Culinary Arts & Meal Planning

First edition | 10 units | 50 lessons · one school year | A video for every lesson

FIRST EDITION

Course guide

This is a full high-school course in cooking and meal planning, ten units and fifty lessons. It begins where every professional cook begins: with Auguste Escoffier's organized kitchen, mise en place, and the food-handler standard that keeps the people you feed safe. From there it moves through knife skills and tools, the dry-heat and moist-heat cooking methods, sauces, eggs and breakfast, baking and pastry, flavor, spice and the grill, nutrition and the balanced diet, meal planning and budgeting, and finally hospitality: the family table, cooking for a crowd, and a capstone three-course meal the student plans, budgets, shops for, cooks and serves to guests.

Each lesson follows the same path. First comes **the story**: a real cook, scientist or moment, from Hannah Glasse and Mary Randolph to Fannie Farmer, Julia Child, Jacques Pépin and Clarence Saunders. Then **how they figured it out**, **the kitchen science** at a high-school level, and **let's cook**: a real recipe made in a skill lab with a written technique standard, a self-assessment and a repeat round. Worked examples and a practice set in every lesson build the kitchen arithmetic a cook uses daily: scaling recipes, converting units, yield percentages, baker's percentages, food cost and cost per serving, cooling times and cooking timelines.

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, stewardship and hospitality, never in terms of weight or appearance. The motto of the course is the old Latin saying *Fabricando fit faber*, "by making, one becomes a maker": by cooking, and cooking again, one becomes a cook.

> Most videos come from teaching kitchens and public sources: America's Test Kitchen and Cook's Country, the Culinary Institute of America, King Arthur Baking, KQED's Jacques Pépin clips, Serious Eats, the USDA, the FDA, university extension services, TED-Ed,

> Reactions from the American Chemical Society, and careful cooking teachers chosen lesson by lesson. Every video was previewed for content, accuracy, modest dress and settings suitable for students. Some channels end with an invitation to subscribe or a word about their other videos; you can stop the video when the teaching ends.

Start with Lesson 1.1 →

Who it is for

Written for students in grades 9–12 (about ages 14–18). No prerequisite beyond pre-algebra arithmetic: fractions, decimals, percentages and simple proportions. Students work fairly independently, with a parent checking work and at home for every stove, oven, knife and grill lab. Nothing needs to be bought beyond an ordinary kitchen, ordinary groceries, an instant-read thermometer and a digital kitchen scale.

How to use this course

1. **The weekly rhythm.** The course has 50 lessons in 10 units. Each lesson takes three sessions of about 50 minutes: (1) the warm-up, video, teaching, picture study and worked examples; (2) the kitchen lab and lab notebook (cooking days may run to 90 minutes); (3) the practice set and corrections. A unit test follows each unit, a midterm follows Unit 5 and a final follows Unit 10. At five sessions a week, the course fills a school year.
2. **A parent supervises.** A parent or responsible adult is at home for every lab and watches the student do each new knife, stove, oven, broiler and grill task safely before the student does it alone. Check every recipe against your own family's food allergies; each recipe card names the major allergens it contains and offers swaps.
3. **The high-school safety standard.** Students may use a chef's knife, the stove, oven, broiler and grill on their own once a parent has watched them do it safely, with a parent in the house. There is no deep frying in this course: pan-frying uses no more than about ½ inch of oil. Adults light charcoal; a student may light a gas grill with a parent present and the lid open. No liquid charcoal starter is used. The pressure cooker is used with a parent present. Never taste unbaked dough or batter, and use only cooked or pasteurized eggs.

4. **Story, science, then the lab.** Read the core ideas carefully; they are the textbook. The paragraphs marked *The story* and *How they figured it out* tell what happened, *The kitchen science* explains why the food behaves as it does, and *Let's cook* names the recipe and the technique standard for the lab.
5. **Worked examples and practice.** Work each example with a pencil before reading the steps. Practice sets run from easy to challenge; do them on the third day, then check the answers and correct every miss in a different color.
6. **Picture study.** Each lesson pairs with one public-domain painting or historic photograph of a kitchen, a market, a harvest or a table. Look for two quiet minutes, describe it from memory, then work through the questions, which tie the picture to the lesson's technique or idea.
7. **The lab notebook.** For every lab, record the date, the recipe as you actually made it, weights and temperatures, times, observations, a sketch or photo of the plate, a family rating, and one change for the repeat round. Then cook it again and make the change. Cook it, record it, improve it.
8. **How we talk about food and bodies.** This course never discusses weight or how bodies look. Calories appear only as a unit of food energy. Foods are "nutrient-dense foods" and "treats," never "good" or "bad." Feasts and treats are good gifts in their place.
9. **Groceries.** Recipes feed a family of four to six from ordinary grocery-store ingredients, so most labs can become the family's supper. Read each recipe card a few days ahead and add it to the shopping list. Units 9 and 10 turn grocery shopping itself into the lesson.
10. **An optional food-handler card.** After Unit 1, many students like to earn a real food-handler card. Many states and counties accept short online food-handler courses, usually for a small fee; check your own state or county health department. It is optional and not required for this course.
11. **Tests, exams and unit projects.** Each unit test is worth 100 points and mixes calculations, concepts and one short essay; calculators are allowed. Each unit ends with a unit project, a real meal, plan or record kept in a portfolio. The capstone in Lesson 10.5 is a three-course meal for guests.

Scope and sequence

UNIT 1 · WEEKS 1–4

The Professional Kitchen and Food Safety

Escoffier's brigade and mise en place; hygiene and the food-handler standard; Clean, Separate, Cook, Chill and the danger zone; cooling and reheating by the FDA Food Code; a food-handler practice exam.

1.1 Escoffier and the Brigade de Cuisine

1.2 Mise en Place: Everything in Its Place

1.3 Typhoid Mary and the Food-Handler Standard

1.4 Clean, Separate, Cook, Chill and the Danger Zone

1.5 The Food Code, Cooling Leftovers and the Food-Handler Card

UNIT 2 · WEEKS 4–7

Knife Skills and Tools

Choosing, honing and sharpening knives; the classic cuts measured with a ruler; herbs, chiffonade and mince; cast iron, stainless steel and nonstick pans; measuring by weight and volume.

2.1 Choosing, Honing and Sharpening Knives

2.2 The Classic Cuts: Julienne, Batonnet, Brunoise and Dice

2.3 Herbs, Chiffonade and Mince: A Genoa Pesto

2.4 Pots, Pans and Materials

2.5 Fannie Farmer, the Level Cup and the Kitchen Scale

UNIT 3 · WEEKS 7–10

Cooking Methods: Dry Heat

Sautéing and searing, roasting, broiling, shallow pan-frying and doneness: each dry-heat method explained by heat transfer and checked with an instant-read thermometer.

3.1 Sautéing and Pan-Searing: Julia Child's Mushrooms

3.2 Roasting: Hannah Glasse and the Roast Chicken

3.3 Broiling: Herschel's Invisible Heat and the Broiled Fish

3.4 Shallow Pan-Frying: Mary Randolph's Fried Chicken

3.5 Doneness, Carryover and the USDA's 2011 Pork Change

UNIT 4 · WEEKS 10–13

Cooking Methods: Moist Heat and Combination

Boiling, simmering and blanching; steaming and latent heat; braising and the conversion of collagen to gelatin; Escoffier's stocks and a homemade soup; the pressure cooker.

4.1 Boiling, Simmering and Blanching: Joseph Black's Latent Heat

4.2 Steaming: James Watt and the Power of Steam

4.3 Braising: Abraham Darby's Iron Pot and Collagen to Gelatin

4.4 Stocks and Soups: Escoffier's Foundations

4.5 The Pressure Cooker: Denis Papin's Steam Digester

UNIT 5 · WEEKS 13–17

Sauces, Eggs and Breakfast

Béchamel and the roux; tomato sauce from Naples; pan sauces and gravy; egg cookery from scrambled eggs to the French omelet; and a family breakfast served hot and on time.

5.1 The Mother Sauces: Carême, Escoffier and the Béchamel

5.2 Tomato Sauce: Antonio Latini and the Neapolitan Tomato

5.3 Pan Sauces and Gravy: Escoffier's Brown Sauce at Home

5.4 Egg Cookery: Mère Poulard's Omelette

5.5 The Family Breakfast: Amelia Simmons, Pearlash and Pancakes

UNIT 6 · WEEKS 17–20

Baking and Pastry

Baker's percentages and hydration; the home yeast loaf; quick breads and the muffin method; pie crust and flakiness; the pound cake and the creaming method.

6.1 Baker's Percentages: Raymond Calvel and the Focaccia

6.2 The Home Loaf: Fleischmann's Yeast, Kneading and Gluten

6.3 Quick Breads: Eben Horsford's Baking Powder and the Muffin Method

6.4 Pie Crust and Cookies: Fat, Flour and Flakiness

6.5 The Pound Cake and the Creaming Method

UNIT 7 · WEEKS 20–23

Flavor, Spice and the Grill

The five tastes and balancing a dish with salt, acid, fat and heat; the spice trade and a homemade spice blend; complementary and contrasting flavors; the two-zone grill; texture and plating.

7.1 The Five Tastes and Balancing a Dish: Ikeda's Umami

7.2 Herbs, Spices and Vasco da Gama's Voyage

7.3 Complementary and Contrasting Flavors: The Flavor Network

7.4 The Grill: George Stephen's Kettle and the Two-Zone Fire

7.5 Texture and Plating: Service à la Russe

UNIT 8 · WEEKS 23–26

Nutrition and the Balanced Diet

MyPlate and the Dietary Guidelines; macronutrients as food energy and eating for sport and growth; the Nutrition Facts label and added sugar; cravings, reward and habits; cooking for guests with food allergies.

8.1 MyPlate and the Dietary Guidelines: From the Basic Seven to Today

8.2 Macronutrients, Food Energy and Eating for Sport

8.3 The Nutrition Facts Label and Added Sugar

8.4 Cravings, Reward and Habits That Last

8.5 Food Allergies: Cooking for Guests Safely

UNIT 9 · WEEKS 27–30

Meal Planning and Budgeting

Planning a week of family meals; Piggly Wiggly, unit prices and the grocery list; cost per serving and a weekly budget; batch cooking and the freezer; reducing food waste.

9.1 Planning a Week of Family Meals: Joseph and the Seven Good Years

9.2 Clarence Saunders, Piggly Wiggly and the Unit Price

9.3 Cost per Serving and a Weekly Budget: The Rumford Kitchen

9.4 Batch Cooking and the Freezer: Clarence Birdseye's Fast Freeze

9.5 Gather Up the Fragments: Reducing Food Waste

UNIT 10 · WEEKS 30–33

Hospitality and the Capstone Meal

Grace and the history of the family table; table setting and service; cooking for a crowd; timelines that bring every dish to the table at once; the capstone three-course meal for guests.

10.1 The Family Table and Saying Grace

10.2 Table Setting and Service: Emily Post and Martha's Kitchen

10.3 Cooking for a Crowd: Fred Harvey and the Harvey Houses

10.4 Timelines: Sarah Josepha Hale and the Thanksgiving Dinner

10.5 The Capstone Meal: Abraham's Welcome

Weekly pacing calendar

WEEK	PLAN
1	• Day 1: Lesson 1.1 Escoffier and the Brigade de Cuisine: video, teaching and worked examples • Day 2: Lesson 1.1: kitchen lab and notebook • Day 3: Lesson 1.1: practice set and corrections • Day 4: Lesson 1.2 Mise en Place: Everything in Its Place: video, teaching and worked examples • Day 5: Lesson 1.2: kitchen lab and notebook *Five sessions a week of about 50 minutes. Families on a four-day week can combine the practice day of one lesson with the teaching day of the next.*
2	• Day 1: Lesson 1.2: practice set and corrections • Day 2: Lesson 1.3 Typhoid Mary and the Food-Handler Standard: video, teaching and worked examples • Day 3: Lesson 1.3: kitchen lab and notebook • Day 4: Lesson 1.3: practice set and corrections • Day 5: Lesson 1.4 Clean, Separate, Cook, Chill and the Danger Zone: video, teaching and worked examples
3	• Day 1: Lesson 1.4: kitchen lab and notebook • Day 2: Lesson 1.4: practice set and corrections • Day 3: Lesson 1.5 The Food Code, Cooling Leftovers and the Food-Handler Card: video, teaching and worked examples • Day 4: Lesson 1.5: kitchen lab and notebook • Day 5: Lesson 1.5: practice set and corrections
4	• Day 1: Unit 1 test • Day 2: Lesson 2.1 Choosing, Honing and Sharpening Knives: video, teaching and worked examples • Day 3: Lesson 2.1: kitchen lab and notebook • Day 4: Lesson 2.1: practice set and corrections • Day 5: Lesson 2.2 The Classic Cuts: Julienne, Batonnet, Brunoise and Dice: video, teaching and worked examples
5	• Day 1: Lesson 2.2: kitchen lab and notebook • Day 2: Lesson 2.2: practice set and corrections

WEEK	PLAN
	• Day 3: Lesson 2.3 Herbs, Chiffonade and Mince: A Genoa Pesto: video, teaching and worked examples • Day 4: Lesson 2.3: kitchen lab and notebook • Day 5: Lesson 2.3: practice set and corrections
6	• Day 1: Lesson 2.4 Pots, Pans and Materials: video, teaching and worked examples • Day 2: Lesson 2.4: kitchen lab and notebook • Day 3: Lesson 2.4: practice set and corrections • Day 4: Lesson 2.5 Fannie Farmer, the Level Cup and the Kitchen Scale: video, teaching and worked examples • Day 5: Lesson 2.5: kitchen lab and notebook
7	• Day 1: Lesson 2.5: practice set and corrections • Day 2: Unit 2 test • Day 3: Lesson 3.1 Sautéing and Pan-Searing: Julia Child's Mushrooms: video, teaching and worked examples • Day 4: Lesson 3.1: kitchen lab and notebook • Day 5: Lesson 3.1: practice set and corrections
8	• Day 1: Lesson 3.2 Roasting: Hannah Glasse and the Roast Chicken: video, teaching and worked examples • Day 2: Lesson 3.2: kitchen lab and notebook • Day 3: Lesson 3.2: practice set and corrections • Day 4: Lesson 3.3 Broiling: Herschel's Invisible Heat and the Broiled Fish: video, teaching and worked examples • Day 5: Lesson 3.3: kitchen lab and notebook
9	• Day 1: Lesson 3.3: practice set and corrections • Day 2: Lesson 3.4 Shallow Pan-Frying: Mary Randolph's Fried Chicken: video, teaching and worked examples • Day 3: Lesson 3.4: kitchen lab and notebook • Day 4: Lesson 3.4: practice set and corrections • Day 5: Lesson 3.5 Doneness, Carryover and the USDA's 2011 Pork Change: video, teaching and worked examples
10	• Day 1: Lesson 3.5: kitchen lab and notebook • Day 2: Lesson 3.5: practice set and corrections • Day 3: Unit 3 test

WEEK	PLAN
	• Day 4: Lesson 4.1 Boiling, Simmering and Blanching: Joseph Black's Latent Heat: video, teaching and worked examples • Day 5: Lesson 4.1: kitchen lab and notebook
11	• Day 1: Lesson 4.1: practice set and corrections • Day 2: Lesson 4.2 Steaming: James Watt and the Power of Steam: video, teaching and worked examples • Day 3: Lesson 4.2: kitchen lab and notebook • Day 4: Lesson 4.2: practice set and corrections • Day 5: Lesson 4.3 Braising: Abraham Darby's Iron Pot and Collagen to Gelatin: video, teaching and worked examples
12	• Day 1: Lesson 4.3: kitchen lab and notebook • Day 2: Lesson 4.3: practice set and corrections • Day 3: Lesson 4.4 Stocks and Soups: Escoffier's Foundations: video, teaching and worked examples • Day 4: Lesson 4.4: kitchen lab and notebook • Day 5: Lesson 4.4: practice set and corrections
13	• Day 1: Lesson 4.5 The Pressure Cooker: Denis Papin's Steam Digester: video, teaching and worked examples • Day 2: Lesson 4.5: kitchen lab and notebook • Day 3: Lesson 4.5: practice set and corrections • Day 4: Unit 4 test • Day 5: Lesson 5.1 The Mother Sauces: Carême, Escoffier and the Béchamel: video, teaching and worked examples
14	• Day 1: Lesson 5.1: kitchen lab and notebook • Day 2: Lesson 5.1: practice set and corrections • Day 3: Lesson 5.2 Tomato Sauce: Antonio Latini and the Neapolitan Tomato: video, teaching and worked examples • Day 4: Lesson 5.2: kitchen lab and notebook • Day 5: Lesson 5.2: practice set and corrections
15	• Day 1: Lesson 5.3 Pan Sauces and Gravy: Escoffier's Brown Sauce at Home: video, teaching and worked examples • Day 2: Lesson 5.3: kitchen lab and notebook • Day 3: Lesson 5.3: practice set and corrections

WEEK	PLAN
	• Day 4: Lesson 5.4 Egg Cookery: Mère Poulard's Omelette: video, teaching and worked examples • Day 5: Lesson 5.4: kitchen lab and notebook
16	• Day 1: Lesson 5.4: practice set and corrections • Day 2: Lesson 5.5 The Family Breakfast: Amelia Simmons, Pearlash and Pancakes: video, teaching and worked examples • Day 3: Lesson 5.5: kitchen lab and notebook • Day 4: Lesson 5.5: practice set and corrections • Day 5: Unit 5 test
17	• Day 1: Review day for the midterm • Day 2: Midterm exam • Day 3: Lesson 6.1 Baker's Percentages: Raymond Calvel and the Focaccia: video, teaching and worked examples • Day 4: Lesson 6.1: kitchen lab and notebook • Day 5: Lesson 6.1: practice set and corrections
18	• Day 1: Lesson 6.2 The Home Loaf: Fleischmann's Yeast, Kneading and Gluten: video, teaching and worked examples • Day 2: Lesson 6.2: kitchen lab and notebook • Day 3: Lesson 6.2: practice set and corrections • Day 4: Lesson 6.3 Quick Breads: Eben Horsford's Baking Powder and the Muffin Method: video, teaching and worked examples • Day 5: Lesson 6.3: kitchen lab and notebook
19	• Day 1: Lesson 6.3: practice set and corrections • Day 2: Lesson 6.4 Pie Crust and Cookies: Fat, Flour and Flakiness: video, teaching and worked examples • Day 3: Lesson 6.4: kitchen lab and notebook • Day 4: Lesson 6.4: practice set and corrections • Day 5: Lesson 6.5 The Pound Cake and the Creaming Method: video, teaching and worked examples
20	• Day 1: Lesson 6.5: kitchen lab and notebook • Day 2: Lesson 6.5: practice set and corrections • Day 3: Unit 6 test

WEEK	PLAN
	• Day 4: Lesson 7.1 The Five Tastes and Balancing a Dish: Ikeda's Umami: video, teaching and worked examples • Day 5: Lesson 7.1: kitchen lab and notebook
21	• Day 1: Lesson 7.1: practice set and corrections • Day 2: Lesson 7.2 Herbs, Spices and Vasco da Gama's Voyage: video, teaching and worked examples • Day 3: Lesson 7.2: kitchen lab and notebook • Day 4: Lesson 7.2: practice set and corrections • Day 5: Lesson 7.3 Complementary and Contrasting Flavors: The Flavor Network: video, teaching and worked examples
22	• Day 1: Lesson 7.3: kitchen lab and notebook • Day 2: Lesson 7.3: practice set and corrections • Day 3: Lesson 7.4 The Grill: George Stephen's Kettle and the Two-Zone Fire: video, teaching and worked examples • Day 4: Lesson 7.4: kitchen lab and notebook • Day 5: Lesson 7.4: practice set and corrections
23	• Day 1: Lesson 7.5 Texture and Plating: Service à la Russe: video, teaching and worked examples • Day 2: Lesson 7.5: kitchen lab and notebook • Day 3: Lesson 7.5: practice set and corrections • Day 4: Unit 7 test • Day 5: Lesson 8.1 MyPlate and the Dietary Guidelines: From the Basic Seven to Today: video, teaching and worked examples
24	• Day 1: Lesson 8.1: kitchen lab and notebook • Day 2: Lesson 8.1: practice set and corrections • Day 3: Lesson 8.2 Macronutrients, Food Energy and Eating for Sport: video, teaching and worked examples • Day 4: Lesson 8.2: kitchen lab and notebook • Day 5: Lesson 8.2: practice set and corrections
25	• Day 1: Lesson 8.3 The Nutrition Facts Label and Added Sugar: video, teaching and worked examples • Day 2: Lesson 8.3: kitchen lab and notebook • Day 3: Lesson 8.3: practice set and corrections

WEEK	PLAN
	• Day 4: Lesson 8.4 Cravings, Reward and Habits That Last: video, teaching and worked examples • Day 5: Lesson 8.4: kitchen lab and notebook
26	• Day 1: Lesson 8.4: practice set and corrections • Day 2: Lesson 8.5 Food Allergies: Cooking for Guests Safely: video, teaching and worked examples • Day 3: Lesson 8.5: kitchen lab and notebook • Day 4: Lesson 8.5: practice set and corrections • Day 5: Unit 8 test
27	• Day 1: Lesson 9.1 Planning a Week of Family Meals: Joseph and the Seven Good Years: video, teaching and worked examples • Day 2: Lesson 9.1: kitchen lab and notebook • Day 3: Lesson 9.1: practice set and corrections • Day 4: Lesson 9.2 Clarence Saunders, Piggly Wiggly and the Unit Price: video, teaching and worked examples • Day 5: Lesson 9.2: kitchen lab and notebook
28	• Day 1: Lesson 9.2: practice set and corrections • Day 2: Lesson 9.3 Cost per Serving and a Weekly Budget: The Rumford Kitchen: video, teaching and worked examples • Day 3: Lesson 9.3: kitchen lab and notebook • Day 4: Lesson 9.3: practice set and corrections • Day 5: Lesson 9.4 Batch Cooking and the Freezer: Clarence Birdseye's Fast Freeze: video, teaching and worked examples
29	• Day 1: Lesson 9.4: kitchen lab and notebook • Day 2: Lesson 9.4: practice set and corrections • Day 3: Lesson 9.5 Gather Up the Fragments: Reducing Food Waste: video, teaching and worked examples • Day 4: Lesson 9.5: kitchen lab and notebook • Day 5: Lesson 9.5: practice set and corrections
30	• Day 1: Unit 9 test • Day 2: Lesson 10.1 The Family Table and Saying Grace: video, teaching and worked examples • Day 3: Lesson 10.1: kitchen lab and notebook

WEEK	PLAN
	• Day 4: Lesson 10.1: practice set and corrections • Day 5: Lesson 10.2 Table Setting and Service: Emily Post and Martha's Kitchen: video, teaching and worked examples
31	• Day 1: Lesson 10.2: kitchen lab and notebook • Day 2: Lesson 10.2: practice set and corrections • Day 3: Lesson 10.3 Cooking for a Crowd: Fred Harvey and the Harvey Houses: video, teaching and worked examples • Day 4: Lesson 10.3: kitchen lab and notebook • Day 5: Lesson 10.3: practice set and corrections
32	• Day 1: Lesson 10.4 Timelines: Sarah Josepha Hale and the Thanksgiving Dinner: video, teaching and worked examples • Day 2: Lesson 10.4: kitchen lab and notebook • Day 3: Lesson 10.4: practice set and corrections • Day 4: Lesson 10.5 The Capstone Meal: Abraham's Welcome: video, teaching and worked examples • Day 5: Lesson 10.5: kitchen lab and notebook
33	• Day 1: Lesson 10.5: practice set and corrections • Day 2: Unit 10 test • Day 3: Review day for the final • Day 4: Final exam

Materials

Lab notebook (a bound notebook or a binder)

One for the whole year: recipes as made, weights, temperatures, times, observations, sketches, family ratings and the repeat round.

An instant-read food thermometer (required)

Used in nearly every lab from Lesson 1.4 on. Calibrate it in ice water (Lesson 3.5).

A digital kitchen scale that reads grams (required)

Used from Lesson 2.5 on for measuring by weight, yield percentages and baker's percentages.

A refrigerator thermometer

Inexpensive. Keep the refrigerator at or below 40 °F (4 °C) and the freezer at 0 °F (−18 °C).

Measuring cups (dry and liquid), measuring spoons and a timer
Used in every lab.

A calculator
For worked examples, practice sets and tests.

A chef's knife (8 inch), a paring knife, a serrated bread knife, a honing steel and two cutting boards
One board for raw meat, poultry and fish and one for ready-to-eat foods. Put a damp towel under the board so it cannot slide.

A 12-inch skillet, a medium saucepan, a large pot or Dutch oven with lid, two rimmed sheet pans, a loaf pan, a 9-inch round or square pan, and a muffin tin
Ordinary home equipment. A cast-iron skillet is useful but optional.

Mixing bowls, whisk, wooden spoon, rubber spatula, tongs, ladle, colander, cooling rack and oven mitts
Basic tools for every unit.

Optional: a grill, a pressure cooker, a stand or hand mixer, a candy thermometer, a whetstone
Never required. Every grill recipe has a broiler or grill-pan method, and every pressure-cooker recipe has a stovetop method.

Grading

Grades balance the kitchen and the page: labs and the notebook show skill and care, practice sets and tests show understanding. A dish that fails but is honestly recorded, analyzed and made again with one improvement earns full lab credit.

PART	%
Practice sets (completed and corrected)	15
Kitchen labs (safety, technique, measurement, cleanup and the repeat round)	25
Lab notebook	10
Unit tests	30
Midterm exam	10

PART	%
Final exam	**10**

Scale: A 90–100, B 80–89, C 70–79, D 60–69. Below 60: review the unit, redo the practice set and retake the test.

- Labs are graded on safety, technique, measurement, cleanup and honest records, not on whether the dish was perfect.
- Unit projects (one per unit) are graded with their own rubric and count within the kitchen-lab portion.
- A notebook page earns full marks when it has the date, the recipe as made, at least two measurements (weight, temperature or time), an observation, a sketch or photo, a family rating and one planned change.
- Never grade or comment on anyone's body, size or how much they ate.

A NOTE TO PARENTS

You do not need to be a chef to teach this course. Your jobs are to be present in the house for the labs, to watch each new knife, stove, oven and grill skill the first time, to taste and give honest, kind feedback, and to check the practice sets against the answers. Ask two questions often: "What is the technique standard for this dish?" and "What will you change next time?"

Expect some failures. Bread will come out dense, sauces will break, a roast will overcook. A recorded failure followed by a better second try is exactly how cooks learn, and the grading gives full credit for it. *Fabricando fit faber*: by making, one becomes a maker.

We keep the conversation on skill, nourishment, thankfulness, stewardship and hospitality, never on weight or appearance. Food allergies and medical diets belong to your family and your doctor: read each recipe card's allergen note and make the swaps your family needs. By the end of the year your student should be able to plan, budget, shop for and cook a week of family meals, and to welcome guests to your table.

UNIT 1

The Professional Kitchen and Food Safety

Every good cook begins with order and safety. In this unit you will meet Auguste Escoffier, who turned the chaotic kitchens of the 1800s into the orderly brigade that professional restaurants still use, and you will learn mise en place, the habit of having everything ready before the heat goes on. Then you will learn the food-handler standard: personal hygiene, Clean, Separate, Cook, Chill, the danger zone, and the two-stage cooling rule of the FDA Food Code.

The stories are real and sometimes sobering: a healthy cook who carried typhoid from house to house, and a 1993 outbreak of *E. coli* O157:H7 that changed how the nation cooks ground beef. Each lesson has a lab: a potato-leek soup cooked as a brigade, a fried rice that depends on mise en place, a ready-to-eat salad made by the hygiene rules, burgers checked to 160 °F, and a big batch of chili cooled by the Food Code. The unit ends with a food-handler practice exam; afterward many students choose to earn a real state food-handler card.

PREREQUISITES

- Comfortable with fractions, decimals and percentages
- Has used a stove and oven under a parent's supervision
- Owns or can borrow an instant-read thermometer

MASTERY CHECKLIST

- ☐ I can describe Escoffier's brigade and use mise en place before every lab.
- ☐ I can scale a recipe with a yield factor and calculate yield percentage.
- ☐ I can follow the food-handler hygiene rules and explain why a healthy-looking cook can spread illness.
- ☐ I can state the four steps, the danger zone, the two-hour rule and the USDA safe minimum internal temperatures, and convert °F and °C.
- ☐ I can cool a large batch of food by the two-stage rule and reheat leftovers to 165 °F.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **FoodSafety.gov: Safe Minimum Internal Temperatures chart**: Free (search the chart's name at FoodSafety.gov). A printable chart of the USDA temperatures; tape it inside a cupboard door for the whole year.
- **FDA: Food Code**: Free. The FDA's page for the current Food Code, the model rules behind state restaurant inspections. Skim the hygiene and cooling sections for Lessons 1.3 and 1.5.
- **An instant-read food thermometer and a refrigerator thermometer**: The thermometer is required for the course from Lesson 1.4 on; the refrigerator thermometer is inexpensive and shows whether your refrigerator stays at or below 40 °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

1.1	**Escoffier and the Brigade de Cuisine**	3 sessions of 50–90 minutes
1.2	**Mise en Place: Everything in Its Place**	3 sessions of 50–90 minutes
1.3	**Typhoid Mary and the Food-Handler Standard**	3 sessions of 50 minutes
1.4	**Clean, Separate, Cook, Chill and the Danger Zone**	3 sessions of 50 minutes
1.5	**The Food Code, Cooling Leftovers and the Food-Handler Card**	3 sessions of 50–90 minutes

Unit 1 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Name the station chef who handles (a) sauces, (b) roasts, (c) pastry, and explain in one sentence how Escoffier's brigade made a kitchen faster.

2. **8 pts**

   A recipe serves 6 and uses 2½ lb of potatoes. Scale it for 20 servings.

3. **6 pts**

   You buy 4.0 lb of broccoli and keep 3.0 lb of florets. Find the yield percentage, and find how much to buy for 4.5 lb of florets.

4. **6 pts**

   Define mise en place and give two reasons it matters for a stir-fry.

5. **8 pts**

   Who was Mary Mallon, and what lesson did her case teach about food handlers?

6. **6 pts**

   Bacteria double every 20 minutes. How many will 30 bacteria become in 2 hours?

7. **6 pts**

   List the steps and the time for proper handwashing, and four times a cook must wash.

8. **6 pts**

   Convert 145 °F and 40 °F to Celsius.

9. **6 pts**

   Give the USDA safe minimum internal temperatures for poultry, ground beef, whole cuts of pork, fish, egg dishes and reheated leftovers.

10. **8 pts**

    Explain why ground beef must be cooked to 160 °F while a beef steak may be served at 145 °F, and describe the outbreak that taught America this lesson.

11. **6 pts**

    Chicken salad is set out at a 93 °F picnic at 12:20 p.m. By what time must it be refrigerated or thrown away?

12. **8 pts**

    A pot of soup is 135 °F at 4:00 p.m., 82 °F at 6:00 p.m., and 40 °F at 9:30 p.m. Evaluate it against the two-stage cooling rule, and describe what should have been done.

13. **6 pts**

    Where should raw meat go in a refrigerator, and what temperature should the refrigerator and freezer be?

14. **6 pts**

    Predict: a cook puts 3 gallons of hot chili, still in its deep stockpot, into the refrigerator overnight. What will happen to the center of the chili, and why is that dangerous?

15. **8 pts**

    Essay (one paragraph): Using Escoffier, Mary Mallon and the 1993 outbreak, explain why food safety is a matter of character and system as well as rules.

ANSWER KEY

1. (a) saucier, (b) rôtisseur, (c) pâtissier. The parts of a dish were made at the same time by different stations and assembled at the pass, instead of one cook making the whole dish in sequence.
2. Factor $20/6 = 3.33$; $2.5 \times 3.33 = 8.3$ lb.
3. 75%; $4.5/0.75 = 6.0$ lb.
4. Everything prepared and in place before cooking. Stir-fries cook in minutes, so there is no time to prep during cooking; leaving a hot pan to chop is unsafe and burns the food.
5. A New York cook (1906–1915) who was a healthy carrier of *Salmonella* Typhi and spread typhoid to the families she cooked for. A cook who feels well can still spread disease, so handwashing and sick-worker rules protect everyone.
6. $30 \times 2^6 = 1{,}920$
7. Wet with warm water, apply soap, scrub hands, backs, between fingers and under nails for at least 20 seconds, rinse, dry with a clean towel. Four times: before cooking, after the restroom, after touching raw meat, after touching face, hair, phone or trash.
8. 62.8 °C and 4.4 °C.
9. Poultry 165 °F; ground beef 160 °F; whole cuts of pork 145 °F with a 3-minute rest; fish 145 °F; egg dishes 160 °F; leftovers 165 °F.
10. Bacteria live on the surface of whole cuts and are killed by searing; grinding spreads them through the meat. In 1993 undercooked fast-food hamburgers contaminated with *E. coli* O157:H7 sickened more than 700 people in four western states and killed four children, leading the USDA to declare the bacterium an adulterant in ground beef (1994) and require safe-handling labels.
11. By 1:20 p.m.: above 90 °F the limit is 1 hour.
12. Stage 1 failed: 82 °F at 2 hours (must be 70 °F or below). It should have been divided into shallow pans 2 inches deep or less, cooled in an ice bath with stirring, and logged. (Stage 2 would have passed if Stage 1 had.)
13. Bottom shelf in a container; refrigerator at or below 40 °F, freezer at 0 °F.
14. The center will stay warm, in the danger zone, for many hours because heat escapes only through the small top surface; spore-forming bacteria such as *Clostridium perfringens* can multiply to unsafe levels.

15. Answers vary. A strong answer: Escoffier built order and discipline into the kitchen so good habits were part of the system; Mallon's case shows that personal honesty and hygiene protect others even when one feels well; the 1993 outbreak shows that safety depends on every link, from processor to cook, and that rules (160 °F, labels) grew from real harm. A faithful cook loves the neighbor he feeds.

UNIT PROJECT: FOOD-HANDLER PRACTICE EXAM AND HOME KITCHEN AUDIT

Part 1: Write and take a 30-question food-handler practice exam covering hygiene, the four steps, temperatures, the danger zone, cross-contamination, cooling and reheating. Write the questions yourself from this unit, trade with a parent who grades it with your answer key, and score at least 80%. If you like, then take an accredited online food-handler course accepted by your state or county (usually a small fee) and add your card to your portfolio.

