grocery stores sell small amounts in the bulk aisle.

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	Magellan's Voyage and the Clove Islands	2 sessions of 50–60 minutes
7.2	Edmond Albius and the Secret of Vanilla	2 sessions of 50–60 minutes
7.3	The Two-Zone Grill: Pork Tenderloin	2 sessions of 60–90 minutes
7.4	Pairing Flavors: Grilled Chicken with Mango Salsa	2 sessions of 50–60 minutes

UNIT 7 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. 8 pts

Why did Magellan's expedition sail west in 1519, and what did the *Victoria* bring back in 1522?

2. 8 pts

Match each spice with its plant part: cloves, cinnamon, nutmeg, black pepper, ginger.

3. 8 pts

What does it mean to “bloom” spices, and why does it work?

4. 8 pts

What did Edmond Albius discover in 1841, and why did it matter?

5. 8 pts

Why is real vanilla so expensive?

6. 8 pts

Explain direct and indirect heat and why a two-zone fire is useful for a pork tenderloin.

7. 10 pts

List five grill safety rules from this unit.

8. 8 pts

Calculation: two pork tenderloins weigh 1.1 pounds and 1.2 pounds. Pork tenderloin costs \$4.80 per pound. The meal serves 6. What is the cost of the pork, and the pork cost per serving? Show your work.

9. 8 pts

What did Yong-Yeol Ahn's 2011 study find about North American and East Asian recipes?

10. 8 pts

Predict: your salsa tastes flat and too sweet. What two ingredients could you add, and why?

11. 8 pts

Calculation: a marinade recipe for 2 pounds of chicken uses 3 tablespoons of lime juice. How much lime juice do you need for 5 pounds? Give the answer in tablespoons and in cups (16 tablespoons = 1 cup).

12. 10 pts

Written answer: Plan a balanced grilled dinner for your family. Name the main dish, a side and a topping or sauce, and explain how the meal balances at least four of these: salt, sweet, sour, heat, cool, fat, herb, smoke.

ANSWER KEY

1. To reach the Spice Islands (the Moluccas) by a western route, since Portugal controlled the route around Africa. The Victoria, under Elcano, returned with 18 survivors and a cargo of cloves valuable enough to pay for the voyage, completing the first circumnavigation.
2. Cloves: flower buds. Cinnamon: bark. Nutmeg: seed. Black pepper: berry. Ginger: root (underground stem).
3. To warm ground spices briefly in oil before adding liquid. Many aroma compounds dissolve in fat and are released by gentle heat, so the flavor becomes stronger and rounder.
4. At age twelve, he discovered how to pollinate vanilla flowers by hand by lifting the rostellum with a stick and pressing the parts together with his thumb. It made vanilla farming possible outside Mexico, and the method is still used everywhere vanilla is grown.
5. Every flower must be pollinated by hand on the one morning it opens, pods take about nine months to ripen, and they must be cured for months to develop their flavor.
6. Direct heat cooks food right over the fire, fast and hot, for searing. Indirect heat cooks food beside the fire with the lid closed, gently, like an oven. A tenderloin is seared over direct heat for flavor and then finished over indirect heat so the center reaches 145 °F without burning the outside.
7. Any five: outdoors only on a flat spot away from the house, railings, overhangs and dry leaves; only adults light the grill; no liquid charcoal starter ever; young children stay 3 feet back; students grill only with an adult beside them; long tongs, not forks; a lid ready to smother flare-ups; a hose or extinguisher nearby; never leave a lit grill alone; coals cool 24–48 hours before an adult disposes of them in a metal can.
8. $1.1 + 1.2 = 2.3$ pounds. $2.3 \times \$4.80 = \$11.04$. $\$11.04 \div 6 = \$1.84$ per serving.
9. North American and Western European recipes tend to pair ingredients that share many flavor compounds; East Asian recipes often pair ingredients that share few, using contrast.
10. Salt, to brighten the flavors, and acid such as lime juice, to cut the sweetness and make it lively. (A little chili for heat is also a good answer.)
11. $5 \div 2 = 2.5$. $3 \times 2.5 = 7.5$ tablespoons. $7.5 \div 16 \approx 0.47$ cup, a little less than $\frac{1}{2}$ cup.

12. Answers vary. Example: grilled pork tenderloin with herb rub (salt, smoke, herb), grilled corn with butter and lime (sweet, fat, sour), and cucumber-yogurt salad (cool, sour), with a pinch of chili on the corn (heat).

UNIT CHALLENGE: A FAMILY GRILLED (OR BROILED) DINNER WITH A HOMEMADE RUB

Plan, prepare and cook a family dinner on the grill with an adult right beside you, or indoors with a skillet and broiler. Make your own spice rub, and write its recipe with exact measurements and the plant part and home region of each spice. Use a two-zone fire for at least one food, and include a fresh salsa, sauce or side that balances the meal.

Record the safe temperature of each meat, the zones you used, and a timeline of the cooking. After dinner, ask each person to rate the meal and name a flavor pair they liked. Write a one-page reflection with a flavor-balance chart and one improvement for next time.

LOOK FOR	WHAT IT MEANS
Planning	A written menu, shopping list, timeline and a site map for the grill (or a plan for the indoor way).
Safety	Adult lit the grill with no liquid charcoal starter; adult beside the student; raw meat kept separate; temperatures checked and recorded.
Spice rub and flavor balance	Rub recipe measured and written so it can be repeated; a flavor-balance chart for the meal.
Grilling skill	Two-zone fire used correctly; food browned but not burnt and cooked to its safe temperature.
Service and cleanup	Table set, meal served with thanks, kitchen cleaned, and coals left to cool safely.

7.1 MAGELLAN'S VOYAGE AND THE CLOVE ISLANDS

OBJECTIVES

- Tell the story of Magellan's expedition (1519–1522) and why cloves from the Moluccas were worth a voyage around the world.
- Name the plant part each common spice comes from and explain what gives spices their aroma.
- Make clove-and-cinnamon spiced meatballs in tomato sauce, cooked to 160 °F.

Warm-up. With your eyes closed, smell a whole clove, a cinnamon stick, a whole nutmeg and a few black peppercorns. Then crush or grate a little of each and smell again. Which became stronger? Guess which part of a plant each one is: seed, bark, flower bud or berry.

WATCH

Ferdinand Magellan - First Circumnavigation of the Earth

Simple History · 8:21

<https://www.youtube.com/watch?v=ylwiOLab5AA>

WHEN TO WATCH

After The story. Watch the route on the map and listen for what the expedition was looking for.

Note: From Simple History, an animated history channel. It shows, in simple cartoon style, the battle in the Philippines in which Magellan died.

KEY TERMS

spice

A dried seed, fruit, bark, root or flower bud used to flavor food, such as pepper, cinnamon, cloves and nutmeg. Herbs are leaves.

cloves

The dried, unopened flower buds of the clove tree, native to a few small islands in the Moluccas (now part of Indonesia).

Moluccas

The “Spice Islands” of eastern Indonesia, once the world’s only source of cloves and nutmeg.

aromatic compounds

Molecules that evaporate easily and give spices their smell; for example, eugenol in cloves and cinnamaldehyde in cinnamon.

circumnavigation

Sailing all the way around the world.

CORE IDEAS

The story. In the early 1500s, cloves and nutmeg grew on only a handful of tiny islands in the Moluccas, on the far side of the world from Europe. By the time they reached Europe, after passing through many traders’ hands, they were worth more than their weight in silver. Portugal controlled the route east around Africa.

Ferdinand Magellan, a Portuguese sailor working for the king of Spain, proposed reaching the Spice Islands by sailing west. On September 20, 1519, he left Spain with five ships and about 270 men.

How they figured it out. Magellan’s fleet crossed the Atlantic, searched the coast of South America for a passage, and in late 1520 found the narrow, stormy strait at its southern tip that still bears his name. Then they sailed into an ocean so much larger than anyone had imagined that they ran out of food and suffered from scurvy.

Magellan was killed in a battle in the Philippines in April 1521. The surviving crew reached the clove island of Tidore in November 1521 and loaded their ships with cloves. Only one ship, the *Victoria*, commanded by Juan Sebastián Elcano, made it back to Spain, on September 6, 1522, with 18 of the original crew. They had sailed around the world, and the cloves in the hold were valuable enough to pay for the expedition.

The kitchen science. Spices come from many plant parts: cloves are **flower buds**, cinnamon is **bark**, nutmeg is a **seed**, black pepper is a dried **berry**, and ginger is a **root** (an underground stem). Their flavor comes from **aromatic compounds** stored in oil glands. The main aroma in cloves is **eugenol**, strong enough that one clove can flavor a whole pot. Whole spices keep their oils sealed in; grinding releases them, and they fade after months on a shelf. Many oils dissolve in fat, so cooks often

“bloom” ground spices by warming them briefly in oil to wake up their aroma. A little goes a long way, especially with cloves.

Let’s cook. You will make meatballs spiced with a little ground cloves, cinnamon and cumin, in the style of meatballs cooked across the Mediterranean and Middle East, and simmer them in tomato sauce. The skill is **blooming spices** and checking ground meat to **160 °F**.

PICTURE STUDY



Maris Pacifici (Map of the Pacific Ocean), Abraham Ortelius, 1589 · Hand-colored engraved map · Published in Antwerp in Ortelius's atlas *Theatrum Orbis Terrarum*
Image: [Wikimedia Commons](#), public domain

Abraham Ortelius made the first modern atlas. This map of 1589 was the first printed map devoted to the Pacific Ocean, which Magellan named *Mar Pacífico*, the peaceful sea, after his ships crossed it in calm weather. In the middle of the ocean Ortelius drew the ship *Victoria*, with a little poem in Latin praising it as the first to sail around the world.

Look closely

- Find the large ship. What is written near it?
- Find South America and the narrow strait at its southern tip.
- Find the islands on the far left side. Somewhere there are the Spice Islands.
- Look for sea creatures and decorations. Why did mapmakers add them?

Talk about it

1. Trace Magellan's route with your finger. How many months do you think it took to cross this ocean?
2. Why would sailors risk such a voyage for a hold full of dried flower buds?
3. What spices in your kitchen came from far away, and how do they reach you today?

Safety first. Keep raw ground meat on its own board and wash hands after shaping meatballs; cook them to 160 °F in the center. Bloom spices over medium-low heat with an adult nearby; ground spices scorch quickly and can sting the eyes. Whole cloves are sharp and should be removed before serving to small children.

Clove-and-Cinnamon Spiced Meatballs

You will smell-test whole and ground spices, make a spice blend, bloom it in oil, and cook meatballs in tomato sauce, checking them with a thermometer.

You will need

- A large bowl and a raw-meat cutting board
- A rimmed baking sheet lined with foil and lightly oiled
- A large deep skillet or pot with a lid, a wooden spoon
- An instant-read thermometer and oven mitts
- A small dish for the spice blend, and a mortar and pestle if you have one

SPICED MEATBALLS IN TOMATO SAUCE

Serves 6 (about 30 meatballs) · Prep 25 min · Bake 15 min · Simmer 15 min

Ingredients

- **Spice blend:** 1 teaspoon ground cumin, 1 teaspoon ground cinnamon, ½ teaspoon ground coriander, ¼ teaspoon ground cloves, ½ teaspoon black pepper
- **Meatballs:** 1½ pounds (680 g) ground beef (85% lean) or half beef and half ground lamb
- 1 small onion, grated or very finely chopped
- 2 cloves garlic, minced
- ½ cup (30 g) dry bread crumbs
- 1 large egg
- ¼ cup chopped fresh parsley
- 1 teaspoon salt
- **Sauce:** 1 tablespoon olive oil
- 1 onion, chopped
- One 28-ounce (794 g) can crushed tomatoes
- ½ cup (120 mL) water or broth

- ½ teaspoon salt and 1 teaspoon sugar (optional)
- Cooked rice, couscous or pasta and plain yogurt for serving

Method

1. With an adult nearby, heat the oven to 425 °F (220 °C). Mix the spice blend in the small dish.
2. In the large bowl, combine the beef, grated onion, garlic, bread crumbs, egg, parsley, salt and **half** the spice blend. Mix gently with clean hands just until combined. Roll into 1½-inch balls and set them on the oiled baking sheet. Wash your hands and the board.
3. Bake the meatballs 12–15 minutes, until browned. They will finish cooking in the sauce.
4. Meanwhile make the sauce: heat the oil in the skillet over medium heat. Add the chopped onion and cook until soft, 5 minutes. Lower the heat, add the rest of the spice blend, and stir for 30 seconds until fragrant (blooming). Add the tomatoes, water, salt and sugar. Simmer 5 minutes.
5. Add the meatballs to the sauce, cover, and simmer 10 minutes. Check the center of the largest meatball: it must read 160 °F (71 °C).
6. Serve over rice or couscous with a spoonful of yogurt and more parsley. Refrigerate leftovers within 2 hours; reheat to 165 °F.

Allergy check: Contains eggs, wheat (bread crumbs) and milk (yogurt for serving). For egg-free, leave out the egg and add 2 tablespoons milk or water. Use gluten-free crumbs or oats for wheat-free; skip the yogurt for milk-free.