Part 2: Audit your home kitchen like a health inspector. Record refrigerator and freezer temperatures on three days, check where raw meat is stored, check that a thermometer is available and calibrated, look at handwashing supplies, and inspect leftovers for labels and dates. Write a one-page report with three improvements, make them, and attach your chili cooling log as evidence of safe cooling.

LOOK FOR	WHAT IT MEANS
Exam	Thirty clear questions with a correct answer key; score of 80% or higher.
Audit data	Temperatures recorded on three days; every audit item checked and noted honestly.
Improvements	Three specific improvements made, with before-and-after notes or photos.
Cooling evidence	A complete cooling log and graph judged correctly against the two-stage rule.
Presentation	Neat, organized report a family member could follow.

1.1 Escoffier and the Brigade de Cuisine

OBJECTIVES

- Tell how Auguste Escoffier organized the professional kitchen into stations, and name the main positions of the brigade de cuisine.
- Explain why dividing work into stations makes a kitchen faster, safer and more consistent.
- Scale a recipe with a yield factor and plan parallel tasks so a dish is finished on time.
- Cook a classic potato-leek soup, running your family kitchen as a small brigade.

> **Warm-up.** Think of the last big family meal. Who did what? Make a quick list of every job that had to be done, from shopping to dishwashing. Which jobs could two people have done at the same time, and which had to wait for another job to finish?

WATCH

Kitchen Hierarchy | Kitchen Brigade System | What is Chef de Partie | Sous Chef Responsibilities

Private Chef Academy / Clara.kitchen · 5:55

https://www.youtube.com/watch?v=-EGPc99638k

> **WHEN TO WATCH**
> After the story paragraph. Pause at the chart of stations and copy the main positions into your notebook.

Note: From a private-chef cooking school. A clear walk through the brigade positions; stop when the teaching ends and the closing promotion begins.

KEY TERMS

brigade de cuisine

The system of kitchen stations and ranks organized by Auguste Escoffier, in which each cook is responsible for one part of the menu.

chef de cuisine

The head chef, who plans the menu, trains and directs the cooks and is responsible for every plate that leaves the kitchen.

sous-chef

The "under-chef," second in command, who runs the line during service and takes charge when the head chef is away.

chef de partie

A station chef, such as the saucier (sauces and sautéed dishes), rôtisseur (roasts), entremetier (vegetables, soups and eggs), garde manger (cold foods) or pâtissier (pastry).

yield factor

The number you multiply each ingredient by to scale a recipe: new yield divided by old yield.

CORE IDEAS

The story. Georges Auguste Escoffier was born in 1846 in Villeneuve-Loubet, near Nice in the south of France, and began working in his uncle's restaurant kitchen at about thirteen. In his day great kitchens were hot, crowded and disorderly: cooks worked long hours over coal fires, and a single cook might make a whole dish from beginning to end while others waited. In 1890 Escoffier joined the hotelier César Ritz at the new Savoy Hotel in London, and later opened the kitchens of the Ritz in Paris (1898) and the Carlton in London (1899). There he built the kitchen system that most professional restaurants still use, and in 1903 he published *Le Guide Culinaire*, a book of about five thousand recipes that cooks still study.

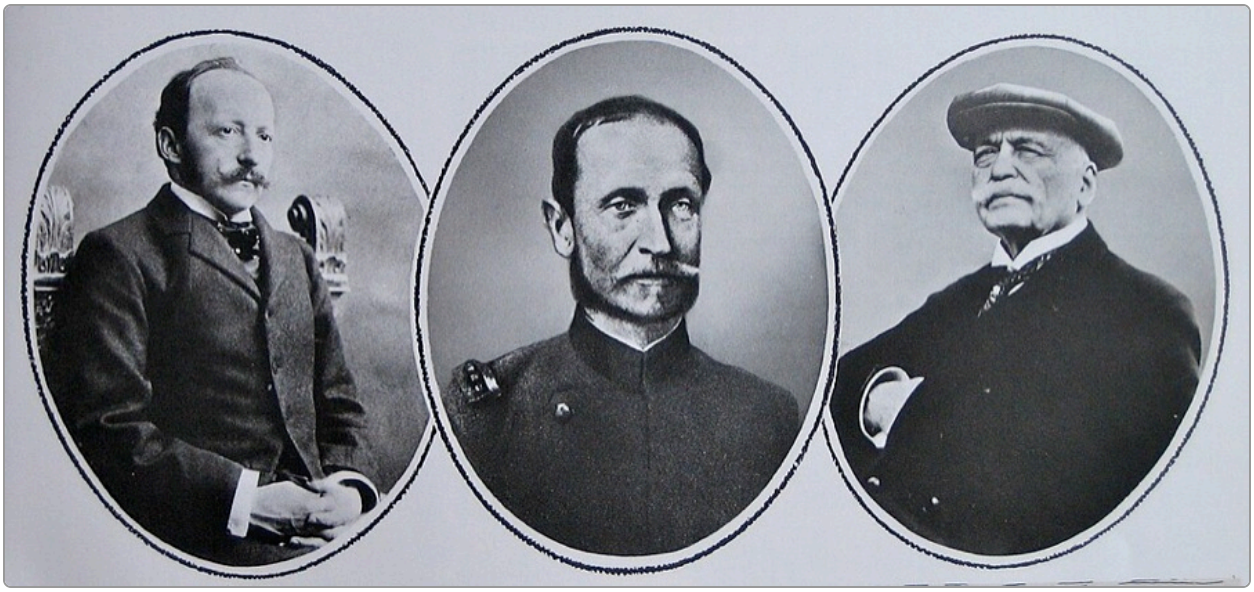
How he figured it out. Escoffier had served as an army cook and had seen how a well-drilled unit works: every person has one clear job and one person gives the orders. He divided his kitchen into stations, or *parties*, each led by a chef de partie. The saucier made sauces and sautéed dishes, the rôtisseur roasted and grilled, the entremetier cooked vegetables, soups and eggs, the poissonnier cooked fish, the garde manger prepared cold foods, and the pâtissier made pastry. Commis (junior cooks) worked under each station chef. When an order came in, the parts of a dish were made at the same time by different stations and assembled at the pass. A dish that once waited on one cook now came together from several stations at once, and every plate was made the same way every time.

The kitchen science. The brigade is really an idea about **time and order**. Tasks that do not depend on each other can run *in parallel*, so the total time is set by the longest chain of tasks that must happen one after another (cooks and engineers call this the

critical path). Stations also make the kitchen safer: each cook knows which knives, burners and boards are his, raw foods stay in their own area, and the head chef can watch the whole line. Escoffier insisted on clean uniforms, sober conduct and quiet, orderly work, and he banned shouting and rough language in his kitchens. Good order is part of good food.

Let's cook. You will make *potage Parmentier*, the French potato-leek soup named for Antoine Parmentier, who promoted the potato in France in the 1770s. It is a classic entremetier dish and a perfect first lab: leeks to wash and slice, potatoes to peel and dice, a gentle sweat in butter, a simmer and a purée. Run it as a brigade. You are chef de cuisine: write the prep list, assign stations to anyone helping, and hold the standard. The technique standard: leeks completely free of grit, vegetables cut evenly, leeks softened without browning, potatoes simmered until they crush easily, and a smooth soup seasoned to taste.

PICTURE STUDY



César Ritz, Max Pfyffer and Auguste Escoffier, Unknown photographer, Late 1890s · Photograph · Wikimedia Commons

Image: Wikimedia Commons, public domain

This old photograph shows Auguste Escoffier with the hotelier César Ritz and their business partner. Ritz ran the dining room and the hotel; Escoffier ran the kitchen. Together they made the hotel restaurant a place where families could dine well in public, served by an orderly kitchen and a polished dining room.

Look closely

- Find Escoffier. How is he dressed? What does his clothing say about how he wanted cooks to be seen?
- Notice that the chef is photographed beside the owners as a partner. What does that suggest about his place in the business?
- Look at the posture of each man. Who seems to be in charge here, and why do you think so?

Talk about it

1. Why did a famous hotel need both a great dining room manager and a great chef?
2. Escoffier wanted cooks to be respected professionals. Name two habits from this lesson that help a cook earn that respect.

3. If you were the chef de cuisine of your family kitchen this week, what would your first order be?

Safety first. A parent or responsible adult is at home for every lab in this course and watches you do each new knife, stove and oven task safely before you do it on your own; check every recipe against your family's food allergies. When puréeing hot soup, fill a blender no more than half full, vent the lid and hold it down with a folded towel, or use an immersion blender with the blade kept below the surface.

KITCHEN LAB

Run a Family Brigade: Potato-Leek Soup

You will cook potage Parmentier as chef de cuisine of a small brigade, writing a prep list and station plan first, then timing the work to see how stations change the clock.

You will need

- A chef's knife, a paring knife or peeler, and a cutting board on a damp towel
- A large pot or Dutch oven with a lid
- A blender or immersion blender (or a potato masher for a rustic soup)
- Measuring cups and spoons, a kitchen scale, a ladle and a timer
- A large bowl of cold water for washing leeks

Potage Parmentier (Potato-Leek Soup)

Serves 6 (about 10 cups) · Prep 25 min · Cook 35 min

Ingredients

- 3 tablespoons (42 g) butter or olive oil
- 3 medium leeks (about 1½ lb / 680 g whole), white and light-green parts only
- 1 small onion, diced (optional)
- 2 lb (900 g) Yukon Gold or russet potatoes, peeled and cut into ¾-inch dice
- 6 cups (1.4 L) chicken or vegetable broth
- 1 bay leaf
- 1 teaspoon salt (less if the broth is salted) and ½ teaspoon black pepper
- ½ cup (120 mL) milk or cream (optional)
- Snipped chives or parsley for garnish

Method

1. Trim off the dark-green tops and the roots of the leeks. Slice each leek in half lengthwise, then into ¼-inch half-moons. Swish the slices in a big

bowl of cold water, let the grit sink, and lift the leeks out with your hands or a slotted spoon. Repeat until no grit remains.

2. Melt the butter in the pot over medium-low heat. Add the leeks (and onion) with a pinch of salt and cook gently, stirring often, 8–10 minutes, until soft and sweet but not browned.
3. Add the potatoes, broth and bay leaf. Bring to a boil, then lower to a gentle simmer, cover partly and cook 20–25 minutes, until a potato cube crushes easily against the side of the pot.
4. Remove the bay leaf. Purée with an immersion blender, or in a blender in batches no more than half full with the lid vented under a towel. For a rustic soup, mash in the pot.
5. Stir in the milk or cream if using, and heat through without boiling. Taste and adjust the salt and pepper. Serve hot with chives.
6. Cool leftovers quickly in shallow containers and refrigerate within 2 hours; reheat to 165 °F.

Allergy check: Contains milk (butter, cream). For a milk-free soup, use olive oil and skip the cream. Check the broth label: some contain wheat or soy.

Steps

1. **Prep list.** Before you touch a knife, write every task in the recipe on its own line with an estimated time, and mark which tasks must wait for others.
2. **Station plan.** Assign the tasks to stations (even if you are a brigade of one or two): vegetable prep, soup, table and cleanup. Draw the critical path.
3. **Mise en place.** Wash hands, tie back hair, put on an apron, and set out every tool and ingredient before you begin cooking.
4. Cook the soup. Record the actual start and finish time of each task.
5. **Technique check.** Score yourself 1–3 on each standard: grit-free leeks, even dice, leeks soft but not brown, potatoes fully tender, smooth texture, seasoning.
6. **Taste and adjust.** Taste before and after the final salt. Record what changed.
7. **Compare.** How close was your estimated time to the actual time? Which task took longest? What was your critical path?

8. Clean up as a brigade: each station cleans its own area; wash, dry and put away everything; wipe the stove and counters.
9. **Repeat round.** Within two weeks, make the soup again (or a variation with cauliflower or celery root) and try to beat your time while keeping every standard.

Tips

- Cut the potatoes the same size so they finish together.
- Sweat the leeks over low heat with a pinch of salt: the salt draws out water and keeps them from browning.
- Season at the end; broth reduces as it simmers and becomes saltier.

Check your work

- ☐ I can name the main positions of the brigade and what each station does.
- ☐ I wrote a prep list and station plan and found my critical path.
- ☐ I cooked a smooth, grit-free, well-seasoned potato-leek soup and recorded my times.

LAB NOTEBOOK

1. Draw an organization chart of Escoffier's brigade, with the chef de cuisine at the top, and write one sentence on each station.
2. Paste or copy your prep list and timeline, marking the critical path in color, and record estimated versus actual times.
3. Record the soup lab: weights, simmer time, technique scores, family rating, and one change for the repeat round.

KEY FORMULAS

$$\text{yield factor} = \frac{\text{new yield}}{\text{old yield}}$$

$$\text{new quantity} = \text{old quantity} \times \text{yield factor}$$

$$\text{time with stations} \approx \text{the longest chain of tasks that must be done in order}$$

> **From history.** Escoffier also simplified the menus of his day, which often listed dozens of heavy dishes, and he helped popularize the à la carte menu, from which each guest orders separately. He was made a member of France's Legion of Honor in 1920, the first chef to be so honored, and he died in 1935.

WORKED EXAMPLES

Example 1. The soup recipe serves 6 and uses 2 lb of potatoes, 3 leeks and 6 cups of broth. Scale it for 15 guests.

Show solution

1. Yield factor: $\dfrac{15 \text{ servings}}{6 \text{ servings}} = 2.5$.
2. Potatoes: $2 \text{ lb} \times 2.5 = 5 \text{ lb}$.
3. Leeks: $3 \times 2.5 = 7.5$, so buy 8 leeks.
4. Broth: $6 \text{ cups} \times 2.5 = 15 \text{ cups} = 3.75 \text{ qt}$.

Answer: Yield factor 2.5: 5 lb potatoes, about 8 leeks and 15 cups (3¾ quarts) of broth. Season by taste rather than multiplying the salt exactly; taste and adjust at the end.

Example 2. One cook makes dinner alone: washing and slicing leeks (12 min), peeling and dicing potatoes (15 min), setting the table (8 min) and making a salad (10 min), then 30 min of cooking the soup, which can start only after both the leeks and the potatoes are ready. How long does dinner take with one cook, and with a brigade of three?

Show solution

1. One cook does everything in order: $12 + 15 + 8 + 10 + 30 = 75$ min.
2. With three cooks, the leeks and potatoes are prepared at the same time by two cooks; the soup can start when the slower of them is done, after 15 min.
3. Critical path: $15 + 30 = 45$ min. The third cook sets the table and makes the salad (18 min) while the soup simmers, so these jobs add no time.

Answer: 75 minutes alone; about 45 minutes as a brigade of three. The critical path (prep the slowest vegetable, then simmer) sets the time.

Example 3. Escoffier's cooks plated a banquet for 240 guests. If each station chef with two commis can plate 4 plates per minute, how many minutes does it take one station to plate the course, and how long if the work is split evenly between two identical stations?

Show solution

1. One station: $\dfrac{240 \text{ plates}}{4 \text{ plates/min}} = 60 \text{ min}.$
2. Two stations at the same rate: $\dfrac{240}{2 \times 4} \text{ min} = 30 \text{ min}.$

Answer: 60 minutes for one station, 30 minutes for two. Doubling the stations halves the plating time, which is why banquet kitchens set up long plating lines.

PRACTICE

1. Easy Name the station chef responsible for (a) sauces and sautéed dishes, (b) roasts, (c) vegetables, soups and eggs, (d) cold foods, (e) pastry.

   Show answer

   (a) saucier, (b) rôtisseur, (c) entremetier, (d) garde manger, (e) pâtissier.

2. Easy A recipe serves 4. What is the yield factor to serve 10?

   Show answer

   $10/4 = 2.5$

3. Easy In what year did Escoffier publish *Le Guide Culinaire*, and about how many recipes did it hold?

   Show answer

   1903; about 5,000 recipes.

4. Medium A soup recipe for 8 uses 3 lb of potatoes. How much for 12 servings? For 6?

   Show answer

   Factor 1.5: 4.5 lb. Factor 0.75: 2.25 lb (2 lb 4 oz).

5. Medium Why is it wise to multiply the salt and spices by a little less than the yield factor when scaling a recipe up a lot, and then taste?

Show answer

Salt and strong spices do not always need to rise in exact proportion (evaporation and pot size differ, and a small measuring error grows); adding most of it and adjusting by taste prevents an oversalted batch that cannot be fixed.

6. Medium Three tasks must be done in order: wash leeks (10 min), sweat leeks (10 min), simmer soup (25 min). Peeling potatoes (12 min) must be done before the simmer but can run alongside the leek work. What is the shortest total time with two cooks?

Show answer

Leek chain 10 + 10 = 20 min; potatoes (12 min) finish earlier, so the simmer starts at 20 min. Total $20 + 25 = 45$ min.

7. Medium Give two safety advantages of a kitchen organized into stations.

Show answer

Any two: raw foods stay in their own area; each cook knows his own knives and burners, so fewer collisions and burns; the head chef can watch the whole line; clear responsibility for cleaning each area.

8. Hard A banquet needs 180 bowls of soup in 20 minutes. One server ladles 5 bowls per minute. How many servers are needed?

Show answer

Needed rate $180/20 = 9$ bowls/min; $9/5 = 1.8$, so 2 servers.

9. Hard Scaling a recipe for 6 to 1 serving gives ⅙ cup of cream. Convert this to tablespoons (1 cup = 16 Tbsp).

Show answer

$16/6 \approx 2.7$ Tbsp, about 2⅔ tablespoons.

10. **Challenge** Escoffier said that much of cooking is simplicity and order. Using the idea of the critical path, explain why adding more cooks to a kitchen eventually stops making dinner any faster.

    Show answer

    Once every independent task has its own cook, the time is set by the longest chain of tasks that must happen in order (for example, the soup cannot simmer before the vegetables are cut, and simmering takes 25 minutes no matter how many people watch it). Extra cooks cannot shorten that chain and may crowd the kitchen.

COMMON MISTAKES

- Skipping the leek wash. Leeks grow in sandy soil, and grit hides between the layers; one gritty spoonful ruins a pot.
- Browning the leeks. Potage Parmentier should be pale and sweet; high heat makes it bitter and brown.
- Filling a blender to the top with hot soup. Steam pushes off the lid. Fill halfway, vent and hold with a towel.
- Multiplying salt exactly when scaling up a lot. Add most of it, then taste.

> **Make it a game · Brigade Roll Call.** Your parent calls out kitchen jobs: making sauces, grilling, pastry, cold salads, running the whole kitchen, second in command. You name the position or station in under five seconds. Run twelve calls and log your score. Then explain in two sentences why Escoffier's stations made a busy kitchen faster. Aim to beat your record.

> **Scripture.** “And whatsoever ye do, do it heartily, as to the Lord, and not unto men;” (Colossians 3:23, KJV)
>
> A cook’s work is often unseen: washed leeks, an even dice, a clean station. Doing it well because God sees it is the root of every good kitchen.

1.2 Mise en Place: Everything in Its Place

OBJECTIVES

- Define mise en place and set up a working station with every tool and ingredient ready before cooking.
- Calculate yield percentage from as-purchased and edible-portion weights, and use it to decide how much to buy.
- Cook chicken fried rice, a fast stir-fried dish that works only when the mise en place is complete.
- Tell the story of the founding of the Culinary Institute of America in 1946.

> **Warm-up.** Time yourself making a simple sandwich while fetching each item only when you need it. Then put everything out first, in the order you will use it, and make a second sandwich. Compare the times and the mess.

WATCH

01 Mise en Place - Culinary Techniques for Healthy School Meals

NFSMIatOleMiss · 5:19

https://www.youtube.com/watch?v=PDFBdk0d21A

> **WHEN TO WATCH**
> After the story. Watch for the written prep schedule near the end and copy its format for your own lab.

Note: From the National Food Service Management Institute at the University of Mississippi, which trains school-cafeteria cooks.

BACKUP VIDEO

Mise en Place Explained (theory of food preparation) - French Cooking Basics Ep05

French Cooking Academy · 14:14

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

Optional, after the lab: a French-trained cook explains how he plans and lays out his station.

KEY TERMS

mise en place

French for “putting in place”: having every ingredient measured and prepared and every tool ready before cooking begins.

as-purchased (AP) weight

The weight of an ingredient as it comes from the store, before trimming or peeling.

edible-portion (EP) weight

The weight left after trimming, peeling, seeding or boning: the part you actually cook.

yield percentage

Edible-portion weight divided by as-purchased weight, times 100.

stir-fry

Cooking small, evenly cut pieces quickly over high heat in a little oil while tossing them constantly.

CORE IDEAS

The story. In 1946, as soldiers came home from the Second World War, Frances Roth, a lawyer, and Katharine Angell opened a small cooking school in New Haven, Connecticut, called the New Haven Restaurant Institute. Its first students were veterans learning a trade. The school grew into the Culinary Institute of America, which moved in 1972 to a large former seminary building above the Hudson River at Hyde Park, New York. Like every serious culinary school, it teaches the habit French cooks call *mise en place* from the first day.

How they figured it out. Professional cooks learned mise en place the hard way, during service, when dozens of orders arrive at once and there is no time to look for a knife or peel an onion. A cook who prepares everything beforehand, measured and arranged in the order it will be used, can cook each order in minutes and keep the station clean. The habit spread from French kitchens to cooking schools everywhere. It is not only about ingredients: it includes reading the whole recipe first, setting out tools, preheating the oven, and planning when each task must be done.

The kitchen science. Ingredients are bought at **as-purchased** weight, but you cook the **edible portion** after peeling, trimming, seeding or boning. The ratio is the **yield**

percentage. Onions lose their skins and root ends, peppers their seeds and stems, and chicken thighs their bones and skin. Knowing the yield tells you how much to buy so the recipe has enough. Mise en place also matters for safety: stir-frying happens over high heat in a few minutes, and a cook who walks away from a hot wok to chop a forgotten onion risks scorched food or a fire.

Let's cook. You will make chicken fried rice, a dish that is all mise en place. The rice is cooked a day ahead and chilled so its grains firm up and stay separate. Everything else is cut and measured into small bowls. The cooking itself takes about ten minutes. The technique standard: every ingredient prepared before the pan is hot, chicken in even ½-inch pieces cooked to 165 °F, eggs fully set, rice hot and separate rather than mushy, and the station clean when you finish.

PICTURE STUDY



The Kitchen Maid, Jean-Siméon Chardin, 1738 · Oil on canvas · National Gallery of Art, Washington, D.C.
Image: Wikimedia Commons, public domain

Chardin loved quiet scenes of ordinary work. Here a kitchen maid has stopped for a moment while preparing turnips. Around her are the tools of her job, set where she can reach them. This is mise en place three centuries ago: the vegetables gathered, the pot ready, the work laid out.

Look closely

- Find the turnips. Which are peeled and which are not? How can you tell where she is in her task?
- Find the knife and the pot. Are they close enough to her work?
- Look at her apron and cap. Why were these part of a cook's standard then, as they are now?
- Notice the peelings. Where are they going?

Talk about it

1. What would she need next to finish this dish? Make her prep list.
2. Turnips lose their peel and root ends. If she started with 5 lb and kept 4 lb, what was her yield percentage?
3. Chardin painted her pausing. Why is a short pause to think part of good mise en place?

> **Safety first.** Cook the chicken to 165 °F and keep raw chicken, its board and its knife away from the vegetables and cooked rice. Heat the oil until it shimmers but not until it smokes, keep the pan handle turned in, and never leave a hot pan to fetch a missing ingredient: that is why mise en place comes first.

KITCHEN LAB

Mise en Place Lab: Chicken Fried Rice

You will set a full mise en place, weigh as-purchased and edible-portion amounts to find your own yield percentages, and cook a fast stir-fry with everything ready.

You will need

- Two cutting boards (raw chicken and vegetables), a chef's knife and a paring knife
- A kitchen scale
- A 12-inch skillet or wok and a wide spatula
- Small bowls or cups for each prepared ingredient
- An instant-read thermometer, measuring cups and spoons

Chicken Fried Rice

Serves 4–6 · Prep 25 min · Cook 12 min (rice cooked and chilled a day ahead)

Ingredients

- 4 cups (about 600 g) cold cooked long-grain rice, cooked a day ahead and refrigerated
- 1 lb (450 g) boneless, skinless chicken thighs, cut in ½-inch pieces
- 3 large eggs, beaten with a pinch of salt
- 3 tablespoons neutral oil (canola or vegetable), divided
- 1 medium carrot, cut in small dice
- 1 cup frozen peas
- 4 green onions, white and green parts sliced separately
- 2 cloves garlic, minced
- 1 tablespoon minced fresh ginger
- 3 tablespoons soy sauce, plus more to taste
- 1 teaspoon toasted sesame oil (optional)

Method

1. Set out every prepared ingredient in its own bowl, in the order you will use it. Break up any clumps of rice with clean hands.
2. Heat 1 tablespoon oil in the skillet over medium-high heat. Add the eggs and scramble until fully set with no liquid left, about 1 minute. Move to a plate.
3. Add 1 tablespoon oil and the chicken in one layer. Cook, stirring every minute, 5–6 minutes, until browned and 165 °F in the thickest piece. Move to the egg plate. Wash the thermometer stem.
4. Add the last tablespoon of oil, the carrot and the white parts of the green onions. Stir-fry 2 minutes. Add the garlic and ginger and stir 30 seconds, until fragrant.
5. Add the rice, pressing it against the hot pan and tossing, 3–4 minutes, until steaming hot. Add the peas, chicken, eggs and soy sauce and toss 1–2 minutes more.
6. Off the heat, stir in the green-onion tops and sesame oil. Taste and add soy sauce if needed. Serve at once; refrigerate leftovers within 2 hours.

Allergy check: Contains eggs, soy and wheat (soy sauce) and sesame (sesame oil). Use tamari labeled gluten-free for a wheat-free version, and skip the sesame oil if needed.

Steps

1. Read the recipe through twice. Write a prep list in the order the ingredients enter the pan.
2. **Yield data.** Weigh the carrot, the green onions and the chicken (if you trim it) before and after trimming. Record AP weight, EP weight and yield percentage in a table.
3. Prepare and arrange every bowl. Photograph your mise en place before cooking.
4. Cook the fried rice, timing the cooking from the moment the pan goes on.
5. Check the chicken with the thermometer and record the temperature.
6. **Technique check.** Score 1–3: complete mise en place, even cuts, eggs fully set, chicken at 165 °F, rice hot and separate, clean station at the end.
7. Clean up: raw-meat board and knife in hot soapy water first, then everything else; wipe and sanitize counters.

8. **Repeat round.** Make fried rice again with a different protein or vegetables and try to finish the cooking in under 12 minutes with every standard met.

Tips

- Freshly cooked rice turns gummy. If you must use it the same day, spread it on a sheet pan and chill it uncovered for 30 minutes.
- Do not crowd the pan: cook the chicken in two batches if your skillet is small.
- Keep a “garbage bowl” on the counter for trimmings so you are not walking to the trash.

Check your work

- ☐ I set a full mise en place before turning on the heat.
- ☐ I measured yield percentages for my ingredients.
- ☐ I cooked fried rice with chicken at 165 °F, set eggs and separate grains, and left a clean station.

LAB NOTEBOOK

1. Sketch your mise-en-place layout from above, labeling each bowl and its order.
2. Record your yield table (ingredient, AP weight, EP weight, yield %) and compare with a classmate or a reference table.
3. Write the lab record: cooking time, chicken temperature, technique scores, family rating and one change for the repeat round.

KEY FORMULAS

$$\text{yield } \% = \frac{\text{EP weight}}{\text{AP weight}} \times 100$$

$$\text{AP needed} = \frac{\text{EP needed}}{\text{yield } \%/100}$$

From history. The Culinary Institute of America’s Hyde Park campus is in a building that was once a Jesuit seminary, St. Andrew-on-Hudson. The school bought it in 1970 and moved there in 1972. Students still begin with knife skills, sanitation and mise en place before they cook for the public in the school’s restaurants.

WORKED EXAMPLES

Example 1. You buy 2.00 lb of bell peppers. After removing stems, seeds and ribs, you have 1.64 lb. Find the yield percentage.

Show solution

1. $\text{Yield } \% = \dfrac{1.64 \text{ lb}}{2.00 \text{ lb}} \times 100 = 82\%$.

Answer: 82%.

Example 2. Your recipe needs 1¼ lb of trimmed boneless chicken thigh meat. Bone-in, skin-on thighs have a yield of about 70% when you bone and skin them yourself. How many pounds of bone-in thighs should you buy?

Show solution

1. EP needed: 1.25 lb.
2. $\text{AP needed} = \dfrac{1.25 \text{ lb}}{0.70} = 1.79 \text{ lb}$.
3. Round up to the next package size: about 1.8–2 lb.

Answer: About 1.8 lb; buy a 2-lb package.

Example 3. Onions cost $1.29 per pound as purchased and have an 88% yield. What is the cost per pound of usable (edible-portion) onion?

Show solution

1. Each AP pound gives 0.88 lb EP.
2. $\text{EP cost} = \dfrac{\$1.29}{0.88 \text{ lb}} = \$1.47 \text{ per lb}$.

Answer: About $1.47 per usable pound. Trim loss raises the true cost of every ingredient.

PRACTICE

1. Easy What does *mise en place* mean, and name three things it includes besides cutting vegetables.

   Show answer

   "Putting in place." Any three: reading the whole recipe, measuring ingredients, setting out tools, preheating the oven or pan, planning the order of tasks, setting out clean towels and a trash bowl.

2. Easy A 3.0 lb bag of carrots gives 2.4 lb after peeling and trimming. Find the yield percentage.

   Show answer

   $2.4 / 3.0 \times 100 = 80\%$

3. Easy Why is the rice for fried rice cooked a day ahead?

   Show answer

   Chilled, day-old rice has firmed up and dried slightly, so the grains stay separate and fry instead of turning mushy.

4. Medium You need 12 oz of diced onion. Onions yield 88%. How many ounces should you buy?

   Show answer

   $12 / 0.88 = 13.6$ oz, so about 14 oz (a little under 1 lb).

5. Medium Broccoli crowns cost $2.49/lb and yield 75% as florets. What is the cost per pound of florets?

   Show answer

   $2.49 / 0.75 = \$3.32$ per pound.

6. Medium Who founded the school that became the Culinary Institute of America, and in what year and city?

   Show answer

   Frances Roth and Katharine Angell, in 1946, in New Haven, Connecticut.

7. Medium Explain why stir-frying without mise en place is a safety problem as well as a quality problem.

Show answer

The pan is very hot and food cooks in seconds; walking away to prep scorches food, can let oil overheat and smoke or ignite, and leaves a hot pan unattended.

8. Hard A fried-rice recipe for 4 needs 1 lb of boneless chicken. You will cook for 10 and buy bone-in thighs with a 70% yield. How much should you buy?

Show answer

EP $1 \times 10/4 = 2.5$ lb; AP $2.5/0.70 = 3.6$ lb.

9. Hard A pineapple weighs 3.5 lb and yields 52% usable fruit. How many cups of chunks is that if 1 cup weighs about 165 g? (1 lb = 454 g)

Show answer

EP $3.5 \times 0.52 = 1.82$ lb $= 826$ g; $826/165 \approx 5$ cups.

10. Challenge Design a mise-en-place layout for fried rice: list the bowls in the order they go into the pan and explain your order.

Show answer

Example: oil; eggs (scrambled first and set aside); chicken (needs the longest cooking, to 165 °F); garlic, ginger and white parts of green onion (fragrant, cook briefly); vegetables; cold rice; sauce; green onion tops and sesame oil to finish. Order follows cooking time, longest first, aromatics briefly, delicate finishes last.

COMMON MISTAKES

- Starting to cook before everything is prepared, then leaving a hot pan to chop.
- Using warm, freshly cooked rice, which clumps and turns mushy.
- Putting cooked chicken back on the plate or board that held it raw.
- Forgetting trim loss when shopping, and running short.

Make it a game · Mise en Place Sprint. Your parent reads a short recipe card aloud, such as chicken fried rice. Set a timer and gather and prepare every ingredient and tool in bowls before the stove is touched. Record your time and have your parent inspect. Then compute yield percentage: edible weight divided by as-purchased weight, for any vegetable you trimmed.

Scripture. “Let all things be done decently and in order.” (1 Corinthians 14:40, KJV)

Paul wrote this about worship, but the principle fits the kitchen: order serves people, and a well-ordered station lets a cook serve with care instead of confusion.

1.3 Typhoid Mary and the Food-Handler Standard

OBJECTIVES

- Tell the history of Mary Mallon and explain what a healthy carrier is.
- List the personal-hygiene rules of the food-handler standard, including handwashing, glove use and when an ill worker must stay out of the kitchen.
- Use the doubling formula to estimate bacterial growth over time.
- Prepare a ready-to-eat salad with a clean, sanitized station and correct hand hygiene.

> **Warm-up.** Rub a pinch of cinnamon and a little oil on your hands as if it were germs. Wash for 5 seconds with cold water only, then look. Wash again for a full 20 seconds with soap, scrubbing backs, thumbs, between fingers and under nails. What was left the first time, and where?

WATCH

Proper Hygiene for Food Handlers

RivCoEH · 4:00

https://www.youtube.com/watch?v=toT5NBLrfJ4

> **WHEN TO WATCH**
> After the story of Mary Mallon. List every hygiene rule the video shows, then compare with the list in the core ideas.

Note: From the Riverside County (California) Department of Environmental Health. It briefly shows a worker smoking as an example of what not to do before handling food.

BACKUP VIDEO

Module 2 — Hand Washing

Southern Nevada Health District · 2:15

https://www.youtube.com/watch?v=w-fRZ-_Y5Es

Before the lab: copy the handwashing steps onto your hygiene poster.

KEY TERMS

healthy carrier

A person who carries and spreads a disease-causing microbe without feeling sick.

kill step

A step, usually cooking to a safe temperature, that destroys harmful bacteria. Ready-to-eat foods have none left, so they must be handled with extra care.

generation time

The time it takes a population of bacteria to double under given conditions; as short as about 20 minutes for some bacteria in ideal conditions.

ready-to-eat food

Food that will not be cooked again before it is eaten, such as salads, sandwiches, cut fruit and cooked foods being served.

sanitize

To reduce germs on a cleaned surface to a safe level with heat or a chemical sanitizer. Cleaning removes dirt; sanitizing reduces germs.