Steps

1. **Smell test.** Record your warm-up results. Then look up and record the plant part and the home region of each spice you smelled.
2. **Blooming test.** Smell a pinch of the spice blend raw. Then smell it right after blooming in the oil. Describe the difference.
3. Make the meatballs and sauce, checking the temperature of three meatballs.
4. **Rate it.** Ask your family to rate the meatballs and how strong the spices were (too little, just right, too much).
5. **Map it.** On a world map or sketch, mark where each spice in your blend first came from.

6. Clean up: wash the bowl, board and baking sheet in hot soapy water; wipe the counter.
7. **Improve it.** Write one change: more or less clove, a pinch of allspice or nutmeg, or using ground turkey (cook to 165 °F).

Tips

- Grating the onion keeps the meatballs moist and tender.
- Wet your hands lightly with water so the meat does not stick when rolling.
- Ground cloves are very strong. Measure carefully; too much tastes medicinal.

Check your work

- ☐ I can tell the story of Magellan's expedition and why cloves were so valuable.
- ☐ I can name the plant part each spice comes from and explain blooming.
- ☐ I made spiced meatballs and checked them to 160 °F.

COOK'S NOTEBOOK

1. Draw Magellan's route on a simple world map, marking Spain, the strait, the Philippines, Tidore and the return route around Africa.
2. Make a spice chart: name, plant part, home region and a smell word for each of six spices.
3. Write the recipe in your own words with your family's ratings.

COMMON MISTAKES

- Using old, faded ground spices. Smell them; if the aroma is weak, the flavor will be too.
- Burning spices while blooming. Use low heat and stir for only 30 seconds before adding liquid.
- Judging meatballs by color. Check the center of the largest one: 160 °F.

Make it a game · Spice Route Map. Draw a map of the Moluccas, Europe and the route Magellan's ships took from 1519 to 1522. Mark where cloves grew. Then name six spices and the plant part each comes from, such as bark, bud, seed or root. Your parent calls a spice, and you answer in five seconds. Explain what gives them aroma.

Scripture. “Take thou also unto thee principal spices, of pure myrrh five hundred shekels, and of sweet cinnamon half so much, even two hundred and fifty shekels, and of sweet calamus two hundred and fifty shekels,” (Exodus 30:23, KJV)

Cinnamon and other precious spices were already treasured in the time of Moses, carried by traders across deserts and seas. God commanded that the finest of them be used in His worship.

7.2 EDMOND ALBIUS AND THE SECRET OF VANILLA

OBJECTIVES

- Tell how a twelve-year-old boy named Edmond Albius discovered a way to pollinate vanilla flowers by hand in 1841.
- Explain where vanilla comes from, why it was so hard to grow outside Mexico, and how real vanilla is cured.
- Make a creamy stovetop vanilla rice pudding, explaining how rice starch thickens it.

Warm-up. Smell a little vanilla extract on a spoon. Describe it in three words. Now taste a tiny drop on your finger. (It tastes bitter, not sweet!) Why do you think something that smells so sweet tastes bitter by itself?

WATCH

How to pollinate the Vanilla orchid, step by step

My Green Pets • 3:10

<https://www.youtube.com/watch?v=1RdoTcDD2EU>

WHEN TO WATCH

After How he figured it out. Watch closely as the grower lifts the flap and presses the pollen into place, exactly as Edmond Albius did.

Note: A short demonstration filmed in a greenhouse.

BACKUP VIDEO

Creamy Rice Pudding Recipe

Preppy Kitchen • 4:34

<https://www.youtube.com/watch?v=f52Pyr6swKQ>

Before you cook. Watch how the rice is simmered slowly and stirred as it thickens.

KEY TERMS

vanilla

The cured seed pods of a climbing orchid native to Mexico and Central America. Its main flavor molecule is vanillin.

rostellum

A thin flap in the vanilla flower that separates the male and female parts. Albius lifted it so the two could be pressed together.

gelatinization

Starch granules soaking up liquid and swelling when heated, which thickens puddings and sauces.

pollination

Moving pollen from the male part of a flower to the female part so that fruit and seeds can form.

curing

The weeks or months of sweating and drying that turn green, flavorless vanilla pods into dark, fragrant vanilla beans.

CORE IDEAS

The story. Vanilla comes from an orchid that grows wild in Mexico, where the Totonac people grew it and the Aztecs flavored chocolate with it. Spanish explorers brought it to Europe in the 1500s, and in the 1800s the French planted vanilla vines on Réunion, a tropical island in the Indian Ocean. The vines grew and flowered beautifully, but almost never made a single pod. On a plantation there lived a boy named Edmond, born in 1829, who was enslaved. His owner, Ferréol Bellier-Beaumont, was an amateur botanist who taught Edmond about plants.

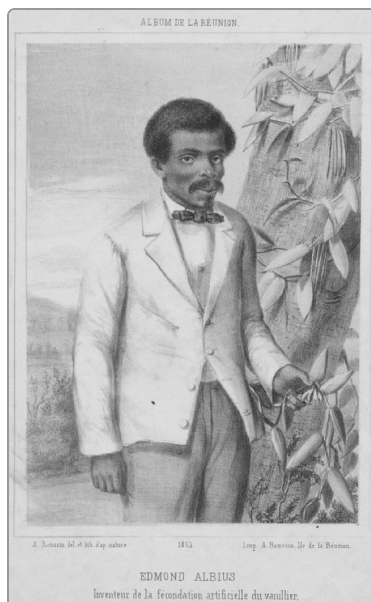
How he figured it out. In 1841 twelve-year-old Edmond noticed something no one else had. Each vanilla flower has a thin flap, the **rostellum**, that keeps its pollen away from the part that receives it. In Mexico certain bees and other insects get past it; on Réunion there were none. Edmond used a small stick or a sliver of bamboo to lift the flap and pressed the two parts together with his thumb. The flower set a pod. Bellier-Beaumont was amazed and had Edmond teach the method to workers across the island. Within decades Réunion and nearby Madagascar became the largest vanilla producers in the world. In 1848, when France abolished slavery, Edmond was freed and took the name Albius. He received little reward and died poor in 1880, but every

vanilla flower grown for market today is still pollinated by hand, using the method of a twelve-year-old boy.

The kitchen science. Each flower opens for only a few hours on one morning, so workers check the vines every day. A pollinated flower makes a green pod that takes about nine months to ripen. The pods have almost no smell until they are **cured**: blanched, sweated and slowly dried for months, so enzymes release the **vanillin** and hundreds of other aroma compounds. That long work is why real vanilla is expensive. Vanilla extract is made by soaking the beans in a liquid that dissolves their flavor. In a rice pudding, the warm milk carries the vanilla's aroma, and the **starch** from the rice gelatinizes, swelling and thickening the milk into a creamy pudding.

Let's cook. You will make a stovetop rice pudding with milk, a little sugar, cinnamon and vanilla. The skill is **gentle simmering and stirring**: low heat, frequent stirring along the bottom, and patience as the rice slowly releases its starch.

PICTURE STUDY



*Edmond Albius, Antoine Roussin, 1863 · Lithograph · From *Album de l'île de la Réunion**

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

This portrait of Edmond Albius was published on Réunion in 1863, when he was a young man in his thirties. The artist drew him beside a vanilla vine, honoring his discovery. It is the only picture of him made during his lifetime.

Look closely

- Find the vanilla vine. How does it grow?
- Look at Albius's face and posture. How did the artist want him to be seen?
- Look at his clothes. What can you tell about the time and place?
- Look for flowers or pods on the vine.

Talk about it

1. Why do you think a twelve-year-old saw what experienced growers had missed?
2. Albius received little reward for his discovery. How should people who make discoveries be honored?
3. What everyday foods would taste different if vanilla could grow only in Mexico?

Safety first. Milk and starch scorch easily: cook over medium-low heat with an adult nearby and stir often, scraping the bottom. Thick pudding holds heat and can bubble and spatter; stir with a long wooden spoon and let it cool a few minutes before tasting. Refrigerate leftovers within 2 hours.

Creamy Vanilla Rice Pudding

You will make rice pudding, measure how much it thickens over time, and compare flavor with and without vanilla.

You will need

- A heavy medium saucepan and a long wooden spoon
- Measuring cups and spoons
- A timer, a ruler or a spoon for a “drip test,” and small bowls

STOVETOP VANILLA RICE PUDDING

Serves 6 • Cook 35–45 min • Cool 15 min

Ingredients

- $\frac{3}{4}$ cup (150 g) medium- or short-grain white rice (such as Arborio), or long-grain rice
- $1\frac{1}{2}$ cups (360 mL) water
- $\frac{1}{4}$ teaspoon salt
- 4 cups (950 mL) whole milk
- $\frac{1}{3}$ cup (65 g) sugar
- $1\frac{1}{2}$ teaspoons vanilla extract, or seeds scraped from $\frac{1}{2}$ vanilla bean
- $\frac{1}{2}$ teaspoon ground cinnamon, plus more for serving
- Optional: $\frac{1}{3}$ cup raisins; fresh berries or sliced peaches for serving

Method

1. With an adult nearby, bring the rice, water and salt to a boil in the saucepan. Lower the heat, cover, and simmer until the water is absorbed, about 12–15 minutes.
2. Stir in the milk and sugar (and vanilla bean seeds, if using). Raise the heat to medium and bring just to a gentle simmer, stirring.
3. Lower the heat to medium-low. Cook uncovered, stirring every 2–3 minutes and scraping the bottom, until the rice is very soft and the

pudding is thick and creamy, 20–30 minutes. Add the raisins for the last 10 minutes if using.

4. Turn off the heat. Stir in the vanilla extract and cinnamon. The pudding will thicken more as it cools.
5. Serve warm or chilled, sprinkled with cinnamon and topped with fruit. Refrigerate leftovers within 2 hours, covered, up to 4 days.

Allergy check: Contains milk. For milk-free pudding, use a creamy oat milk or coconut milk beverage; it will be a little thinner.

Steps

1. **Vanilla taste.** Record the warm-up. Smell real vanilla extract and, if you have it, imitation vanilla. Can you tell the difference?
2. **Thickening log.** Every 5 minutes after adding the milk, dip a spoon, lift it, and record how the pudding drips: thin and fast, slow, or coating the spoon. Note when it changed most.
3. **Vanilla test.** Before adding the vanilla, put 2 tablespoons of pudding in a small bowl. Taste it beside the finished pudding. How much did vanilla change the flavor?
4. **Rate it.** Serve warm and chilled. Ask your family which they prefer and to rate it.
5. **Clean up:** fill the saucepan with warm water right away to soak (milk sticks), then wash it.
6. **Improve it.** Write one change: brown rice (cook longer), nutmeg or cardamom, orange zest or less sugar.

Tips

- Medium- and short-grain rice release more starch and make a creamier pudding.
- A heavy pan spreads the heat evenly and helps prevent scorching.
- If the pudding is too thick after chilling, stir in a little milk.

Check your work

- ☐ I can tell the story of Edmond Albius and his discovery.

- ☐ I can explain how vanilla is pollinated and cured, and how starch thickens the pudding.
- ☐ I made rice pudding without scorching it and recorded how it thickened.

COOK'S NOTEBOOK

1. Draw a vanilla flower with the rostellum labeled, and show how Albius's stick and thumb pollinated it.
2. Draw the steps from flower to pod to cured bean to extract, with the time each step takes.
3. Write the recipe in your own words with your family's ratings.

From history. Before Albius's discovery, the Belgian botanist Charles Morren had pollinated vanilla by hand in a greenhouse in 1836, but his method was slow and not widely used. Albius's quick thumb-and-stick method was simple enough for workers to pollinate a thousand flowers a day.

COMMON MISTAKES

- Cooking rice pudding on high heat. The milk scorches on the bottom; low heat and stirring are the secret.
- Adding vanilla extract at the start of a long simmer. Some of the aroma cooks away; stir it in at the end.
- Thinking the pudding is too thin when it is hot. Starch thickens more as it cools.

Make it a game • Edmond's Secret. Tell the story of Edmond Albius, the twelve-year-old who found how to pollinate vanilla by hand in 1841. Demonstrate the motion with a flower and a toothpick or pencil tip. Your parent asks why vanilla was hard to grow outside Mexico, and you answer. Then explain how real vanilla is cured.

7.3 THE TWO-ZONE GRILL: PORK TENDERLOIN

OBJECTIVES

- Tell how outdoor barbecues were already a part of American life in George Washington’s day, and explain the grill safety rules.
- Explain direct and indirect heat and set up a two-zone fire with an adult.
- Grill (or sear and roast indoors) a pork tenderloin to 145 °F with a 3-minute rest, with an adult beside you.

Warm-up. With your family, walk around your yard or the place where a grill would be used. Find the safest spot: flat, outdoors, at least 10 feet from the house, away from railings, overhangs, fences, dry leaves and play areas. Draw a map and mark the spot and a “kid-free zone” 3 feet around it.

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

Before the adult lights the grill. Watch how the lit coals are poured to one side to make a hot zone and a cool zone.

Note: From Weber Grills, a grill maker’s official channel. It uses a chimney starter, never liquid starter.

BACKUP VIDEO

How To Use Your New Weber Kettle Grill | Weber Grills

Weber Grills · 2:46

<https://www.youtube.com/watch?v=RMu8GH7tWRY>

Watch how the chimney starter is used and the coals are spread before grilling.

KEY TERMS

direct heat

Cooking food right over the coals or burners. Fast and hot; good for searing and for thin foods.

indirect heat

Cooking food beside the fire with the lid closed, so hot air surrounds it like an oven. Good for thicker foods.

two-zone fire

A grill set up with a hot side and a cool side, so food can be seared over direct heat and finished over indirect heat.

chimney starter

A metal cylinder that lights charcoal with crumpled newspaper underneath. No liquid charcoal starter is needed.

silver skin

A thin, shiny, tough membrane on the surface of some cuts like pork tenderloin, trimmed off before cooking.

CORE IDEAS

The story. Cooking meat over glowing coals outdoors is one of the oldest kinds of cooking, and in colonial Virginia a “barbecue” was already a favorite community gathering. George Washington’s diaries mention barbecues he attended in the 1760s and 1770s; in May 1769 he wrote that he went to one in Alexandria and stayed all night. In those days a whole hog or side of beef was cooked slowly over a pit of coals for many hours. Backyard grills for families came much later, after the Second World War, with the charcoal briquette and the covered kettle grill.

How they figured it out. Pitmasters long knew that food cooks differently right over the fire and off to the side. Over the coals, radiant heat is intense: the outside browns fast, but a thick piece can burn before the center is cooked. Off to the side with a lid closed, hot air circulates around the food by convection, cooking it gently like an oven. The modern answer is the **two-zone fire**: all the coals on one side, none on the other. Sear over the hot side for flavor and grill marks, then move the food to the cool side, close the lid, and let it finish evenly. On a gas grill, turn the burners on high on one side and off on the other.

The kitchen science. A pork tenderloin is a long, lean, tender muscle, about 1½–2 inches thick: too thick to cook through over direct heat without charring, but perfect

for two zones. Sear it on all sides over direct heat, then finish it over indirect heat until the thickest part reads 145 °F (63 °C), and rest it 3 minutes. Because it is lean, it dries out quickly if overcooked, so the thermometer matters. **Grill rules:** outdoors only, on a flat spot away from the house, railings, overhangs and dry leaves; **only adults light the grill**, with a chimney starter or gas, and **no one uses liquid charcoal starter**; long tongs, never a fork; a lid ready to smother flare-ups; a hose or extinguisher nearby; never leave a lit grill alone; coals cool for 24–48 hours before an adult empties them into a metal can.

Let's cook. This year, after an adult lights the grill, **you may grill with the adult right beside you.** You will help set up the two zones, sear the tenderloin, move it to the cool side, and check it with the thermometer. No grill? Sear it in an oven-safe skillet on the stove and finish it in a 400 °F oven. The skill is **managing two zones** and moving food with long tongs.

PICTURE STUDY



Saying Grace Before the Barbecue Dinner, Pie Town Fair, Russell Lee, for the Farm Security Administration, 1940 · Photograph · Library of Congress, Washington, D.C.

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

In 1940 the photographer Russell Lee visited Pie Town, New Mexico, a small community of homesteading families. At their fair, the men cooked meat outdoors over a fire for hours, and the whole town shared a free barbecue dinner. Before anyone ate, they stood and gave thanks together. Grilling and barbecue have always been about feeding people together.

Look closely

- Look at the men's hats. What are they doing with them, and why?
- Look at the children. How are they standing?
- Count how many different ages you can see: children, parents, grandparents.
- Look at the cars and the field. What can you tell about the time and place?

Talk about it

1. How would the cooks at this barbecue have kept such a big fire safe with so many children around?
2. Why do you think barbecues became favorite community gatherings?
3. How does stopping to give thanks change the way people eat a meal?

Safety first. Only an adult lights the grill, using a chimney starter or gas, and no one ever uses liquid charcoal starter. Grill outdoors on a flat spot away from the house, railings, overhangs and dry leaves; younger children stay 3 feet back; you grill only with an adult right beside you, using long tongs and oven mitts, with a lid ready for flare-ups and a hose or extinguisher nearby. Cook pork to 145 °F with a 3-minute rest, and never leave a lit grill alone.

KITCHEN PROJECT

Two-Zone Grilled Pork Tenderloin

You will map the grill's hot and cool zones, grill a pork tenderloin with an adult beside you, and record its temperature in each zone.

You will need

- A charcoal grill with a chimney starter (adult) or a gas grill; or for indoors, an oven-safe skillet
- Long-handled tongs, heatproof grill mitts and a clean platter
- An instant-read thermometer and a timer
- A raw-meat cutting board, a paring knife and a small bowl for the rub
- A hose or fire extinguisher nearby

GRILLED PORK TENDERLOIN WITH HERB RUB

Serves 4–6 • Prep 15 min • Grill 18–25 min • Rest 5 min

Ingredients

- 2 pork tenderloins, about 1 to 1¼ pounds (450–570 g) each
- 1 tablespoon olive oil
- **Herb rub:** 1½ teaspoons salt
- 1 teaspoon brown sugar
- 1 teaspoon paprika
- 1 teaspoon garlic powder
- 1 teaspoon dried thyme or rosemary, crumbled
- ½ teaspoon black pepper
- **To serve:** grilled vegetables or a green salad, and a spoonful of mustard or applesauce

Method

1. Mix the rub ingredients in the small bowl. With an adult beside you, slide the paring knife under the silver skin on the tenderloins and trim it away, angling the blade up. Fold the thin tail end under and tie or tuck it so the meat is evenly thick.

2. Pat the tenderloins dry, rub with oil, and coat with the rub. Wash your hands and the board.
3. **Grill:** An adult lights a chimney of charcoal and, when the coals are covered with gray ash, pours them onto one side of the grill (or turns one side of a gas grill to high and leaves the other off). Replace the grate, close the lid and heat 5 minutes.
4. With the adult beside you, use long tongs to place the tenderloins over the hot side. Sear 2–3 minutes per side, turning to brown all four sides, about 10 minutes in all.
5. Move them to the cool side, close the lid, and cook 8–15 minutes more, until the thickest part reads 145 °F (63 °C). Move them to a clean platter and rest 3–5 minutes before slicing into ½-inch medallions.
6. **Indoor way:** With an adult nearby, heat the oven to 400 °F (200 °C). Sear the tenderloins in 1 tablespoon oil in an oven-safe skillet over medium-high heat, turning to brown all sides, 6–8 minutes. Move the skillet to the oven and roast 10–15 minutes to 145 °F. Use oven mitts; the handle stays hot.
7. Refrigerate leftovers within 2 hours. An adult lets charcoal cool completely, 24–48 hours, before emptying it into a metal can.

Allergy check: Contains none of the nine major allergens. Check any mustard or sauce served alongside.

Steps

1. **Site map.** Finish the warm-up map with the grill spot, the kid-free zone, the hose or extinguisher and the path to the kitchen.
2. **Zone check.** With the grill heated, the adult holds a hand about 5 inches above the grate and counts seconds until it is too hot, first over the hot side, then over the cool side. Record both. (2–4 seconds is high heat; 5–7 is medium.)
3. Grill the tenderloin with the adult beside you. Record its temperature when you move it to the cool side and every 3 minutes after.
4. **Rest and slice.** Record the temperature after the 3-minute rest. Look at the slices: is the center slightly pink and juicy? That is correct and safe at 145 °F.
5. **Rate it.** Ask your family to rate the tenderloin and the rub.

6. Clean up: wash the board, tongs and platter; the adult brushes the grate clean once it has cooled enough and shuts off the grill or closes the vents.
7. **Improve it.** Write one change: a longer sear, a different rub, brining it first (Lesson 5.4), or a glaze brushed on in the last 5 minutes.

Tips

- Leave the lid closed as much as you can. Every peek lets heat escape.
- Sugary rubs and glazes burn easily over direct heat. Keep the sugar small, or add glazes only at the end over the cool side.
- Two tenderloins cook more evenly than one big pork loin and are easier to turn.

Check your work

- ☐ I can explain direct and indirect heat and set up a two-zone fire with an adult.
- ☐ I know and follow every grill safety rule, including that only adults light the grill and no liquid charcoal starter is used.
- ☐ I grilled (or seared and roasted) pork tenderloin to 145 °F with an adult beside me.

COOK'S NOTEBOOK

1. Draw a kettle grill from above, showing the hot zone and cool zone, and where the tenderloin goes at each step.
2. Write the grill safety rules in your own words as a poster for the grill area.
3. Write the recipe in your own words with your temperature log and family ratings.

From history. Charcoal briquettes became popular after Henry Ford's company began making them in the 1920s from the wood scraps left over from building car bodies. The business later took the name of Edward Kingsford, a relative of Ford who helped find the site for the factory in Michigan.

COMMON MISTAKES

- Using liquid charcoal starter or squirting it on coals. It is dangerous and never needed; adults use a chimney starter or a gas grill.
- Cooking a thick piece of meat only over direct heat. It chars outside before the center is done; finish it on the cool side.

- Poking meat with a fork to turn it. Use long tongs; a fork lets juices run out and brings your hand too close.

Make it a game · Two-Zone Setup Quiz. Draw your grill from above and mark the hot and cool zones. Your parent calls out a cut of meat, such as pork tenderloin, and you decide the order: sear first or cook gently first. List every grill safety rule you can in sixty seconds. Mention the chimney starter and silver skin, and the adult who lights it.

7.4 PAIRING FLAVORS: GRILLED CHICKEN WITH MANGO SALSA

OBJECTIVES

- Describe what a 2011 study of tens of thousands of recipes found about how cooks in different regions pair ingredients.
- Explain complementary and contrasting flavors and how cooks balance salt, sweet, sour, bitter, heat and fat.
- Grill or broil chicken thighs to 165 °F and make a mango salsa that balances five kinds of flavor.

Warm-up. Set out a slice of mango or another sweet fruit. Taste it plain. Then taste it with a tiny pinch of salt, then with a squeeze of lime, then with a sprinkle of chili powder. (Check for allergies first.) What did each one change?

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 How they figured it out. Listen for the 2011 flavor-network study and the difference between shared and contrasting flavors.

Note: From a food scientist who teaches on her own channel.

KEY TERMS

complementary flavors

Flavors that share some aroma compounds or support each other, so they taste harmonious together, like tomato and basil.

contrasting flavors

Flavors that are different and balance each other, like sweet and salty, rich and sour, or spicy and cool.

balance

A dish in which no single taste overwhelms the others.

capsaicin

The compound in chili peppers that creates a burning feeling. It is concentrated in the white ribs and seeds.

salsa

Spanish for “sauce.” A fresh salsa is a chopped mixture of fruit or vegetables, herbs, acid and often chili.

CORE IDEAS

The story. Why does tomato taste so good with basil, or chocolate with strawberries? In 2011 a team of scientists led by Yong-Yeol Ahn, a physicist who studies networks, set out to look for patterns. They gathered more than 56,000 recipes from cookbook and recipe websites and listed the main flavor compounds found in each of hundreds of ingredients, using chemistry databases.

How they figured it out. The team built a “flavor network,” a map linking every ingredient to every other ingredient that shares flavor compounds with it. Then they compared the map with real recipes. In North American and Western European recipes, cooks tended to pair ingredients that **share** many flavor compounds, like milk, butter and eggs, or tomato and basil. In East Asian recipes, cooks often did the opposite, pairing ingredients that share **few** compounds, like soy sauce, ginger and green onion, for contrast. Both approaches make delicious food. The study did not give a single rule; it showed that cooks around the world use both harmony and contrast.

The kitchen science. A balanced dish usually has several tastes and sensations working together. **Salt** brightens and reduces bitterness. **Acid** (lime, vinegar) cuts richness and makes flavors pop. **Sweetness** balances heat, sourness and bitterness. **Fat** carries aromas and softens spicy heat. **Heat** from chili adds excitement; **cool** things like cucumber, yogurt or avocado calm it. **Herbs** add fresh aroma. A mango salsa on smoky grilled chicken has nearly all of these: sweet mango, sour lime, salty seasoning, a little chili heat, fresh cilantro, and the rich, browned chicken underneath. When a dish tastes flat, ask which of these is missing.

Let's cook. You will grill marinated chicken thighs with an adult beside you, or broil them indoors, and make a fresh mango salsa, tasting and adjusting it one ingredient at a time. The skill is **tasting and balancing**, and cutting a mango and a jalapeño safely.

PICTURE STUDY



East Indian Market Stall, Attributed to Albert Eckhout, c. 1640s · Oil on canvas · Rijksmuseum, Amsterdam

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

In the 1600s Dutch artists traveled with merchant ships to Brazil and the East Indies and painted the plants and foods they found, so that people back home could see them. This market stall is heaped with tropical fruits, many of them, like mangoes, unknown in Europe at the time. Each fruit has its own sweetness, sourness and aroma, a whole palette of flavors for a cook to pair.