CORE IDEAS

The story. In the summer of 1906, six of the eleven people in a household renting a summer house in Oyster Bay, Long Island, came down with typhoid fever. The owners hired George Soper, a sanitary engineer, to find the cause. Soper found that the family had hired a new cook a few weeks before the illness began, and that she had moved on. Her name was Mary Mallon, an Irish-born cook who worked for wealthy New York families. Tracing her past jobs, Soper found typhoid cases in household after household where she had cooked.

How they figured it out. Mallon felt perfectly well, and she refused to believe she could make anyone sick. When health officials finally tested her in 1907, her samples were full of the typhoid bacterium, *Salmonella* Typhi. She was a **healthy carrier**, the first one identified in the United States. One of her favorite dishes to serve was ice cream with fresh, raw peaches: a food with no kill step, made by hands that were not washed well enough. She was isolated by the New York health department, released

in 1910 on the promise not to work as a cook, and later found cooking again under another name at a maternity hospital in 1915, where an outbreak followed. She was then isolated until her death in 1938. Investigators linked her to at least 51 cases of typhoid, three of them fatal. Her case taught public-health officials that a healthy-looking food handler can spread disease, and that handwashing and sick-worker rules protect everyone.

The kitchen science. Many foodborne illnesses are spread by the cook's hands. Today's rules come from the FDA Food Code, a model set of rules for restaurants that nearly every state adopts. Wash hands with soap and warm water, scrubbing for at least 20 seconds, before cooking, after touching raw meat, the face, hair, phone or trash, and after using the restroom. Do not touch ready-to-eat food with bare hands in a food business (use utensils or gloves; change gloves between tasks). Keep nails short and clean, tie back hair, remove rings and bracelets, and cover any cut with a bandage and a glove. A worker with vomiting, diarrhea or jaundice must stay out of the kitchen. The Food Code names six pathogens so easily spread by food workers that a diagnosis with any of them keeps a worker out: norovirus, hepatitis A, *Shigella*, Shiga toxin-producing *E. coli*, *Salmonella* Typhi and nontyphoidal *Salmonella*.

Think it through. Why so strict? Under ideal conditions some bacteria double about every 20 minutes. One hundred bacteria left on a salad become $100 \times 2^6 = 6{,}400$ after two hours in a warm kitchen. Cooking kills most bacteria, but a salad, a sandwich or cut fruit is never cooked again, so whatever the cook's hands leave on it is served to the guest.

Let's cook. You will make a Mediterranean chopped salad with chickpeas, cucumbers, tomatoes and feta, served with warm pita. Nothing in the salad will be cooked, so this is a hygiene lab. The technique standard: hands washed correctly at every required moment, produce washed under running water, a cleaned and sanitized board and counter, utensils (not bare hands) for mixing and serving, and the salad kept cold until it is served.

PICTURE STUDY



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

Image: Wikimedia Commons, public domain

Chardin painted a scullery maid, the kitchen worker who scrubbed the pots and pans. It was hard, humble work, and without it no kitchen could cook safely. In Escoffier's brigade this job still has a name: the plongeur, or dishwasher, whom good chefs treat with respect.

Look closely

- Find the tub and the pot she is cleaning. What is she using to scrub it?
- Look for the other vessels around her. Which are clean and which wait their turn?
- Look at her cap and apron. How do they keep hair and clothing out of the work?

Talk about it

1. In her day there was no dish soap or bleach as we know them. What could she use to clean, and how could heat help?
2. Why is the dishwasher one of the most important people in a safe kitchen?
3. What would a modern food-safety inspector want to see at her washing station?

Safety first. Wash hands with soap and warm water for at least 20 seconds before and during this lab, and use clean utensils rather than bare hands to mix and serve the salad, since it is never cooked. Use unscented bleach sanitizer only on surfaces, never on food, and never mix bleach with other cleaners. Keep the salad refrigerated until serving and return leftovers to the refrigerator within 2 hours.

KITCHEN LAB

Hygiene Lab: Mediterranean Chopped Salad

You will set up a clean, sanitized station, follow the food-handler hygiene rules step by step, and make a ready-to-eat salad that is safe because of how you handle it.

You will need

- Hand soap, paper towels and a nail brush
- A cutting board, chef's knife and paring knife
- A spray bottle or bowl of sanitizer (1 Tbsp unscented bleach per gallon of water, or a kitchen sanitizer used by its label)
- A large bowl, a small jar for the dressing, tongs or salad servers
- A colander for washing produce

Mediterranean Chopped Salad with Warm Pita

Serves 6 · Prep 30 min

Ingredients

- 2 cans (15 oz each) chickpeas, drained and rinsed
- 1 large English cucumber, cut in ½-inch dice
- 1 pint cherry tomatoes, halved
- 1 red or yellow bell pepper, diced
- ½ small red onion, finely diced
- ½ cup chopped fresh parsley
- 4 oz (115 g) feta cheese, crumbled
- ½ cup pitted olives, halved (optional)
- **Dressing:** ⅓ cup (80 mL) olive oil
- 3 tablespoons lemon juice
- 1 tablespoon white vinegar or more lemon juice
- 1 small clove garlic, finely grated
- 1 teaspoon dried oregano, ½ teaspoon salt, ¼ teaspoon pepper

- 6 pita breads, for serving

Method

1. Wash your hands for 20 seconds. Clean the counter and board with hot soapy water, rinse, then sanitize and let air-dry.
2. Wash the cucumber, tomatoes, pepper and parsley under cool running water, rubbing firm produce with your hands; dry with clean paper towels.
3. Cut the vegetables, moving finished pieces into the large bowl with the knife or a bench scraper.
4. Shake the dressing ingredients in the jar.
5. Add the chickpeas, feta and olives to the bowl, pour on the dressing and toss with tongs. Taste with a clean spoon each time.
6. Warm the pita in a 350 °F oven for 5 minutes, or in a dry skillet 30 seconds a side. Serve the salad cold with the warm pita.

Allergy check: Contains milk (feta) and wheat (pita). For milk-free, omit the feta; for wheat-free, serve without pita or with gluten-free flatbread.

Steps

1. **Hygiene check-in.** Before you start: hair tied back, rings and bracelets off, nails short and clean, clean apron, any cut covered.
2. **Clean and sanitize.** Mix the sanitizer and record the amounts. Clean, rinse, sanitize and air-dry the board and counter.
3. **Handwash log.** During the lab, make a tally each time you wash your hands and note why (for example, after touching your phone or opening the trash).
4. Make the salad and dressing as the recipe says, using utensils to mix, taste and serve.
5. **Peer check.** Ask a parent to watch for one minute and write down any moment you touched your face, hair or phone without washing afterward.
6. Serve the salad cold. Record the time it came out of the refrigerator and the time leftovers went back in.
7. Clean up: wash, rinse and sanitize the board and counter again.

8. **Repeat round.** Make the salad again (or a fruit salad, also ready-to-eat) and aim for a perfect hygiene log with no missed handwashes.

Tips

- Cold, clean produce and cold dressing make a crisper salad and a safer one.
- Taste with a clean spoon each time; never double-dip.
- Sanitizer works only on a surface that has first been cleaned.

Check your work

- ☐ I can tell Mary Mallon's story and explain what a healthy carrier is.
- ☐ I followed every handwashing and hygiene rule in my log.
- ☐ I made a ready-to-eat salad with a sanitized station and served it cold.

LAB NOTEBOOK

1. Make a one-page food-handler hygiene poster for your kitchen: the six steps of handwashing, the times to wash, and the stay-home rule.
2. Record your handwash tally and sanitizer recipe, and graph bacterial growth from 100 bacteria over 3 hours (doubling every 20 minutes).
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$N = N_0 \cdot 2^{t/g}$ (N_0 = starting number, t = time, g = doubling time in the same units)
Sanitizer for home kitchens (FoodSafety.gov): about 1 tablespoon unscented liquid chlorine bleach per gallon of water.

From history. George Soper published his account of the investigation in 1907. The nickname "Typhoid Mary" came from the newspapers. Mary Mallon spent her last years in a small cottage on North Brother Island in New York's East River, where she worked in the hospital laboratory.

WORKED EXAMPLES

Example 1. A cook's unwashed hand leaves 50 bacteria on a bowl of cut fruit. The fruit sits at room temperature, where these bacteria double every 20 minutes. How many are there after 3 hours?

Show solution

1. Number of doublings: $\dfrac{180\text{ min}}{20\text{ min}} = 9$.
2. $N = 50 \times 2^{9} = 50 \times 512 = 25{,}600$.

Answer: About 25,600 bacteria. The same fruit kept at 38 °F in the refrigerator would barely change, which is why ready-to-eat food goes back in the cold quickly.

Example 2. You need 2 quarts of sanitizing solution. Using 1 tablespoon of bleach per gallon, how many teaspoons of bleach do you use? (1 Tbsp = 3 tsp; 1 gallon = 4 quarts)

Show solution

1. 2 quarts is $\frac{2}{4} = \frac{1}{2}$ gallon.
2. Bleach: $\frac{1}{2} \times 1\text{ Tbsp} = \frac{1}{2}\text{ Tbsp} = 1.5\text{ tsp}$.

Answer: 1½ teaspoons of unscented bleach in 2 quarts of water.

Example 3. How long does it take 10 bacteria to become more than 1,000,000 if they double every 20 minutes?

Show solution

1. We need $2^{n} > \dfrac{1{,}000{,}000}{10} = 100{,}000$.
2. $2^{16} = 65{,}536$ is too small; $2^{17} = 131{,}072$.
3. 17 doublings × 20 min = 340 min ≈ 5 h 40 min.

Answer: About 17 doublings, under 6 hours. Food left out all afternoon can carry enormous numbers of bacteria.

PRACTICE

1. Easy What is a healthy carrier? Give the historical example from this lesson.

Show answer

A person who carries and spreads a disease-causing microbe without feeling ill. Mary Mallon, “Typhoid Mary,” carried *Salmonella* Typhi.

2. Easy List five times a cook must wash his or her hands.

Show answer

Any five: before starting, after the restroom, after touching raw meat, poultry, fish or eggs, after touching face, hair or phone, after handling trash or dirty dishes, after coughing or sneezing, after eating, before putting on gloves, when switching tasks.

3. Easy What is the difference between cleaning and sanitizing?

Show answer

Cleaning removes dirt and food with soap and water; sanitizing then reduces germs on the clean surface to a safe level with heat or a sanitizer.

4. Medium Why did Mary Mallon’s raw-peach ice cream spread typhoid so well?

Show answer

It had no kill step: the peaches and cream were never cooked after she handled them, so bacteria from her hands went straight to the guests.

5. Medium Starting with 200 bacteria that double every 20 minutes, how many are there after 2 hours?

Show answer

$200 \times 2^{6} = 12{,}800$

6. Medium How much unscented bleach is used for 3 gallons of sanitizer?

Show answer

3 tablespoons.

7. Medium Name the six pathogens the FDA Food Code treats as so easily spread by workers that a diagnosed worker must stay out of the kitchen.

Show answer

Norovirus, hepatitis A, *Shigella*, Shiga toxin-producing *E. coli*, *Salmonella* Typhi and nontyphoidal *Salmonella*.

8. Hard Bacteria in a warm room double every 30 minutes. How many hours until 100 become 51,200?

Show answer

$51{,}200/100 = 512 = 2^9$; 9 doublings × 30 min = 4.5 h.

9. Hard A cook wears gloves to make sandwiches, then takes out the trash and returns to the sandwiches without changing gloves. Explain the problem and the correct procedure.

Show answer

Gloves pick up germs just as hands do. After touching trash she must remove the gloves, wash her hands, and put on new gloves before touching ready-to-eat food.

10. Challenge Health officials in Mallon's time had to balance her freedom against the safety of the public. Write a short paragraph on how a cook today shows love of neighbor through hygiene and honesty about illness.

Show answer

Answers vary. A strong answer mentions washing hands faithfully even when no one is watching, staying home and telling the employer when sick with vomiting or diarrhea, and accepting rules that protect people who cannot see the danger.

COMMON MISTAKES

- Rinsing hands quickly in cold water without soap; soap and 20 seconds of scrubbing are what remove germs.
- Treating gloves as clean no matter what they touch.
- Cooking while sick "because I feel fine now." Norovirus can be spread for days after symptoms end.
- Spraying sanitizer on a dirty surface: clean first, then sanitize.

> **Make it a game · Spot the Violation.** Your parent silently performs a kitchen routine with five planted hygiene errors, such as touching hair, skipping handwashing after a phone call, or wiping hands on an apron. Call each error as you catch it. Then explain what a healthy carrier is and why Mary Mallon's case changed food-handler rules.

1.4 Clean, Separate, Cook, Chill and the Danger Zone

OBJECTIVES

- Explain the four food-safety steps (Clean, Separate, Cook, Chill) and the danger zone of 40–140 °F.
- Tell how a 1993 outbreak of *E. coli* O157:H7 changed the rules for ground beef in the United States.
- Convert temperatures between Fahrenheit and Celsius and explain why ground beef must reach 160 °F while a steak may be served at 145 °F.
- Cook burgers to 160 °F, checking each with an instant-read thermometer.

> **Warm-up.** Look in your refrigerator. Where is the raw meat kept? What is on the shelf below it? Is there a thermometer, and what does it read? Write down three things you would change.

WATCH

Basic Food Safety: Chapter 3 "Temperature Control" (English)

eFoodhandlers Inc. · 6:30

https://www.youtube.com/watch?v=0dL9et91nJA

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Note every temperature shown and write it in your chart.

Note: A restaurant food-handler training video. It uses the FDA Food Code's restaurant numbers (41 °F and 135 °F, and 155 °F for ground beef held to a time standard); at home we use the USDA's consumer numbers: 40–140 °F and 160 °F for ground beef.

BACKUP VIDEO

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

USDAFoodSafety · 3:17

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

Before the lab: watch how to place the thermometer in a burger.

KEY TERMS

danger zone

The temperature range of 40–140 °F (4–60 °C) in which bacteria grow fastest. The FDA Food Code uses 41–135 °F for restaurants.

cross-contamination

The transfer of harmful germs from one food, surface or hand to another, especially from raw meat to ready-to-eat food.

***E. coli* O157:H7**

A strain of the bacterium *Escherichia coli* that makes Shiga toxin and can cause severe illness; found in the intestines of cattle and sometimes in undercooked ground beef.

safe minimum internal temperature

The USDA temperature that food must reach in its thickest part to be safe: poultry 165 °F; ground beef, pork and lamb 160 °F; whole cuts and fish 145 °F (whole cuts with a 3-minute rest).

two-hour rule

Perishable food should not sit in the danger zone more than 2 hours total, or 1 hour when it is above 90 °F.

CORE IDEAS

The story. In January 1993, doctors in Washington State noticed a sudden wave of children with bloody diarrhea, some with kidney failure. Health investigators traced the illnesses to hamburgers served at the restaurants of one West Coast fast-food chain. The patties were contaminated with *E. coli* O157:H7 and had been cooked to too low a temperature. More than 700 people in four states became ill, most of them children, and four children died. It was the outbreak that changed how Americans cook ground beef.

How they figured it out. Investigators compared what sick and healthy people had eaten and found the common food, then tested the meat. The cause was not one careless cook but a whole system: contaminated beef from the processor, and a cooking temperature that did not reliably kill the bacteria. In 1994 the U.S. Department of Agriculture declared *E. coli* O157:H7 an adulterant in raw ground beef, so contaminated beef could not be sold, and it began requiring “safe handling instructions” on packages of raw meat and poultry. In 1997 the USDA, FDA and CDC

joined food companies and consumer groups to launch the *Fight BAC!* campaign, which taught the four steps: **Clean, Separate, Cook, Chill.**

The kitchen science. Bacteria live mostly on the *surface* of a whole cut of meat. Searing a steak to 145 °F in the center kills them on the outside. Grinding spreads the surface bacteria all through the meat, so the inside of a burger is as risky as the outside and must reach **160 °F**. Color is not a reliable test: some burgers brown early and others stay pink when safe, so only a thermometer tells the truth. The danger zone, 40–140 °F, is where bacteria multiply fastest; cold slows them and heat kills them. Perishable food should spend no more than 2 hours in the danger zone (1 hour above 90 °F).

Let's cook. You will make skillet burgers. The technique standard: raw beef kept on its own plate and board; hands washed after shaping; patties of even thickness with a thumbprint dent so they cook flat; a hot pan and a good brown crust; every patty checked from the side with an instant-read thermometer to 160 °F; cooked burgers placed on a clean plate; and toppings kept cold until served.

PICTURE STUDY



Cooking Class in a Washington, D.C., High School, Frances Benjamin Johnston, c. 1899 · Photograph · Library of Congress, Washington, D.C.

Image: Wikimedia Commons, public domain

Frances Benjamin Johnston photographed the public schools of Washington, D.C., around 1899. In this cooking class, high-school students learned the domestic science of their day, including cleanliness, careful measurement and safe cooking, decades before anyone had heard of *E. coli* O157:H7.

Look closely

- Look at the students' aprons and hair. Which food-handler rules are they already following?
- Find the worktables. How is the work laid out, and is there room for a separate area for raw foods?
- Look for any source of heat. Where would the cooking happen?

Talk about it

1. What tool from our kitchens is missing from theirs, and why does it matter for cooking meat safely?
2. These students had no refrigerators at home, only iceboxes. How would that affect the Chill step?
3. Which of the four steps could they practice perfectly with the tools in this room?

> **Safety first.** Keep raw ground beef on its own plate and board, wash hands after shaping the patties, and put cooked burgers on a clean plate. Check every patty from the side with an instant-read thermometer to 160 °F; clean the thermometer stem between batches. Keep a lid near the skillet in case of a grease flare; never put water on a grease fire.

KITCHEN LAB

Thermometer Lab: Skillet Burgers to 160 °F

You will cook burgers by the four steps and record a temperature for every patty, testing whether color predicts doneness.

You will need

- A 12-inch skillet (cast iron if you have one) and a sturdy spatula
- An instant-read thermometer
- Two plates (one for raw, one for cooked) and two cutting boards
- A spoon or scale for even patties
- A lid that fits the skillet

Classic Skillet Burgers

Serves 6 · Prep 15 min · Cook 10–12 min

Ingredients

- 1½ lb (680 g) ground beef, 80–85% lean
- 1 teaspoon kosher salt and ½ teaspoon black pepper
- 1 teaspoon neutral oil
- 6 slices cheese (optional)
- 6 hamburger buns, toasted
- Toppings: lettuce, sliced tomato, sliced onion, pickles, ketchup and mustard

Method

1. Wash and prepare the toppings first on the clean board and refrigerate them.
2. Divide the beef into 6 equal portions (about 4 oz / 113 g each). Shape gently into patties ¾ inch thick and a little wider than the buns. Press a shallow dent in the center of each. Wash your hands.
3. Season both sides of the patties with salt and pepper just before cooking.

4. Heat the oil in the skillet over medium-high heat until shimmering. Cook the patties, in two batches if needed, 4–5 minutes, until well browned. Flip once and cook 3–5 minutes more. Add cheese in the last minute and cover the pan to melt it.
5. Insert the thermometer through the side into the center of each patty. Cook until every patty reads 160 °F. Move to a clean plate.
6. Toast the buns in the skillet or toaster and assemble with the cold toppings.

Allergy check: Buns contain wheat and often milk, eggs, soy or sesame seeds; check the label. Cheese contains milk. For wheat-free, serve on lettuce leaves or gluten-free buns.

Steps

1. **Clean.** Wash hands and set up a raw-meat area with its own board and plate, away from the toppings.
2. **Separate.** Draw your station layout in your notebook before you start, showing raw and ready-to-eat zones.
3. **Cook.** Cook the burgers. For each patty, record the minutes per side, the color in the center when cut (for one test patty) and the thermometer reading.
4. **Color test.** Cut one patty at 150 °F and one at 160 °F and photograph the centers. Does color tell you which is safe?
5. **Chill.** Refrigerate leftovers within 2 hours and record the time.
6. **Technique check.** Score 1–3: even patties, good crust, all patties at 160 °F, no cross-contamination, cold toppings, clean station.
7. Clean up: raw-meat board, plate and spatula in hot soapy water; sanitize the counter.
8. **Repeat round.** Make turkey burgers (165 °F) or cook beef burgers again with a different thickness, and record how thickness changes cooking time.

Tips

- Handle the meat gently and briefly; overworked beef makes dense burgers.
- Salt the outside just before cooking; salt mixed in long before turns the texture sausage-like.

- Do not press the patties with the spatula; it squeezes out juices and can splash fat.

Check your work

- ☐ I can explain Clean, Separate, Cook, Chill and the danger zone.
- ☐ I can convert temperatures between °F and °C.
- ☐ I cooked burgers with every patty checked to 160 °F and no cross-contamination.

LAB NOTEBOOK

1. Make a temperature chart in °F and °C: freezer, refrigerator, danger zone, fish and whole cuts, ground meat, poultry and reheated leftovers.
2. Record your burger data table and the two photos from the color test, with your conclusion.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$C = \frac{5}{9}(F - 32)$
$F = \frac{9}{5}C + 32$

From history. The "safe handling instructions" label required since 1994 shows four symbols for the four steps. Look for it on any package of raw meat or poultry in your refrigerator.

WORKED EXAMPLES

Example 1. Convert the danger zone, 40 °F to 140 °F, to degrees Celsius.

Show solution

1. $C = \frac{5}{9}(40 - 32) = \frac{5}{9}(8) = 4.4\ ^\circ\text{C}$.
2. $C = \frac{5}{9}(140 - 32) = \frac{5}{9}(108) = 60\ ^\circ\text{C}$.

Answer: About 4 °C to 60 °C.

Example 2. A burger reads 71 °C on a Celsius thermometer. Is it done by the USDA standard of 160 °F?

Show solution

1. $F = \frac{9}{5}(71) + 32 = 127.8 + 32 = 159.8\ ^\circ\text{F}$.

Answer: 159.8 °F is a hair short of 160 °F. Cook it a few seconds longer and check again; 160 °F is 71.1 °C.

Example 3. Burgers for a picnic left the cooler at 12:15 p.m. on an 88 °F day. Cooked burgers sat on the table from 1:05 p.m. By what time must the leftovers be refrigerated? What if the day were 94 °F?

Show solution

1. At 88 °F the two-hour rule applies: 1:05 + 2 h = 3:05 p.m.
2. Above 90 °F the limit is 1 hour: 1:05 + 1 h = 2:05 p.m.
3. (The raw patties should have stayed in the cooler with ice until they went on the grill.)

Answer: By 3:05 p.m. on an 88 °F day; by 2:05 p.m. on a 94 °F day.

PRACTICE

1. Easy Name the four food-safety steps.

   Show answer

   Clean, Separate, Cook, Chill.

2. Easy Give the USDA safe minimum internal temperatures for chicken, ground beef, a pork chop and salmon.

   Show answer

   Chicken 165 °F; ground beef 160 °F; pork chop 145 °F with a 3-minute rest; salmon 145 °F.

3. Easy Convert 165 °F to Celsius.

   Show answer

   $\frac{5}{9}(133) = 73.9\ ^\circ\text{C}$

4. **Medium** Convert 0 °F (freezer) and 212 °F (boiling water at sea level) to Celsius.

Show answer

−17.8 °C and 100 °C.

5. **Medium** Explain why a steak may be safe at 145 °F but a burger must reach 160 °F.

Show answer

Bacteria are on the surface of a whole cut, and searing kills them; grinding mixes surface bacteria into the center of the burger, so the center must reach a temperature that kills them.

6. **Medium** Why is the color of a burger not a reliable test of doneness?

Show answer

Meat can turn brown before it reaches 160 °F (premature browning) or stay pink after it is safe, depending on the meat and its pH; only a thermometer measures the temperature.

7. **Medium** What changed in U.S. rules after the 1993 *E. coli* O157:H7 outbreak?

Show answer

In 1994 the USDA declared *E. coli* O157:H7 an adulterant in raw ground beef and required safe-handling labels on raw meat and poultry; in 1997 the Fight BAC! campaign taught Clean, Separate, Cook, Chill.

8. **Hard** Where should raw ground beef be stored in the refrigerator, and why?

Show answer

On the bottom shelf, in a container or on a plate, so its juices cannot drip onto ready-to-eat foods below it.

9. **Hard** A refrigerator thermometer reads 5 °C. Is the refrigerator cold enough?

Show answer

$F = \frac{9}{5}(5) + 32 = 41$ °F. No: it should be at or below 40 °F; turn it colder.

10. Hard Potato salad was set out at 6:10 p.m. at a 92 °F outdoor party. It is now 7:20 p.m. Is it safe to put the leftovers away and serve them tomorrow? Explain.

Show answer

No. Above 90 °F the limit is 1 hour, and it has been out 1 hour 10 minutes; throw it away.

11. Challenge At what temperature do the Fahrenheit and Celsius scales read the same number? Show your work.

Show answer

Set $F = C = x$: $x = \frac{9}{5}x + 32 \Rightarrow -\frac{4}{5}x = 32 \Rightarrow x = -40$. At −40 degrees.

COMMON MISTAKES

- Judging doneness by color.
- Carrying cooked burgers back on the plate that held them raw.
- Thawing meat on the counter. Thaw it in the refrigerator, in cold water changed every 30 minutes, or in the microwave if cooking right away.
- Pushing the thermometer all the way through to the pan, which reads the pan's temperature.

> **Make it a game · Danger Zone Drill.** Your parent calls out temperatures. Stand if the food is in the danger zone, 40 to 140 degrees Fahrenheit; sit if it is colder; raise one hand if it is hotter. Run fifteen calls with no mistakes allowed. Then recite the four steps, clean, separate, cook, chill, and the two-hour rule from memory.

1.5 The Food Code, Cooling Leftovers and the Food-Handler Card

OBJECTIVES

- Explain what the FDA Food Code is and how state food-handler cards are earned.
- Apply the two-stage cooling rule (135 °F to 70 °F within 2 hours, then to 41 °F within 4 more) to real data.
- Choose methods that cool a large batch of food quickly: shallow pans, ice baths and dividing.
- Cook a big batch of chili, cool it safely, and reheat a portion to 165 °F.

> **Warm-up.** Put 4 cups of hot tap water in a deep pot and 4 cups in a shallow baking dish. Measure the temperature of each now and again in 20 minutes. Which cooled faster? Why?

WATCH

Cooling It! Methods for Cooling Food Safely

Institute of Child Nutrition · 8:30

https://www.youtube.com/watch?v=cov-gIoUQro

> **WHEN TO WATCH**
> After the story. Pause at each cooling method and predict which will cool fastest.

Note: From the Institute of Child Nutrition, which trains school-cafeteria staff; it follows the FDA Food Code.

BACKUP VIDEO

Proper Cooling Methods for Foods

Multnomah County Health Department · 4:05

https://www.youtube.com/watch?v=VTvx4Y8LSEg

Optional: a county health inspector and a chef show the ice bath, shallow pans and portioning.

KEY TERMS

FDA Food Code

A model set of food-safety rules for restaurants, stores and other food businesses, published by the U.S. Food and Drug Administration and adopted in some version by the states.

food-handler card

A certificate showing that a food worker has passed a basic food-safety course and test; required by many states and counties for restaurant workers.

two-stage cooling

The Food Code rule for cooling cooked food: from 135 °F to 70 °F within 2 hours, and from 70 °F to 41 °F or below within the next 4 hours.

ice bath

A sink or large bowl of ice and water in which a container of hot food is set and stirred to cool it quickly.

reheating

Bringing cooked leftovers back to a safe temperature; leftovers should reach 165 °F.

CORE IDEAS

The story. For most of history, each city or county wrote its own food rules. Beginning in the 1930s the U.S. Public Health Service published model ordinances that local governments could adopt, and in 1993 the Food and Drug Administration issued the first *Food Code* under that name. It is updated regularly by scientists, inspectors and the food industry working together, and every state now bases its rules for restaurants and food stores on some edition of it. Many states and counties also require restaurant workers to earn a **food-handler card** by passing a short course and test. Many accept accredited online courses for a small fee; if you would like a real card after this unit, check your own state or county health department. It is optional for this course.

How they figured it out. When investigators studied outbreaks traced to restaurants, one cause kept appearing: large batches of food cooled too slowly. A big pot of chili, soup, rice or beans can stay warm for many hours in a refrigerator, because heat escapes only from the surface. Bacteria that form spores, such as *Clostridium perfringens*, survive cooking and grow quickly in warm food as it cools. So the Food

Code set a **two-stage cooling rule**: from 135 °F to 70 °F within 2 hours (the fastest-growth range), and then to 41 °F within 4 more hours.

The kitchen science. Heat leaves food through its surface. A deep pot has a small surface for its volume, so its center cools slowly. Spreading the food into shallow pans no more than 2 inches deep, dividing it into small containers, setting the pot in an ice bath and stirring, and leaving containers uncovered (or loosely covered) until cool all speed cooling. At home the USDA advice is simple: divide large amounts into shallow containers and refrigerate within 2 hours. Eat leftovers within 3–4 days, or freeze them, and reheat them to 165 °F.

Let's cook. You will make a big pot of turkey and bean chili, serve some for dinner, and cool the rest by the two-stage rule while you log the temperatures. The technique standard: turkey cooked to 165 °F, chili simmered and seasoned to taste, leftovers spread in shallow containers and cooled to 70 °F within 2 hours and 41 °F within 6, then one portion reheated to 165 °F.

PICTURE STUDY



Kitchen Utensils with Copper Cauldron, Pestle and Mortar, Jug, Eggs and Spring Onion, Jean-Siméon Chardin, c. 1734–35 · Oil on canvas · Private collection (formerly in Paris)

Image: Wikimedia Commons, public domain

Chardin often painted the plain tools of the kitchen. The big copper cauldron was the batch-cooking pot of his day, used for soups and stews that fed a household for days. Before refrigerators, cooks had to think hard about how long a big pot of food could safely sit.

Look closely

- Find the cauldron. How deep do you think it is? How long would a full pot of stew take to cool?
- Find the eggs and the onion. Which foods here are perishable and which keep well?
- Look at the jug. What might it hold, and where would it be kept cool?

Talk about it

1. How would you cool a full cauldron of stew quickly without a refrigerator?
2. Why might a cook in Chardin's day have cooked smaller amounts more often?
3. What does the shape of a shallow pan do that this cauldron cannot?

> **Safety first.** Cook ground turkey to 165 °F. Hot chili causes burns: use oven mitts to lift the pot and ladle slowly when dividing it into pans. Cool leftovers by the two-stage rule in shallow containers, refrigerate within 2 hours, use within 3–4 days, and reheat portions to 165 °F.

KITCHEN LAB

Cooling Lab: Big-Batch Turkey and Bean Chili

You will cook a big batch of chili, then run a real cooling log: one sample cooled the slow way in a deep container and the rest in shallow pans, to see the two-stage rule in action.

You will need

- A large pot or Dutch oven (6 quarts or more)
- An instant-read thermometer and a timer
- Two or more shallow pans or containers (2 inches deep or less) and one deep container
- A large bowl or the sink for an ice bath, and ice
- A ladle, cutting board and chef's knife

Big-Batch Turkey and Bean Chili

Serves 10–12 (about 14 cups) · Prep 20 min · Cook 50 min

Ingredients

- 2 tablespoons olive oil
- 2 lb (900 g) ground turkey
- 2 medium onions, diced
- 2 bell peppers, diced
- 4 cloves garlic, minced
- 3 tablespoons chili powder
- 1 tablespoon ground cumin
- 2 teaspoons dried oregano
- 1½ teaspoons salt and ½ teaspoon black pepper
- 1 can (28 oz) crushed tomatoes
- 1 can (15 oz) tomato sauce
- 2 cans (15 oz each) kidney beans and 1 can (15 oz) black beans, drained and rinsed

- 1½ cups (360 mL) chicken broth or water
- Toppings: grated cheese, sour cream, chopped green onions

Method

1. Heat the oil in the pot over medium-high heat. Add the turkey and cook, breaking it up, 7–8 minutes, until no pink remains and it reads 165 °F.
2. Add the onions and peppers and cook 6–8 minutes, until soft. Add the garlic, chili powder, cumin and oregano and stir 1 minute.
3. Add the tomatoes, tomato sauce, beans, broth, salt and pepper. Bring to a boil, then simmer uncovered 30–40 minutes, stirring now and then, until thick.
4. Taste and adjust the seasoning. Serve with toppings.
5. Cool the rest by the cooling lab steps below, then refrigerate or freeze. Reheat individual portions to 165 °F.

Allergy check: Contains none of the nine major allergens if the broth is allergen-free (check the label); cheese and sour cream toppings contain milk.

Steps

1. Cook the chili and serve dinner. Record the turkey's temperature.
2. **Set up the test.** Ladle 2 cups of hot chili into the deep container (the control). Spread the rest into shallow pans no more than 2 inches deep. Set one shallow pan in an ice bath and stir it every 10 minutes.
3. **Cooling log.** Record the temperature of each container at the start (about 135 °F or higher) and every 30 minutes for 2 hours, then at 4 and 6 hours if you are awake (otherwise move everything to the refrigerator at 2 hours and check the next morning).
4. Graph temperature against time for all containers. Mark 70 °F at 2 hours and 41 °F at 6 hours on the graph.
5. Decide which containers passed each stage. Discard or reheat any that failed Stage 1, as the Food Code requires.
6. **Reheat.** The next day, reheat one portion to 165 °F and record the time it took.
7. Clean up: wash the pot, pans and thermometer; sanitize the counter.

8. **Unit project prep.** Use your log as evidence in the Unit 1 project.

Tips

- Stir the pan in the ice bath; stirring moves hot chili from the center to the cold edges.
- Leave pans uncovered or loosely covered in the refrigerator until fully cool, then cover.
- Label and date leftovers.

Check your work

- ☐ I can explain the Food Code and how to earn a food-handler card.
- ☐ I logged and graphed cooling data and judged it against the two-stage rule.
- ☐ I cooked a big batch of chili safely and reheated a portion to 165 °F.

LAB NOTEBOOK

1. Draw your cooling graph with all containers on one set of axes, and write a two-sentence conclusion.
2. Write a one-page "house rules" card for leftovers in your family kitchen: how to cool, label, store, use and reheat.
3. Record the chili lab with a family rating and one change for the repeat round.