Look closely

- How many different fruits can you count? Which ones can you name?
- Find a fruit that looks sweet and one that looks sour or sharp.
- Look at how the fruits are piled. Why would a seller arrange them this way?
- Look at the textures: smooth, bumpy, spiky, hairy. How did the painter show each one?

Talk about it

1. Choose two fruits from this stall that you think would taste good together. Is that pairing harmony or contrast?
2. Why would a painting like this have amazed people in Amsterdam in the 1600s?

3. Which of these fruits could go into a salsa with grilled chicken?

Safety first. Only an adult lights the grill, with no liquid charcoal starter; you grill with the adult beside you using long tongs, and the indoor broiler is used with an adult nearby, rack 5–6 inches from the heat. Cook chicken to 165 °F and keep the raw marinade away from cooked food. Wear gloves or wash your hands right after cutting the jalapeño, and never touch your eyes; capsaicin burns.

KITCHEN PROJECT

Grilled Chicken Thighs with Mango Salsa

You will make a mango salsa in stages, tasting after each addition, and grill or broil marinated chicken thighs. Then you will make a flavor-balance chart for the meal.

You will need

- A chef's knife, a paring knife and two cutting boards (one for raw chicken)
- A bowl or bag for marinating and a medium bowl for salsa
- Thin disposable gloves for the jalapeño (optional)
- A grill (lit by an adult) with long tongs, or a broiler pan or foil-lined rimmed baking sheet
- An instant-read thermometer and a clean platter

LIME-GARLIC CHICKEN THIGHS WITH FRESH MANGO SALSA

Serves 4–6 • Prep 25 min • Marinate 30 min–4 hr • Cook 12–16 min

Ingredients

- 2 pounds (900 g) boneless, skinless chicken thighs
- **Marinade:** 3 tablespoons olive oil, 3 tablespoons lime juice, 2 cloves garlic minced, 1 teaspoon ground cumin, 1 teaspoon paprika, 1 teaspoon salt, ½ teaspoon black pepper
- **Mango salsa:** 2 ripe mangoes, peeled and diced (about 2 cups)
- ½ red bell pepper, finely diced
- ¼ cup finely chopped red onion
- ½ small jalapeño, seeds and ribs removed, minced (or less, to taste)
- ¼ cup chopped cilantro
- 2 tablespoons lime juice (1 lime)
- ¼ teaspoon salt
- Rice and black beans, or warm tortillas, for serving

Method

1. Whisk the marinade in the bowl. Add the chicken, turn to coat, cover and refrigerate 30 minutes to 4 hours. Wash your hands.
2. Make the salsa in stages: put the mango in the bowl and taste a piece. Add the bell pepper and onion; taste. Add the lime juice and salt; taste. Add the jalapeño a little at a time, tasting after each. Stir in the cilantro. Refrigerate until serving.
3. **Grill:** An adult lights the grill and sets up medium-high direct heat (about 400–450 °F). With the adult beside you, lift the chicken from the marinade with tongs (throw the marinade away) and lay it on the grate. Grill 5–7 minutes per side, turning once with long tongs, until the thickest piece reads 165 °F (74 °C).
4. **Indoor way:** With an adult nearby, set the oven rack 5–6 inches from the broiler and heat the broiler. Lay the chicken on the foil-lined pan and broil 6–8 minutes per side to 165 °F.
5. Move the chicken to a clean platter and rest 5 minutes. Serve topped with mango salsa, with rice and beans or tortillas.
6. Refrigerate leftovers within 2 hours; salsa keeps 2 days.

Allergy check: Contains none of the nine major allergens as written. Mango is related to cashews and pistachios, and a few people with those allergies react to mango skin; an adult can peel the mangoes.

Steps

1. **Fruit test.** Record what salt, lime and chili each did to the taste of the mango in the warm-up.
2. **Salsa in stages.** As you build the salsa, rate it after each addition for sweet, sour, salty, heat and freshness (1–5). How did the balance change?
3. Grill or broil the chicken, checking each piece to 165 °F.
4. **Flavor-balance chart.** Draw a chart of the finished plate and label where each kind of flavor comes from: sweet, sour, salty, bitter, heat, cool, fat, herb, smoke.
5. **Rate it.** Ask your family to rate the chicken with and without the salsa.
6. **Clean up:** throw away the marinade, wash the raw-chicken board and tongs, wipe the counter, and wash your hands well after the jalapeño.

7. **Improve it.** Write one change: pineapple or peach instead of mango, avocado for creaminess, or a different herb.

Tips

- A mango has a long, flat pit in the middle. Stand it on its end and cut down each side of the pit to get two “cheeks.”
- Most of a chili’s heat is in the white ribs and seeds. Remove them for a milder salsa.
- Chicken thighs stay juicy on the grill and are hard to overcook; they are even better at 175 °F.

Check your work

- ☐ I can describe what the 2011 flavor-network study found.
- ☐ I can explain complementary and contrasting flavors and balance a dish by tasting.
- ☐ I grilled or broiled chicken to 165 °F with an adult and made a balanced salsa.

COOK’S NOTEBOOK

1. Draw a small flavor network: five ingredients you love, with lines between the ones that taste good together. Label each line “harmony” or “contrast.”
2. Copy your salsa-stage ratings as a chart.
3. Write the recipe in your own words with your family’s ratings.

COMMON MISTAKES

- Adding all the chili at once. Add a little, taste, and add more; you cannot take heat out.
- Touching your eyes after cutting a hot pepper. Wash your hands with soap right away, or wear gloves.
- Using the raw-chicken marinade as a sauce. Throw it away, or boil a separate portion that never touched raw chicken.

Make it a game • Pairing Study Cards. Make cards for salt, sweet, sour, bitter, heat and fat. Draw two and decide whether they complement or contrast, then name a dish that uses them, such as chicken with mango salsa. Describe what the 2011 study of tens of thousands of recipes found about regional pairings. Win a point for each justified match.

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

Balancing a dish, grilling safely, and serving others well are all small ways to honor God with ordinary work.

UNIT 7

FIRE, THE GRILL & SPICE

This is the fun unit, full of smoke, fire and fragrance. You will sail around the world with Magellan's fleet in search of the islands where cloves grow, and meet Edmond Albius, a twelve-year-old boy on the island of Réunion who discovered in 1841 how to pollinate vanilla flowers by hand, making vanilla possible to grow outside Mexico. You will cook a clove-and-cinnamon meatball supper and a creamy vanilla rice pudding.

Then you will step up to the grill. This year, after an adult lights it, **you may grill with an adult right beside you.** You will learn to build a two-zone fire, sear over direct heat and finish over indirect heat, and cook pork tenderloin to 145 °F. Last, you will look at what food scientists have learned about why some flavors go together, and grill chicken with a mango salsa that balances sweet, sour, salty, heat and herb. Every grill recipe has an **indoor way**, with a skillet, grill pan or broiler, for families without a grill.

PREREQUISITES

- Knows the fire triangle and that a grease fire is smothered, never doused with water (earlier grades)
- Knows the safe temperatures: pork 145 °F with a 3-minute rest, ground beef 160 °F, chicken 165 °F (Unit 1)
- Knows the Maillard reaction and searing (Units 4 and 5)
- Can use a chef's knife and the stove and oven with an adult nearby

MASTERY CHECKLIST

- ☐ I can tell the story of Magellan's voyage and the clove islands, and name where common spices come from.
- ☐ I can tell how Edmond Albius discovered hand-pollination of vanilla and why it mattered.
- ☐ I can set up a two-zone grill with an adult, explain direct and indirect heat, and follow every grill safety rule.
- ☐ I can grill or broil meat to its safe temperature with an adult beside me.
- ☐ I can balance a dish using complementary and contrasting flavors.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **NFPA: Grilling safety:** Free. Grilling safety tips and a printable tip sheet from the National Fire Protection Association. Read together before Lesson 7.3.
- **For the adult griller: a chimney starter and long-handled tongs:** A chimney starter lights charcoal with crumpled newspaper, so no liquid starter is ever needed. A gas grill needs neither. Not required: every recipe also works indoors.
- **Whole spices: cloves, cinnamon sticks, black peppercorns, nutmeg:** Optional but fun for the smell tests in Lesson 7.1. Many grocery stores sell small amounts in the bulk aisle.

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	Magellan's Voyage and the Clove Islands	2 sessions of 50–60 minutes
7.2	Edmond Albius and the Secret of Vanilla	2 sessions of 50–60 minutes
7.3	The Two-Zone Grill: Pork Tenderloin	2 sessions of 60–90 minutes
7.4	Pairing Flavors: Grilled Chicken with Mango Salsa	2 sessions of 50–60 minutes

UNIT 7 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. 8 pts

Why did Magellan's expedition sail west in 1519, and what did the *Victoria* bring back in 1522?

2. 8 pts

Match each spice with its plant part: cloves, cinnamon, nutmeg, black pepper, ginger.

3. 8 pts

What does it mean to “bloom” spices, and why does it work?

4. **8 pts**

What did Edmond Albius discover in 1841, and why did it matter?

5. **8 pts**

Why is real vanilla so expensive?

6. **8 pts**

Explain direct and indirect heat and why a two-zone fire is useful for a pork tenderloin.

7. **10 pts**

List five grill safety rules from this unit.

8. **8 pts**

Calculation: two pork tenderloins weigh 1.1 pounds and 1.2 pounds. Pork tenderloin costs \$4.80 per pound. The meal serves 6. What is the cost of the pork, and the pork cost per serving? Show your work.

9. **8 pts**

What did Yong-Yeol Ahn's 2011 study find about North American and East Asian recipes?

10. **8 pts**

Predict: your salsa tastes flat and too sweet. What two ingredients could you add, and why?

11. **8 pts**

Calculation: a marinade recipe for 2 pounds of chicken uses 3 tablespoons of lime juice. How much lime juice do you need for 5 pounds? Give the answer in tablespoons and in cups (16 tablespoons = 1 cup).

12. **10 pts**

Written answer: Plan a balanced grilled dinner for your family. Name the main dish, a side and a topping or sauce, and explain how the meal balances at least four of these: salt, sweet, sour, heat, cool, fat, herb, smoke.

ANSWER KEY

1. To reach the Spice Islands (the Moluccas) by a western route, since Portugal controlled the route around Africa. The Victoria, under Elcano, returned with 18 survivors and a cargo of cloves valuable enough to pay for the voyage, completing the first circumnavigation.
2. Cloves: flower buds. Cinnamon: bark. Nutmeg: seed. Black pepper: berry. Ginger: root (underground stem).
3. To warm ground spices briefly in oil before adding liquid. Many aroma compounds dissolve in fat and are released by gentle heat, so the flavor becomes stronger and rounder.
4. At age twelve, he discovered how to pollinate vanilla flowers by hand by lifting the rostellum with a stick and pressing the parts together with his thumb. It made vanilla farming possible outside Mexico, and the method is still used everywhere vanilla is grown.
5. Every flower must be pollinated by hand on the one morning it opens, pods take about nine months to ripen, and they must be cured for months to develop their flavor.
6. Direct heat cooks food right over the fire, fast and hot, for searing. Indirect heat cooks food beside the fire with the lid closed, gently, like an oven. A tenderloin is seared over direct heat for flavor and then finished over indirect heat so the center reaches 145 °F without burning the outside.
7. Any five: outdoors only on a flat spot away from the house, railings, overhangs and dry leaves; only adults light the grill; no liquid charcoal starter ever; young children stay 3 feet back; students grill only with an adult beside them; long tongs, not forks; a lid ready to smother flare-ups; a hose or extinguisher nearby; never leave a lit grill alone; coals cool 24–48 hours before an adult disposes of them in a metal can.
8. $1.1 + 1.2 = 2.3$ pounds. $2.3 \times \$4.80 = \$11.04$. $\$11.04 \div 6 = \$1.84$ per serving.
9. North American and Western European recipes tend to pair ingredients that share many flavor compounds; East Asian recipes often pair ingredients that share few, using contrast.
10. Salt, to brighten the flavors, and acid such as lime juice, to cut the sweetness and make it lively. (A little chili for heat is also a good answer.)
11. $5 \div 2 = 2.5$. $3 \times 2.5 = 7.5$ tablespoons. $7.5 \div 16 \approx 0.47$ cup, a little less than $\frac{1}{2}$ cup.

12. Answers vary. Example: grilled pork tenderloin with herb rub (salt, smoke, herb), grilled corn with butter and lime (sweet, fat, sour), and cucumber-yogurt salad (cool, sour), with a pinch of chili on the corn (heat).

UNIT CHALLENGE: A FAMILY GRILLED (OR BROILED) DINNER WITH A HOMEMADE RUB

Plan, prepare and cook a family dinner on the grill with an adult right beside you, or indoors with a skillet and broiler. Make your own spice rub, and write its recipe with exact measurements and the plant part and home region of each spice. Use a two-zone fire for at least one food, and include a fresh salsa, sauce or side that balances the meal.

Record the safe temperature of each meat, the zones you used, and a timeline of the cooking. After dinner, ask each person to rate the meal and name a flavor pair they liked. Write a one-page reflection with a flavor-balance chart and one improvement for next time.

LOOK FOR	WHAT IT MEANS
Planning	A written menu, shopping list, timeline and a site map for the grill (or a plan for the indoor way).
Safety	Adult lit the grill with no liquid charcoal starter; adult beside the student; raw meat kept separate; temperatures checked and recorded.
Spice rub and flavor balance	Rub recipe measured and written so it can be repeated; a flavor-balance chart for the meal.
Grilling skill	Two-zone fire used correctly; food browned but not burnt and cooked to its safe temperature.
Service and cleanup	Table set, meal served with thanks, kitchen cleaned, and coals left to cool safely.

UNIT 8

MEAL PLANNING & THE FAMILY TABLE

A cook who can follow a recipe can make a dish. A cook who can plan can feed a family. In this last unit you will meet three women who taught America to plan and cook well. Irma Rombauer, a widow in St. Louis, self-published a cookbook in 1931 that became the most famous American kitchen book of the century. Ellen Swallow Richards, the first woman to study at MIT, brought chemistry into the home and helped found the field of home economics. Hazel Stiebeling, a USDA scientist, designed food plans in 1933 that showed families how to eat well at different costs.

You will learn to read and scale a recipe, plan a week of balanced meals, shop with a list and a budget, compare unit prices, cook for leftovers, and waste as little as possible. Then, in the final week, you will plan and cook a full family feast with a menu and a timeline, set the table, welcome your family and give thanks. Everything you have learned this year comes to the table.

PREREQUISITES

- Can cook several dishes from earlier units safely with an adult nearby
- Can scale a recipe up and down using multiplication and fractions
- Knows the MyPlate food groups and how to plan a balanced day (Unit 2)
- Can make a white sauce or gravy, or is ready to learn one in Lesson 8.1

MASTERY CHECKLIST

- ☐ I can tell the stories of Irma Rombauer, Ellen Swallow Richards and Hazel Stiebeling.
- ☐ I can read a recipe all the way through, scale it, and make a roux-thickened sauce.
- ☐ I can plan a week of balanced family meals with a shopping list that uses leftovers wisely.
- ☐ I can compare unit prices and calculate cost per serving.
- ☐ I can plan and cook a family feast with a menu, timeline and budget, set the table and lead or join in giving thanks.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA MyPlate: Shop Simple and Kitchen Timesavers:** Free. MyPlate’s planning tools include tips for budget shopping and planning meals. Useful for Lessons 8.2 and 8.3.
- **USDA Food Plans: Cost of Food Reports:** Free. Monthly USDA reports on what nutritious meals cost at four levels for families of different sizes. Parents may find them useful for the unit challenge.
- ***Joy of Cooking* (any edition):** Optional. The Rombauer-Becker family’s site for the book. Libraries usually have older editions, which are fun to compare with new ones.

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 Irma Rombauer and *The Joy of Cooking*: Chicken Pot Pie

2 sessions of 60–90 minutes

8.2 Ellen Swallow Richards and a Weekly Menu Plan

2 sessions of 60–90 minutes

8.3 Hazel Stiebeling’s Food Plans: Eating Well on a Budget

2 sessions of 50–60 minutes

8.4 The Family Feast

2 sessions of 60–90 minutes, plus the feast

UNIT 8 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

How did Irma Rombauer’s *The Joy of Cooking* begin, and what was her “action method”?

2. **8 pts**

What is a roux, and how does it thicken a sauce?

3. **8 pts**

Who was Ellen Swallow Richards, and name two things she did for American kitchens.

4. **8 pts**

What are planned-overs? Give an example.

5. **8 pts**

How long are cooked leftovers safe in the refrigerator, and to what temperature should they be reheated?

6. **8 pts**

What did Hazel Stiebeling and Medora Ward publish in 1933, and why?

7. **10 pts**

Calculation: a 24-ounce jar of pasta sauce costs \$3.36, and a 45-ounce jar costs \$5.40. Find each unit price. Which is the better buy?

8. **10 pts**

Calculation: your pasta e fagioli used ingredients costing \$1.20 (vegetables), \$2.20 (beans), \$1.25 (tomatoes), \$1.80 (broth), \$0.60 (pasta), \$0.40 (oil and seasonings) and \$1.00 (cheese). It serves 8. What is the total cost and the cost per serving?

9. **8 pts**

Calculation: dinner is at 6:00 p.m. The chicken roasts 45 minutes and rests 10 minutes; the oven takes 15 minutes to heat. When must you turn on the oven, and when must the chicken go in?

10. **8 pts**

Where do the fork, knife and spoon go in a simple place setting? Which way does the knife blade face?

11. **8 pts**

What did Abraham do when the three visitors came (Genesis 18), and what does it teach about hospitality?

12. **8 pts**

Written answer: Describe your plan for the family feast. Explain how the menu is balanced, how you will keep the food safe, and how you will make your family feel welcome.

ANSWER KEY

1. After her husband died in 1930, she collected and tested her favorite recipes and self-published 3,000 copies in 1931, illustrated by her daughter Marion. The action method (1943) names each ingredient in the instructions right where it is used.
2. Equal parts fat and flour cooked together. The fat coats the flour so it does not clump when liquid is whisked in; as the sauce heats, the starch granules swell and burst (gelatinize), thickening it.
3. The first woman to graduate from MIT (1873), a chemist who founded home economics. Any two: the New England Kitchen (1890), the Rumford Kitchen at the 1893 Chicago fair, Boston school lunches, the Lake Placid conferences, first president of the American Home Economics Association (1908), teaching about clean water and nutrition.
4. Extra food cooked on purpose to become a different meal later in the week. Example: chili served one night and over baked potatoes later; roast chicken that becomes pot pie.
5. 3–4 days; reheat to 165 °F.
6. Food plans at four levels of cost and nutrition, showing what a family needed to buy each week to eat well at each cost, to help families and relief agencies during the Great Depression.
7. $\$3.36 \div 24 = \$0.14$ per ounce. $\$5.40 \div 45 = \$0.12$ per ounce. The 45-ounce jar is the better buy (if it will be used before it spoils).
8. Total = $1.20 + 2.20 + 1.25 + 1.80 + 0.60 + 0.40 + 1.00 = \$8.45$. Per serving: $\$8.45 \div 8 \approx \$1.06$.
9. Chicken out by 5:50 (6:00 – 10 minutes rest). In by 5:05 (5:50 – 45 minutes). Oven on by 4:50 (5:05 – 15 minutes).
10. Fork on the left of the plate; knife on the right with the blade facing the plate; spoon to the right of the knife. (Napkin on the left or on the plate; glass above the knife.)
11. He ran to meet them, invited them to rest, had Sarah bake cakes, prepared a tender calf, served butter and milk, and stood by them while they ate. It teaches that hospitality is generous, quick, joyful and shared by the whole household.
12. Answers vary. A good answer names at least four dishes covering the food groups, explains temperatures and keeping hot food hot and cold food cold,

includes a timeline idea, and describes setting the table, greeting guests and giving thanks.

UNIT CHALLENGE: THE FAMILY FEAST

Plan, shop for, cook and host a family feast. Your portfolio includes a menu card; a shopping list with a budget, unit prices and the final cost per person; a timeline from the day before to the moment of serving, with what actually happened marked beside it; and a temperature log for every dish that needs one.

Set the table, welcome your family, lead or join in grace, and serve the meal. Afterward, collect a rating and a comment for each dish, and write a thank-you note to someone who taught you to cook this year. Finish with a one-page reflection on your year as a cook.

LOOK FOR	WHAT IT MEANS
Planning	A balanced menu of at least four dishes (three from this year), a shopping list, budget and realistic timeline.
Cooking and safety	Dishes cooked well and safely with an adult nearby; temperatures checked and recorded; leftovers stored within 2 hours.
Timing	Dishes ready together and served close to the planned time; the timeline compared honestly with what happened.
Hospitality	Table set neatly, guests welcomed warmly, thanks given, and the cook sat down with the family.
Reflection and cleanup	A thoughtful reflection on the feast and the year, a thank-you note written, and the kitchen left clean.

8.1 IRMA ROMBAUER AND *THE JOY OF COOKING*: CHICKEN POT PIE

OBJECTIVES

- Tell how Irma Rombauer wrote and self-published *The Joy of Cooking* in 1931.
- Read a recipe all the way through before starting, scale it, and organize the work with *mise en place*.
- Make a chicken pot pie with a roux-thickened sauce and a biscuit topping.

Warm-up. Look through any cookbook in your home, or an old family recipe card. Find one recipe and read it all the way through. List every piece of equipment it needs and every step that takes waiting time. What would happen if you started cooking without reading to the end?

WATCH

"Joy of Cooking" and its recipe for success

CBS Sunday Morning · 4:57

<https://www.youtube.com/watch?v=kSeseACJK1Y>

WHEN TO WATCH

After The story. Listen for how the book began and how the family kept it going.

Note: A short news feature from CBS Sunday Morning.

BACKUP VIDEO

How to Make an Easy Yet Ultra-Comforting Double-Crusted Chicken Pot Pie

America's Test Kitchen · 12:50

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

Before you cook. Watch how the sauce is thickened and how the pie is assembled.

KEY TERMS

mise en place

French for “everything in its place.”
Measuring and preparing every ingredient and tool before you begin to cook.

white sauce

A sauce made by whisking milk into a roux; in French cooking, béchamel.
With broth instead of milk it is called a velouté.

roux

Equal parts fat and flour cooked together, then whisked with liquid to make a smooth, thick sauce. The starch in the flour gelatinizes.

scaling

Multiplying or dividing every ingredient in a recipe by the same number to make more or fewer servings.

self-publish

To pay to print and sell your own book instead of having a publishing company do it.

CORE IDEAS

The story. Irma Rombauer was a homemaker in St. Louis, Missouri, known among her friends as a lively hostess but not as a great cook. After her husband died in 1930, she was fifty-two, grieving, and short of money. Her children encouraged her to collect her favorite recipes into a book. She tested and rewrote them, and her daughter, Marion, an artist, drew the illustrations. In 1931 Irma spent about half of her savings to have a local printing company print 3,000 copies of *The Joy of Cooking*, and she sold them herself from her apartment.

How she figured it out. Rombauer wrote the way she talked, warmly and with humor, as if she were standing beside the reader in the kitchen. She included simple everyday dishes alongside party food, and she assumed her readers might be new to cooking. A publisher brought out an expanded edition in 1936, and in 1943 she introduced a new way of writing recipes, the “action method,” in which each ingredient appears in the instructions right where it is used. Marion later became her co-author, and Marion’s son and grandson carried on the book. *Joy of Cooking* has sold millions of copies and has been revised again and again for nearly a century.

The kitchen science. Every good cook, from Irma Rombauer to a restaurant chef, starts the same way: **read the whole recipe first**. Then set out *mise en place*, every ingredient measured and every tool ready. Pot pie teaches a classic technique, the **roux**. Butter and flour are cooked together for a minute or two, which coats each grain of flour in fat and cooks away the raw taste. When hot liquid is whisked in, the fat keeps the flour from clumping, and as the sauce heats toward a simmer, the starch granules swell and burst (gelatinization), thickening it. Scaling a recipe is simple multiplication, but some things, like baking time and pan size, do not scale the same way, so the cook must think.

Let's cook. You will make a chicken pot pie: a creamy filling of chicken and vegetables in a roux-thickened sauce, topped with drop biscuits and baked until golden. The skill is a **smooth roux sauce** and planning the steps so the oven, the filling and the biscuits are ready at the same time.

PICTURE STUDY



Girl Peeling Potatoes, Albert Anker, 1886 · Oil on canvas · Private collection, Switzerland

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

Albert Anker painted the families of his Swiss village with warmth and respect. Here a girl sits peeling potatoes for the family meal, a job that children everywhere have done for generations. She works carefully, with her attention on her task. Getting the vegetables ready before the cooking begins is the oldest form of *mise en place*.

Look closely

- Find the potatoes: unpeeled, peeled and the peelings.
- Look at how she holds the knife and potato. Is she rushing?
- Look at her face. What is she thinking about?
- Look at the shelves and counter. What kind of kitchen is this?

Talk about it

1. What meal might these potatoes become?
2. What jobs could you do ahead of time to make a family dinner go smoothly?
3. Why do you think Anker chose such an ordinary moment to paint?

Safety first. Whisk the roux and sauce with an adult nearby, adding liquid slowly and standing back from the steam; hot sauce sticks to skin. Use cooked chicken (or cook it to 165 °F first), and bake the filled pie until it bubbles and the center reaches 165 °F. Use oven mitts for the hot dish, and set it on a trivet.

Chicken Pot Pie with Biscuit Topping

You will read the recipe all the way through, write a timeline, set out *mise en place*, and make a pot pie. Then you will scale the recipe for a larger group.