KEY FORMULAS

Stage 1: $135\ ^\circ\text{F} \to 70\ ^\circ\text{F}$ in ≤ 2 h; Stage 2: $70\ ^\circ\text{F} \to 41\ ^\circ\text{F}$ in ≤ 4 h more

$$\text{average cooling rate} = \frac{\text{temperature drop}}{\text{time}}$$

> **From history.** The USDA's Meat and Poultry Hotline, 1-888-674-6854, has answered home cooks' food-safety questions since 1985, including thousands of calls every November about thawing and cooking the Thanksgiving turkey.

WORKED EXAMPLES

Example 1. A pot of chili is 135 °F at 6:00 p.m. It reads 98 °F at 7:00 p.m. and 79 °F at 8:00 p.m. Does it pass Stage 1?

Show solution

1. Stage 1 requires 70 °F or below by 8:00 p.m. (2 hours after 6:00).
2. At 8:00 p.m. it is 79 °F, which is above 70 °F.

Answer: It fails Stage 1. Under the Food Code it must be reheated to 165 °F and cooling started over (allowed only if caught within the 2 hours) or discarded. The fix: divide it into shallow pans and use an ice bath.

Example 2. Chili cooled in shallow pans drops from 135 °F to 70 °F in 1 h 30 min. By what clock time must it reach 41 °F if it reached 70 °F at 7:30 p.m.? What was its average cooling rate in Stage 1?

Show solution

1. Stage 2 allows 4 hours after reaching 70 °F: 7:30 p.m. + 4 h = 11:30 p.m.
2. Rate $= \dfrac{135 - 70}{1.5\ \text{h}} = \dfrac{65\ ^\circ\text{F}}{1.5\ \text{h}} \approx 43\ ^\circ\text{F/h}.$

Answer: By 11:30 p.m.; about 43 °F per hour in Stage 1.

Example 3. You have 12 cups of chili to cool. Your shallow pans are 9 × 13 inches, and the chili may be no more than 2 inches deep. How many pans do you need? (1 cup ≈ 14.4 in^3)

Show solution

1. Volume of chili: $12 \times 14.4\ \text{in}^3 = 173\ \text{in}^3$.
2. One pan at 2 inches deep holds $9 \times 13 \times 2 = 234\ \text{in}^3$.
3. One pan is enough by volume; the chili will be $173/117 \approx 1.5$ inches deep.

Answer: One 9 × 13 pan, filled about 1½ inches deep. Shallower is faster; two pans would cool it faster still.

PRACTICE

1. **Easy** State the two-stage cooling rule.

   Show answer

   Cool from 135 °F to 70 °F within 2 hours, then from 70 °F to 41 °F within the next 4 hours (6 hours total).

2. **Easy** To what temperature should leftovers be reheated?

   Show answer

   165 °F.

3. **Easy** How long may leftovers be kept in the refrigerator?

   Show answer

   3–4 days (or freeze them).

4. **Medium** List four ways to cool a large pot of soup quickly.

   Show answer

   Divide into shallow containers (2 inches deep or less); set the pot in an ice bath and stir; divide into small containers; use an ice paddle or add ice in place of some water; leave uncovered or loosely covered until cool.

5. **Medium** Why does a deep pot of food cool so slowly in a refrigerator?

   Show answer

   Heat escapes only through the surface, and a deep pot has little surface for its large volume; the center stays warm for hours.

6. **Medium** Rice cooled from 135 °F at 1:00 p.m. to 70 °F at 2:45 p.m. and to 41 °F at 7:15 p.m. Does it pass both stages?

   Show answer

   Stage 1: 1 h 45 min (pass). Stage 2: 2:45 to 7:15 is 4 h 30 min (fail; limit 4 h).

7. **Medium** What is the FDA Food Code?

   Show answer

   A model set of food-safety rules for food businesses, published by the FDA and adopted in some version by the states.

8. Hard Why does the cooling rule give only 2 hours for the first stage but 4 for the second?

Show answer

Bacteria grow fastest in the middle of the range (roughly 70–125 °F), so food must pass through that range quickly; below 70 °F growth slows, so more time is allowed.

9. Hard Soup cools from 135 °F to 90 °F in its first hour. At that same rate, will it reach 70 °F within 2 hours? (Real cooling slows as food nears room temperature.)

Show answer

Rate 45 °F/h; it needs 20 °F more, about 27 more minutes, so on paper yes (about 1 h 27 min). But real cooling slows, so check with a thermometer.

10. Hard Convert the Food Code numbers 135 °F, 70 °F and 41 °F to Celsius.

Show answer

57.2 °C, 21.1 °C and 5.0 °C.

11. Challenge A cook plans to cool 3 gallons of chili in one 12-inch-deep stockpot in the walk-in refrigerator overnight. Write a short corrective plan as if you were the health inspector, with reasons.

Show answer

Divide into shallow pans no more than 2 inches deep (or several small containers), use an ice bath and stir first, leave loosely covered, log temperatures at 2 and 6 hours to prove 135→70 °F in 2 h and 70→41 °F in 4 h. A deep pot keeps the center in the danger zone for many hours, where spore-forming bacteria can grow.

COMMON MISTAKES

- Putting a large, hot pot straight into the refrigerator; it warms everything around it and cools too slowly.
- Waiting for food to cool on the counter “so it doesn’t heat the fridge.” Refrigerate within 2 hours, in shallow containers.
- Reheating leftovers only until warm. Bring them to 165 °F.
- Keeping leftovers for a week. Use them within 3–4 days or freeze them.

Make it a game · Cooling Clock. Your parent gives a clock time and says a pot of chili is at 135 degrees Fahrenheit. Without notes, state the two deadlines: 70 degrees within two hours, then 41 within four more. Do six different starting times. Add an ice-bath plan for each and a reason shallow pans cool faster than a deep pot.

UNIT 1

The Professional Kitchen and Food Safety

Every good cook begins with order and safety. In this unit you will meet Auguste Escoffier, who turned the chaotic kitchens of the 1800s into the orderly brigade that professional restaurants still use, and you will learn mise en place, the habit of having everything ready before the heat goes on. Then you will learn the food-handler standard: personal hygiene, Clean, Separate, Cook, Chill, the danger zone, and the two-stage cooling rule of the FDA Food Code.

The stories are real and sometimes sobering: a healthy cook who carried typhoid from house to house, and a 1993 outbreak of *E. coli* O157:H7 that changed how the nation cooks ground beef. Each lesson has a lab: a potato-leek soup cooked as a brigade, a fried rice that depends on mise en place, a ready-to-eat salad made by the hygiene rules, burgers checked to 160 °F, and a big batch of chili cooled by the Food Code. The unit ends with a food-handler practice exam; afterward many students choose to earn a real state food-handler card.

PREREQUISITES

- Comfortable with fractions, decimals and percentages
- Has used a stove and oven under a parent's supervision
- Owns or can borrow an instant-read thermometer

MASTERY CHECKLIST

- ☐ I can describe Escoffier's brigade and use mise en place before every lab.
- ☐ I can scale a recipe with a yield factor and calculate yield percentage.
- ☐ I can follow the food-handler hygiene rules and explain why a healthy-looking cook can spread illness.
- ☐ I can state the four steps, the danger zone, the two-hour rule and the USDA safe minimum internal temperatures, and convert °F and °C.
- ☐ I can cool a large batch of food by the two-stage rule and reheat leftovers to 165 °F.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **FoodSafety.gov: Safe Minimum Internal Temperatures chart**: Free (search the chart's name at FoodSafety.gov). A printable chart of the USDA temperatures; tape it inside a cupboard door for the whole year.
- **FDA: Food Code**: Free. The FDA's page for the current Food Code, the model rules behind state restaurant inspections. Skim the hygiene and cooling sections for Lessons 1.3 and 1.5.
- **An instant-read food thermometer and a refrigerator thermometer**: The thermometer is required for the course from Lesson 1.4 on; the refrigerator thermometer is inexpensive and shows whether your refrigerator stays at or below 40 °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

1.1	**Escoffier and the Brigade de Cuisine**	3 sessions of 50–90 minutes
1.2	**Mise en Place: Everything in Its Place**	3 sessions of 50–90 minutes
1.3	**Typhoid Mary and the Food-Handler Standard**	3 sessions of 50 minutes
1.4	**Clean, Separate, Cook, Chill and the Danger Zone**	3 sessions of 50 minutes
1.5	**The Food Code, Cooling Leftovers and the Food-Handler Card**	3 sessions of 50–90 minutes

Unit 1 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Name the station chef who handles (a) sauces, (b) roasts, (c) pastry, and explain in one sentence how Escoffier's brigade made a kitchen faster.

2. **8 pts**

   A recipe serves 6 and uses 2½ lb of potatoes. Scale it for 20 servings.

3. **6 pts**

   You buy 4.0 lb of broccoli and keep 3.0 lb of florets. Find the yield percentage, and find how much to buy for 4.5 lb of florets.

4. **6 pts**

   Define mise en place and give two reasons it matters for a stir-fry.

5. **8 pts**

   Who was Mary Mallon, and what lesson did her case teach about food handlers?

6. **6 pts**

   Bacteria double every 20 minutes. How many will 30 bacteria become in 2 hours?

7. **6 pts**

   List the steps and the time for proper handwashing, and four times a cook must wash.

8. **6 pts**

   Convert 145 °F and 40 °F to Celsius.

9. **6 pts**

   Give the USDA safe minimum internal temperatures for poultry, ground beef, whole cuts of pork, fish, egg dishes and reheated leftovers.

10. **8 pts**

    Explain why ground beef must be cooked to 160 °F while a beef steak may be served at 145 °F, and describe the outbreak that taught America this lesson.

11. **6 pts**

    Chicken salad is set out at a 93 °F picnic at 12:20 p.m. By what time must it be refrigerated or thrown away?

12. **8 pts**

    A pot of soup is 135 °F at 4:00 p.m., 82 °F at 6:00 p.m., and 40 °F at 9:30 p.m. Evaluate it against the two-stage cooling rule, and describe what should have been done.

13. **6 pts**

    Where should raw meat go in a refrigerator, and what temperature should the refrigerator and freezer be?

14. **6 pts**

    Predict: a cook puts 3 gallons of hot chili, still in its deep stockpot, into the refrigerator overnight. What will happen to the center of the chili, and why is that dangerous?

15. **8 pts**

    Essay (one paragraph): Using Escoffier, Mary Mallon and the 1993 outbreak, explain why food safety is a matter of character and system as well as rules.

ANSWER KEY

1. (a) saucier, (b) rôtisseur, (c) pâtissier. The parts of a dish were made at the same time by different stations and assembled at the pass, instead of one cook making the whole dish in sequence.
2. Factor $20/6 = 3.33$; $2.5 \times 3.33 = 8.3$ lb.
3. 75%; $4.5/0.75 = 6.0$ lb.
4. Everything prepared and in place before cooking. Stir-fries cook in minutes, so there is no time to prep during cooking; leaving a hot pan to chop is unsafe and burns the food.
5. A New York cook (1906–1915) who was a healthy carrier of *Salmonella* Typhi and spread typhoid to the families she cooked for. A cook who feels well can still spread disease, so handwashing and sick-worker rules protect everyone.
6. $30 \times 2^6 = 1{,}920$
7. Wet with warm water, apply soap, scrub hands, backs, between fingers and under nails for at least 20 seconds, rinse, dry with a clean towel. Four times: before cooking, after the restroom, after touching raw meat, after touching face, hair, phone or trash.
8. 62.8 °C and 4.4 °C.
9. Poultry 165 °F; ground beef 160 °F; whole cuts of pork 145 °F with a 3-minute rest; fish 145 °F; egg dishes 160 °F; leftovers 165 °F.
10. Bacteria live on the surface of whole cuts and are killed by searing; grinding spreads them through the meat. In 1993 undercooked fast-food hamburgers contaminated with *E. coli* O157:H7 sickened more than 700 people in four western states and killed four children, leading the USDA to declare the bacterium an adulterant in ground beef (1994) and require safe-handling labels.
11. By 1:20 p.m.: above 90 °F the limit is 1 hour.
12. Stage 1 failed: 82 °F at 2 hours (must be 70 °F or below). It should have been divided into shallow pans 2 inches deep or less, cooled in an ice bath with stirring, and logged. (Stage 2 would have passed if Stage 1 had.)
13. Bottom shelf in a container; refrigerator at or below 40 °F, freezer at 0 °F.
14. The center will stay warm, in the danger zone, for many hours because heat escapes only through the small top surface; spore-forming bacteria such as *Clostridium perfringens* can multiply to unsafe levels.

15. Answers vary. A strong answer: Escoffier built order and discipline into the kitchen so good habits were part of the system; Mallon's case shows that personal honesty and hygiene protect others even when one feels well; the 1993 outbreak shows that safety depends on every link, from processor to cook, and that rules (160 °F, labels) grew from real harm. A faithful cook loves the neighbor he feeds.

UNIT PROJECT: FOOD-HANDLER PRACTICE EXAM AND HOME KITCHEN AUDIT

Part 1: Write and take a 30-question food-handler practice exam covering hygiene, the four steps, temperatures, the danger zone, cross-contamination, cooling and reheating. Write the questions yourself from this unit, trade with a parent who grades it with your answer key, and score at least 80%. If you like, then take an accredited online food-handler course accepted by your state or county (usually a small fee) and add your card to your portfolio.

Part 2: Audit your home kitchen like a health inspector. Record refrigerator and freezer temperatures on three days, check where raw meat is stored, check that a thermometer is available and calibrated, look at handwashing supplies, and inspect leftovers for labels and dates. Write a one-page report with three improvements, make them, and attach your chili cooling log as evidence of safe cooling.

LOOK FOR	WHAT IT MEANS
Exam	Thirty clear questions with a correct answer key; score of 80% or higher.
Audit data	Temperatures recorded on three days; every audit item checked and noted honestly.
Improvements	Three specific improvements made, with before-and-after notes or photos.
Cooling evidence	A complete cooling log and graph judged correctly against the two-stage rule.
Presentation	Neat, organized report a family member could follow.

UNIT 2

Knife Skills and Tools

A cook's hands, knife and pans are the tools of the trade. In this unit you will learn to choose, hone and care for a knife, and you will cut the classic shapes, julienne, batonnet, brunoise and dice, to standard sizes checked with a ruler. You will learn the herb cuts, chiffonade and mince, and see why a sharp knife keeps basil green.

Then you will study pots and pans the way an engineer would, comparing heat capacity and conductivity with real calculations, and you will learn to measure the way Fannie Farmer taught America, level and exact, and then the more accurate way, by weight. The stories range from Sheffield steel and a gas cylinder that came out "empty" to Jacques Pépin's photographs and Fannie Farmer's level cup.

PREREQUISITES

- Completed Unit 1: hygiene, the four steps and the danger zone
- Safe use of a chef's knife with a parent watching the first time
- Comfort with fractions, squares and basic right-triangle trigonometry (sine), taught here where needed

MASTERY CHECKLIST

- ☐ I can hone a knife, explain honing versus sharpening, and care for knives properly.
- ☐ I can cut julienne, batonnet, brunoise and small, medium and large dice to standard size.
- ☐ I can chiffonade and mince herbs and convert between fresh and dried herbs.
- ☐ I can choose the right pan for a job and calculate heat with

$q = .$
$mc\Delta T$

- ☐ I can measure by volume correctly and by weight accurately, and convert units.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **King Arthur Baking: Ingredient Weight Chart**: Free. The standard grams-per-cup chart used in Lesson 2.5 and the baking unit.
- **A honing steel and (optional) a two-sided whetstone**: A honing steel is inexpensive and used weekly. A 1000/6000-grit whetstone is optional; sharpen only with a parent watching. A local knife sharpener is a fine alternative.
- **A digital kitchen scale that reads grams**: Required from Lesson 2.5 on. Choose one that reads to 1 g and has a tare button.

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	**Choosing, Honing and Sharpening Knives**	3 sessions of 50 minutes
2.2	**The Classic Cuts: Julienne, Batonnet, Brunoise and Dice**	3 sessions of 50 minutes
2.3	**Herbs, Chiffonade and Mince: A Genoa Pesto**	3 sessions of 50 minutes
2.4	**Pots, Pans and Materials**	3 sessions of 50 minutes
2.5	**Fannie Farmer, the Level Cup and the Kitchen Scale**	3 sessions of 50–90 minutes

Unit 2 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Explain the difference between honing and sharpening, and how often each is done.

2. **6 pts**
   What did Harry Brearley discover in 1913, and why does it resist rust?

3. **8 pts**

   A knife blade is 1.6 inches wide. What spine height gives a 15° sharpening angle, and what is the total edge angle?

4. **6 pts**

   Give the dimensions of julienne, batonnet, brunoise and medium dice.

5. **8 pts**

   Find the surface-to-volume ratio of ¼-inch and ½-inch cubes, and estimate how much longer the ½-inch cubes take to cook if heating time grows with the square of thickness.

6. **6 pts**

   How many ½-inch dice can be cut from a 3-inch cube?

7. **6 pts**

   Convert 2 tablespoons fresh rosemary to dried, and explain why fresh herbs bruise under a dull knife.

8. **6 pts**

   Who was Jacques Pépin, and what did *La Technique* (1976) contribute?

9. **8 pts**

   How much heat raises a 1.8-kg cast-iron skillet (c = 0.45 J/(g·°C)) from 22 °C to 210 °C? How long at 1,500 W, ignoring losses?

10. **6 pts**

    Which pan would you choose for scrambled eggs, a seared steak and a tomato sauce? Explain.

11. **6 pts**

    Tell the story of Roy Plunkett’s discovery and one rule for using nonstick pans.

12. **8 pts**

    Convert 340 g to ounces and pounds.

13. **6 pts**

    A cook scoops 152 g for a 120-g cup of flour. Find the percent error.

14. **6 pts**

    Predict: a cake recipe written for spooned-and-leveled flour is made with 3 scooped cups. What will happen to the cake, and why?

15. **8 pts**

    Essay (one paragraph): Using Brearley, Plunkett and Fannie Farmer, explain how careful observation and measurement made cooking better.

ANSWER KEY

1. Honing realigns a bent edge (often, every few uses); sharpening grinds away metal to form a new edge (when honing no longer helps, a few times a year).
2. Stainless steel (about 12.8% chromium). Chromium forms a thin, self-healing chromium-oxide layer that seals the surface from oxygen and acids.
3. $h = 1.6 \times \sin 15^\circ = 0.41$ in; total edge angle 30°.
4. Julienne ⅛ × ⅛ × 1–2 in; batonnet ¼ × ¼ × 2–2½ in; brunoise ⅛ in cube; medium dice ½ in.
5. 24 in^{-1} and 12 in^{-1}; $(0.5/0.25)^2 = 4$ times as long (roughly).
6. $(3/0.5)^3 = 216$
7. 2 teaspoons dried. A dull knife crushes cells, releasing enzymes that brown the leaves and letting aroma escape.
8. A French-trained chef who came to America in 1959 and taught cooking; his book showed professional techniques in step-by-step photographs so home cooks and students could learn them.
9. $q = 1800 \times 0.45 \times 188 = 152{,}000$ J; $t = 152{,}000/1500 \approx 101$ s (about 1.7 min).
10. Nonstick for eggs (low heat, no sticking); cast iron or clad stainless for steak (stores heat); stainless or enameled for tomato sauce (non-reactive with acid).
11. In 1938 at DuPont, a gas cylinder that seemed empty still weighed as much as a full one; inside he found PTFE, a slippery polymer. Rule: do not heat nonstick pans empty or above medium-high heat.
12. 12.0 oz; 0.75 lb.
13. 26.7%.
14. It will be dry, dense and possibly domed or cracked, because scooping packs in roughly 20–25% more flour, absorbing liquid and strengthening the structure.
15. Answers vary. A strong answer: Brearley noticed a sample that would not etch and saw its use; Plunkett weighed a seemingly empty cylinder and found a new material; Farmer replaced vague measures with level, standard ones. Each paid attention to what could be measured and recorded honestly, and each made cooking more reliable for ordinary households.

UNIT PROJECT: KNIFE-SKILLS PRACTICAL AND CLASSIC-CUTS VEGETABLE SOUP

Prepare a knife-skills practical: on one cutting board, cut and arrange 10 pieces each of julienne, batonnet, brunoise, small dice, medium dice and a basil chiffonade. Time yourself, photograph the board beside a ruler, and measure a sample of each cut to report the percentage within tolerance.

Then use the cuts in a vegetable soup for the family (onion, carrot and celery in small dice, potato in medium dice, green beans in batonnet, finished with the chiffonade), weighing each vegetable as purchased and after trimming to report yield percentages. Write a one-page reflection comparing your first cut board in Lesson 2.2 with this one.

LOOK FOR	WHAT IT MEANS
Accuracy	At least 80% of measured pieces within tolerance; even, clean cuts.
Safety and technique	Correct grips, steady board, knife honed and cared for, safe cleanup (parent sign-off).
Soup	Vegetables cooked evenly and the soup seasoned well; family rating recorded.
Data	Times, measurements, and yield percentages recorded and calculated correctly.
Reflection	Honest comparison of progress with a plan for further practice.

2.1 Choosing, Honing and Sharpening Knives

OBJECTIVES

- Tell how Harry Brearley's 1913 discovery of stainless steel in Sheffield changed the kitchen knife.
- Name the parts of a chef's knife and explain the difference between honing and sharpening.
- Use trigonometry to find the spine height that holds a knife at a chosen sharpening angle.
- Hone a knife safely and use it to make pico de gallo, judged by clean cuts through ripe tomatoes.

> **Warm-up.** Try slicing a ripe tomato with the dullest knife in the drawer and then with the sharpest, using the same gentle pressure. Describe both cuts. Which knife needed more force, and which would be more likely to slip?

WATCH

How to Sharpen a Knife on a Whetstone

Serious Eats · 2:49

https://www.youtube.com/watch?v=AFbjn0aUZAU

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Watch once through, then again with your knife and steel in front of you (not yet moving).

Note: From Serious Eats, with J. Kenji López-Alt. He shows a honing steel first, then whetstones; whetstone sharpening is optional and should be done with a parent watching.

BACKUP VIDEO

The Best Way to Maintain and Store Your Knives

America's Test Kitchen · 3:22

https://www.youtube.com/watch?v=cjI3tUtbF7U

Optional: how to keep an edge longer by cutting, honing and storing knives well.

KEY TERMS

stainless steel

Steel containing at least about 10.5% chromium, which forms a thin, invisible oxide layer that resists rust.

honing

Straightening the knife's fine edge, which bends over with use, by drawing it along a honing steel. It removes little or no metal.

sharpening

Grinding away metal on a whetstone or sharpener to form a new, keen edge.

edge angle

The angle between each side of the edge bevel and the center line of the blade, often about 15° per side on Japanese-style knives and about 20° on many Western knives.

grit

A number describing how coarse or fine a sharpening stone is: low numbers (about 200–1000) grind quickly, high numbers (3000 and up) polish the edge.

CORE IDEAS

The story. For centuries the city of Sheffield in northern England was famous for cutlery. Its knives were made of carbon steel, which takes a fine edge but rusts and stains, especially from acidic foods like tomatoes, lemons and onions. In 1913 Harry Brearley, a metallurgist at a Sheffield research laboratory, was testing steels with added chromium in search of a metal that would resist wear. When he tried to etch his samples with acid to study them under a microscope, a steel with about 12.8% chromium would hardly etch at all. Brearley saw at once what this could mean for knives. A Sheffield cutlery firm made blades from the new metal, and they were sold as "stainless."

How he figured it out. Brearley noticed what others might have thrown away as a failed test: a sample that refused to react. He compared it with ordinary steel in vinegar and lemon juice, the very acids that stained table knives, and it stayed bright. Chemists later explained why. Chromium reacts with oxygen to form an

extremely thin, tough layer of chromium oxide that seals the surface and heals itself when scratched. Today most kitchen knives are made of stainless steel; some cooks still prefer carbon steel because it can be very sharp, and they dry it carefully after every use.

The kitchen science. A knife edge is two bevels meeting in a line far thinner than a hair. Using a knife bends this fine edge over, so the knife feels dull even though the metal is still there. A **honing steel** pushes the edge back into line; hone often, a few light strokes on each side. When honing no longer helps, the edge has worn away and must be **sharpened**: metal is ground off on a whetstone (or a good sharpener) to form new bevels. The edge angle is a trade-off: a smaller angle cuts more easily but chips and dulls sooner; a larger angle is tougher. A sharp knife is a *safer* knife, because it cuts with less force and is less likely to skid off a tomato skin or an onion and into your hand.

Let's cook. You will hone your chef's knife, test it on paper and tomatoes, and make pico de gallo, a fresh tomato salsa that shows off a sharp knife: clean tomato dice with no crushed juice, fine onion, and minced pepper and cilantro. The technique standard: board steady on a damp towel, a proper pinch grip and claw grip, tomatoes cut cleanly without squashing, even ¼-inch dice, and the knife washed, dried and stored right after use.

PICTURE STUDY



Still Life with Quince, Cabbage, Melon and Cucumber, Juan Sánchez Cotán, c. 1602 · Oil on canvas · San Diego Museum of Art

Image: Wikimedia Commons, public domain

Juan Sánchez Cotán painted a few plain foods in a stone window, the kind of cool pantry window Spanish households used to store produce. A few years after this painting he entered a monastery. The objects curve down from the hanging quince to the cucumber, and one clean wedge has been cut from the melon.

Look closely

- Find the cut melon. Look at the cut faces. Were they made with a sharp knife or a dull one? How can you tell?
- Find the hanging quince and cabbage. Why might foods be hung on strings in a pantry window?
- Look at how the light falls on each food. Which looks freshest?

Talk about it

1. What would the melon's cut surface look like if it had been cut with a dull, sawing knife?
2. Describe how you would cut the rest of this melon safely into wedges and then cubes.
3. Which of these foods would stain a carbon-steel knife, and why?

> **Safety first.** Hone and sharpen with the edge pointing away from your body and your fingers clear of the edge, with a parent watching the first time. Never try to catch a falling knife: step back and let it fall. Wash knives by hand one at a time, never leave them in a sink of soapy water, and wash your hands after cutting hot peppers before touching your eyes.

KITCHEN LAB

Knife Lab: Hone, Test and Make Pico de Gallo

You will learn the pinch grip and the claw, hone your knife, test its sharpness, and make a fresh salsa that rewards a keen edge, with baked tortilla chips on the side.

You will need

- A chef's knife and a honing steel (a whetstone is optional)
- A cutting board on a damp towel
- A sheet of printer paper for the edge test
- Two rimmed sheet pans, a mixing bowl, a citrus juicer
- Disposable gloves (optional) for the hot pepper

Pico de Gallo with Baked Tortilla Chips

Serves 6 · Prep 25 min · Bake 12 min

Ingredients

- 1½ lb (680 g) ripe Roma tomatoes (about 6)
- ½ medium white onion
- 1–2 jalapeño peppers, seeds and ribs removed for a milder salsa
- ½ cup (about 15 g) fresh cilantro leaves and tender stems
- 2 tablespoons fresh lime juice (1 lime)
- ¾ teaspoon salt
- **Chips:** 12 corn tortillas (6 inch)
- 2 tablespoons neutral oil and ½ teaspoon salt

Method

1. Heat the oven to 375 °F (190 °C). Brush the tortillas lightly with oil on both sides, stack and cut each into 6 wedges. Spread in one layer on the sheet pans and sprinkle with salt.
2. Bake 10–14 minutes, turning the pans halfway, until crisp and lightly golden. Cool on the pans; they crisp further as they cool.

3. Meanwhile, core the tomatoes, cut them in half, scoop out the seeds and cut into ¼-inch dice.
4. Cut the onion into fine (⅛-inch) dice. Mince the jalapeño. Chop the cilantro.
5. Combine everything in the bowl with the lime juice and salt. Taste, adjust the salt and lime, and let stand 10 minutes so the flavors blend.
6. Serve with the chips. Refrigerate leftovers and eat within 2 days.

Allergy check: Contains none of the nine major allergens. Check the tortilla label if allergies are severe.

Steps

1. **Grip practice.** With a parent watching, practice the pinch grip (thumb and forefinger pinching the blade just ahead of the handle) and the claw (fingertips curled under, knuckles guiding the blade) on a carrot before you cut anything soft.
2. **Before test.** Hold a sheet of paper by one corner and slice down through the edge. Record how the knife cuts: cleanly, ragged, or not at all. Slice a tomato and record whether the skin resisted.
3. **Hone.** Hold the steel vertically with its tip on a towel. Draw the knife down it, heel to tip, at about 15–20°, 5 light strokes per side, alternating sides.
4. **After test.** Repeat the paper and tomato tests and record the difference.
5. Make the chips and the pico de gallo. Measure 10 of your tomato dice with a ruler and record the range of sizes.
6. **Technique check.** Score 1–3: steady board, correct grips, clean tomato cuts, even dice, safe handling, knife washed, dried and stored.
7. Clean up: wash the knife by hand, dry and store it immediately; wash the board and sheet pans.
8. **Repeat round.** Make a mango or cucumber salsa and aim for a tighter dice size range.

Tips

- Use the knife's length: slice with a forward-and-down motion rather than pressing straight down.
- Seeding the tomatoes keeps the salsa from turning watery.

- Lime juice and salt draw juice out of the tomatoes; make pico within a few hours of serving.

Check your work

- ☐ I can tell Brearley's story and explain how stainless steel resists rust.
- ☐ I can hone a knife safely and explain honing versus sharpening.
- ☐ I made pico de gallo with clean, even tomato dice.

LAB NOTEBOOK

1. Draw and label a chef's knife: tip, edge, heel, spine, bolster, tang, handle, and the edge bevel seen end-on with its angle.
2. Record the before-and-after sharpness tests and the dice-size measurements.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$\sin\theta = \dfrac{h}{w}$ (h = height of the spine above the stone, w = width of the blade from edge to spine)

$\text{total edge angle} = 2 \times \text{angle per side}$

From history. Sheffield cutlers were making knives as early as the 1300s; Geoffrey Chaucer mentions a "Sheffield thwitel" (a small knife) in *The Canterbury Tales*. In the 1740s the Sheffield clockmaker Benjamin Huntsman developed crucible steel, melting steel in clay pots to make it more uniform, which made the city's blades famous.

WORKED EXAMPLES

Example 1. Your chef's knife is 1.75 inches wide at the heel. How high must the spine be lifted off the stone to sharpen at 15° per side? At 20°?

Show solution

1. Use $h = w \sin\theta$.
2. 15°: $h = 1.75 \text{ in} \times \sin 15^\circ = 1.75 \times 0.259 = 0.45 \text{ in}$.
3. 20°: $h = 1.75 \text{ in} \times \sin 20^\circ = 1.75 \times 0.342 = 0.60 \text{ in}$.

Answer: About 0.45 inch (a little less than half an inch) for 15°, and 0.60 inch for 20°. Two stacked coins under the spine make a handy guide while practicing.

Example 2. A knife sharpened at 15° per side has what total edge angle? Which is tougher, a 30° or a 40° total edge, and why?

Show solution

1. Total edge angle $= 2 \times 15^\circ = 30^\circ$.
2. A 40° edge has more metal behind it, so it bends and chips less but needs more force to cut.

Answer: 30° total. The 40° edge is tougher; the 30° edge cuts more easily.

Example 3. A good chef's knife costs $48 and lasts 15 years of cooking 5 days a week. What does it cost per day of cooking? Compare a $12 knife that must be replaced every 3 years.

Show solution

1. Days of use: $15 \times 52 \times 5 = 3900$.
2. Good knife: $\dfrac{\$48}{3900} = \$0.012$ per day.
3. Cheap knife over the same 15 years: 5 knives × $12 = $60, or $\$60/3900 = \$0.015$ per day.

Answer: About 1.2¢ per day for the good knife versus 1.5¢ for the cheap ones, and the good knife cuts better the whole time.

PRACTICE

1. Easy What is the difference between honing and sharpening?

   Show answer

   Honing realigns a bent edge without removing much metal; sharpening grinds metal away to make a new edge.

2. Easy What element makes steel "stainless," and roughly what percentage did Brearley's 1913 steel contain?

   Show answer

   Chromium; about 12.8%.

3. Easy Why is a sharp knife safer than a dull one?

Show answer

It needs less force and does not skid off food, so it is less likely to slip into a hand.

4. Medium A paring knife is 0.9 inch wide. What spine height gives a 20° angle?

Show answer

$0.9 \times \sin 20^\circ = 0.31$ in.

5. Medium A Japanese-style knife is sharpened at 15° per side and a Western knife at 20°. Find each total edge angle.

Show answer

30° and 40°.

6. Medium Explain why carbon-steel knives stain when cutting tomatoes or lemons while stainless knives do not.

Show answer

Acids react with the iron in carbon steel; in stainless steel a thin chromium-oxide layer seals the surface and keeps the acid from reaching the iron.

7. Medium List four rules for caring for a good knife.

Show answer

Any four: hand-wash and dry immediately; never leave it in a sink of water; store in a block, sheath or magnetic strip; cut on wood or plastic boards, never glass, stone or plates; hone regularly; never use the edge to scrape food off the board (use the spine).

8. Hard Your blade is 2.0 inches wide and you hold the spine 0.5 inch above the stone. What angle are you sharpening at?

Show answer

$\theta = \sin^{-1}(0.5/2.0) = 14.5^\circ$

9. Hard A whetstone set costs $40 and professional sharpening costs $8 per knife. You have 3 knives sharpened 3 times a year. How many years until the stones pay for themselves?

Show answer

Professional cost per year $3 \times 3 \times \$8 = \$72$; the stones pay for themselves in about 7 months ($40/72 \approx 0.56$ year).

10. Challenge Brearley noticed a sample that "failed" to etch. Describe another case, from science or the kitchen, where an unexpected result turned out to be useful, and explain what habit of mind it takes to notice such results.

Show answer

Answers vary (for example, Fleming's penicillin mold, Percy Spencer's melted candy bar, Plunkett's Teflon in Lesson 2.4). The habit: careful observation, curiosity, and recording results honestly instead of discarding the unexpected.

COMMON MISTAKES

- Running a good knife through the dishwasher, which dulls and loosens it.
- Scraping chopped food off the board with the sharp edge; turn the knife over and use the spine.
- Honing with heavy pressure. Light strokes realign the edge; pressure rolls it.
- Cutting on a glass or stone board, which dulls an edge in a few strokes.

Make it a game · Hone and Test. Challenge your parent to a knife-vocabulary duel. Alternate naming a part of the chef's knife, a grit number or an edge fact, with no repeats and ten seconds each. Then explain how Harry Brearley's 1913 stainless steel changed knives, and describe the difference between honing and sharpening. Loser washes the board.

Scripture. "If the iron be blunt, and he do not whet the edge, then must he put to more strength: but wisdom is profitable to direct." (Ecclesiastes 10:10, KJV)

Solomon knew what every cook learns: a dull blade needs more force, and wisdom (here, a few minutes with the steel) saves strength and danger.

2.2 The Classic Cuts: Julienne, Batonnet, Brunoise and Dice

OBJECTIVES

- Name and cut the classic knife cuts to standard dimensions, checked with a ruler.
- Explain with surface-area-to-volume ratios why evenly sized pieces cook evenly and smaller pieces cook faster.
- Tell how Jacques Pépin's *La Technique* (1976) taught home cooks professional knife work.
- Cook chicken fajitas with evenly cut peppers and onions.

> **Warm-up.** Cut two potato pieces, one ½-inch cube and one 1-inch cube, and drop them into the same pot of boiling water. Poke each with a fork every 2 minutes. How many times longer did the big cube take? Make a guess before you start.

WATCH

Cuts

American Culinary Federation · 10:16

https://www.youtube.com/watch?v=rf1zAk6cMlg

> **WHEN TO WATCH**
> After the story. Keep a ruler beside you and pause after each cut to write its dimensions.

Note: From the American Culinary Federation's procedure series, taught by a Certified Master Chef using a potato.

BACKUP VIDEO

Classic Knife Cuts

Escoffier Home Gourmet · 3:18

https://www.youtube.com/watch?v=5wSUMQCgCbQ

A short review of the same cuts on a carrot, from the online program of the Auguste Escoffier School of Culinary Arts.

KEY TERMS

batonnet

A stick about ¼ × ¼ inch and 2–2½ inches long.

brunoise

A tiny cube about ⅛ inch on a side, cut from julienne (fine brunoise is ⅛ inch).

julienne

A thin matchstick about ⅛ × ⅛ inch and 1–2 inches long (fine julienne is ⅛ inch).

dice

Cubes: small ¼ inch, medium ½ inch, large ¾ inch.

surface-area-to-volume ratio

How much outside a piece has for its size; for a cube of side s it is $6/s$. Higher ratios heat through faster.

CORE IDEAS

The story. Jacques Pépin was born in 1935 in Bourg-en-Bresse, France, and began his apprenticeship in a hotel kitchen at thirteen. He trained in the strict French system, where an apprentice might spend months on knife work before cooking a single dish for a guest. He came to the United States in 1959 and spent about ten years developing recipes for the Howard Johnson's restaurant company, learning how to teach professional methods to cooks who had never trained in France. In 1976 he published *La Technique,* a thick book of step-by-step photographs showing exactly how a professional holds the knife, peels, slices and cuts each vegetable. It became a classic for home cooks and culinary students alike.

How he figured it out. Pépin realized that most recipes said "dice the carrot" without showing how, and that cooks learned faster by seeing hands at work than by reading. So he photographed every stage. The classic French cuts gave him a common language: a recipe that says "brunoise" or "batonnet" tells every trained cook the same size. Professional kitchens use the standard sizes so that every portion looks the same and cooks the same.

The kitchen science. Heat enters food through its surface. A cube of side s has surface area $6s^2$ and volume s^3, so its surface-to-volume ratio is $6/s$. Halving the size doubles the ratio. Better still, the time for heat to reach the center grows roughly

with the *square* of the thickness, so a piece half as thick cooks in about a quarter of the time. That is why a soup with ½-inch and 1-inch potato chunks has some pieces mushy and others raw, and why recipes specify a cut. Even cuts also look better and give each bite the same texture.

Let's cook. You will cut peppers and onions into even ¼-inch strips and chicken into even strips for fajitas, and cut a carrot into each classic shape for a practice board. The technique standard: a stable flat side on every round vegetable before cutting, consistent claw grip, strips within ⅛ inch of target width, chicken cooked to 165 °F, and vegetables tender-crisp.

PICTURE STUDY



Old Woman Chopping Onions, Gerrit Dou, 17th century · Oil on panel · Unknown collection

Image: Wikimedia Commons, public domain

Gerrit Dou, a pupil of Rembrandt, painted small, minutely detailed scenes of daily work in Leiden. Here an old woman cuts onions, a task she has clearly done thousands of times. Long practice shows in the calm way she holds the knife and the food.

Look closely

- Look at how she holds the onion and the knife. Is she cutting toward herself, away, or onto a board?
- Find the knife. Is it a large chef's knife or a small one? Why might she choose it?
- Look at her face and posture. What do they tell you about her skill?

Talk about it

1. How would you cut an onion into small dice today, and how is your method safer than cutting it in your hand?
2. Why do onions make cooks' eyes water, and how does a sharp knife help?
3. What does years of repetition do for a cook's knife skills?

> **Safety first.** Cut with the board on a damp towel, keep the claw grip with fingertips curled, and give every round vegetable a flat side before cutting. Keep raw chicken on its own board and cook it to 165 °F. Wash your hands after handling raw chicken and after cutting peppers.

KITCHEN LAB

Knife Lab: The Cut Board and Chicken Fajitas

You will cut a practice board of the classic cuts measured against a ruler, then use your best batonnet and julienne skills on fajita vegetables.

You will need

- A chef's knife, cutting boards (one for raw chicken), a damp towel
- A ruler
- A 12-inch skillet (cast iron if you have it)
- Tongs, an instant-read thermometer, a bowl and a plate
- Foil or a clean towel to keep tortillas warm

Chicken Fajitas with Peppers and Onions

Serves 4–6 · Prep 30 min · Marinate 30 min · Cook 15 min

Ingredients

- 1½ lb (680 g) boneless, skinless chicken thighs or breasts
- 3 bell peppers of different colors
- 1 large onion
- **Marinade:** 3 tablespoons oil, 2 tablespoons lime juice
- 2 teaspoons chili powder, 1 teaspoon ground cumin, ½ teaspoon smoked paprika
- 1 teaspoon salt, ½ teaspoon pepper, 2 cloves garlic, minced
- 1 tablespoon oil for the pan
- 8–12 flour or corn tortillas, warmed
- To serve: salsa, sour cream, grated cheese, sliced avocado, lime wedges

Method

1. Whisk the marinade. Cut the chicken across into ¼- to ⅜-inch strips on the raw-meat board and toss with half the marinade; refrigerate 30 minutes to 2 hours. Wash hands, knife and board.

2. On the clean board, cut the peppers into ¼-inch strips and the onion into ¼-inch slices from root to tip. Toss with the remaining marinade.
3. Heat 1 tablespoon oil in the skillet over medium-high heat until shimmering. Cook the chicken in one layer, in two batches if needed, 5–7 minutes, turning, until browned and 165 °F. Move to a clean plate.
4. Add the vegetables to the hot pan and cook 5–6 minutes, tossing, until tender-crisp with some browned edges.
5. Return the chicken, toss, and serve at once with warm tortillas and toppings.

Allergy check: Flour tortillas contain wheat; toppings may contain milk (sour cream, cheese). Use corn tortillas for wheat-free and skip the dairy toppings for milk-free.

Steps

1. **Cut board.** On a carrot and a potato, cut 5 pieces each of batonnet, julienne, brunoise, small dice and medium dice. Lay them in labeled rows on a plate.
2. **Measure.** Measure each piece with a ruler and record the actual sizes; calculate how many were within ⅛ inch (1⁄16 inch for brunoise) of target.
3. Photograph the board. Use the scraps in a soup or stock (Unit 4).
4. Make the fajitas, cutting the peppers and onions to ¼ inch. Record the chicken's final temperature.
5. **Even-cooking test.** Taste five pepper strips from different parts of the pan. Were they all equally tender?
6. **Technique check.** Score 1–3: flat side first, claw grip, accurate cuts, separate raw-meat board, chicken at 165 °F, tender-crisp vegetables.
7. Clean up: raw-meat board and knife first in hot soapy water; sanitize the counter.
8. **Repeat round.** Cut a second board in a week and compare your accuracy and your time.

Tips

- Peppers cut more easily skin-side down; the knife slides through the inside wall.
- Cut onions for fajitas from root to tip so the strips hold their shape.

- Do not crowd the pan or the vegetables will steam instead of brown.

Check your work

- ☐ I can name and cut the classic cuts to standard size.
- ☐ I can explain why even pieces cook evenly using surface-to-volume ratio.
- ☐ I cooked fajitas with even vegetables and chicken at 165 °F.

LAB NOTEBOOK

1. Draw each classic cut to actual size with its dimensions.
2. Record your cut-board measurements in a table with the percentage within tolerance.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

cube: $\dfrac{SA}{V} = \dfrac{6s^2}{s^3} = \dfrac{6}{s}$

$t \propto L^2$ (heating time grows roughly with the square of thickness L)

$$\text{number of cubes} = \left(\frac{\text{block side}}{\text{cube side}}\right)^3$$

From history. Jacques Pépin later co-hosted the television series *Julia and Jacques Cooking at Home* with Julia Child (1999–2000) and in 2016 started a foundation to teach cooking skills to adults seeking work.

WORKED EXAMPLES

Example 1. Compare the surface-to-volume ratios of a ¼-inch small dice and a ¾-inch large dice.

Show solution

1. Small: $6/0.25 \text{ in} = 24 \text{ in}^{-1}$.
2. Large: $6/0.75 \text{ in} = 8 \text{ in}^{-1}$.
3. Ratio: $24/8 = 3$.

Answer: The small dice has 3 times as much surface per unit volume, so it heats through much faster.

Example 2. Medium-dice potatoes (½ inch) boil tender in 8 minutes. Estimate the time for large dice (¾ inch) and for 1-inch chunks.

Show solution

1. Use $t \propto L^2$: $t = 8 \text{ min} \times \left(\dfrac{0.75}{0.5}\right)^2 = 8 \times 2.25 = 18 \text{ min}$.
2. 1-inch: $8 \times (1/0.5)^2 = 8 \times 4 = 32 \text{ min}$.
3. (Real times are somewhat shorter because the outside starts cooking at once, but the rule shows the trend.)

Answer: Roughly 18 minutes for ¾-inch and 30 minutes or so for 1-inch chunks: doubling the size roughly quadruples the time.

Example 3. How many ¼-inch dice can be cut from a 2-inch cube of potato? How many ⅛-inch brunoise?

Show solution

1. ¼-inch: $(2/0.25)^3 = 8^3 = 512$.
2. ⅛-inch: $(2/0.125)^3 = 16^3 = 4096$.

Answer: 512 small dice, or 4,096 brunoise, which is why brunoise is used in small amounts as a garnish.

PRACTICE

1. Easy Give the standard dimensions of batonnet, julienne, brunoise, and small, medium and large dice.

   Show answer

   Batonnet ¼ × ¼ × 2–2½ in; julienne ⅛ × ⅛ × 1–2 in; brunoise ⅛ in cube; small dice ¼ in; medium ½ in; large ¾ in.

2. Easy Brunoise is cut from which other cut?

   Show answer

   Julienne (cut across into cubes).

3. Easy Why do you cut a thin slice off a round vegetable before dicing it?

   Show answer

   To give it a flat side so it sits still and does not roll under the knife.

4. **Medium** Find the surface-to-volume ratio of a ½-inch cube and of a 1-inch cube.

Show answer

12 in^{-1} and 6 in^{-1}.

5. **Medium** A julienne stick is ⅛ × ⅛ × 2 inches. Find its volume and surface area.

Show answer

$V = 0.125 \times 0.125 \times 2 = 0.03125$ in^3; $SA = 4(0.125 \times 2) + 2(0.125^2) = 1.03$ in^2.

6. **Medium** When did Jacques Pépin publish *La Technique*, and why were its photographs so helpful?

Show answer

1976. It showed each step of professional knife work in pictures, so cooks could see hand positions and cuts instead of guessing from words.

7. **Medium** Carrots in medium dice roast in 25 minutes. About how long would small dice take?

Show answer

$25 \times (0.25/0.5)^2 \approx 6$ minutes by the square rule; in practice about 10–15 minutes, since browning and moisture also matter. Small dice cook much faster.

8. **Hard** A soup has potatoes cut anywhere from ½ to 1 inch. When the 1-inch pieces are just tender, what has happened to the ½-inch pieces, and how does this affect the soup?

Show answer

They have cooked about four times as long as they needed; they are falling apart and clouding and thickening the soup, while the big ones are just done.

9. **Hard** How many medium-dice (½-inch) cubes fit in one cup? (1 cup ≈ 14.4 in^3, and loose cubes fill about 60% of the space.)

Show answer

$0.6 \times 14.4/0.125 \approx 69$ cubes.

10. **Challenge** Explain why cooking time grows with the square of thickness, not just in proportion to it. (Hint: think about how far heat must travel and how fast it travels through food.)

    Show answer

    Heat moves inward by conduction, and the distance heat spreads in a time t grows roughly as the square root of t. To reach a center twice as deep, heat needs about four times as long: t is proportional to L^2.

COMMON MISTAKES

- Cutting a round onion or carrot without a flat side; it rolls under the knife.
- Lifting the knife high and chopping straight down instead of slicing with a rocking or forward motion.
- Uneven pieces in one pan, so some burn while others stay raw.
- Speed before accuracy. Speed comes from accurate, repeated motion.

> **Make it a game · Cut to Spec.** Take a carrot and a ruler. Your parent names a cut: julienne, batonnet, brunoise or dice. Cut it to spec, then measure three pieces and mark each pass or fail. Run five rounds and log accuracy. Finish by explaining how surface area to volume changes cooking time of small versus large pieces.

2.3 Herbs, Chiffonade and Mince: A Genoa Pesto

OBJECTIVES

- Mince, chop and chiffonade fresh herbs with a sharp knife, keeping them green rather than bruised.
- Convert between fresh and dried herbs and scale an herb sauce.
- Tell the history of pesto alla genovese, first printed in 1863.
- Make basil pesto and toss it with pasta, garnished with a basil chiffonade.

> **Warm-up.** Rub a basil leaf between your fingers and smell. Then tear one leaf, cut one with a dull knife and one with a sharp knife, and leave them on a plate for 20 minutes. Which edges darken first?

WATCH

Knife Skills: How to Cut Herbs

Serious Eats · 2:00

https://www.youtube.com/watch?v=DpAAT-F0jqs

> **WHEN TO WATCH**
> Before the lab. Watch the slice, the chiffonade and the chop, then practice each on a few leaves before you make the pesto.

BACKUP VIDEO

Knife Skills: How to Slice, Chop, and Chiffonade Different Herbs

Institute of Culinary Education · 1:18

https://www.youtube.com/watch?v=9kGwzLp2YJM

A second short look at the same three cuts from a culinary school chef instructor.

KEY TERMS

chiffonade

Leaves stacked, rolled tightly and sliced across into thin ribbons.

mince

To cut into very fine pieces, smaller than a chop.

herb

The fresh or dried leaves of a plant used for flavor, such as basil, parsley, cilantro, mint, oregano and thyme. Spices come from seeds, bark, roots, buds or fruit.

pesto

From the Italian *pestare*, "to pound": a sauce of herbs crushed with garlic, nuts, cheese and oil, traditionally in a mortar.

enzymatic browning

Darkening caused when cell damage lets plant enzymes (polyphenol oxidases) react with compounds in the plant and oxygen in the air.

CORE IDEAS

The story. Liguria, the narrow strip of coast around Genoa in northwest Italy, grows a sweet, small-leaved basil on its sunny hillsides. Cooks there pounded basil with garlic, cheese, pine nuts and the region's olive oil in a marble mortar with a wooden pestle. The first known printed recipe for *pesto alla genovese* appeared in 1863 in *La Cuciniera Genovese* ("The Genoese Cook") by Giovanni Battista Ratto. Sailors from Genoa carried the taste of it around the Mediterranean, and Italian families brought it to America.

How they figured it out. Ligurian cooks learned by long practice that basil is delicate. Pounded gently, it gives a bright green, fragrant sauce; worked roughly or left in the air, it turns dark and dull. They added the cheese and oil to coat and protect the crushed leaves, and they made pesto shortly before eating it. Modern cooks use a food processor, and food scientists have explained what the old cooks knew by taste.

The kitchen science. Herb leaves are full of tiny oil glands holding their aroma, and their cells hold enzymes kept separate from the compounds they react with. A dull knife crushes and tears cells, releasing juices that the enzymes turn brown and dark, and letting aroma escape onto the board. A sharp knife slices cleanly through, so herbs stay green and fragrant. For a **chiffonade**, stack the leaves, roll them into a tight tube and slice across into ribbons. For a **mince**, gather the leaves, slice, then rock the knife over them with your other hand flat on the spine. Dried herbs are

concentrated, about three times as strong as fresh: 1 tablespoon of fresh equals about 1 teaspoon of dried.

Let's cook. You will make basil pesto and toss it with pasta, adding a little starchy pasta water to make it creamy, and finish the dish with a chiffonade of basil and halved tomatoes. The technique standard: herbs washed and dried well; a clean, green chiffonade; minced garlic fine and even; pesto bright green and balanced in salt; pasta cooked al dente and sauced so every piece is coated.

PICTURE STUDY



The Vegetable Market in Amsterdam, Gabriel Metsu, c. 1661–62 · Oil on canvas · Musée du Louvre, Paris

Image: Wikimedia Commons, public domain

Gabriel Metsu painted the busy greengrocers' market on one of Amsterdam's canals. Women sold cabbages, carrots, turnips, greens and herbs from baskets and wheelbarrows. Shoppers came early, when everything was freshest.

Look closely

- Find the baskets and the wheelbarrow of produce. Which vegetables can you name?
- Look for leafy greens. How do you think the sellers kept them from wilting in the sun?
- Find the shoppers. What are they doing to choose their food?

Talk about it

1. How would you choose the freshest bunch of herbs at a market today?
2. How should fresh herbs be stored at home so they last?
3. What could you cook from this market for a family supper?

Safety first. Wash herbs and tomatoes under running water and dry them well. Keep fingertips curled when mincing and chiffonading; herbs are small, and fingers get close to the blade. Pine nuts are tree nuts: check for allergies and use the seed swap if needed. Drain pasta by pouring away from you into a colander in the sink.

KITCHEN LAB

Herb Lab: Basil Pesto Pasta with a Chiffonade

You will practice the three herb cuts, run a browning test, and make a fresh basil pesto pasta.

You will need

- A sharp chef's knife and a cutting board
- A food processor or blender (or a mortar and pestle)
- A large pot, colander, measuring cup for pasta water
- A small skillet for toasting nuts
- Salad spinner or clean towels

Pasta with Basil Pesto and Tomatoes

Serves 6 · Prep 20 min · Cook 15 min

Ingredients

- **Pesto:** 2 cups (2 oz / 57 g) packed fresh basil leaves, plus 10 leaves for garnish
- ⅓ cup (45 g) pine nuts or sunflower seeds, toasted
- 2 cloves garlic
- ½ cup (40 g) finely grated Parmesan cheese
- ½ cup (120 mL) olive oil
- ¼ teaspoon salt, more to taste, and 1 teaspoon lemon juice
- **Pasta:** 1 lb (450 g) short pasta such as fusilli or penne
- 1 tablespoon salt for the pasta water
- 1 pint cherry tomatoes, halved

Method

1. Toast the pine nuts in a dry skillet over medium-low heat, shaking often, 3–4 minutes, until golden. Watch closely; they burn quickly. Cool.
2. Pulse the garlic and nuts in the food processor until finely chopped. Add the basil and salt and pulse to a coarse paste, scraping down the sides.

3. With the machine running, pour in the oil. Add the cheese and lemon juice and pulse just to combine. Taste for salt.
4. Bring 4 quarts of water and the tablespoon of salt to a boil. Cook the pasta to al dente by the package time, tasting a minute before. Scoop out 1 cup of pasta water before draining.
5. Toss the hot pasta with the pesto and ¼–½ cup of pasta water until creamy and glossy. Fold in the tomatoes.
6. Stack, roll and chiffonade the 10 reserved basil leaves and scatter on top. Serve at once.

Allergy check: Contains tree nuts (pine nuts), milk (Parmesan) and wheat (pasta). Use toasted sunflower seeds for nut-free, nutritional yeast or more seeds for milk-free, and gluten-free pasta for wheat-free.

Steps

1. **Three cuts.** On parsley, practice the chop and the mince; on chives, the slice; on basil, the chiffonade. Photograph each.
2. **Browning test.** Cut basil three ways (torn, dull knife, sharp knife) and photograph at 0, 20 and 60 minutes. Rank them.
3. Make the pesto and pasta. Measure and record how much pasta water you added.
4. **Taste and adjust.** Taste the pesto before and after adding lemon and salt. Record the change.
5. **Technique check.** Score 1–3: clean chiffonade, fine garlic, green pesto, al dente pasta, sauce coating every piece, safe draining.
6. Store leftover pesto in a small jar with plastic pressed onto its surface; refrigerate up to 3 days or freeze in an ice-cube tray.
7. Clean up: wash the processor blade carefully by hand, blade pointed away.
8. **Repeat round.** Make a parsley-mint or cilantro-lime herb sauce and compare.

Tips

- Dry herbs completely before cutting; wet leaves bruise and stick to the knife.
- Store basil like flowers, stems in a glass of water at room temperature; store parsley and cilantro the same way in the refrigerator.

- Add the cheese at the end; long processing warms and dulls the pesto.

Check your work

- ☐ I can chop, mince, slice and chiffonade herbs cleanly.
- ☐ I can convert fresh and dried herbs.
- ☐ I made a bright green pesto pasta with a chiffonade garnish.

LAB NOTEBOOK

1. Draw the chiffonade in four steps: stack, roll, slice, fluff.
2. Record your browning test with photos or sketches and a ranking.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

1 Tbsp fresh herbs ≈ 1 tsp dried, or dried $= \frac{1}{3} \times$ fresh by volume

$1\ \text{Tbsp} = 3\ \text{tsp}, \quad 1\ \text{cup} = 16\ \text{Tbsp}$

From history. Genoa holds a pesto championship every two years in which cooks make pesto by hand in marble mortars. The traditional recipe is protected by a Genoese consortium that names basil from Genoa's hills (*Basilico Genovese*) as the right leaf.

WORKED EXAMPLES

Example 1. A soup recipe calls for 2 tablespoons of fresh thyme. You have only dried thyme. How much should you use?

Show solution

1. Dried is about 3 times as strong: $2\ \text{Tbsp} \times \frac{1}{3} = \frac{2}{3}\ \text{Tbsp}$.
2. Convert: $\frac{2}{3}\ \text{Tbsp} \times 3\ \text{tsp/Tbsp} = 2\ \text{tsp}$.

Answer: 2 teaspoons of dried thyme.

Example 2. The pesto recipe makes 1 cup with 2 oz (57 g) basil, ⅓ cup pine nuts and ½ cup cheese. You need 2½ cups for a party. Scale it.

Show solution

1. Factor $2.5/1 = 2.5$.
2. Basil $2 \times 2.5 = 5$ oz; pine nuts $\frac{1}{3} \times 2.5 = 0.83$ cup, about ¾ cup + 1 Tbsp; cheese $0.5 \times 2.5 = 1.25$ cups.

Answer: 5 oz basil, a generous ¾ cup pine nuts and 1¼ cups cheese (and 2½ times the other ingredients).

Example 3. Homemade pesto: basil $3.00, pine nuts $3.50 (⅓ cup), cheese $2.00, oil and garlic $1.00, for 1 cup. A 6-oz jar (¾ cup) costs $5.49. Compare cost per cup.

Show solution

1. Homemade: $\$3.00 + \$3.50 + \$2.00 + \$1.00 = \$9.50$ per cup.
2. Jarred: $\$5.49 \div 0.75 = \$7.32$ per cup.

Answer: Homemade costs about $2 more per cup with pine nuts, but using sunflower seeds ($0.50) brings it to about $6.50, cheaper than the jar, and fresher.

PRACTICE

1. Easy How do you cut a chiffonade?

   Show answer

   Stack the leaves, roll them tightly lengthwise, and slice across the roll into thin ribbons.

2. Easy Convert 3 tablespoons of fresh parsley to dried.

   Show answer

   1 tablespoon (3 teaspoons) dried.

3. Easy What is the difference between an herb and a spice?

   Show answer

   Herbs are leaves; spices come from other plant parts such as seeds, bark, roots, buds or fruit.

4. Medium Why does basil cut with a dull knife turn black faster?

Show answer

The dull knife crushes cells, releasing enzymes and compounds that react with oxygen (enzymatic browning).

5. Medium A recipe needs 1 teaspoon dried oregano. How much fresh oregano would you use?

Show answer

About 1 tablespoon.

6. Medium When and where was the first known pesto recipe printed?

Show answer

1863, in Genoa, in Giovanni Battista Ratto's *La Cuciniera Genovese*.

7. Medium Why is a little starchy pasta water added when tossing pasta with pesto?

Show answer

The starch and water loosen and emulsify the oil and cheese into a creamy sauce that clings to the pasta.

8. Hard A 0.75-oz package of fresh basil costs $2.49. You need 2 oz for pesto. How many packages, and what is the cost?

Show answer

$2 / 0.75 = 2.67$, so 3 packages for $7.47 (or buy a larger bunch or grow basil).

9. Hard Store-bought pesto is dark green; yours turned dark on top overnight. Explain and give two ways to prevent it.

Show answer

Air oxidized the surface (enzymatic browning). Press plastic wrap directly onto the surface or pour a thin layer of oil on top; some cooks blanch the basil briefly first to stop the enzymes.

10. **Challenge** Pine nuts are a tree-nut allergen for many guests. Design a nut-free pesto and explain what each ingredient contributes.

    Show answer

    Example: basil (aroma), toasted sunflower or pumpkin seeds (body and richness like nuts), Parmesan (salt and umami), garlic (sharpness), olive oil (carries flavor and coats leaves against browning), lemon juice and salt (balance). Check seeds are processed without tree nuts.

COMMON MISTAKES

- Chopping wet herbs into a dark paste.
- Toasting pine nuts and walking away; they burn in seconds once golden.
- Draining away all the pasta water before saucing.
- Using dried basil for pesto; pesto needs fresh leaves.

> **Make it a game · Herb Drill.** Your parent tosses out herb jobs: chiffonade basil, mince parsley, a pesto for four scaled to twelve, three teaspoons dried herb into fresh. Answer or demonstrate each in thirty seconds, pretending with a pile of leaves. Explain why a sharp knife keeps basil green instead of bruised. Record your correct count.

2.4 Pots, Pans and Materials

OBJECTIVES

- Tell how Roy Plunkett discovered PTFE (Teflon) in 1938 and how it came to coat frying pans.
- Compare cast iron, stainless steel, aluminum, copper and nonstick pans by heat capacity, conductivity and care.
- Use $q = mc\Delta T$ to compare the heat needed to preheat different pans.
- Cook skillet home fries in two different pans and compare the results.

> **Warm-up.** Put a cast-iron or heavy pan and a thin pan side by side on two burners set to the same heat. Hold your hand 4 inches above each (do not touch) and count how many seconds until it feels hot. Which heats faster? Which do you think holds heat longer?

WATCH

What's the Best Pan Money Can Buy?

Chris Young · 15:50

https://www.youtube.com/watch?v=LdORIBH3R88

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Pause at each chart of heat capacity and diffusivity and copy the ranking of metals.

Note: Chris Young, a former culinary scientist and co-author of Modernist Cuisine, tests pans of six metals with a thermal camera. Longer than most, and worth it.

BACKUP VIDEO

The Science of Heat Conduction in Aluminum and Cast-Iron Pans

America's Test Kitchen · 1:23

https://www.youtube.com/watch?v=PjeBhXcJ0JQ

A quick butter-melting test that shows conduction versus heat storage.

KEY TERMS

specific heat capacity

The energy needed to raise 1 gram of a material by 1 °C. Aluminum about 0.90 J/(g·°C); iron about 0.45; stainless steel about 0.50.

thermal conductivity

How fast heat moves through a material. Copper and aluminum conduct well; cast iron moderately; stainless steel poorly.

clad pan

A pan made of layers, usually stainless steel outside and an aluminum or copper core, to combine durability with even heating.

seasoning

A hard, slick layer of oil polymerized by heat onto cast iron or carbon steel that resists sticking and rust.

PTFE

Polytetrafluoroethylene, the slippery plastic coating of most nonstick pans; it should not be heated empty or above medium-high heat.

CORE IDEAS

The story. On April 6, 1938, Roy Plunkett, a young chemist at DuPont's laboratory in New Jersey, opened the valve on a cylinder of tetrafluoroethylene gas he had stored for an experiment on refrigerants. Nothing came out, though the cylinder still weighed as much as when it was full. Curious, he and his assistant cut the cylinder open and found a waxy white powder coating the inside. The gas had linked itself into long chains, a polymer, polytetrafluoroethylene, or PTFE. It was astonishingly slippery and resisted almost every chemical. In the 1950s a French engineer, Marc Grégoire, used it to coat his fishing tackle; his wife, Colette, asked him to coat her frying pan, and in 1956 they started the company Tefal to sell nonstick pans.

How they figured it out. Plunkett did not discard the "empty" cylinder; the weight told him something must be inside. He studied the powder and found its strange properties: it would not melt easily, dissolve or stick to almost anything. Coating metal with PTFE took years of work, because the very slipperiness that made it useful made it hard to bond to a pan. Each kind of pan in your kitchen has a similar history of trade-offs.

The kitchen science. Two properties matter most. **Conductivity** decides how evenly heat spreads across the pan: aluminum and copper spread heat quickly and evenly; stainless steel spreads it poorly, so good stainless pans have an aluminum or copper core (they are "clad"). **Heat capacity**, the mass times the specific heat, decides how much heat the pan stores: a heavy cast-iron skillet takes longer to heat but holds its temperature when cold food hits it, which is why it sears so well. Nonstick PTFE pans are best for eggs, fish and pancakes at low to medium heat; they should not be heated empty on high, because PTFE begins to break down above about 500 °F (260 °C). Cast iron needs seasoning and drying; stainless can take high heat and metal utensils.

Let's cook. You will make skillet home fries twice, half the batch in a heavy pan (cast iron or clad stainless) and half in a lighter pan (nonstick or thin aluminum), with the same potatoes, oil and heat. The technique standard: potatoes cut evenly, par-cooked so the centers are tender, pan properly preheated, potatoes left alone long enough to brown before turning, and a golden, crisp crust.

PICTURE STUDY



Kitchen Interior, Willem Kalf, c. 1640s · Oil on panel · See the image source page

Image: Wikimedia Commons, public domain

Before Willem Kalf became famous for elegant still lifes, he painted humble kitchen corners like this one, full of pots and pans of every material. Each vessel was chosen for a job: copper for even heat, iron for the fire, earthenware for slow cooking and storage.

Look closely

- Find every pot and pan you can. Which look like copper or brass, which like iron, and which like clay?
- Which vessels would sit on the fire and which would be used for storage?
- Look at the shine on the copper. Why would a cook keep copper polished and tinned inside?

Talk about it

1. If you could take three vessels from this kitchen into yours, which would you choose and what would you cook in each?
2. Which material here would you use for a slow-simmered stew, and why?
3. Compare this kitchen's equipment with your own. What has changed, and what has stayed the same?

> **Safety first.** Cast iron handles get as hot as the pan: always use a dry oven mitt or towel, and drape a mitt over the handle as a reminder. Never heat a nonstick pan empty on high. Lower potatoes into hot oil with a spatula, never by hand, and keep a lid nearby in case of a grease flare.

KITCHEN LAB

Pan Lab: Skillet Home Fries, Two Pans

You will cook the same home fries in two different pans and compare preheat time, browning and evenness, with data.

You will need

- Two skillets of different materials (for example, cast iron and nonstick), about the same size
- A chef's knife and board
- A large pot or microwave-safe bowl for par-cooking
- A thin metal spatula, oven mitts, a timer, an instant-read thermometer
- A kitchen scale

Skillet Home Fries

Serves 4–6 · Prep 15 min · Par-cook 8 min · Cook 15 min

Ingredients

- 2 lb (900 g) Yukon Gold or red potatoes, scrubbed and cut in ¾-inch dice
- 3 tablespoons neutral oil (divided between pans)
- 1 small onion, diced
- 1 bell pepper, diced (optional)
- 1 teaspoon salt, ½ teaspoon black pepper
- 1 teaspoon smoked or sweet paprika
- 2 tablespoons chopped parsley

Method

1. Put the potatoes in a pot of cold salted water, bring to a boil and simmer 4–5 minutes, until a knife meets slight resistance in the center. Drain well and let steam dry 5 minutes. (Or microwave covered with 2 tablespoons water, 6–8 minutes.)
2. Divide the potatoes, onion and pepper into two equal batches by weight.
3. Preheat each pan over medium heat with 1½ tablespoons oil until the oil shimmers. Record the preheat time.

4. Add a batch of potatoes in one layer. Cook without stirring 4–5 minutes, until a golden crust forms on the bottom. Turn with the spatula and repeat until browned on several sides, about 12–15 minutes in all, adding the onion and pepper for the last 6 minutes.
5. Season with salt, pepper and paprika, sprinkle with parsley and serve hot.

Allergy check: Contains none of the nine major allergens.

Steps

1. **Predict.** Write which pan you think will brown better and why, using heat capacity and conductivity.
2. Par-cook and divide the potatoes by weight so both batches are equal.
3. **Preheat data.** Time how long each pan takes for the oil to shimmer on the same burner setting.
4. **Cook data.** Record the time to first golden crust and the total time in each pan, and photograph both batches side by side.
5. **Evaluate.** Rate color, crispness, evenness (center versus edge of pan) and sticking from 1 to 5 for each pan.
6. Write a conclusion: which pan won, and does the result match your prediction?
7. Clean each pan the right way: cast iron rinsed, dried on the burner and oiled; nonstick washed gently with a soft sponge; stainless soaked if needed.
8. **Repeat round.** Cook a third batch in the winning pan with one change (higher heat, less stirring, or drier potatoes) and compare.

Tips

- Dry potatoes brown; wet potatoes steam. Let them steam-dry after par-cooking.
- Leave them alone: turning too often prevents a crust.
- Crowding the pan drops its temperature; cook in batches if needed.