You will need

- A chef's knife, cutting board and small bowls for *mise en place*
- A large heavy saucepan or deep skillet and a whisk
- A 9×13-inch baking dish or deep 10-inch oven-safe skillet
- A mixing bowl and a large spoon for the biscuit dough
- An instant-read thermometer, oven mitts and a trivet

CHICKEN POT PIE WITH DROP-BISCUIT TOPPING

Serves 6–8 • Prep 30 min • Cook 15 min • Bake 25–30 min

Ingredients

- **Filling:** 4 tablespoons (55 g) butter
- 1 onion, diced
- 2 carrots, diced
- 2 stalks celery, diced
- ⅓ cup (40 g) all-purpose flour
- 2 cups (480 mL) chicken broth
- 1 cup (240 mL) milk
- 1 teaspoon dried thyme, ½ teaspoon salt, ¼ teaspoon pepper
- 3 cups (about 1 pound / 450 g) cooked chicken, pulled into pieces or diced (leftover roast chicken or a store rotisserie chicken)
- 1 cup frozen peas
- **Biscuit topping:** 2 cups (240 g) all-purpose flour
- 1 tablespoon baking powder and ½ teaspoon salt
- 6 tablespoons (85 g) cold butter, cut in small pieces
- 1 cup (240 mL) cold milk

Method

1. Read the whole recipe. With an adult nearby, heat the oven to 400 °F (200 °C). Dice the vegetables and measure everything into bowls.
2. Melt 4 tablespoons butter in the saucepan over medium heat. Add the onion, carrots and celery and cook, stirring, until softened, 6–8 minutes.
3. Sprinkle the flour over the vegetables and stir for 1–2 minutes to cook the roux. Slowly whisk in the broth, a little at a time, then the milk, whisking out any lumps. Add the thyme, salt and pepper.
4. Bring to a gentle simmer, stirring, and cook until thick enough to coat a spoon, 3–4 minutes. Stir in the chicken and peas. Pour into the baking dish.
5. Make the biscuits: whisk the flour, baking powder and salt. Rub in the cold butter with your fingertips until it looks like coarse crumbs. Stir in the cold milk just until a sticky dough forms. Drop 8–10 large spoonfuls over the hot filling.
6. Bake 25–30 minutes, until the biscuits are golden and the filling bubbles at the edges. The center of the filling should read 165 °F (74 °C). Let it stand 10 minutes before serving. Refrigerate leftovers within 2 hours.

Allergy check: Contains wheat and milk. For milk-free, use olive oil or plant butter and unsweetened plain plant milk (soy milk contains soy). For wheat-free, thicken with a gluten-free flour blend and top with gluten-free biscuits.

Steps

1. **Read and plan.** Write a timeline from the moment you start until dinner is served, including the oven heating and the 10-minute rest. Mark which tasks can happen at the same time.
2. **Mise en place.** Photograph your measured ingredients and tools before you cook.
3. Make the pot pie.
4. **Sauce check.** Describe the sauce before it simmers and after. When did it thicken most? Explain using the word gelatinization.
5. **Scale it.** Rewrite the filling ingredients to serve 20 people. Show your multiplication and round to sensible kitchen measures.

6. **Rate it.** Ask your family to rate the pie and say what they liked best.
7. Clean up and **improve it:** wash the saucepan and dish; write one change, such as mushrooms, turkey, or a pastry crust.

Tips

- Warm broth whisks into a roux more smoothly than cold broth.
- Drop biscuits need no rolling. Keep the butter and milk cold for the tallest biscuits.
- Pot pie is a perfect “planned leftover” dish for the chicken from Lesson 5.4.

Check your work

- ☐ I can tell the story of Irma Rombauer and

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- ☐ I can read a recipe all the way through, plan a timeline and scale a recipe.
- ☐ I made a smooth roux sauce and baked a pot pie to 165 °F.

COOK'S NOTEBOOK

1. Copy your cooking timeline neatly.
2. Write your scaled recipe for 20 people with your calculations.
3. Write the pot pie recipe in the “action method” style, with each ingredient named in the step where it is used.

From history. Rombauer’s action method was a new way of writing recipes, but the habit of standard, level measurements came earlier, from Fannie Farmer’s *Boston Cooking-School Cook Book* of 1896. Between them, these two women shaped how American recipes are still written.

COMMON MISTAKES

- Starting to cook before reading the whole recipe. You may discover a step that needed an hour of chilling or an ingredient you do not have.

- Dumping all the liquid into a roux at once. Add it gradually, whisking, to keep the sauce smooth.
- Scaling everything, including baking time, by the same number. A bigger dish may need more time and a lower temperature, not double the time.

Make it a game · Read First, Cook Second. Your parent hands you a pot pie recipe with one hidden problem, such as a step that needs an ingredient not yet prepared. Read through the recipe in two minutes and find the problem. Set out the mise en place. Then explain roux and white sauce, and tell how Irma Rombauer self-published her cookbook in 1931.

8.2 ELLEN SWALLOW RICHARDS AND A WEEKLY MENU PLAN

OBJECTIVES

- Tell how Ellen Swallow Richards brought chemistry into the home and helped found home economics.
- Plan a week of balanced family dinners that use “planned-overs” and leftovers wisely.
- Cook a big batch of turkey and bean chili for two different meals.

Warm-up. Open the refrigerator and pantry with a parent. List five foods that need to be used up this week. Think of one meal that could use at least two of them.

WATCH

Chemist, Professor & Social Reformer: Ellen Swallow Richards - Freedom's Way NHA Heritage Stories

Freedom's Way National Heritage Area • 9:08

<https://www.youtube.com/watch?v=fyYAr2JLrHI>

WHEN TO WATCH

After The story. Listen for the Rumford Kitchen and what Richards wanted every home to know.

Note: From Freedom’s Way National Heritage Area, a historical heritage organization in Massachusetts.

BACKUP VIDEO

Ellen Swallow Richards

National Women's History Museum • 1:31

<https://www.youtube.com/watch?v=dy-A59Kvpj8>

A short summary of Richards’s life from the National Women’s History Museum.

KEY TERMS

home economics

The study of managing a household well: food, nutrition, budgeting, cleanliness and care for the family, using science.

menu plan

A written plan of what the family will eat each day, made before shopping.

planned-overs

Extra food cooked on purpose to become a different meal later in the week, like chili that becomes chili-topped potatoes.

batch cooking

Cooking a large amount at once to save time, money and cleanup later.

FIFO

“First in, first out.” Using older food before newer food so nothing spoils.

CORE IDEAS

The story. Ellen Swallow was born in Massachusetts in 1842. After graduating from Vassar College, she applied to study chemistry at the Massachusetts Institute of Technology, which had never admitted a woman. In 1871 MIT accepted her as a special student, and in 1873 she earned a bachelor of science degree, becoming the first woman to graduate from MIT. She married Robert Richards, a professor of mining, and spent her life teaching women and families how science could make homes healthier: testing water, air and food, and teaching nutrition and cleanliness.

How she figured it out. Richards believed that ordinary families could eat better and spend less if they understood food. In 1890 she helped open the New England Kitchen in Boston, which sold inexpensive, nourishing soups and stews prepared with careful methods. At the 1893 World’s Columbian Exposition in Chicago, she ran the Rumford Kitchen, named for Count Rumford, which served meals with cards showing their nutrients and cost. She helped start school lunches in Boston, and from 1899 she led a series of conferences at Lake Placid, New York, that created the field of **home economics**. In 1908 she became the first president of the American Home Economics Association.

The kitchen science. Richards's great lesson was planning. A family that plans a week of meals before shopping buys what it needs, wastes less, and eats more balanced meals. A good weekly plan uses **batch cooking** and **planned-overs**: cook a big pot once, then serve it two different ways. It puts quick meals on busy nights and slower ones on free nights, and it uses perishable food early in the week. Cooked leftovers stay safe in the refrigerator for 3–4 days, or can be frozen; reheat them to 165 °F. Planning also honors those who cook, by dividing the work fairly.

Let's cook. You will plan a week of family dinners, then make a big pot of turkey and bean chili to serve two ways: as chili with cornbread or crackers one night, and as chili-topped baked potatoes later in the week. The skill is **batch cooking and cooling** a large pot safely.

PICTURE STUDY



Ellen Swallow Richards, Unknown photographer, c. 1870 • Photograph • MIT Museum, Cambridge, Massachusetts (historic photograph)

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

This photograph shows Ellen Swallow as a young woman, around the time she finished at Vassar College and began her studies at MIT. She believed that every kitchen could be a little laboratory, and that a well-run home was a work of science and of love.

Look closely

- Look at her face and expression. What kind of teacher do you think she was?
- Look at her clothing and the books beside her. What do they suggest about her?
- Notice how simple the photograph is. What does that tell you about her?
- Imagine her standing in a kitchen. What would she be measuring?

Talk about it

1. Why do you think it mattered that the first woman to graduate from MIT used her science to help ordinary homes?
2. What would Richards say about planning meals before shopping?
3. Which of her ideas does your family already use?

Safety first. Brown ground turkey to 165 °F with an adult nearby, breaking it up so it cooks evenly. Cool the big pot of chili quickly, divided into shallow containers, and refrigerate it within 2 hours; use it within 3–4 days or freeze it. Reheat leftovers to 165 °F.

KITCHEN PROJECT

A Week of Dinners and a Big Pot of Chili

You will write a seven-day dinner plan with at least one planned-over, make chili for two meals, and cool and store the second half safely.

You will need

- A large heavy pot (at least 5 quarts) and a wooden spoon
- A chef's knife and cutting board
- A can opener and measuring cups and spoons
- Shallow containers with lids, labels and a marker
- An instant-read thermometer

BIG-BATCH TURKEY AND BEAN CHILI

Serves 10–12 (two meals for a family of 5–6) • Prep 20 min • Cook 50 min

Ingredients

- 2 tablespoons olive oil
- 2 onions, chopped
- 2 bell peppers, chopped
- 4 cloves garlic, minced
- 2 pounds (900 g) ground turkey (or lean ground beef)
- 3 tablespoons chili powder
- 1 tablespoon ground cumin and 1 teaspoon dried oregano
- 1½ teaspoons salt
- Two 28-ounce (794 g) cans crushed tomatoes
- Two 15-ounce cans kidney beans and one 15-ounce can black beans, rinsed and drained
- 2 cups (480 mL) water or broth
- 1 cup frozen corn
- **For serving:** grated cheese, plain yogurt or sour cream, chopped green onions; cornbread, crackers or baked potatoes

Method

1. With an adult nearby, heat the oil in the large pot over medium heat. Add the onions and peppers and cook until soft, 7–8 minutes. Add the garlic for 1 minute.
2. Add the turkey. Cook, breaking it up with the spoon, until no pink remains and it reaches 165 °F (160 °F for beef), 8–10 minutes.
3. Stir in the chili powder, cumin, oregano and salt and cook 1 minute to bloom the spices.
4. Add the tomatoes, beans and water. Bring to a boil, then lower the heat and simmer, partly covered, 30 minutes, stirring now and then. Add the corn for the last 5 minutes. Taste and adjust the salt.
5. Serve half for tonight's dinner with toppings.
6. Divide the other half among shallow containers, cool uncovered in the refrigerator, then cover, label with the date and refrigerate (3–4 days) or freeze (up to 3 months). Reheat to 165 °F.

Allergy check: Contains none of the nine major allergens as written. Cheese, yogurt or sour cream add milk; cornbread and crackers usually contain wheat, and cornbread often contains eggs and milk.

Steps

1. **Inventory.** Use your warm-up list. Plan to use those foods first (FIFO).
2. **Plan the week.** Write seven dinners. Include at least one batch-cooked meal with a planned-over, one quick meal for a busy night, and a vegetable at every dinner. Check each against MyPlate.
3. **Shopping list.** Write the list grouped by store section (produce, meat, dairy, canned, frozen, bakery).
4. Make the chili. Serve the first meal.
5. **Cool and label.** Record the temperature of the stored chili when it goes in the refrigerator and 2 hours later.
6. **Second meal.** Later in the week, reheat the chili to 165 °F and serve it over baked potatoes. Ask your family to rate both meals.
7. Clean up and **improve it:** wash the pot and tools; write one change to the plan or the chili.

Tips

- Bloom the spices in the fat before adding tomatoes for deeper flavor.
- Bake potatoes in a 425 °F oven for about 1 hour, or microwave them with an adult nearby, pricking the skins first.
- Post the weekly plan on the refrigerator so everyone knows what is coming and can help.

Check your work

- ☐ I can tell the story of Ellen Swallow Richards and home economics.
- ☐ I planned a week of balanced dinners with a planned-over and a shopping list.
- ☐ I batch-cooked chili, cooled and stored it safely, and served it two ways.

COOK'S NOTEBOOK

1. Copy your week of dinners neatly as a menu calendar.
2. Draw a refrigerator shelf map showing where leftovers, raw meat and produce belong.
3. Write the chili recipe in your own words with both meals' ratings.

COMMON MISTAKES

- Shopping without a plan or list. Families buy more and waste more.
- Putting a full, hot stockpot straight into the refrigerator. Divide it into shallow containers so it cools quickly.
- Forgetting leftovers until they spoil. Label them with dates and plan a meal for them.

Make it a game • Planned-Overs Menu. Plan five dinners in ten minutes. At least two must use planned-overs from an earlier meal. Name the batch-cooking day and the FIFO rule for the refrigerator. Your parent finds one weak spot, and you fix it. Then explain how Ellen Swallow Richards brought chemistry into the home and helped found home economics.

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 31 plans ahead to feed everyone in her household. Planning meals is a way of loving the people who will eat them.

8.3 HAZEL STIEBELING'S FOOD PLANS: EATING WELL ON A BUDGET

OBJECTIVES

- Tell how Hazel Stiebeling designed USDA food plans at different cost levels in 1933.
- Compare unit prices and calculate cost per serving.
- Cook a budget pasta e fagioli for the family and calculate its cost per serving.

Warm-up. Find two sizes of the same food in your pantry or at the store (for example, a small and a large jar of peanut butter, or two boxes of oats). Write the price and the size of each. Which do you think is the better buy? How could you check?

WATCH

How to Make the Most Comforting Pasta e Fagioli

America's Test Kitchen • 6:57

<https://www.youtube.com/watch?v=8EYgUXRAN7s>

WHEN TO WATCH

Before you cook. Watch how a few inexpensive ingredients are built into a rich soup.

KEY TERMS

unit price

The price per unit of measure, such as per ounce or per pound. Found by dividing the price by the amount. Most store shelf tags show it.

cost per serving

The total cost of a recipe divided by the number of servings.

food plan

A plan showing what foods, and how much, a family can buy to eat nutritious meals at a certain cost.

staples

Basic, inexpensive foods kept on hand, such as rice, oats, flour, dried beans, pasta, canned tomatoes and onions.

pasta e fagioli

Italian for “pasta and beans,” a thick, hearty soup traditionally made from inexpensive pantry staples.

CORE IDEAS

The story. In the early 1930s, during the Great Depression, millions of American families had very little money for food. Government relief agencies needed to know: how little could a family spend and still eat well? Hazel Stiebeling, a nutrition scientist at the U.S. Department of Agriculture’s Bureau of Home Economics, set out to answer that question with research rather than guesses.

How she figured it out. In 1933 Stiebeling and her colleague Medora Ward published food plans at four levels of cost and nutrition. They worked out how much of each kind of food, measured by the pound or quart, a family would need in a week to meet its needs for energy, protein, minerals and vitamins, and then priced the plans using real store prices. The cheaper plans leaned on staples like dried beans, whole grains, potatoes, milk and seasonal vegetables; the more expensive ones added more meat, fruit and variety. The USDA still publishes food plans today, updated every month with current prices, and they are used to set food assistance and to help families plan.

The kitchen science. Stiebeling’s plans show that eating well does not depend on expensive foods. Dried and canned beans, lentils, oats, rice, pasta, eggs, carrots, cabbage, onions, potatoes and frozen vegetables are some of the most nutrient-dense foods for their cost. Smart shoppers compare **unit prices**: $\text{price} \div \text{amount}$. A 32-ounce bag of rice for \$3.20 costs \$0.10 per ounce; a 12-ounce box for \$1.80 costs \$0.15 per ounce, so the bag is the better buy, if you will use it before it spoils. To find **cost per serving**, add up what you used of each ingredient and divide by the number of servings.

Let’s cook. You will make pasta e fagioli, a hearty Italian soup of beans, pasta, tomatoes and vegetables made from pantry staples, and calculate exactly what each bowl costs. The skill is **building flavor from inexpensive ingredients**: browning the vegetables, blooming garlic and herbs, and simmering.

PICTURE STUDY



Poultry Market at Gisors, Camille Pissarro, 1885 · Gouache and pastel on paper · Museum of Fine Arts, Boston

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

Camille Pissarro lived in the countryside of Normandy and loved to paint its weekly markets. Here in the town of Gisors, women gather to buy and sell poultry and produce. Market days were when families bought what they would eat for the week, so every coin had to be spent wisely, and bargaining was part of the fun.

Look closely

- Find a buyer and a seller. What are they doing?
- Look at the baskets and what is in them.
- Look at the faces. Who seems to be thinking hard about a price?
- Look at the crowd. How is this different from a modern supermarket?

Talk about it

1. How would a family at this market plan its week of meals?
2. What did these shoppers have that helped them choose well, even without unit-price tags?
3. Would you rather shop at a market like this or a supermarket? Why?

Safety first. Cook with an adult nearby, keeping the pot handle turned in; stir the thick soup along the bottom so it does not scorch and spatter. Lift the lid away from your face. Refrigerate leftovers within 2 hours and reheat to 165 °F.

KITCHEN PROJECT

Pasta e Fagioli and the Cost-per-Serving Challenge

You will compare unit prices on at least five foods, make a pot of pasta e fagioli, and calculate its cost per serving from your receipts.

You will need

- A large heavy pot with a lid and a wooden spoon
- A chef's knife and cutting board
- Your grocery receipt, a calculator and the notebook
- Measuring cups and spoons

PASTA E FAGIOLI (PASTA AND BEAN SOUP)

Serves 6–8 • Prep 20 min • Cook 40 min

Ingredients

- 2 tablespoons olive oil
- 1 onion, diced
- 2 carrots, diced
- 2 stalks celery, diced
- 3 cloves garlic, minced
- 1 teaspoon dried Italian seasoning and a pinch of red pepper flakes
- One 15-ounce (425 g) can crushed or diced tomatoes
- Two 15-ounce cans cannellini or great northern beans, rinsed and drained (or 3 cups home-cooked dried beans)
- 6 cups (1.4 L) chicken or vegetable broth (or water plus 2 bouillon cubes)
- 1 cup (about 110 g) small pasta, such as ditalini or small shells
- 2 cups chopped spinach or kale (optional)
- 1 teaspoon salt and ½ teaspoon black pepper, to taste
- Grated Parmesan for serving

Method

1. With an adult nearby, heat the oil in the pot over medium heat. Add the onion, carrots and celery and cook, stirring, until soft and lightly golden, 8–10 minutes.
2. Add the garlic, Italian seasoning and red pepper flakes and stir for 1 minute.
3. Add the tomatoes, beans and broth. With the back of the spoon, mash about a cup of the beans against the side of the pot to thicken the soup. Bring to a boil, then lower the heat and simmer 15 minutes.
4. Add the pasta and simmer, stirring often, until tender, 10–12 minutes. Stir in the spinach for the last 2 minutes. Add water if it becomes too thick.
5. Taste and season with salt and pepper. Serve with Parmesan.
6. Refrigerate leftovers within 2 hours. The pasta keeps soaking up broth; add a little water when you reheat to 165 °F.

Allergy check: Contains wheat (pasta) and milk (Parmesan). Use gluten-free pasta for wheat-free, and skip the cheese for milk-free. Check the broth or bouillon label.

Steps

1. **Unit-price hunt.** At the store or online, compare two sizes or brands of five foods. Calculate each unit price and circle the better buy. Note if the bigger size might go to waste.
2. Make the soup.
3. **Cost per serving.** From your receipt, find the cost of each ingredient. For partly used items, calculate the fraction used (for example, 2 tablespoons from a 16-ounce bottle of oil). Add them up and divide by the number of servings. Show your work in a table.
4. **Compare.** Compare your cost per serving with a restaurant or frozen soup of the same size.
5. **Rate it.** Ask your family to rate the soup and say whether they would want it in the regular rotation.
6. Clean up and **improve it:** wash the pot and tools; write one change, such as dried beans to save money, Italian sausage, or a different green.

Tips

- Dried beans cost less than canned. Soak them overnight and simmer until tender; 1 pound dried makes about 6 cups cooked.
- Store brands are often the same quality as name brands for less.
- Shelf tags list the unit price in small print, but check that both items are priced in the same unit (per ounce or per pound).

Check your work

- ☐ I can tell how Hazel Stiebeling designed food plans at different costs.
- ☐ I can compare unit prices and calculate cost per serving.
- ☐ I made pasta e fagioli and found its cost per serving.

COOK'S NOTEBOOK

1. Copy your unit-price table with your calculations.
2. Copy your cost-per-serving table.
3. Write the recipe in your own words with the family rating and your cost per serving.

COMMON MISTAKES

- Assuming the larger package is always cheaper. Check the unit price; sometimes sales make the smaller one a better buy.
- Buying a bargain that spoils before you use it. A good deal is only good if the food is eaten.
- Forgetting the small costs (oil, spices, broth) in cost per serving. They add up.

Make it a game • Cost per Serving Challenge. Pick two dinners and their ingredients from the pantry or store flyer. Work out the unit price of each ingredient and the cost per serving. Write the math on paper. Beat the other dinner or beat your estimate. Then explain what Hazel Stiebeling's 1933 food plans were and why staples keep the cost low.

Scripture. “When they were filled, he said unto his disciples, Gather up the fragments that remain, that nothing be lost.” (John 6:12, KJV)

After feeding five thousand people, Jesus told His disciples to save the leftovers. Careful planning and wasting nothing are ways of honoring God's gifts.

8.4 THE FAMILY FEAST

OBJECTIVES

- Plan a full family feast with a balanced menu, a shopping list and budget, and a cooking timeline.
- Cook several dishes from the year with an adult nearby and serve them hot (or cold) and on time.
- Set the table, welcome your family as guests, and lead or join in giving thanks.

Warm-up. Remember the best meal you have ever shared with family or friends.

Write down who was there, what was served, and what made it special. How much of what made it special was the food, and how much was the people and the welcome?

WATCH

How to Set the Table, With Rajiv Surendra | Life Skills With Rajiv

HGTV Home • 7:23

<https://www.youtube.com/watch?v=J1tyPmnxZ1o>

WHEN TO WATCH

Before you set the table. Watch where the forks, knives, spoons, plates and glasses go.

BACKUP VIDEO

Learn How to Set a Formal Dinner Table

College & Career Ready Labs | Paxton Patterson • 2:56

<https://www.youtube.com/watch?v=p9mzBckf3G4>

A clear top-down demonstration of where each plate, fork, knife and spoon goes in a formal setting.

KEY TERMS

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 task must start so everything is ready together.

make-ahead

A dish or step that can be done hours or a day before the feast, such as bread, dessert or chopping vegetables.

place setting

The plate, utensils, napkin and glass set at each person's place. Forks go on the left; knife (blade facing the plate) and spoon on the right.

hospitality

Welcoming and caring for guests generously, making them feel at home.

CORE IDEAS

The story. The Bible tells of Abraham sitting at the door of his tent in the heat of the day when three visitors appeared. He ran to meet them, bowed, and invited them to rest. Then he hurried: he asked Sarah to bake cakes from three measures of fine meal, ran to the herd for a tender calf, and gave it to a young man to prepare, and set butter and milk before his guests, standing by them under the tree while they ate (Genesis 18:1-8). It is one of the first pictures of hospitality in Scripture: generous, quick, and joyful, with the whole household working together.

How they figured it out. Every good host since Abraham has faced the same problem: how to have everything ready, hot and on the table at the same time, and still be free to welcome the guests. The answer is a **plan**. Professional cooks write a **timeline** by working backward from the serving time: if dinner is at 6:00 and the chicken needs 45 minutes in the oven and 10 minutes to rest, it goes in at 5:05. Bread and dessert are made ahead. Vegetables are chopped in the morning. The table is set before the cooking begins. A good plan turns a stressful day into a joyful one.

The kitchen science. A feast is a test of everything you learned this year: safe handling and temperatures (Unit 1), a balanced menu with all the food groups (Unit 2), contrasts of flavor and texture (Units 3 and 7), the right heat for each dish (Unit 4), browning, bread and brining (Unit 5), treats in their place (Unit 6), and planning, budgeting and hospitality (Unit 8). One oven can hold only so much, so choose dishes that use different equipment: something roasted, something on the stove, something cold, and something made ahead.

Let's cook. You will plan, shop for and cook a feast for your family with an adult nearby, using at least three dishes from this year. A model menu is given: a green

salad with a vinaigrette, herb-roasted chicken thighs with root vegetables, your sandwich loaf (Lesson 5.3) shaped as rolls, and vanilla rice pudding or strawberry sorbet made the day before. The skill is **timing**: following your timeline so every dish is ready together.

PICTURE STUDY



Come, Lord Jesus, Be Our Guest (Das Tischgebet), Fritz von Uhde, 1885 · Oil on canvas · Alte Nationalgalerie, Berlin

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

Fritz von Uhde painted this picture in 1885. Its title comes from a German table prayer that many families still pray before meals: “Come, Lord Jesus, be our guest, and let these gifts to us be blessed.” A poor farming family has gathered around a plain meal, and the painter shows Jesus himself coming through the door to share it. The family is humble, the food is simple, and the welcome is complete.

Look closely

- Find the food on the table. What kind of meal is it?
- Look at each member of the family. Who notices the guest, and how do they respond?
- Find Jesus. How is he different from the family, and how is he the same?
- Look at the light in the room. Where does it come from?