Check your work

☐ I can tell Plunkett's story and explain how nonstick coatings should be used.

- ☐ I can compare pan materials using heat capacity and conductivity, with calculations.
- ☐ I cooked crisp home fries and judged two pans with data.

LAB NOTEBOOK

1. Make a pan comparison chart: material, conductivity, heat capacity, best uses, cautions, care.
2. Record your two-pan data table and side-by-side photos with your conclusion.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$q = mc\Delta T$

$t = \dfrac{q}{P}$ (time to deliver heat q at power P; 1 W = 1 J/s)

From history. PTFE's first major use was not in kitchens but in industry, as gaskets and seals for chemicals too corrosive for other materials. It was later used in space suits and as a coating in many machines. The trade name Teflon was registered by DuPont in 1945.

WORKED EXAMPLES

Example 1. How much heat does it take to warm a 2.3-kg (5-lb) cast-iron skillet from 20 °C to 200 °C? Compare a 1.0-kg aluminum skillet. ($c_{\text{iron}} = 0.45\ \text{J/(g}\cdot\text{°C)}$, $c_{\text{Al}} = 0.90\ \text{J/(g}\cdot\text{°C)}$)

Show solution

1. Iron: $q = 2300\ \text{g} \times 0.45 \times 180\ \text{°C} = 186{,}000\ \text{J} = 186\ \text{kJ}$.
2. Aluminum: $q = 1000\ \text{g} \times 0.90 \times 180\ \text{°C} = 162{,}000\ \text{J} = 162\ \text{kJ}$.

Answer: About 186 kJ for the cast iron and 162 kJ for the aluminum. The iron stores more heat to give back to cold food.

Example 2. If the burner delivers 1,200 W to the pan, about how long does each pan in the last example take to preheat (ignoring heat lost to the air)?

Show solution

1. Iron: $t = \dfrac{186{,}000\ \text{J}}{1200\ \text{J/s}} = 155\ \text{s} \approx 2.6\ \text{min}$.
2. Aluminum: $t = \dfrac{162{,}000}{1200} = 135\ \text{s} \approx 2.3\ \text{min}$.
3. Real times are longer because the pan loses heat to the air, and because cast iron conducts slowly, its edges lag behind the center.

Answer: Roughly 2½ minutes versus 2¼ minutes in theory; in practice cast iron needs 5 minutes or more on medium to heat evenly.

Example 3. You drop 450 g of cold potatoes ($c \approx 3.5\ \text{J/(g·°C)}$) at 20 °C into each pan at 200 °C. How much heat must flow to warm the potatoes to 100 °C, and how much would the aluminum pan cool if it alone supplied that heat?

Show solution

1. Potatoes: $q = 450 \times 3.5 \times 80 = 126{,}000\ \text{J}$.
2. Aluminum pan cooling: $\Delta T = \dfrac{126{,}000}{1000 \times 0.90} = 140\ ^\circ\text{C}$, down to about 60 °C if the burner added nothing.
3. Cast iron: $\Delta T = \dfrac{126{,}000}{2300 \times 0.45} = 122\ ^\circ\text{C}$.

Answer: 126 kJ. Either pan would cool sharply, which is why we cook potatoes in batches, keep the burner on, and let a heavy pan recover. The heavier pan drops less.

PRACTICE

1. Easy Which pan materials conduct heat best? Which worst?

   Show answer

   Copper and aluminum best; stainless steel worst (cast iron in between).

2. Easy Who discovered PTFE, and in what year?

   Show answer

   Roy Plunkett, at DuPont, in 1938.

3. Easy Why should a nonstick pan not be preheated empty on high heat?

Show answer

The PTFE coating can overheat and begin to break down above about 500 °F (260 °C).

4. Medium What is seasoning on cast iron, and how do you protect it?

Show answer

A layer of oil polymerized by heat. Wash briefly, dry immediately (on the burner), wipe with a thin film of oil; avoid soaking.

5. Medium How much heat warms a 1.5-kg stainless pan (c = 0.50 J/(g·°C)) from 20 °C to 180 °C?

Show answer

$1500 \times 0.50 \times 160 = 120{,}000$ J

6. Medium Why are good stainless pans made with an aluminum or copper core?

Show answer

Stainless conducts heat poorly, so a pure stainless pan has hot spots; the core spreads heat evenly while the stainless surface stays durable and non-reactive.

7. Medium Which pan would you choose for (a) searing a steak, (b) scrambled eggs, (c) a tomato sauce, (d) a pan sauce with browned bits? Explain briefly.

Show answer

(a) cast iron or clad stainless (holds heat); (b) nonstick (low heat, no sticking); (c) stainless or enameled (non-reactive with acid); (d) clad stainless (forms a fond you can deglaze).

8. Hard A 2.0-kg cast-iron skillet at 230 °C has 300 g of steak at 5 °C (c ≈ 3.5) dropped in. If the pan alone supplied the heat to bring the steak to 50 °C, how much would the pan cool?

Show answer

Steak: $300 \times 3.5 \times 45 = 47{,}250$ J; pan $\Delta T = 47{,}250 / (2000 \times 0.45) = 52.5\ ^\circ\text{C}$.

9. Hard Why do acidic foods like tomato sauce sometimes taste metallic in bare cast iron or aluminum?

Show answer

Acid reacts with the bare metal and dissolves a little iron or aluminum, adding off-flavors and dulling seasoning; stainless and enamel are non-reactive.

10. Challenge Plunkett noticed the cylinder still weighed as much as a full one. Explain how weighing told him the gas had not leaked out, and connect this to measuring by weight in the kitchen (Lesson 2.5).

Show answer

Mass is conserved: if the gas had escaped, the cylinder would weigh less, so the material must still be inside in another form (a solid polymer). Weighing gives reliable, form-independent information, just as weighing flour gives the true amount however packed it is.

COMMON MISTAKES

- Putting food into a cold pan; it sticks and steams instead of browning.
- Soaking cast iron or running it through the dishwasher, which strips the seasoning and causes rust.
- Using metal utensils or abrasive pads on nonstick coatings.
- Grabbing a cast-iron handle bare-handed after it leaves the stove.

> **Make it a game · Pan Showdown.** Line up three pans from your kitchen: cast iron, stainless and nonstick. Your parent names a job, such as searing, eggs or tomato sauce. Pick the best pan and defend the choice with specific heat capacity, thermal conductivity or reactivity. Then tell how Roy Plunkett's accident led to a Teflon pan. Three rounds.

2.5 Fannie Farmer, the Level Cup and the Kitchen Scale

OBJECTIVES

- Tell how Fannie Farmer's 1896 cookbook made level, standard measurements the American rule.
- Measure dry and liquid ingredients correctly by volume, and explain why weighing is more accurate.
- Convert between grams, ounces, cups and spoons, and calculate percent error.
- Bake skillet cornbread with every ingredient weighed.

> **Warm-up.** Scoop a cup of flour straight from the bag and weigh it. Then spoon flour lightly into the cup, level it with a knife and weigh again. Write both numbers. How different are they?

WATCH

Measuring and Sifting Flour

University of Illinois Extension · 3:43

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

> **WHEN TO WATCH**
> Before the measuring trial. Watch how the extension educator fills and levels the cup.

Note: From University of Illinois Extension.

BACKUP VIDEO

Weight vs. Volume Measurement - Joyofbaking.com

Joy of Baking · 10:31

https://www.youtube.com/watch?v=nF3vFMYOM8Y

After the lab: a baker weighs cup after cup of flour and shows how much they differ.

KEY TERMS

level measurement

Filling a measuring cup or spoon and sweeping off the excess with a straight edge so it holds exactly its stated volume.

tare

To reset a scale to zero with a bowl on it, so only the ingredient is weighed.

liquid measuring cup

A clear cup with a spout and lines below the rim, read at eye level at the bottom of the curved surface.

density

Mass per volume. A cup of flour, sugar and water each weigh different amounts because their densities differ.

percent error

$$\frac{|\text{measured} - \text{target}|}{\text{target}} \times 100.$$

CORE IDEAS

The story. Fannie Merritt Farmer was born in Boston in 1857. As a teenager she suffered a paralytic illness that left her with a limp and ended her schooling. In her late twenties she enrolled at the Boston Cooking School, became its star student, and later its principal. In 1896 she published *The Boston Cooking-School Cook Book*. Older recipes called for "a teacup of flour," "butter the size of an egg" or "a pinch." Farmer used standard measuring cups and spoons and insisted that every measurement be *level*. Her book sold millions of copies, and her exact method spread across the country; she is often called "the mother of level measurements."

How she figured it out. Farmer taught that cooking could be reliable if it were exact: the same measure gives the same result every time. She tested recipes in her school's kitchen, standardized them, and taught students to measure carefully. She also cared about the sick and taught classes in cooking for invalids at Harvard Medical School. Her level cup was a great step forward. A century later, many cooks have taken the next step: weighing.

The kitchen science. A cup measures *volume*, but what matters to a recipe is *mass*, how much flour is actually there. Flour packs down: a cup scooped from the bag can weigh 140–150 g, while a cup spooned in lightly and leveled weighs about 120–125 g. That 20% difference can turn a tender cornbread into a dry one. A scale measures

mass directly, whatever the packing. Standard weights (King Arthur Baking's chart): 1 cup all-purpose flour 120 g, 1 cup granulated sugar 198 g, 1 cup packed brown sugar 213 g, 1 cup butter 227 g, 1 cup water or milk about 227–240 g. For volume, use dry cups for dry ingredients (spoon and level) and a liquid cup read at eye level for liquids.

Let's cook. You will bake skillet cornbread with every ingredient weighed in grams, after first measuring the flour by scoop and by spoon to see the difference. The technique standard: scale tared for each ingredient, measurements within 2% of target, batter mixed just until combined, skillet preheated so the edges sizzle, and the bread baked until a toothpick in the center comes out clean.

PICTURE STUDY



The Grocer's Shop, Gerrit Dou, 1672 · Oil on panel · Royal Collection, United Kingdom

Image: Wikimedia Commons, public domain

Gerrit Dou painted a grocer's shop seen through a stone window frame, a favorite device of his. The shopkeeper is weighing out goods on a balance scale. In Dou's time spices, sugar and dried fruit were sold by weight, and honest scales were a matter of law and conscience.

Look closely

- Find the balance scale. How does it compare two masses?
- Look at the jars, boxes and packets. Which goods might be sold by weight?
- Find the customer. What is she watching?

Talk about it

1. Why might a customer watch the scale closely?
2. How is a balance scale different from your digital kitchen scale, and what does each measure?
3. Why do we still say a pound of butter or a 5-pound bag of flour instead of measuring them in cups?

> **Safety first.** Preheat the skillet in the oven and handle it only with dry oven mitts; tell everyone in the kitchen the handle is hot and leave a mitt draped over it. Do not taste the unbaked batter, which contains uncooked egg and raw flour. Bake until a toothpick comes out clean.

KITCHEN LAB

Measuring Lab: Weighed Skillet Cornbread

You will compare volume and weight measurements with data, then bake a cornbread with every ingredient weighed.

You will need

- A digital kitchen scale that reads grams
- Dry measuring cups, a liquid measuring cup and measuring spoons
- A 10-inch cast-iron or oven-safe skillet (or a 9-inch square pan)
- Two mixing bowls, a whisk, a spatula, a toothpick
- Oven mitts

Skillet Cornbread by Weight

Serves 8 · Prep 15 min · Bake 20–25 min

Ingredients

- 140 g (1 cup) yellow cornmeal
- 120 g (1 cup) all-purpose flour
- 50 g (¼ cup) granulated sugar
- 12 g (1 tablespoon) baking powder
- 3 g (½ teaspoon) salt
- 300 g (1¼ cups) milk
- 100 g (2 large) eggs
- 85 g (6 tablespoons) butter, melted, plus 14 g (1 tablespoon) for the pan

Method

1. Put the skillet in the oven and heat the oven to 400 °F (205 °C).
2. Set a large bowl on the scale, tare, and weigh in the cornmeal, flour, sugar, baking powder and salt, taring between each. Whisk together.
3. In a second bowl, weigh the milk and eggs and whisk; whisk in the melted butter.

4. Pour the wet ingredients into the dry and fold with a spatula just until no dry streaks remain; a few lumps are fine.
5. With mitts, take out the hot skillet, add the tablespoon of butter and swirl. Pour in the batter; the edges should sizzle.
6. Bake 20–25 minutes, until golden and a toothpick in the center comes out clean. Cool 5 minutes and cut into wedges.

Allergy check: Contains wheat, milk and eggs. Use a gluten-free flour blend for wheat-free, oat or soy milk and oil for milk-free; eggs are harder to replace in this recipe.

Steps

1. **Measuring trial.** Measure 1 cup of flour five ways (scooped, scooped and packed, spooned and leveled, sifted then spooned, and as your family usually does) and weigh each. Record the masses and the percent error against 120 g.
2. **Liquid trial.** Measure 1 cup of water in a liquid cup at eye level and weigh it. Compare with 237 g.
3. Bake the cornbread by weight, recording each actual mass next to its target.
4. **Accuracy check.** Calculate the percent error for each ingredient. Were all within 2%?
5. **Technique check.** Score 1–3: correct taring, accurate weights, gentle mixing, hot skillet, clean toothpick, safe handling of the hot pan.
6. Taste and rate the cornbread for tenderness, moisture and sweetness.
7. Clean up: wash bowls and whisk; clean the cast iron the right way (Lesson 2.4).
8. **Repeat round.** Bake again with the flour scooped by volume instead of weighed, and compare texture. Record which you prefer.

Tips

- Tare the scale with the bowl on it before every ingredient.
- Overmixing develops gluten and makes cornbread tough with tunnels.
- Weighing sticky ingredients like honey or molasses on a tared scale saves scraping out cups.

Check your work

☐ I can tell Fannie Farmer’s story and measure by volume correctly.

- ☐ I can weigh, convert units and calculate percent error.
- ☐ I baked a weighed cornbread with all measurements within 2%.

LAB NOTEBOOK

1. Make a conversion card: grams per cup for flour, sugar, brown sugar, butter, milk and water; ounces to grams; tablespoons to teaspoons and cups.
2. Record your measuring trials with a bar graph of flour masses.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$1\ \text{oz} = 28.35\ \text{g}, \quad 1\ \text{lb} = 453.6\ \text{g}$$

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$\%\ \text{error} = \frac{|\text{measured} - \text{target}|}{\text{target}} \times 100$$

From history. Fannie Farmer opened her own cooking school in 1902, Miss Farmer's School of Cookery, and lectured widely. Even after strokes left her using a wheelchair, she kept teaching until days before her death in 1915. Revised editions of her cookbook are still in print.

WORKED EXAMPLES

Example 1. A recipe written by weight needs 120 g of flour. A student scoops and gets 148 g. What is the percent error, and how much extra flour is in a recipe calling for 3 cups?

Show solution

1. $\text{Error} = \dfrac{148 - 120}{120} \times 100 = 23\%$.
2. Extra in 3 cups: $3 \times 28\ \text{g} = 84\ \text{g}$, about ⅔ cup more flour than intended.

Answer: 23% too much; about 84 g (⅔ cup) of extra flour in 3 cups, enough to make the bake dry and dense.

Example 2. Convert 8 oz of butter to grams and to cups (1 cup butter = 227 g).

Show solution

1. $8\ \text{oz} \times 28.35\ \text{g/oz} = 227\ \text{g}$.
2. $227\ \text{g} \div 227\ \text{g/cup} = 1\ \text{cup}$.

Answer: 227 g, which is 1 cup (2 sticks).

Example 3. Find the density of honey if 1 cup (237 mL) weighs 340 g. How much does ⅓ cup weigh?

Show solution

1. $\text{Density} = \dfrac{340\ \text{g}}{237\ \text{mL}} = 1.43\ \text{g/mL}$.
2. ⅓ cup: $\frac{1}{3} \times 340\ \text{g} = 113\ \text{g}$.

Answer: 1.43 g/mL; ⅓ cup weighs about 113 g. Weighing sticky honey straight into the bowl on a tared scale is easier than scraping a cup.

PRACTICE

1. Easy Who wrote *The Boston Cooking-School Cook Book*, and in what year?

   Show answer

   Fannie Merritt Farmer, 1896.

2. Easy How do you correctly measure a cup of flour by volume?

   Show answer

   Stir or fluff the flour, spoon it lightly into a dry measuring cup until heaping, and sweep off the excess with a straight edge; do not pack or tap.

3. Easy Convert 250 g to ounces.

   Show answer

   $250 / 28.35 = 8.8\ \text{oz}$

4. Medium Convert 2¼ cups of all-purpose flour to grams (120 g per cup).

   Show answer

   270 g.

5. **Medium** A student measures 210 g for a target of 198 g of sugar. Find the percent error.

   Show answer

   $$12/198 \times 100 = 6.1\%$$

6. **Medium** How do you read a liquid measuring cup correctly?

   Show answer

   Set it on a level counter and read with your eye at the level of the line, at the bottom of the curved surface (meniscus).

7. **Medium** Why is weighing more accurate than measuring flour by volume?

   Show answer

   Flour compresses, so the mass in a cup depends on how it was filled; weight measures the actual amount regardless of packing.

8. **Hard** Milk has a density of about 1.03 g/mL. How many grams is 1¼ cups (1 cup = 237 mL)?

   Show answer

   $$1.25 \times 237 \times 1.03 = 305 \text{ g}$$

9. **Hard** A cornbread recipe uses 140 g cornmeal, 120 g flour and 50 g sugar. Scale it to a 12-inch skillet with 1.44 times the area of a 10-inch skillet.

   Show answer

   Area ratio $(12/10)^2 = 1.44$: cornmeal 202 g, flour 173 g, sugar 72 g (scale the rest by 1.44 too).

10. **Challenge** Fannie Farmer's level cup made recipes reliable across a country of different kitchens. Argue whether American home recipes should now be written in grams, giving one advantage and one drawback.

    Show answer

    Answers vary. Advantage: grams are exact, independent of packing, and easier to scale. Drawback: many home cooks lack scales, and familiar cup recipes would need conversion. A strong answer suggests giving both.

COMMON MISTAKES

- Scooping flour with the measuring cup, which packs in up to 25% extra.

- Forgetting to tare between ingredients.
- Reading a liquid measure from above instead of at eye level.
- Using a liquid cup for flour or a dry cup for milk.

> **Make it a game · Weigh It Right.** Scoop one cup of flour three ways: spooned, scooped and packed. Weigh each on a scale and compute percent error against the 125-gram standard. Predict each result first. Then explain why Fannie Farmer's 1896 level measurement helped, and why weighing beats volume. Closest prediction scores a point.

> **Scripture.** "A false balance is abomination to the LORD: but a just weight is his delight." (Proverbs 11:1, KJV)
>
> In Bible times goods were sold by weight, and honest scales were a matter of justice. A cook who weighs carefully serves others honestly too.

UNIT 2

Knife Skills and Tools

A cook's hands, knife and pans are the tools of the trade. In this unit you will learn to choose, hone and care for a knife, and you will cut the classic shapes, julienne, batonnet, brunoise and dice, to standard sizes checked with a ruler. You will learn the herb cuts, chiffonade and mince, and see why a sharp knife keeps basil green.

Then you will study pots and pans the way an engineer would, comparing heat capacity and conductivity with real calculations, and you will learn to measure the way Fannie Farmer taught America, level and exact, and then the more accurate way, by weight. The stories range from Sheffield steel and a gas cylinder that came out "empty" to Jacques Pépin's photographs and Fannie Farmer's level cup.

PREREQUISITES

- Completed Unit 1: hygiene, the four steps and the danger zone
- Safe use of a chef's knife with a parent watching the first time
- Comfort with fractions, squares and basic right-triangle trigonometry (sine), taught here where needed

MASTERY CHECKLIST

- ☐ I can hone a knife, explain honing versus sharpening, and care for knives properly.
- ☐ I can cut julienne, batonnet, brunoise and small, medium and large dice to standard size.
- ☐ I can chiffonade and mince herbs and convert between fresh and dried herbs.
- ☐ I can choose the right pan for a job and calculate heat with

$q = .$
$mc\Delta T$

- ☐ I can measure by volume correctly and by weight accurately, and convert units.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **King Arthur Baking: Ingredient Weight Chart**: Free. The standard grams-per-cup chart used in Lesson 2.5 and the baking unit.
- **A honing steel and (optional) a two-sided whetstone**: A honing steel is inexpensive and used weekly. A 1000/6000-grit whetstone is optional; sharpen only with a parent watching. A local knife sharpener is a fine alternative.
- **A digital kitchen scale that reads grams**: Required from Lesson 2.5 on. Choose one that reads to 1 g and has a tare button.

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	**Choosing, Honing and Sharpening Knives**	3 sessions of 50 minutes
2.2	**The Classic Cuts: Julienne, Batonnet, Brunoise and Dice**	3 sessions of 50 minutes
2.3	**Herbs, Chiffonade and Mince: A Genoa Pesto**	3 sessions of 50 minutes
2.4	**Pots, Pans and Materials**	3 sessions of 50 minutes
2.5	**Fannie Farmer, the Level Cup and the Kitchen Scale**	3 sessions of 50–90 minutes

Unit 2 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Explain the difference between honing and sharpening, and how often each is done.

2. **6 pts**
   What did Harry Brearley discover in 1913, and why does it resist rust?

3. **8 pts**

   A knife blade is 1.6 inches wide. What spine height gives a 15° sharpening angle, and what is the total edge angle?

4. **6 pts**

   Give the dimensions of julienne, batonnet, brunoise and medium dice.

5. **8 pts**

   Find the surface-to-volume ratio of ¼-inch and ½-inch cubes, and estimate how much longer the ½-inch cubes take to cook if heating time grows with the square of thickness.

6. **6 pts**

   How many ½-inch dice can be cut from a 3-inch cube?

7. **6 pts**

   Convert 2 tablespoons fresh rosemary to dried, and explain why fresh herbs bruise under a dull knife.

8. **6 pts**

   Who was Jacques Pépin, and what did *La Technique* (1976) contribute?

9. **8 pts**

   How much heat raises a 1.8-kg cast-iron skillet (c = 0.45 J/(g·°C)) from 22 °C to 210 °C? How long at 1,500 W, ignoring losses?

10. **6 pts**

    Which pan would you choose for scrambled eggs, a seared steak and a tomato sauce? Explain.

11. **6 pts**

    Tell the story of Roy Plunkett's discovery and one rule for using nonstick pans.

12. **8 pts**

    Convert 340 g to ounces and pounds.

13. **6 pts**

    A cook scoops 152 g for a 120-g cup of flour. Find the percent error.

14. **6 pts**

    Predict: a cake recipe written for spooned-and-leveled flour is made with 3 scooped cups. What will happen to the cake, and why?

15. **8 pts**

    Essay (one paragraph): Using Brearley, Plunkett and Fannie Farmer, explain how careful observation and measurement made cooking better.

ANSWER KEY

1. Honing realigns a bent edge (often, every few uses); sharpening grinds away metal to form a new edge (when honing no longer helps, a few times a year).
2. Stainless steel (about 12.8% chromium). Chromium forms a thin, self-healing chromium-oxide layer that seals the surface from oxygen and acids.
3. $h = 1.6 \times \sin 15^\circ = 0.41$ in; total edge angle 30°.
4. Julienne ⅛ × ⅛ × 1–2 in; batonnet ¼ × ¼ × 2–2½ in; brunoise ⅛ in cube; medium dice ½ in.
5. 24 in^{-1} and 12 in^{-1}; $(0.5/0.25)^2 = 4$ times as long (roughly).
6. $(3/0.5)^3 = 216$
7. 2 teaspoons dried. A dull knife crushes cells, releasing enzymes that brown the leaves and letting aroma escape.
8. A French-trained chef who came to America in 1959 and taught cooking; his book showed professional techniques in step-by-step photographs so home cooks and students could learn them.
9. $q = 1800 \times 0.45 \times 188 = 152{,}000$ J; $t = 152{,}000/1500 \approx 101$ s (about 1.7 min).
10. Nonstick for eggs (low heat, no sticking); cast iron or clad stainless for steak (stores heat); stainless or enameled for tomato sauce (non-reactive with acid).
11. In 1938 at DuPont, a gas cylinder that seemed empty still weighed as much as a full one; inside he found PTFE, a slippery polymer. Rule: do not heat nonstick pans empty or above medium-high heat.
12. 12.0 oz; 0.75 lb.
13. 26.7%.
14. It will be dry, dense and possibly domed or cracked, because scooping packs in roughly 20–25% more flour, absorbing liquid and strengthening the structure.
15. Answers vary. A strong answer: Brearley noticed a sample that would not etch and saw its use; Plunkett weighed a seemingly empty cylinder and found a new material; Farmer replaced vague measures with level, standard ones. Each paid attention to what could be measured and recorded honestly, and each made cooking more reliable for ordinary households.

UNIT PROJECT: KNIFE-SKILLS PRACTICAL AND CLASSIC-CUTS VEGETABLE SOUP

Prepare a knife-skills practical: on one cutting board, cut and arrange 10 pieces each of julienne, batonnet, brunoise, small dice, medium dice and a basil chiffonade. Time yourself, photograph the board beside a ruler, and measure a sample of each cut to report the percentage within tolerance.

Then use the cuts in a vegetable soup for the family (onion, carrot and celery in small dice, potato in medium dice, green beans in batonnet, finished with the chiffonade), weighing each vegetable as purchased and after trimming to report yield percentages. Write a one-page reflection comparing your first cut board in Lesson 2.2 with this one.

LOOK FOR	WHAT IT MEANS
Accuracy	At least 80% of measured pieces within tolerance; even, clean cuts.
Safety and technique	Correct grips, steady board, knife honed and cared for, safe cleanup (parent sign-off).
Soup	Vegetables cooked evenly and the soup seasoned well; family rating recorded.
Data	Times, measurements, and yield percentages recorded and calculated correctly.
Reflection	Honest comparison of progress with a plan for further practice.

UNIT 3

Cooking Methods: Dry Heat

Dry-heat cooking surrounds food with hot air, hot metal, hot fat or radiant heat, and no added water, so the surface can rise above the boiling point and brown. In this unit you will learn the five great dry-heat methods: sautéing and searing, roasting, broiling, shallow pan-frying, and finishing with a thermometer-guided sense of doneness.

Each method comes with a story: Julia Child's warning about crowded mushrooms, Hannah Glasse's roast before the fire, William Herschel's discovery of the invisible heat that a broiler uses, Mary Randolph's fried chicken, and the USDA's 2011 change to pork temperatures. The labs make a family dinner each time: steak with mushrooms, a roast chicken, broiled salmon, crispy chicken cutlets and a roast pork tenderloin, every one checked with a calibrated thermometer.

PREREQUISITES

- Units 1 and 2: food safety, knife skills, pan materials and measurement
- An instant-read thermometer
- Comfort with squares, areas of circles and simple ratios

MASTERY CHECKLIST

- ☐ I can sauté and sear without crowding, and explain browning with latent heat and the Maillard reaction.
- ☐ I can roast meat and vegetables and account for carryover cooking.
- ☐ I can broil safely, using rack position to control intense radiant heat.
- ☐ I can bread and shallow pan-fry food safely, choosing oil by smoke point and never deep frying.
- ☐ I can calibrate a thermometer and cook every meat to its USDA safe temperature.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA FSIS: Safe Temperature Chart**: Free, on the USDA Food Safety and Inspection Service website (fsis.usda.gov). The USDA's own chart, including the 145 °F rest rule for whole cuts.
- **A heavy 12-inch skillet (cast iron or clad stainless)**: Useful for searing and pan-frying all year; a thin pan works but browns less evenly.
- **An oven thermometer**: Optional and inexpensive. Hang it in the oven to see whether your oven runs hot or cold.

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	**Sautéing and Pan-Searing: Julia Child's Mushrooms**	3 sessions of 50 minutes
3.2	**Roasting: Hannah Glasse and the Roast Chicken**	3 sessions of 50–90 minutes
3.3	**Broiling: Herschel's Invisible Heat and the Broiled Fish**	3 sessions of 50 minutes
3.4	**Shallow Pan-Frying: Mary Randolph's Fried Chicken**	3 sessions of 50–90 minutes
3.5	**Doneness, Carryover and the USDA's 2011 Pork Change**	3 sessions of 50 minutes

Unit 3 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Define sauté and sear, and explain why patting meat dry helps it brown.

2. **8 pts**
   How much energy evaporates 250 g of water from crowded vegetables? Why does this explain Julia Child's rule about mushrooms?

3. **6 pts**

   Give the USDA safe minimum internal temperatures for a steak, a whole chicken, fish, ground beef and a pork chop.

4. **6 pts**

   Who was Hannah Glasse, and how did cooks of her time control the heat of a roast?

5. **8 pts**

   A 5-lb chicken roasts at 16 min/lb and rests 15 minutes. Dinner is at 6:15 p.m. When must it go into the oven?

6. **6 pts**

   What is carryover cooking, and why does a large roast carry over more than a small one?

7. **6 pts**

   Describe Herschel's 1800 experiment and what it showed.

8. **8 pts**

   Using the inverse-square rule, compare the broiler intensity at 3 inches and at 5 inches. Which would you use for a thin fish fillet?

9. **6 pts**

   What volume of oil (in cups) gives ¼-inch depth in a pan with a 9-inch-wide bottom? (1 cup ≈ 14.4 in^3)

10. **6 pts**

    List the standard breading procedure and explain the dry-hand, wet-hand method.

11. **6 pts**

    What should you do if a pan of oil catches fire?

12. **8 pts**

    Your thermometer reads 35 °F in ice water and 144 °F in a pork roast. What is the true temperature? Is it safe to serve after a 3-minute rest?

13. **6 pts**

About what temperature does water boil at 4,000 feet? Why is ice water a better calibration standard?

14. **6 pts**

Predict: chicken cutlets go into oil that is only 275 °F. Describe the result and explain it.

15. **8 pts**

Essay (one paragraph): Compare sautéing, roasting, broiling and pan-frying by how heat reaches the food (conduction, convection, radiation), and give the best use of each.

ANSWER KEY

1. Sauté: cook small pieces quickly in a little hot fat. Sear: brown the surface of a larger piece in a very hot pan. Surface water must evaporate (using about 2,260 J per gram) before the surface can rise above 212 °F and brown, so dry meat browns faster.
2. $250 \times 2260 = 565{,}000$ J. A crowded pan must boil off a large amount of water, which cannot escape quickly; the food stews below 212 °F instead of browning.
3. Steak 145 °F + 3-min rest; chicken 165 °F; fish 145 °F; ground beef 160 °F; pork chop 145 °F + 3-min rest.
4. Author of *The Art of Cookery, Made Plain and Easy* (1747). They roasted before an open fire on a spit and controlled heat by the size of the fire and the distance of the meat from it.
5. Roast 80 min + rest 15 min = 95 min; in by 4:40 p.m.
6. The rise in internal temperature after removal from heat; a larger roast has a thicker hot outer layer storing more heat to flow inward.
7. He split sunlight with a prism and measured temperatures in each color with a control thermometer beyond the red; the region beyond the red was warmest, revealing invisible heat rays (infrared).
8. $(5/3)^2 = 2.8$; about 2.8 times as intense at 3 inches. Use the closer position (3–4 inches) for a thin fillet that cooks quickly.
9. $\pi(4.5)^2(0.25) = 15.9 \text{ in}^3 \approx 1.1$ cups.
10. Flour, egg, crumbs. One hand handles only the dry flour and crumbs, the other only the wet egg, so hands do not clump with breading.
11. Turn off the heat, cover the pan with a lid or baking sheet, leave it covered; never use water; get out and call 911 if it spreads.
12. Error +3 °F; true $144 - 3 = 141$ °F. Not yet; it needs to reach 145 °F (cook a few minutes more or confirm carryover).
13. $212 - 8 = 204$ °F. Ice water is 32 °F at any elevation.
14. Pale, greasy, soggy cutlets: too little steam forms to keep oil out, browning is slow, and the meat may overcook before the crust is crisp.
15. Sautéing/searing: conduction from hot pan and fat; small pieces and steaks. Roasting: convection of hot air and radiation from oven walls, with conduction inward; whole birds, roasts, vegetables. Broiling: intense radiation from above; thin, quick-cooking foods. Pan-frying: conduction and convection through hot

oil; breaded cutlets and fritters. Strong answers note that in all of them the surface rises above 212 °F and browns.

UNIT PROJECT: ONE PROTEIN, FOUR DRY HEATS

Choose one protein (chicken thighs, pork chops or thick fish fillets) and cook four portions by four dry-heat methods: sauté or sear, roast, broil and breaded pan-fry. Use the same seasoning and starting weight for each, and record preheat temperature, cooking time, internal temperature before and after resting, and weight after cooking (to calculate moisture loss as a percentage).

Hold a family blind tasting and rate each portion for browning, juiciness, tenderness and flavor. Present your data in a table and a bar graph, write a one-page conclusion explaining the differences with heat transfer, and serve the meal with a vegetable and a grain.

LOOK FOR	WHAT IT MEANS
Safety	Thermometer calibrated; every portion reached its USDA temperature; raw and cooked kept separate; safe hot-oil and broiler handling.
Fair test	Same protein, size, seasoning and starting weight; only the method changed.
Data	Complete table with times, temperatures and percent cooking loss; clear graph.
Explanation	Differences explained correctly with conduction, convection, radiation, evaporation and browning.
Meal and reflection	A complete meal served; family ratings recorded; one honest improvement planned.

3.1 Sautéing and Pan-Searing: Julia Child's Mushrooms

OBJECTIVES

- Explain the difference between sautéing and pan-searing and why a crowded pan steams instead of browns.
- Use latent heat of vaporization to explain why wet food will not brown until its surface water is gone.
- Tell how Julia Child brought French technique to American home kitchens.
- Pan-sear a steak to 145 °F and sauté mushrooms and onions to a deep brown.

> **Warm-up.** Put a handful of sliced mushrooms in a cold, crowded skillet and another handful spread out in a hot skillet. Before you start, predict which will brown first. Watch both for 5 minutes and describe what you see and hear.

WATCH

How to Make Pan-Seared Strip Steaks with Bridget Lancaster

America's Test Kitchen · 7:08

https://www.youtube.com/watch?v=Nl0pwffjrYs

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Note when she flips the steaks and the temperature she aims for; we cook to the USDA's 145 °F with a 3-minute rest.