Talk about it

1. What do you think the painter wanted families to remember every time they sat down to eat?
2. How can a simple meal be a feast?

3. How will you welcome your family at your feast?

Safety first. Cook with an adult nearby throughout the feast day. Follow every temperature: chicken 165 °F, reheated dishes 165 °F; keep cold dishes cold and hot dishes hot, and refrigerate leftovers within 2 hours. Plan the oven and stove so that no one reaches over a hot pan, and keep oven mitts, a lid and baking soda near the stove.

Plan, Cook and Host the Family Feast

You will plan and host a feast: menu, shopping list, budget, timeline, table, grace and the cooking itself. Use the model menu or choose your own dishes from the year.

You will need

- Your notebook, a calculator and a clock or timer
- Equipment for each dish on your menu (check them all a day ahead)
- Large rimmed baking sheet, oven mitts and an instant-read thermometer
- A tablecloth or placemats, napkins, plates, glasses and utensils for each guest
- Menu cards or place cards (optional)

MODEL FEAST MAIN DISH: HERB-ROASTED CHICKEN THIGHS WITH ROOT VEGETABLES

Serves 6 • Prep 25 min • Roast 40–50 min • Rest 5 min

Ingredients

- 8 bone-in, skin-on chicken thighs (about 3½ pounds / 1.6 kg), brined for 1–2 hours if you like (Lesson 5.4)
- 1½ pounds (680 g) small potatoes, halved
- 4 carrots, cut into 2-inch pieces
- 1 red onion, cut into wedges
- 3 tablespoons olive oil, divided
- 1 teaspoon salt (½ teaspoon if the chicken was brined), ½ teaspoon black pepper
- 2 teaspoons chopped fresh rosemary or thyme (or 1 teaspoon dried)
- 4 cloves garlic, smashed
- 1 lemon, cut into wedges

- **Rest of the model menu:** green salad with vinaigrette (Lesson 4.1), sandwich-loaf dough shaped into 12 rolls (Lesson 5.3, bake 18–22 minutes), and vanilla rice pudding (Lesson 7.2) or strawberry sorbet (Lesson 4.4) made the day before

Method

1. With an adult nearby, heat the oven to 425 °F (220 °C).
2. On a large rimmed baking sheet, toss the potatoes, carrots and onion with 2 tablespoons oil, half the salt and pepper, and half the herbs. Spread them out.
3. Pat the chicken dry. Rub with the remaining oil, salt, pepper and herbs. Nestle the thighs skin side up among the vegetables, with the garlic and lemon wedges. Wash your hands.
4. Roast 40–50 minutes, until the skin is crisp and golden, the vegetables are tender, and the thickest thigh reads at least 165 °F (74 °C), not touching bone.
5. Rest 5 minutes. Squeeze the roasted lemon over everything and arrange on a warm platter.
6. After the feast, refrigerate leftovers within 2 hours. They make excellent chicken pot pie (Lesson 8.1).

Allergy check: The main dish contains none of the nine major allergens. Check every other dish on your menu: the rolls contain wheat and milk, the rice pudding contains milk, and the salad dressing may contain mustard. Make swaps for your guests' allergies.

Steps

1. **Menu.** Plan a balanced menu of at least four dishes, including at least three from this year, with a vegetable, a protein, a grain and a fruit or dessert. Check it against MyPlate and your guests' allergies.
2. **List and budget.** Write the shopping list, estimate the cost with unit prices, and calculate the cost per person after shopping.
3. **Timeline.** Choose a serving time and work backward. Include make-ahead tasks the day before, morning prep, oven times, resting times, setting the table, and a 15-minute buffer.

4. **Cook.** Follow your timeline with an adult nearby. Check every temperature and record it.
5. **Set the table and welcome.** Set a place for everyone. Greet your family at the door or the table as honored guests. Lead or join in grace.
6. **Serve and listen.** Serve the meal, ask each person to share something they are thankful for from this year, and collect a rating for each dish.
7. **Clean up together** and write a reflection: what went to plan, what did not, and what you would change for the next feast.

Tips

- Choose at least one make-ahead dessert. It frees the oven and your hands on the day.
- Set the table the night before or in the morning; it makes the day feel festive from the start.
- Plan to have everything done 15 minutes early. Something always takes longer than expected.

Check your work

- ☐ I planned a balanced feast menu with a shopping list, budget and timeline.
- ☐ I cooked several dishes safely and served them together on time.
- ☐ I set the table, welcomed my family and gave thanks.

COOK'S NOTEBOOK

1. Write your feast menu as a decorated menu card.
2. Copy your timeline, marking what actually happened beside each planned time.
3. Write a one-page reflection on your year of cooking: your favorite dish, the hardest skill, the biggest improvement, and one thing you will cook for others next year.

COMMON MISTAKES

- Planning too many dishes that need the oven at different temperatures at the same time. Plan your oven use and make some dishes ahead.
- Being so busy in the kitchen that you miss your own feast. Plan so that you can sit down with your guests.

- Forgetting to give thanks. A feast begins with gratitude to God and to those who helped.

Make it a game • Feast Timeline Duel. Plan a full feast with a menu, shopping list and budget. Then write the cooking timeline on a sheet of paper, working backward from serving time, and list which dishes are make-ahead. Your parent adds a surprise, such as a late guest. Rework your plan in three minutes and set the table. Then say grace.

Scripture. “Use hospitality one to another without grudging.” (1 Peter 4:9, KJV)

Hospitality is not only for special occasions or perfect cooks. Peter tells every Christian to welcome others gladly. Your feast is practice for a lifetime of open tables.

UNIT 8

MEAL PLANNING & THE FAMILY TABLE

A cook who can follow a recipe can make a dish. A cook who can plan can feed a family. In this last unit you will meet three women who taught America to plan and cook well. Irma Rombauer, a widow in St. Louis, self-published a cookbook in 1931 that became the most famous American kitchen book of the century. Ellen Swallow Richards, the first woman to study at MIT, brought chemistry into the home and helped found the field of home economics. Hazel Stiebeling, a USDA scientist, designed food plans in 1933 that showed families how to eat well at different costs.

You will learn to read and scale a recipe, plan a week of balanced meals, shop with a list and a budget, compare unit prices, cook for leftovers, and waste as little as possible. Then, in the final week, you will plan and cook a full family feast with a menu and a timeline, set the table, welcome your family and give thanks. Everything you have learned this year comes to the table.

PREREQUISITES

- Can cook several dishes from earlier units safely with an adult nearby
- Can scale a recipe up and down using multiplication and fractions
- Knows the MyPlate food groups and how to plan a balanced day (Unit 2)
- Can make a white sauce or gravy, or is ready to learn one in Lesson 8.1

MASTERY CHECKLIST

- ☐ I can tell the stories of Irma Rombauer, Ellen Swallow Richards and Hazel Stiebeling.
- ☐ I can read a recipe all the way through, scale it, and make a roux-thickened sauce.
- ☐ I can plan a week of balanced family meals with a shopping list that uses leftovers wisely.
- ☐ I can compare unit prices and calculate cost per serving.
- ☐ I can plan and cook a family feast with a menu, timeline and budget, set the table and lead or join in giving thanks.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA MyPlate: Shop Simple and Kitchen Timesavers:** Free. MyPlate’s planning tools include tips for budget shopping and planning meals. Useful for Lessons 8.2 and 8.3.
- **USDA Food Plans: Cost of Food Reports:** Free. Monthly USDA reports on what nutritious meals cost at four levels for families of different sizes. Parents may find them useful for the unit challenge.
- ***Joy of Cooking* (any edition):** Optional. The Rombauer-Becker family’s site for the book. Libraries usually have older editions, which are fun to compare with new ones.

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 Irma Rombauer and *The Joy of Cooking*: Chicken Pot Pie

2 sessions of 60–90 minutes

8.2 Ellen Swallow Richards and a Weekly Menu Plan

2 sessions of 60–90 minutes

8.3 Hazel Stiebeling’s Food Plans: Eating Well on a Budget

2 sessions of 50–60 minutes

8.4 The Family Feast

2 sessions of 60–90 minutes, plus the feast

UNIT 8 REVIEW

Answer each question. Show your work on the calculations. Use complete sentences for explanations. The review is worth 100 points.

1. **8 pts**

How did Irma Rombauer’s *The Joy of Cooking* begin, and what was her “action method”?

2. **8 pts**

What is a roux, and how does it thicken a sauce?

3. (8 pts)

Who was Ellen Swallow Richards, and name two things she did for American kitchens.

4. (8 pts)

What are planned-overs? Give an example.

5. (8 pts)

How long are cooked leftovers safe in the refrigerator, and to what temperature should they be reheated?

6. (8 pts)

What did Hazel Stiebeling and Medora Ward publish in 1933, and why?

7. (10 pts)

Calculation: a 24-ounce jar of pasta sauce costs \$3.36, and a 45-ounce jar costs \$5.40. Find each unit price. Which is the better buy?

8. (10 pts)

Calculation: your pasta e fagioli used ingredients costing \$1.20 (vegetables), \$2.20 (beans), \$1.25 (tomatoes), \$1.80 (broth), \$0.60 (pasta), \$0.40 (oil and seasonings) and \$1.00 (cheese). It serves 8. What is the total cost and the cost per serving?

9. (8 pts)

Calculation: dinner is at 6:00 p.m. The chicken roasts 45 minutes and rests 10 minutes; the oven takes 15 minutes to heat. When must you turn on the oven, and when must the chicken go in?

10. (8 pts)

Where do the fork, knife and spoon go in a simple place setting? Which way does the knife blade face?

11. (8 pts)

What did Abraham do when the three visitors came (Genesis 18), and what does it teach about hospitality?

12. **8 pts**

Written answer: Describe your plan for the family feast. Explain how the menu is balanced, how you will keep the food safe, and how you will make your family feel welcome.

ANSWER KEY

1. After her husband died in 1930, she collected and tested her favorite recipes and self-published 3,000 copies in 1931, illustrated by her daughter Marion. The action method (1943) names each ingredient in the instructions right where it is used.
2. Equal parts fat and flour cooked together. The fat coats the flour so it does not clump when liquid is whisked in; as the sauce heats, the starch granules swell and burst (gelatinize), thickening it.
3. The first woman to graduate from MIT (1873), a chemist who founded home economics. Any two: the New England Kitchen (1890), the Rumford Kitchen at the 1893 Chicago fair, Boston school lunches, the Lake Placid conferences, first president of the American Home Economics Association (1908), teaching about clean water and nutrition.
4. Extra food cooked on purpose to become a different meal later in the week. Example: chili served one night and over baked potatoes later; roast chicken that becomes pot pie.
5. 3–4 days; reheat to 165 °F.
6. Food plans at four levels of cost and nutrition, showing what a family needed to buy each week to eat well at each cost, to help families and relief agencies during the Great Depression.
7. $\$3.36 \div 24 = \$0.14$ per ounce. $\$5.40 \div 45 = \$0.12$ per ounce. The 45-ounce jar is the better buy (if it will be used before it spoils).
8. Total = $1.20 + 2.20 + 1.25 + 1.80 + 0.60 + 0.40 + 1.00 = \$8.45$. Per serving: $\$8.45 \div 8 \approx \$1.06$.
9. Chicken out by 5:50 (6:00 – 10 minutes rest). In by 5:05 (5:50 – 45 minutes). Oven on by 4:50 (5:05 – 15 minutes).
10. Fork on the left of the plate; knife on the right with the blade facing the plate; spoon to the right of the knife. (Napkin on the left or on the plate; glass above the knife.)
11. He ran to meet them, invited them to rest, had Sarah bake cakes, prepared a tender calf, served butter and milk, and stood by them while they ate. It teaches that hospitality is generous, quick, joyful and shared by the whole household.
12. Answers vary. A good answer names at least four dishes covering the food groups, explains temperatures and keeping hot food hot and cold food cold,

includes a timeline idea, and describes setting the table, greeting guests and giving thanks.

UNIT CHALLENGE: THE FAMILY FEAST

Plan, shop for, cook and host a family feast. Your portfolio includes a menu card; a shopping list with a budget, unit prices and the final cost per person; a timeline from the day before to the moment of serving, with what actually happened marked beside it; and a temperature log for every dish that needs one.

Set the table, welcome your family, lead or join in grace, and serve the meal. Afterward, collect a rating and a comment for each dish, and write a thank-you note to someone who taught you to cook this year. Finish with a one-page reflection on your year as a cook.

LOOK FOR	WHAT IT MEANS
Planning	A balanced menu of at least four dishes (three from this year), a shopping list, budget and realistic timeline.
Cooking and safety	Dishes cooked well and safely with an adult nearby; temperatures checked and recorded; leftovers stored within 2 hours.
Timing	Dishes ready together and served close to the planned time; the timeline compared honestly with what happened.
Hospitality	Table set neatly, guests welcomed warmly, thanks given, and the cook sat down with the family.
Reflection and cleanup	A thoughtful reflection on the feast and the year, a thank-you note written, and the kitchen left clean.