Note: America's Test Kitchen cooks steaks to restaurant doneness (below 145 °F); in this course we follow the USDA safe minimum of 145 °F with a 3-minute rest.

BACKUP VIDEO

How to saute mushrooms

FoodlinkNY · 3:01

https://www.youtube.com/watch?v=mHKCBvH-qZc

Watch the mushrooms release their water and then brown: Julia Child's rule in action.

KEY TERMS

sauté

From the French *sauter*, "to jump": cooking small pieces quickly in a little fat over fairly high heat, tossing or stirring them.

sear

To brown the surface of a larger piece of meat or fish in a very hot pan, building flavor through the Maillard reaction.

Maillard reaction

Browning reactions between amino acids and sugars that begin to go quickly above about 280–300 °F (140–150 °C), creating hundreds of savory flavor compounds.

latent heat of vaporization

The energy needed to turn liquid water into steam without changing its temperature: about 2,260 J per gram.

fond

The browned bits stuck to the pan after searing, full of flavor for a pan sauce.

CORE IDEAS

The story. Julia Child was born in Pasadena, California, in 1912 and did not learn to cook until she was in her thirties. In 1948 she moved to Paris with her husband, Paul, ate her first great French meal, and enrolled at the Cordon Bleu cooking school. With two French friends, Simone Beck and Louisette Bertholle, she spent nearly ten years testing and writing *Mastering the Art of French Cooking* (1961), which explained French technique to Americans step by step. In 1963 she began teaching on public television in Boston in *The French Chef*, cooking in front of the camera with good humor and showing that mistakes could be fixed.

How she figured it out. Child tested every recipe again and again in her own kitchen, asking why it worked. One of her famous lessons was about mushrooms: sauté them in hot fat and *do not crowd the pan*, or they will give off their water and stew instead of browning. She explained the rule rather than simply stating it, so cooks could apply it to anything they sautéed.

The kitchen science. Mushrooms are about 90% water. In a crowded pan the water they release cannot escape quickly, so the food sits in liquid that cannot rise above 212 °F (100 °C). Browning by the Maillard reaction goes quickly only well above that,

around 300 °F (150 °C) and higher. Every gram of water must absorb about 2,260 joules to evaporate, so the pan must supply a great deal of energy before browning can start. In a hot pan with space between pieces, water flashes to steam and escapes, the surface dries, and browning begins. Searing a steak works the same way: pat the meat dry, heat the pan until the oil shimmers, and leave the meat alone long enough to form a crust. Whole cuts of beef are safe at 145 °F with a 3-minute rest.

Let's cook. You will pan-sear sirloin steaks and sauté mushrooms and onions in the same pan. The technique standard: meat patted dry and seasoned, pan preheated, steaks seared without moving until well browned, cooked to 145 °F and rested 3 minutes, mushrooms browned in batches without crowding, and steak sliced across the grain.

PICTURE STUDY



Still Life with Mushrooms, Jan Chrucki (Ivan Khrutsky), 1842 · Oil on canvas · National Art Museum of the Republic of Belarus, Minsk

Image: Wikimedia Commons, public domain

Ivan Khrutsky, a painter from what is now Belarus, painted a crate brimming with freshly gathered wild mushrooms. Mushrooms like these are full of water, which is exactly why Julia Child warned cooks not to crowd them in the pan.

Look closely

- Look at the mushroom caps and stems. How fresh and firm do they look?
- Find the green vegetables beside the crate. What could you cook with them?
- Look at the light on the mushrooms. What texture does Khrutsky suggest?

Talk about it

1. About how much of a mushroom's weight is water, and what happens to that water in a hot pan?
2. How many batches would you need to sauté a crate like this without crowding?
3. Why should only an expert ever gather wild mushrooms for eating?

> **Safety first.** Pat meat dry and lower it into the hot pan away from you so the oil does not splash toward you; keep a lid nearby for flare-ups and never put water on a grease fire. Cook steaks to 145 °F with a 3-minute rest, and use a separate board and plate for raw and cooked meat.

KITCHEN LAB

Searing Lab: Pan-Seared Steak with Sautéed Mushrooms and Onions

You will run a crowding test on mushrooms, then sear steaks to a deep crust and check them with the thermometer.

You will need

- A heavy 12-inch skillet (cast iron or clad stainless)
- Tongs, a thin spatula, paper towels, an instant-read thermometer
- Two cutting boards (raw meat and vegetables), a chef's knife
- A plate and a cutting board for resting and slicing
- A timer

Pan-Seared Steak with Sautéed Mushrooms and Onions

Serves 4 · Prep 15 min · Cook 25 min

Ingredients

- 2 boneless sirloin or strip steaks, about 1 inch thick (1½ lb / 680 g total)
- 1½ teaspoons kosher salt and ½ teaspoon black pepper
- 2 tablespoons neutral oil, divided
- 1 lb (450 g) white or cremini mushrooms, sliced ¼ inch thick
- 1 medium onion, sliced
- 2 tablespoons butter
- 2 cloves garlic, minced
- 1 teaspoon fresh thyme leaves (or ⅓ teaspoon dried)
- 1 tablespoon chopped parsley

Method

1. Pat the steaks dry with paper towels and season both sides with 1 teaspoon salt and the pepper. Let them sit 20–40 minutes at room temperature while you prepare the vegetables (no longer than 2 hours).
2. Heat 1 tablespoon oil in the skillet over medium-high heat until it shimmers. Lay in the steaks away from you. Cook without moving 3–4

minutes, until a deep brown crust forms; flip and cook 3–5 minutes more, until 145 °F in the center. Move to a clean board and rest 3 minutes or more.

3. Lower the heat to medium. Add the remaining oil and half the mushrooms in one layer. Cook without stirring 3 minutes, then stir and cook until browned, 5–6 minutes in all. Move to a bowl and repeat.
4. Add the butter and onion to the pan, cook 5 minutes until golden, then add the garlic and thyme for 30 seconds. Return the mushrooms, season with the remaining salt and toss with parsley.
5. Slice the steak across the grain and serve with the mushrooms and onions.

Allergy check: Contains milk (butter). Use oil in place of butter for milk-free.

Steps

1. **Crowding test.** Cook 4 oz of mushrooms in a crowded small pan and 4 oz spread out in the large pan, same heat. Record time to first browning and photograph both at 5 minutes.
2. Prepare and sear the steaks as the recipe says. Record the pan preheat time, sear time per side and the temperature before and after resting.
3. Sauté the remaining mushrooms in batches and the onions.
4. **Slicing test.** Cut one slice with the grain and one across it. Taste both and record which is more tender.
5. **Technique check.** Score 1–3: dry meat, hot pan, deep crust without moving, 145 °F after rest, browned (not gray) mushrooms, sliced across the grain, no cross-contamination.
6. Save the pan with its fond if you are moving on to Lesson 5.3 soon; otherwise deglaze it with a little water while warm to make cleanup easy.
7. Clean up: raw-meat board and tongs in hot soapy water; wipe the stove of splatters.
8. **Repeat round.** Sear a different food (pork chops, chicken thighs, tofu or thick zucchini planks) with the same rules and compare.

Tips

- Hear the sizzle: a loud, steady sizzle means browning; a weak hiss means the pan is too cold or crowded.
- Food sticks at first and releases when the crust forms; wait.
- Salt mushrooms after they brown; early salt draws out water.

Check your work

- ☐ I can explain why crowding prevents browning, with numbers.
- ☐ I can tell Julia Child's story.
- ☐ I seared a steak to 145 °F with a deep crust and browned mushrooms in batches.

LAB NOTEBOOK

1. Draw a side view of a crowded pan and an uncrowded pan, showing where the water and steam go.
2. Record your crowding test and steak data.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$q = mL_v, \quad L_v \approx 2260\ \text{J/g}$

$A_{\text{pan}} = \pi r^2$

From history. Julia Child's kitchen from her home in Cambridge, Massachusetts, was given to the Smithsonian's National Museum of American History in 2001 and is on display in Washington, D.C., with her pots, pans and pegboard just as she arranged them.

WORKED EXAMPLES

Example 1. One pound (454 g) of mushrooms is about 90% water. If half that water must be driven off before they brown, how much energy does the pan need to supply just for evaporation?

Show solution

1. Water in mushrooms: $0.90 \times 454\ \text{g} = 409\ \text{g}$.
2. Half of it: $204\ \text{g}$.
3. Energy: $q = 204\ \text{g} \times 2260\ \text{J/g} = 461{,}000\ \text{J} \approx 461\ \text{kJ}$.

Answer: About 460 kJ, roughly 5 minutes of a strong burner's full output. Crowding the pan makes this slower still, because the steam cannot escape.

Example 2. A 12-inch skillet has a flat cooking surface about 10 inches across. Each mushroom slice covers about 1.5 in^2. How many slices fit in one layer with about a third of the surface left open for steam to escape?

Show solution

1. Area: $\pi(5\ \text{in})^2 = 78.5\ \text{in}^2$.
2. Usable two-thirds: $52\ \text{in}^2$.
3. Slices: $52 / 1.5 \approx 35$.

Answer: About 35 slices, roughly 6–8 oz of mushrooms per batch. A pound needs two or three batches.

Example 3. Steaks come out of the pan at 138 °F and rise 6 °F while resting. Do they meet the USDA standard?

Show solution

1. Final temperature: $138 + 6 = 144\ ^\circ\text{F}$.
2. The standard is 145 °F with a 3-minute rest.

Answer: Not quite; 144 °F is 1 degree short. Return them to the pan briefly or pull them at 140 °F next time. Always confirm with the thermometer after resting.

PRACTICE

1. **Easy** What does *sauté* mean in French, and what does it describe?

   Show answer

   "To jump": cooking small pieces quickly in a little hot fat, tossing them.

2. **Easy** What is the USDA safe minimum internal temperature for a beef steak?

   Show answer

   145 °F with a 3-minute rest.

3. **Easy** Why should meat be patted dry before searing?

   Show answer

   Surface water must evaporate before browning can start; drying lets the crust form faster.

4. **Medium** How much energy evaporates 150 g of water from food?

   Show answer

   $150 \times 2260 = 339{,}000$ J

5. **Medium** Why can a wet, crowded pan not get hotter than about 212 °F at the food's surface?

   Show answer

   While liquid water is present, added energy goes into evaporating it, and liquid water at sea level cannot be hotter than its boiling point.

6. **Medium** What year was *Mastering the Art of French Cooking* published, and when did *The French Chef* begin?

   Show answer

   1961; 1963.

7. **Medium** What is fond, and how can it be used?

   Show answer

   The browned bits stuck to the pan after searing; they can be dissolved with broth or water (deglazing) to make a pan sauce (Lesson 5.3).

8. Hard A 10-inch skillet has a cooking surface about 8 inches across. Compared with the 10-inch surface of a 12-inch skillet, what fraction of the area does it have?

   Show answer

   $(8/10)^2 = 0.64$, about two-thirds of the area, so cook smaller batches.

9. Hard Explain why slicing a cooked steak across the grain makes it more tender to eat.

   Show answer

   Muscle fibers run in long bundles; cutting across them leaves short fibers in each bite, so teeth do not have to chew through long, tough strands.

10. Challenge Julia Child taught that most kitchen mistakes can be fixed. Describe a sautéing mistake (crowding, cold pan or wet food), explain the science of what went wrong, and give the fix.

    Show answer

    Example: crowded mushrooms are gray and wet because the water could not escape; remove half, raise the heat, cook off the liquid, then brown in batches. Or: a cold pan made the steak stick and steam; preheat until the oil shimmers, dry the meat, and wait until it releases.

COMMON MISTAKES

- Moving the meat constantly so no crust forms.
- Adding all the mushrooms at once.
- Cutting into a steak to check doneness instead of using a thermometer.
- Using extra-virgin olive oil or butter alone for a hard sear; they smoke at lower temperatures than neutral oils.

> **Make it a game · Sear or Steam.** Your parent describes a pan scene: crowded mushrooms, wet steak, hot pan with room. Call out sear, sauté or steam for each, with a reason using latent heat of vaporization and the Maillard reaction. Then name the fond and what it is good for. Ten scenes, and the highest score becomes the mark to beat.

3.2 Roasting: Hannah Glasse and the Roast Chicken

OBJECTIVES

- Explain how roasting cooks by radiation and convection, and how the old open-fire roast differs from oven roasting.
- Tell the story of Hannah Glasse's *The Art of Cookery* (1747).
- Estimate roasting times and account for carryover cooking and resting.
- Roast a whole chicken with vegetables, checked to 165 °F in the thickest part.

> **Warm-up.** Turn on the oven light and look inside a hot oven (do not open it). Where do you think the heat comes from: the walls, the air, the heating element? Hold your hand near the oven door glass (not touching). What kind of heat do you feel?

WATCH

How to Make the Perfect Roast Chicken in One Hour

America's Test Kitchen · 8:44

https://www.youtube.com/watch?v=A7jwsYPnrSk

> **WHEN TO WATCH**
> After the story. Watch how they preheat the skillet and where they place the thermometer.

BACKUP VIDEO

What is the Safe Temperature to Cook Chicken to?

America's Test Kitchen · 1:34

https://www.youtube.com/watch?v=aSTSIk1VzQw

Before you check your chicken: why juice color is not a reliable test.

KEY TERMS

roasting
Cooking food, usually meat or vegetables, uncovered with dry heat in an oven or before a fire, so the outside browns while the inside cooks.

convection
Heat carried by moving air or liquid. A convection oven uses a fan to speed it up.

radiation

Heat carried by infrared light from a hot source such as a fire, coals, oven walls or a broiler element.

carryover cooking

The rise in a roast's internal temperature after it leaves the oven, as heat stored in the hotter outer layers moves inward.

trussing

Tying a bird compactly so it cooks evenly.

CORE IDEAS

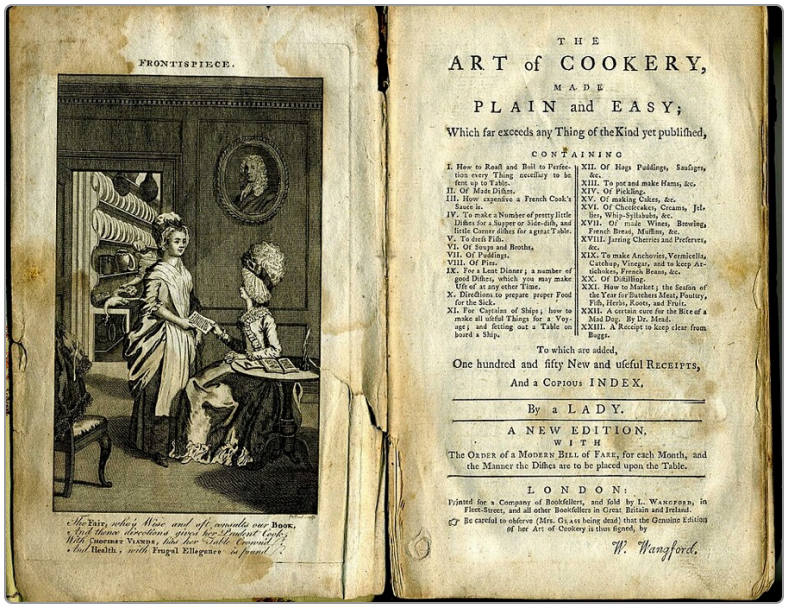
The story. In 1747 a cookbook appeared in London called *The Art of Cookery, Made Plain and Easy*, "by a Lady." The author was Hannah Glasse, and her book became the most popular English cookbook of the century, printed again and again in Britain and in the American colonies. She wrote plainly so that servants who did the cooking could understand, and she explained how to roast meat before an open fire, turning it on a spit, judging the distance from the fire by the size of the joint, and basting it as it turned. (The saying "First catch your hare," often credited to her, is not in her book.)

How she figured it out. Cooks in Glasse's day learned roasting by long experience. She wrote down rules that worked: a small joint near a brisk fire, a large one farther back and longer, so the outside would not burn before the inside was done. She judged doneness by the steam that rose toward the fire when the meat was ready. We now have thermometers, but her rule of matching heat to size is still the heart of roasting.

The kitchen science. True roasting before a fire cooks mainly by **radiation**, the infrared heat you feel on your face. An oven roasts by radiation from its hot walls and elements and by **convection**, hot air moving over the food. The dry, hot surface browns (Maillard reaction) while heat travels inward slowly by conduction. When a roast leaves the oven its outer layers are hotter than its center, so heat keeps flowing inward and the center rises 5–10 °F (more in large roasts): **carryover cooking**. Resting the meat lets this finish and lets juices settle. A whole chicken is safe when the thickest part of the breast and the innermost thigh read **165 °F**.

Let's cook. You will roast a whole chicken on a bed of root vegetables. The technique standard: chicken patted dry and seasoned under and over the skin, oven fully preheated, bird roasted until golden with 165 °F in the breast and thigh, rested 15 minutes, vegetables browned and tender, and the chicken carved into neat pieces.

PICTURE STUDY



Frontispiece and Title Page of The Art of Cookery, Made Plain and Easy, Hannah Glasse (author); unknown engraver, Late 18th-century edition · Printed book with engraved frontispiece · Wikimedia Commons

Image: Wikimedia Commons, public domain

This is an eighteenth-century edition of Hannah Glasse's famous cookbook, opened to its frontispiece and title page. The engraving shows a kitchen with a hearth, where the roasting described inside the book was done. The title page promises cookery "made plain and easy," and names the author only as "a Lady."

Look closely

- Find the hearth in the engraving. Where would a roast have turned?
- Read the title page. What does the book promise its readers?
- Find the words "By a Lady." Why might the author not have printed her name?

Talk about it

1. Why was a cookbook written in plain words so valuable to servants who cooked?
2. What would Hannah Glasse think of a modern oven and thermometer?
3. If you wrote a cookbook, what would you want to make "plain and easy"?

> **Safety first.** Do not rinse raw chicken; it splashes germs around the sink. Wash hands, boards and anything the raw bird touched in hot soapy water. Check the breast and the thigh with the thermometer to 165 °F, and lift the hot pan with dry oven mitts, tilting it away from you to keep hot fat from sloshing.

KITCHEN LAB

Roasting Lab: Roast Chicken with Root Vegetables

You will roast a whole chicken on vegetables, log its temperature as it cooks and rests, and graph carryover cooking.

You will need

- A large roasting pan, 12-inch oven-safe skillet or rimmed sheet pan
- An instant-read thermometer (or a leave-in probe thermometer)
- Kitchen twine (optional), paper towels, tongs
- A cutting board for raw poultry and a separate one for carving
- Oven mitts and a timer

Herb-Roasted Chicken with Root Vegetables

Serves 4–6 · Prep 20 min · Roast 65–80 min · Rest 15 min

Ingredients

- 1 whole chicken, 4–5 lb (1.8–2.3 kg)
- 2 teaspoons kosher salt and ¾ teaspoon black pepper
- 2 tablespoons softened butter or olive oil
- 1 tablespoon chopped fresh thyme or rosemary (or 1 teaspoon dried)
- 1 lemon, halved
- 4 cloves garlic, smashed
- 1½ lb (680 g) small potatoes, halved
- 4 carrots, cut in 2-inch pieces
- 1 large onion, cut in wedges
- 1 tablespoon olive oil and ½ teaspoon salt for the vegetables

Method

1. Heat the oven to 425 °F (220 °C) with a rack in the lower middle.
2. Toss the vegetables with the oil and salt and spread them in the pan.
3. Remove the giblets from the chicken. Pat it very dry inside and out with paper towels. Mix the butter, herbs, salt and pepper. Gently loosen the

breast skin with your fingers and rub some of the mixture under it; rub the rest over the outside. Put the lemon and garlic in the cavity. Tie the legs together if you like. Wash your hands and the board.

4. Set the chicken breast-side up on the vegetables. Roast 65–80 minutes, until the skin is deep golden and the thermometer reads 165 °F in the thickest part of the breast and in the thigh, not touching bone. If the skin browns too fast, lay a piece of foil loosely over the breast.
5. Move the chicken to a clean board and rest 15 minutes. Stir the vegetables in the pan juices and return them to the oven if they need more browning.
6. Carve: remove the legs at the joint, separate thighs and drumsticks, slice the breast off the bone and cut across into slices. Serve with the vegetables.

Allergy check: Contains milk if made with butter. Use olive oil for milk-free.

Steps

1. **Plan the time.** Weigh the chicken and calculate the roasting time and the time it must go in for your dinner hour. Write it down.
2. Prepare and roast the chicken. Wash hands after handling the raw bird.
3. **Temperature log.** Starting 20 minutes before the estimated time, check the breast temperature every 5 minutes. After you remove the bird, keep the thermometer in and record the temperature every 3 minutes for 15 minutes.
4. Graph temperature against time, including the rest, and mark the carryover rise.
5. **Technique check.** Score 1–3: dry, well-seasoned skin, golden color, 165 °F in breast and thigh, proper rest, neat carving, safe handling of raw poultry.
6. Save the carcass and bones in the freezer for stock in Lesson 4.4.
7. Clean up: raw-poultry board and tools in hot soapy water; sanitize the counter and sink area.
8. **Repeat round.** Roast chicken pieces or a turkey breast and compare time per pound.

Tips

- Seasoning under the skin flavors the meat, not just the skin.
- A dry bird browns; for very crisp skin, salt it and leave it uncovered in the refrigerator overnight.
- Start checking early; ovens vary.

Check your work

- ☐ I can explain how an oven roasts by radiation and convection, and what carryover cooking is.
- ☐ I can tell Hannah Glasse's story.
- ☐ I roasted a chicken to 165 °F, logged carryover and carved it neatly.

LAB NOTEBOOK

1. Draw a cross-section of a roast showing temperature from surface to center when it leaves the oven and 10 minutes later.
2. Paste your temperature graph and label the carryover rise.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

Rough roasting time for a whole chicken at 425 °F: $t \approx 15\text{–}18 \text{ min/lb}$ (always confirm with a thermometer)

carryover rise $\approx 5\text{–}10\ ^\circ\text{F}$

> **From history.** Hannah Glasse's book included one of the earliest English recipes for curry ("To make a Currey the India Way," in later editions) and recipes from many regions. It was reprinted in many editions for more than a century, including editions printed in America, where colonial households cooked from it.

WORKED EXAMPLES

Example 1. A 4.5-lb chicken roasts at 425 °F at about 16 minutes per pound. When should it go in to be ready, rested, at 6:30 p.m.?

Show solution

1. Roasting: $4.5 \times 16 = 72$ min.
2. Rest: 15 min. Total: 87 min ≈ 1 h 27 min.
3. 6:30 p.m. − 1 h 27 min = 5:03 p.m. Preheat the oven by 4:45 p.m.

Answer: Into the oven by about 5:00 p.m., with the oven preheated by 4:45. Begin checking the temperature 15 minutes before the estimate.

Example 2. You pull a chicken when the breast reads 160 °F and expect 7 °F of carryover. Will it reach 165 °F?

Show solution

1. $160 + 7 = 167$ °F.
2. Confirm with the thermometer after resting.

Answer: Yes, about 167 °F, as long as you verify it. Many cooks pull poultry at 160 °F for this reason; if it does not reach 165 °F, return it to the oven.

Example 3. Glasse would place a small joint close to the fire. If radiant intensity falls roughly with the square of distance, how much weaker is the heat at 3 feet than at 1½ feet?

Show solution

1. $\left(\dfrac{3}{1.5}\right)^{2} = 4$.

Answer: About one-quarter as strong. That is how a cook before an open fire controlled the heat: by moving the meat.

PRACTICE

1. Easy Who wrote *The Art of Cookery, Made Plain and Easy*, and in what year?

   Show answer

   Hannah Glasse, 1747.

2. Easy What is the safe internal temperature for a whole chicken, and where do you measure it?

Show answer

165 °F, in the thickest part of the breast and the innermost part of the thigh, not touching bone.

3. Easy What is carryover cooking?

Show answer

The rise in internal temperature after food leaves the heat, as stored heat in the outer layers moves inward.

4. Medium A 3.5-lb chicken at 16 min/lb: how long does it roast?

Show answer

56 minutes.

5. Medium Name the two main ways heat reaches food in an oven.

Show answer

Radiation (from walls and elements) and convection (moving hot air).

6. Medium Why do we pat chicken skin dry before roasting?

Show answer

Water on the skin must evaporate before it can brown and crisp; dry skin browns faster and crisper.

7. Medium Why rest a roast before carving?

Show answer

Carryover cooking finishes, and the juices thicken slightly and stay in the meat instead of running onto the board.

8. Hard A 12-lb turkey roasts at about 14 min/lb at 325 °F. Dinner is at 2:00 p.m. with a 30-minute rest. When should it go in?

Show answer

Roasting $12 \times 14 = 168$ min $= 2$ h 48 min; plus 30 min = 3 h 18 min; in by about 10:40 a.m.

9. Hard A convection oven roasts about 25% faster. How long would the 72-minute chicken take?

   Show answer

   $$0.75 \times 72 = 54 \text{ min}$$

10. Challenge Hannah Glasse judged doneness by steam rising toward the fire. Explain what that steam signaled physically, and why a thermometer is more reliable.

    Show answer

    When the interior heats up, juices near the surface boil and steam escapes; strong steaming means much of the meat is hot. But the center may still be cooler than the surface, and steam varies with fire, size and moisture. A thermometer measures the center directly.

COMMON MISTAKES

- Washing raw chicken in the sink.
- Measuring only the breast; the thigh can lag behind, and both must be safe.
- Opening the oven door often, which lets out heat and slows cooking.
- Carving at once, so the juices run out onto the board.

> **Make it a game · Hannah Glasse Quiz.** Be the author of The Art of Cookery for ten minutes. Your parent interviews you about roasting: radiation versus convection, why a chicken is trussed, carryover cooking and the open-fire roast. Answer in character. Your parent slips in one false claim about the oven; catch it for a point. Then swap roles.

3.3 Broiling: Herschel's Invisible Heat and the Broiled Fish

OBJECTIVES

- Explain how a broiler cooks by infrared radiation, and how William Herschel discovered infrared light in 1800.
- Use the inverse-square idea to explain how rack position changes broiling intensity.
- Broil salmon to 145 °F and asparagus to tender-crisp, watching closely to prevent burning.
- Connect Luke 24:42 to the ancient practice of cooking fish over fire.

> **Warm-up.** Hold your hand 6 inches below the light of a desk lamp (an old incandescent bulb if you have one), then 12 inches. What do you feel? Is the heat reaching your hand through the air or as light?

WATCH

Broiled Herb-Crust Salmon Recipe - Easy Broiled Fish Technique

Food Wishes · 4:56

https://www.youtube.com/watch?v=dV18UBsjagU

> **WHEN TO WATCH**
> Before the lab. Notice how close the fish is to the broiler and how he checks it.

Note: Chef John of Food Wishes uses a mayonnaise-and-herb crust; our glaze is honey mustard, but the broiling method is the same.

KEY TERMS

broiling

Cooking with intense radiant heat from above, from a gas flame or electric element in the oven.

infrared radiation

Light with wavelengths longer than red light, invisible to our eyes but felt as heat; it carries most of the heat from fire, coals and broiler elements.

inverse-square law

From a small source, radiant intensity falls with the square of distance: twice as far, one-quarter as strong. A broiler is not a point, so this is only a rough guide.

glaze

A thin, often sweet coating brushed on food that browns and caramelizes under high heat.

fish doneness

Fish is safe at 145 °F; the flesh turns opaque and separates into flakes easily with a fork.

CORE IDEAS

The story. In 1800 the astronomer William Herschel, who had discovered the planet Uranus, wanted to know how much heat each color of sunlight carried. He split sunlight into a rainbow with a glass prism and placed thermometers with blackened bulbs in the different colors, with another thermometer just beyond the red end, where there was no visible light at all, as a control. To his surprise, the temperature beyond the red was the *highest* of all. He concluded that the sun gives off invisible rays that carry heat. We call them **infrared**.

How he figured it out. Herschel used a careful control: thermometers outside the light to show the room's temperature, so he could compare. When the "control" beyond the red warmed up, he did not dismiss it; he repeated the measurement and reported what he found. Infrared is the heat you feel from a campfire, a glowing coal or the red-hot element of a broiler. In the kitchen, broiling and grilling cook mostly by infrared radiation.

The kitchen science. A broiler's element glows at well over 1,000 °F and pours infrared radiation onto the top of the food, browning it in minutes. The closer the food, the more intense the heat; roughly, doubling the distance cuts the intensity to a quarter. Thin, tender foods that cook quickly, such as fish fillets, chops, vegetables and toast, go close to the element (3–4 inches); thicker foods go lower so the inside can cook before the outside burns. Broiling is fast and unforgiving: a sugary glaze can go from golden to black in under a minute, so the cook stays at the oven. Fish is safe at **145 °F**, when the flesh turns opaque and flakes.

Think it through. After His resurrection, Jesus appeared to His disciples in Jerusalem and asked if they had anything to eat. “They gave him a piece of a broiled fish, and of an honeycomb” (Luke 24:42). In Galilee and Judea fish were often cooked over glowing coals, the same radiant heat a broiler uses. Plain broiled fish was ordinary food, and the risen Lord ate it with His friends.

Let’s cook. You will make broiled salmon with a honey-mustard glaze and broiled asparagus on the same pan. The technique standard: rack set at the right distance, fillets patted dry and even in thickness, glaze brushed on near the end, the cook watching the whole time, salmon at 145 °F and just flaking, and asparagus tender-crisp with browned tips.

PICTURE STUDY



Still Life with Salmon, a Lemon and Three Vessels, Luis Egidio Meléndez, 1772 · Oil on canvas · Museo del Prado, Madrid

Image: Wikimedia Commons, public domain

Luis Meléndez, an eighteenth-century Spanish painter, painted ordinary foods with almost scientific care. Here a thick cross-cut steak of salmon lies beside a lemon and the pots that might cook it. You can see the layers of the flesh that will separate into flakes when it is cooked.

Look closely

- Look at the cut face of the salmon. Can you see the lines of the muscle layers and the white bands between them?
- Find the lemon. Why have cooks paired lemon with fish for centuries?
- Look at the vessels. Which would you use to cook this fish, and how?

Talk about it

1. How will the color and texture of this salmon change when it reaches 145 °F?
2. This salmon is a thick steak. Where would you place it under a broiler, compared with a thin fillet?
3. What does Meléndez's careful detail teach a cook about observing food?

> **Safety first.** Stay at the oven the entire time you broil; set a timer for every 2 minutes. Pull the rack out with dry oven mitts, never reaching under the element, and keep a lid or baking sheet nearby to smother any flare-up (turn off the broiler and keep the door closed if a fire starts inside). Honey is never given to babies under one year old.

KITCHEN LAB

Broiling Lab: Honey-Mustard Salmon and Asparagus

You will broil salmon and asparagus on one pan, test rack position, and watch the Maillard reaction and caramelization happen in minutes.

You will need

- A rimmed sheet pan or broiler pan, lined with foil
- Oven mitts, a thin spatula, a pastry brush
- An instant-read thermometer and a ruler
- A small bowl and whisk
- A timer

Broiled Honey-Mustard Salmon with Asparagus

Serves 4 · Prep 10 min · Broil 8–12 min

Ingredients

- 4 salmon fillets, 5–6 oz (140–170 g) each, about 1 inch thick, skin on or off
- 1 bunch asparagus (about 1 lb), tough ends snapped off
- 2 tablespoons olive oil, divided
- ¾ teaspoon salt and ½ teaspoon black pepper, divided
- **Glaze:** 2 tablespoons Dijon mustard
- 1 tablespoon honey
- 1 teaspoon lemon juice and ½ teaspoon grated lemon zest
- Lemon wedges for serving

Method

1. Set an oven rack so the top of the salmon will be 4 inches below the broiler element (measure with a ruler). Heat the broiler on high for 5 minutes.
2. Pat the salmon dry. Rub with 1 tablespoon oil and season with half the salt and pepper. Toss the asparagus with the rest of the oil, salt and pepper.

3. Whisk the glaze ingredients.
4. Place the salmon skin-side down in the center of the foil-lined pan and the asparagus around it in one layer. Broil 5 minutes, watching closely.
5. Brush the glaze over the salmon and turn the asparagus with tongs. Broil 2–5 minutes more, until the glaze is browned in spots and the salmon reads 145 °F in the thickest part and flakes easily. Remove any asparagus that is done early.
6. Serve at once with lemon wedges.

Allergy check: Contains fish. Dijon mustard contains no major allergen but check labels. Honey is not for babies under one year.

Steps

1. **Measure.** Record the distance from the element to the top of the food and the broiler preheat time.
2. Broil the salmon and asparagus. Check and record the salmon temperature every 2 minutes after the first 4.
3. **Rack test.** Broil two extra asparagus spears on a small pan for 3 minutes at 4 inches and two at 8 inches. Photograph and compare browning.
4. **Flake test.** Gently press the salmon with a fork at 135 °F and at 145 °F. Describe the difference.
5. **Technique check.** Score 1–3: correct rack position, cook never left the oven, glaze browned not burned, salmon 145 °F and moist, asparagus tender-crisp.
6. Clean up: let the pan cool before handling; fold up and discard the foil; wash utensils that touched raw fish.
7. **Repeat round.** Broil a different fish or chicken thighs (165 °F) and adjust the rack for thickness.

Tips

- Fold thin tail ends of fillets under so the whole piece is an even thickness.
- Broilers vary greatly; your first time is a calibration run.
- Leave the oven door closed while broiling in most gas ovens and many electric ones; follow your oven's manual.

Check your work

- ☐ I can explain broiling as radiant (infrared) heat and tell Herschel's story.
- ☐ I can use distance to control broiling intensity.
- ☐ I broiled salmon to 145 °F and asparagus to tender-crisp without burning.

LAB NOTEBOOK

1. Draw Herschel's experiment: prism, spectrum, thermometers and the control beyond the red.
2. Draw a side view of your oven showing the element, rack positions and distances, and record your rack test.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$I \propto \frac{1}{d^2}$ (rough guide for a small radiant source)

$$\frac{I_2}{I_1} = \left(\frac{d_1}{d_2}\right)^2$$

From history. Herschel's son John later coined the word "photograph" and helped develop photography. Infrared cameras now show cooks and engineers exactly how evenly a pan or grill heats.

WORKED EXAMPLES

Example 1. Using the inverse-square rule as a rough guide, how much stronger is the broiler's heat on food 3 inches from the element than on food 6 inches away?

Show solution

1. $\frac{I_3}{I_6} = \left(\frac{6}{3}\right)^2 = 4.$

Answer: About 4 times as strong. (Real broilers are wide, not tiny points, so the difference is somewhat smaller, but moving the rack still changes the heat a lot.)

Example 2. A salmon fillet 1 inch thick broils in 8 minutes. Using the square rule for thickness from Lesson 2.2, estimate the time for a ¾-inch fillet.

Show solution

1. $t = 8 \text{ min} \times (0.75/1)^2 = 8 \times 0.5625 = 4.5 \text{ min}$.

Answer: About 4½–5 minutes. Check with a thermometer at 4 minutes.

Example 3. Salmon costs \$11.99 per pound. You need four 5-oz portions. What does the fish cost, and what is the cost per serving?

Show solution

1. Total weight: $4 \times 5 = 20 \text{ oz} = 1.25 \text{ lb}$.
2. Cost: $1.25 \times \$11.99 = \$14.99$.
3. Per serving: $\$14.99 / 4 = \$3.75$.

Answer: \$14.99 total, about \$3.75 per serving for the fish.

PRACTICE

1. Easy What kind of heat does a broiler mostly use?

   Show answer

   Infrared (radiant) heat.

2. Easy What is the safe internal temperature for fish, and how does done fish look?

   Show answer

   145 °F; opaque, and it separates into flakes with a fork.

3. Easy Who discovered infrared radiation, and in what year?

   Show answer

   William Herschel, 1800.

4. Medium How did Herschel's control thermometer help him discover infrared?

   Show answer

   It was placed outside the visible spectrum to show room temperature; when it warmed more than the others, he knew invisible rays were carrying heat.

5. Medium By the inverse-square rule, food moved from 4 inches to 8 inches from the broiler receives what fraction of the heat?

Show answer

One-quarter.

6. Medium Why is a sugary glaze brushed on near the end of broiling, not at the start?

Show answer

Sugar caramelizes and burns quickly under intense radiant heat; added late, it browns without burning before the food is done.

7. Medium Why must the cook stay at the oven while broiling?

Show answer

The heat is so intense that food can go from browned to burned in under a minute, and fat can flare.

8. Hard Where should a 1½-inch-thick pork chop go relative to a ½-inch fish fillet under the broiler, and why?

Show answer

Farther from the element: the thick chop needs more time for heat to reach the center, so it needs gentler surface heat to avoid burning.

9. Hard A broiler pan of asparagus needs 6 minutes at 4 inches. Roughly how long might it take at 6 inches if time grows with the inverse of intensity?

Show answer

Intensity ratio $(4/6)^2 = 0.44$; time $6 / 0.44 \approx 13.5$ min (a rough estimate).

10. Challenge Herschel trusted a surprising result because he had a control. Design a kitchen experiment with a control to test whether brushing salmon with oil changes how fast it browns under the broiler.

Show answer

Use two identical fillets from the same piece, same thickness, same rack position and time; brush one with oil (variable) and leave the other plain (control); photograph both every minute and measure final temperatures. Repeat to confirm.

COMMON MISTAKES

- Walking away from the broiler.
- Brushing on a sweet glaze too early.
- Placing thick food too close, so it burns outside and stays raw inside.
- Overcooking salmon until it is dry and chalky; pull it at 145 °F.

Make it a game · Broiler Math. Hold a flashlight or desk lamp above a sheet of paper at 3 inches, then 6 inches. Observe how the bright circle spreads and dims. Use that to explain the inverse-square idea for broiler rack position. Then tell how Herschel found infrared in 1800. Predict which rack suits thin fish and which suits thick.

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

The risen Christ ate an ordinary meal of broiled fish with His disciples, showing them He was truly alive in His body. Plain food shared with friends is honored here.

3.4 Shallow Pan-Frying: Mary Randolph's Fried Chicken

OBJECTIVES

- Explain how shallow pan-frying cooks and crisps food, and why this course does not use deep frying.
- Choose an oil by smoke point and calculate the oil needed for a given depth and pan.
- Use the standard breading procedure (flour, egg, crumbs) with a dry-hand, wet-hand system.
- Pan-fry breaded chicken cutlets to 165 °F with a crisp, golden crust.

> **Warm-up.** Drop a single bread cube into ¼ inch of oil heating in a skillet (with a parent present). Watch the bubbles. What are they made of? What happens to the bubbles as the cube browns?

WATCH

The Standard Breading Process in 3 Easy Steps - Kitchen Conundrums with Thomas Joseph

Everyday Food · 5:35

https://www.youtube.com/watch?v=-m8bm55-o7Q

> **WHEN TO WATCH**
> Before you bread. Copy his station layout: flour, egg, crumbs, rack.

KEY TERMS

pan-frying
Cooking food in a shallow layer of hot fat, about ¼ to ½ inch deep, turning it once so each side browns.

smoke point
The temperature at which an oil begins to smoke and break down; choose an oil whose smoke point is well above the cooking temperature.

standard breading procedure

Coating food in seasoned flour, then beaten egg, then crumbs, so the coating sticks and fries crisp.

cutlet

A thin, boneless slice of meat or poultry, often pounded to an even thickness.

dredge

To coat food lightly in flour or another dry ingredient.

CORE IDEAS

The story. Mary Randolph was born in Virginia in 1762, a member of one of the colony's leading families. When her family's fortunes fell, she opened a boarding house in Richmond that became famous for its table. In 1824 she published *The Virginia House-Wife*, often called the first regional American cookbook. Among its recipes is "To Fry Chickens": cut the chicken into pieces, dredge it in flour, sprinkle with salt, and fry it in boiling lard until light brown. It is one of the earliest printed American recipes for fried chicken.

How she figured it out. Randolph organized her book "methodically," as her subtitle says, and her recipes reflect long experience running a large kitchen: hot fat, a dry coating and enough room in the pan. She also gave a gravy to serve with the chicken. Home cooks have been pan-frying ever since: a little fat, a hot pan, and a crisp crust that keeps the meat inside juicy.

The kitchen science. Oil can be heated far above water's boiling point, to about 350 °F (175 °C) for pan-frying. When food goes in, its surface water flashes to steam: that is the bubbling. The escaping steam keeps oil from soaking in and keeps the inside moist while the dried surface browns and crisps. If the oil is too cool, the steam stops, oil seeps in, and the food is greasy; too hot, and it smokes and burns outside before the inside cooks. A breading of flour, egg and crumbs gives a crisp shell. Choose a neutral oil with a high smoke point (canola, vegetable or peanut oil, about 400–450 °F). **This course uses only shallow pan-frying, never deep frying**: keep the oil ½ inch deep or less, keep a lid nearby, and never leave hot oil.

Let's cook. You will make crispy breaded chicken cutlets. The technique standard: cutlets pounded to an even ¼–½ inch, breaded by the dry-hand, wet-hand method,

oil at about 350 °F and no more than ¼ inch deep, cutlets laid in away from you, turned once, golden on both sides and 165 °F inside, drained on a rack.

PICTURE STUDY



The Pancake Woman, Rembrandt van Rijn, 1635 · Etching · National Gallery of Art, Washington, D.C.
Image: Wikimedia Commons, public domain

Rembrandt made this etching of a street seller frying pancakes in a pan of hot fat over a small stove, with a crowd of children waiting. Rembrandt drew quickly and truthfully, and you can almost hear the sizzle and the children's chatter.

Look closely

- Find the pan and the stove. How deep do you think the fat is?
- Look at the children. Where are they standing in relation to the hot pan?
- Find the little child with a pancake and the dog. What is happening there?

Talk about it

1. What safety rule would you give these children about hot fat?
2. How would this woman know her fat was hot enough to fry?
3. Why do people gather around food being fried, then and now?

> **Safety first.** Shallow-fry only, with oil no more than ½ inch deep, a lid within reach and the handle turned in. Lay food into the oil away from you, never drop it, and never leave hot oil unattended. Wash hands after handling raw chicken and after breading, and cook the chicken to 165 °F.

KITCHEN LAB

Pan-Frying Lab: Crispy Chicken Cutlets

You will pound, bread and pan-fry chicken cutlets, monitor the oil temperature and test whether your crust is crisp, not greasy.

You will need

- A heavy 12-inch skillet and a lid that fits
- Three shallow dishes for breading and a wire rack set over a sheet pan
- A meat mallet or small heavy pan, plastic wrap, a raw-meat cutting board
- An instant-read thermometer (and a candy thermometer if you have one) and tongs
- Paper towels

Crispy Pan-Fried Chicken Cutlets

Serves 4 · Prep 25 min · Cook 15 min

Ingredients

- 2 boneless, skinless chicken breasts (about 1½ lb / 680 g)
- 1 teaspoon salt and ½ 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 mixed with ¼ cup grated Parmesan (optional) and ½ teaspoon garlic powder
- About 1⅓ cups (320 mL) canola or vegetable oil
- Lemon wedges for serving

Method

1. On the raw-meat board, slice each breast horizontally into 2 thin pieces. Cover with plastic wrap and pound gently to an even ¼–⅜ inch. Season both sides with salt and pepper.
2. Set out the flour, the egg and the crumbs in three dishes. With one dry hand and one wet hand, dredge each cutlet in flour, shake off the extra,

dip in egg, let it drip, then press into the crumbs on both sides. Set on the rack. Wash your hands.

3. Pour ¼ inch of oil into the skillet and heat over medium-high to about 350 °F, when a pinch of crumbs sizzles at once.
4. Lay 2 cutlets into the oil, away from you. Cook 2–3 minutes, until deep golden underneath; turn once with tongs and cook 2–3 minutes more, until 165 °F in the thickest part.
5. Drain on the clean rack. Let the oil recover before the next batch. Serve with lemon wedges.
6. Turn off the burner and let the oil cool completely in the pan before pouring it into a container to discard; never pour hot oil or oil of any temperature down the drain.

Allergy check: Contains wheat (flour, panko), eggs and milk (Parmesan). For wheat-free, use gluten-free flour and crumbs; omit the cheese for milk-free.

Steps

1. **Oil math.** Measure your skillet's bottom and calculate the oil for ¼ inch before you pour.
2. Pound and bread the cutlets with the dry-hand, wet-hand system.
3. **Oil log.** Record the oil temperature before each batch and 1 minute after the cutlets go in, if you have a thermometer that reads that high; otherwise use the crumb test and note the sizzle.
4. Fry the cutlets and record each one's internal temperature.
5. **Grease test.** Press a paper towel on a cutlet from the first batch and one from a batch fried in cooler oil (if one happened). Compare the oil spots.
6. **Technique check.** Score 1–3: even thickness, even breading, oil at the right temperature and depth, safe placement, golden and crisp, 165 °F.
7. Cool and discard the oil safely; wash breading dishes, the raw-meat board and the mallet in hot soapy water.
8. **Repeat round.** Pan-fry eggplant or zucchini slices with the same breading and compare.

Tips

- Let breaded cutlets rest on the rack 10 minutes before frying; the coating sticks better.
- Drain fried food on a rack, not paper towels, so the underside stays crisp.
- Keep finished cutlets warm on the rack in a 200 °F oven while the next batch fries.

Check your work

- ☐ I can explain how frying crisps food and choose an oil by smoke point.
- ☐ I can bread food by the standard procedure.
- ☐ I pan-fried crisp chicken cutlets to 165 °F with safe handling of hot oil.

LAB NOTEBOOK

1. Draw a cross-section of a cutlet in oil, labeling steam escaping, the crust and the moist interior.
2. Record your oil math and oil log.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$V = \pi r^2 h$ (oil in a round pan)
$1 \text{ cup} \approx 14.4 \text{ in}^3$

From history. Mary Randolph's book also gave early American recipes for gumbo, ice cream and many vegetables from her own garden. She was the first person known to have been buried at the site that later became Arlington National Cemetery, in 1828.

WORKED EXAMPLES

Example 1. A 12-inch skillet has a flat bottom about 10 inches across. How much oil gives a depth of ¼ inch?

Show solution

1. $V = \pi(5 \text{ in})^2(0.25 \text{ in}) = 19.6 \text{ in}^3$.
2. Convert: $19.6 \text{ in}^3 \div 14.4 \text{ in}^3/\text{cup} = 1.36$ cups.

Answer: About 1⅓ cups of oil.

Example 2. Two chicken breasts weigh 1.5 lb total. You slice each horizontally into 2 cutlets and pound them to ⅜ inch. If 1 cutlet is 1 serving, how many servings, and how much does each weigh?

Show solution

1. 4 cutlets; $1.5 \text{ lb} \div 4 = 0.375 \text{ lb} = 6 \text{ oz}$.

Answer: 4 servings of about 6 oz each.

Example 3. Canola oil costs $4.29 for 48 fl oz (6 cups). What does the 1⅓ cups for this recipe cost?

Show solution

1. Cost per cup: $\$4.29 / 6 = \$0.715$.
2. For 1.33 cups: $1.33 \times \$0.715 = \$0.95$.

Answer: About 95 cents.

PRACTICE

1. Easy What is the difference between pan-frying and deep frying?

   Show answer

   Pan-frying uses a shallow layer of fat (¼–½ inch) and the food is turned; deep frying submerges food in a large volume of oil. This course uses only pan-frying.

2. Easy List the three stations of the standard breading procedure in order.

   Show answer

   Seasoned flour, beaten egg, crumbs.

3. Easy Who wrote *The Virginia House-Wife*, and when?

   Show answer

   Mary Randolph, 1824.

4. Medium Why do bubbles stream from food when it is fried?

   Show answer

   Water in the food's surface turns to steam and escapes through the oil.

5. **Medium** Why does food fried in oil that is too cool turn greasy?

Show answer

Without vigorous steaming the surface does not seal and dry, so oil soaks in, and the food cooks slowly.

6. **Medium** How much oil makes a ½-inch layer in a pan with an 8-inch-wide bottom?

Show answer

$\pi(4)^2(0.5) = 25.1$ in$^3 \approx 1.75$ cups.

7. **Medium** What should you do if oil in a skillet catches fire?

Show answer

Turn off the burner, slide a lid (or a baking sheet) over the pan to smother it, and leave it covered; never use water. If the fire spreads, get out and call 911.

8. **Hard** Why is it important to keep one hand dry and one hand wet during breading?

Show answer

Otherwise both hands become clumped with flour and egg (“club hands”), coating unevenly and wasting breading; the dry hand handles flour and crumbs, the wet hand the egg.

9. **Hard** Oil at 350 °F drops to 300 °F when cold cutlets go in. Give two ways to limit the drop.

Show answer

Cook fewer pieces at a time; let cutlets sit briefly at room temperature after breading; use a heavier pan that stores more heat; let the oil recover between batches.

10. **Challenge** A chicken cutlet ½ inch thick takes 3 minutes per side. Estimate the time for a ¾-inch cutlet using the square rule, and explain why pounding cutlets thin is better for pan-frying.

Show answer

$3 \times (0.75/0.5)^2 = 6.75$ min per side; the crust would overbrown before the center reached 165 °F, so thin, even cutlets let the inside and outside finish together.

COMMON MISTAKES

- Crowding the pan, which drops the oil temperature and makes greasy food.
- Pouring in more oil than needed; ¼ inch is enough for cutlets.
- Dropping food into hot oil, which splashes.
- Pouring used oil down the sink, which clogs pipes.

> **Make it a game · Oil Duel.** Your parent names a task: shallow frying cutlets, a salad dressing, searing a steak, baking a cake. You choose an oil and give the smoke point reason. Then calculate how much oil fills a 10-inch skillet to a quarter-inch depth. Do eight rounds. Finish by naming the three steps of the standard breading procedure in order.

3.5 Doneness, Carryover and the USDA's 2011 Pork Change

OBJECTIVES

- Calibrate an instant-read thermometer and correct readings for a calibration error.
- Explain why the USDA lowered the safe temperature for whole cuts of pork to 145 °F with a 3-minute rest in 2011.
- Predict carryover cooking and choose a pull temperature for a roast.
- Roast a pork tenderloin to 145 °F, rested, juicy and safe.

> **Warm-up.** Fill a tall glass with ice, add cold water, stir and wait 2 minutes. Put your thermometer in the middle without touching the glass. What does it read? Should it read exactly 32 °F?

WATCH

Calibrating a Thermometer

MSU Extension · 1:44

https://www.youtube.com/watch?v=WMdyNYrzM8U

> **WHEN TO WATCH**
> During the warm-up, then calibrate your own thermometer the same way.

Note: From Michigan State University Extension. It shows how to adjust a dial thermometer; many digital thermometers have a reset button instead.

BACKUP VIDEO

Module 7 — Thermometer Calibration and Verification

Southern Nevada Health District · 1:31

https://www.youtube.com/watch?v=VmycvLI4K58

A health-department version of the same check, with digital thermometers.

KEY TERMS

calibration

Checking an instrument against a known standard and adjusting or correcting it. Ice water is 32 °F (0 °C); boiling water is 212 °F (100 °C) at sea level, lower at altitude.

pull temperature

The temperature at which a cook removes food from the heat, expecting carryover to finish it.

pork tenderloin

A long, narrow, very lean and tender muscle along the backbone of the hog, quick to roast.

rest time

The time cooked meat stays at its final temperature before cutting or eating; it helps kill germs and lets juices settle. Whole cuts of beef, pork, veal and lamb need 3 minutes.

trichinosis

An illness caused by a parasitic roundworm once common in pork; now very rare in the United States because of changes in how hogs are raised.

CORE IDEAS

The story. For decades the USDA told Americans to cook pork to 160 °F, and many cooks went higher "to be safe," which made pork dry and tough. The old advice came from a time when pork could carry the parasite that causes trichinosis. Over the twentieth century, laws against feeding hogs uncooked garbage and modern indoor hog farming made the parasite very rare in U.S. pork. On May 24, 2011, the USDA announced a change: whole cuts of pork are safe at **145 °F with a 3-minute rest**, the same as beef, veal and lamb. Ground pork stays at 160 °F.

How they figured it out. Food-safety scientists looked at decades of data on illness and on how quickly bacteria and parasites die at different temperatures. Killing germs depends on both temperature and time: holding meat at 145 °F for a few minutes destroys the germs of concern in whole cuts, whose interiors are protected. The rest time is part of the safety standard, not just a matter of juiciness.

The kitchen science. A thermometer is only as good as its calibration. Check it in ice water (32 °F) and, if you like, in boiling water (212 °F at sea level, about 1 °F lower for

every 500 feet of elevation). Many digital thermometers can be reset; with others, note the error and correct your readings. Place the tip in the thickest part, away from bone, fat and the pan. Larger, hotter roasts carry over more: a small tenderloin may rise 3–5 °F after leaving a hot oven; a big roast 10 °F or more. Cooks pull meat a few degrees early and let it rest, then confirm the final temperature.

Let's cook. You will sear and roast pork tenderloin with a simple herb rub. The technique standard: thermometer calibrated and correction recorded, tenderloin trimmed of silver skin, seared on all sides, roasted until it reaches 140–142 °F, rested to 145 °F or more for at least 3 minutes, and sliced into juicy, faintly pink medallions.

PICTURE STUDY



Cooking Class in a Washington, D.C., Elementary School, Frances Benjamin Johnston, c. 1899 · Photograph · Library of Congress, Washington, D.C.

Image: Wikimedia Commons, public domain

Frances Benjamin Johnston photographed Washington's schools around 1899, including cooking lessons. These students learned by watching and doing, judging doneness by sight, smell, touch and time, decades before instant-read thermometers.

Look closely

- Find the stove and the teacher. What is she showing the students?
- Look at the students' faces. Who seems most attentive?
- Find any tools that measure: clocks, scales, spoons.

Talk about it

1. Without a thermometer, how might this teacher show that meat was done?
2. Which of those clues are reliable, and which are not?
3. What would you add to this classroom to make cooking safer?

Safety first. Calibrate your thermometer before relying on it. Cook whole cuts of pork to 145 °F with a 3-minute rest and ground pork to 160 °F. Sear with the handle turned in and lay the meat into the pan away from you; use a separate board for raw meat.

KITCHEN LAB

Thermometer Lab: Roast Pork Tenderloin

You will calibrate your thermometer, then sear and roast a pork tenderloin, logging carryover as it rests.

You will need

- An instant-read thermometer and a tall glass of ice water
- An oven-safe 12-inch skillet
- Tongs, a paring knife, paper towels, a raw-meat cutting board
- A clean cutting board for slicing
- A timer

Herb-Roasted Pork Tenderloin

Serves 4–6 · Prep 10 min · Cook 20–25 min · Rest 5 min

Ingredients

- 2 pork tenderloins (about 1 lb / 450 g each)
- 1½ teaspoons kosher salt and ½ teaspoon black pepper
- 1 teaspoon dried thyme or 1 tablespoon fresh, chopped
- 1 teaspoon garlic powder and 1 teaspoon paprika
- 1 tablespoon brown sugar (optional)
- 1 tablespoon neutral oil
- 1 tablespoon butter (optional)

Method

1. Heat the oven to 425 °F (220 °C). Trim off the thin, shiny silver skin by sliding the paring knife just under it, blade angled up. Pat dry.
2. Mix the salt, pepper, thyme, garlic powder, paprika and sugar and rub all over the tenderloins. Wash your hands.
3. Heat the oil in the skillet over medium-high heat until shimmering. Sear the tenderloins, turning every 2 minutes, until browned on all sides, 6–8 minutes.

4. Add the butter if using, then move the skillet to the oven. Roast 10–15 minutes, until the thickest part reads 140–142 °F (corrected for your calibration).
5. With mitts, move the pork to a clean board. Rest at least 3 minutes, until it reaches 145 °F or a little higher.
6. Slice into ½-inch medallions and spoon any pan juices over them. Warn everyone that the skillet handle is hot.

Allergy check: Contains milk if butter is used; otherwise none of the nine major allergens.

Steps

1. **Calibrate.** Run the ice-water test and, if you wish, the boiling-water test. Record the readings and your correction (and your elevation).
2. Trim, season, sear and roast the tenderloins.
3. **Carryover log.** When you remove the pork, leave the thermometer in one tenderloin and record the temperature every minute for 6 minutes.
4. Slice one medallion at the end of the rest. Describe the color and juiciness. Compare with any memory of pork cooked to 160 °F or more.
5. **Technique check.** Score 1–3: calibrated thermometer, silver skin removed, even sear, correct pull temperature, 145 °F with 3-minute rest, juicy slices.
6. Clean up: raw-meat board and knife first; wash the skillet (the handle stays hot a long time).
7. **Unit project prep.** Add your thermometer data to the Unit 3 project.
8. **Repeat round.** Roast boneless pork chops or a beef roast and compare carryover with the tenderloin.

Tips

- Fold the thin tail end of a tenderloin under and tie it so the roast is even.
- Pork at 145 °F may look slightly pink in the center; that is normal and safe.
- If two tenderloins differ in size, take each out when it is ready.

Check your work

☐ I can calibrate a thermometer and correct readings.

☐ I can explain the 2011 USDA pork change and carryover cooking.

- [ ] I roasted a juicy pork tenderloin to 145 °F with a proper rest.

LAB NOTEBOOK

1. Make a thermometer-use card: calibration steps, where to place the tip, and the USDA temperatures.
2. Graph your carryover log.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$T_{\text{true}} = T_{\text{read}} - \text{error}$ (error = reading in ice water − 32 °F)

$T_{\text{boil}} \approx 212\ ^\circ\text{F} - \dfrac{\text{elevation (ft)}}{500}$

From history. Before the 2011 change, the National Pork Board had long promoted lower cooking temperatures. The USDA's safe-minimum chart now lists one number, 145 °F with a 3-minute rest, for whole cuts of beef, pork, veal and lamb, making it easier for cooks to remember.

WORKED EXAMPLES

Example 1. Your thermometer reads 34 °F in ice water. It shows 143 °F in a pork roast. What is the true temperature, and is the pork done?

Show solution

1. Error $= 34 - 32 = +2\ ^\circ\text{F}$ (it reads 2 °F high).
2. True $= 143 - 2 = 141\ ^\circ\text{F}$.

Answer: 141 °F: not yet at 145 °F. Recalibrate the thermometer or remember to subtract 2 °F.

Example 2. You live at 5,280 feet (Denver). At about what temperature does water boil? Would boiling water be a good calibration standard there?

Show solution

1. $212 - \dfrac{5280}{500} = 212 - 10.6 = 201.4\ ^\circ\text{F}$.
2. Boiling point also changes with the weather (air pressure).

Answer: About 201–202 °F. Use the ice-water test, which does not depend on altitude.

Example 3. A tenderloin leaves the oven at 141 °F and its temperature over the next 6 minutes is 141, 143, 144, 145, 145, 145 °F (one reading per minute). Does it meet the USDA standard?

Show solution

1. Carryover: $145 - 141 = 4$ °F.
2. It reaches 145 °F at minute 4 and stays there; the USDA standard is 145 °F followed by a rest of 3 minutes before carving or eating.

Answer: It reached 145 °F; let it rest the full 3 minutes from removal (USDA counts the rest from when it leaves the heat), and it is safe. Carryover was 4 °F.

PRACTICE

1. Easy What are the two standard points for checking a thermometer?

   Show answer

   Ice water, 32 °F (0 °C), and boiling water, 212 °F (100 °C) at sea level.

2. Easy What did the USDA change in May 2011?

   Show answer

   Whole cuts of pork became safe at 145 °F with a 3-minute rest (down from 160 °F).

3. Easy Is ground pork included in the 145 °F rule?

   Show answer

   No; ground pork must reach 160 °F.

4. Medium A thermometer reads 30 °F in ice water. What correction do you apply?

   Show answer

   It reads 2 °F low; add 2 °F to every reading.

5. Medium About what temperature does water boil at 2,500 feet?

   Show answer

   $212 - 5 = 207$ °F

6. Medium Why must the thermometer tip not touch bone or the pan?

Show answer

Bone and pan conduct heat differently and give false readings; you need the temperature of the meat's thickest part.

7. Medium Why did trichinosis become rare in U.S. pork?

Show answer

Laws stopped feeding hogs uncooked garbage, and modern farming keeps hogs away from infected animals and wildlife.

8. Hard A roast is expected to rise 8 °F after leaving the oven. At what temperature should you pull it to finish at 145 °F?

Show answer

137 °F, then confirm it reaches 145 °F during the rest.

9. Hard Explain why food safety depends on both temperature and time.

Show answer

Germs die faster at higher temperatures; holding food at a lower lethal temperature for longer can kill the same number. The 3-minute rest at 145 °F supplies the time.

10. Challenge Design a test to measure carryover cooking in a small and a large roast, and predict which rises more and why.

Show answer

Roast a tenderloin and a 3-lb pork loin at the same oven temperature, insert leave-in probe thermometers, and record center temperature every minute after removal. The large roast rises more because it has a thicker hot outer layer storing more heat that keeps flowing inward.

COMMON MISTAKES

- Trusting an uncalibrated thermometer.
- Cooking pork to 160–170 °F out of habit, making it dry.
- Grabbing the skillet handle after it comes out of the oven.
- Skipping the rest time, which is part of the safety standard for whole cuts.

Make it a game · Pull the Pork. Your parent plays a nervous cook asking when to pull a pork tenderloin, a roast and a burger. Give the pull temperature, the rest time and the reason carryover cooking matters. Explain the 2011 USDA change to 145 degrees Fahrenheit. Then work out a corrected reading if the thermometer reads 2 degrees high in ice water.

UNIT 3

Cooking Methods: Dry Heat

Dry-heat cooking surrounds food with hot air, hot metal, hot fat or radiant heat, and no added water, so the surface can rise above the boiling point and brown. In this unit you will learn the five great dry-heat methods: sautéing and searing, roasting, broiling, shallow pan-frying, and finishing with a thermometer-guided sense of doneness.

Each method comes with a story: Julia Child's warning about crowded mushrooms, Hannah Glasse's roast before the fire, William Herschel's discovery of the invisible heat that a broiler uses, Mary Randolph's fried chicken, and the USDA's 2011 change to pork temperatures. The labs make a family dinner each time: steak with mushrooms, a roast chicken, broiled salmon, crispy chicken cutlets and a roast pork tenderloin, every one checked with a calibrated thermometer.

PREREQUISITES

- Units 1 and 2: food safety, knife skills, pan materials and measurement
- An instant-read thermometer
- Comfort with squares, areas of circles and simple ratios

MASTERY CHECKLIST

- ☐ I can sauté and sear without crowding, and explain browning with latent heat and the Maillard reaction.
- ☐ I can roast meat and vegetables and account for carryover cooking.
- ☐ I can broil safely, using rack position to control intense radiant heat.
- ☐ I can bread and shallow pan-fry food safely, choosing oil by smoke point and never deep frying.
- ☐ I can calibrate a thermometer and cook every meat to its USDA safe temperature.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA FSIS: Safe Temperature Chart**: Free, on the USDA Food Safety and Inspection Service website (fsis.usda.gov). The USDA's own chart, including the 145 °F rest rule for whole cuts.
- **A heavy 12-inch skillet (cast iron or clad stainless)**: Useful for searing and pan-frying all year; a thin pan works but browns less evenly.
- **An oven thermometer**: Optional and inexpensive. Hang it in the oven to see whether your oven runs hot or cold.

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	**Sautéing and Pan-Searing: Julia Child's Mushrooms**	3 sessions of 50 minutes
3.2	**Roasting: Hannah Glasse and the Roast Chicken**	3 sessions of 50–90 minutes
3.3	**Broiling: Herschel's Invisible Heat and the Broiled Fish**	3 sessions of 50 minutes
3.4	**Shallow Pan-Frying: Mary Randolph's Fried Chicken**	3 sessions of 50–90 minutes
3.5	**Doneness, Carryover and the USDA's 2011 Pork Change**	3 sessions of 50 minutes

Unit 3 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Define sauté and sear, and explain why patting meat dry helps it brown.

2. **8 pts**
   How much energy evaporates 250 g of water from crowded vegetables? Why does this explain Julia Child's rule about mushrooms?

3. **6 pts**

   Give the USDA safe minimum internal temperatures for a steak, a whole chicken, fish, ground beef and a pork chop.

4. **6 pts**

   Who was Hannah Glasse, and how did cooks of her time control the heat of a roast?

5. **8 pts**

   A 5-lb chicken roasts at 16 min/lb and rests 15 minutes. Dinner is at 6:15 p.m. When must it go into the oven?

6. **6 pts**

   What is carryover cooking, and why does a large roast carry over more than a small one?

7. **6 pts**

   Describe Herschel's 1800 experiment and what it showed.

8. **8 pts**

   Using the inverse-square rule, compare the broiler intensity at 3 inches and at 5 inches. Which would you use for a thin fish fillet?

9. **6 pts**

   What volume of oil (in cups) gives ¼-inch depth in a pan with a 9-inch-wide bottom? (1 cup ≈ 14.4 in^3)

10. **6 pts**

    List the standard breading procedure and explain the dry-hand, wet-hand method.

11. **6 pts**

    What should you do if a pan of oil catches fire?

12. **8 pts**

    Your thermometer reads 35 °F in ice water and 144 °F in a pork roast. What is the true temperature? Is it safe to serve after a 3-minute rest?

13. **6 pts**

About what temperature does water boil at 4,000 feet? Why is ice water a better calibration standard?

14. **6 pts**

Predict: chicken cutlets go into oil that is only 275 °F. Describe the result and explain it.

15. **8 pts**

Essay (one paragraph): Compare sautéing, roasting, broiling and pan-frying by how heat reaches the food (conduction, convection, radiation), and give the best use of each.

ANSWER KEY

1. Sauté: cook small pieces quickly in a little hot fat. Sear: brown the surface of a larger piece in a very hot pan. Surface water must evaporate (using about 2,260 J per gram) before the surface can rise above 212 °F and brown, so dry meat browns faster.
2. $250 \times 2260 = 565{,}000$ J. A crowded pan must boil off a large amount of water, which cannot escape quickly; the food stews below 212 °F instead of browning.
3. Steak 145 °F + 3-min rest; chicken 165 °F; fish 145 °F; ground beef 160 °F; pork chop 145 °F + 3-min rest.
4. Author of *The Art of Cookery, Made Plain and Easy* (1747). They roasted before an open fire on a spit and controlled heat by the size of the fire and the distance of the meat from it.
5. Roast 80 min + rest 15 min = 95 min; in by 4:40 p.m.
6. The rise in internal temperature after removal from heat; a larger roast has a thicker hot outer layer storing more heat to flow inward.
7. He split sunlight with a prism and measured temperatures in each color with a control thermometer beyond the red; the region beyond the red was warmest, revealing invisible heat rays (infrared).
8. $(5/3)^2 = 2.8$; about 2.8 times as intense at 3 inches. Use the closer position (3–4 inches) for a thin fillet that cooks quickly.
9. $\pi(4.5)^2(0.25) = 15.9 \text{ in}^3 \approx 1.1$ cups.
10. Flour, egg, crumbs. One hand handles only the dry flour and crumbs, the other only the wet egg, so hands do not clump with breading.
11. Turn off the heat, cover the pan with a lid or baking sheet, leave it covered; never use water; get out and call 911 if it spreads.
12. Error +3 °F; true $144 - 3 = 141$ °F. Not yet; it needs to reach 145 °F (cook a few minutes more or confirm carryover).
13. $212 - 8 = 204$ °F. Ice water is 32 °F at any elevation.
14. Pale, greasy, soggy cutlets: too little steam forms to keep oil out, browning is slow, and the meat may overcook before the crust is crisp.
15. Sautéing/searing: conduction from hot pan and fat; small pieces and steaks. Roasting: convection of hot air and radiation from oven walls, with conduction inward; whole birds, roasts, vegetables. Broiling: intense radiation from above; thin, quick-cooking foods. Pan-frying: conduction and convection through hot

oil; breaded cutlets and fritters. Strong answers note that in all of them the surface rises above 212 °F and browns.

UNIT PROJECT: ONE PROTEIN, FOUR DRY HEATS

Choose one protein (chicken thighs, pork chops or thick fish fillets) and cook four portions by four dry-heat methods: sauté or sear, roast, broil and breaded pan-fry. Use the same seasoning and starting weight for each, and record preheat temperature, cooking time, internal temperature before and after resting, and weight after cooking (to calculate moisture loss as a percentage).

Hold a family blind tasting and rate each portion for browning, juiciness, tenderness and flavor. Present your data in a table and a bar graph, write a one-page conclusion explaining the differences with heat transfer, and serve the meal with a vegetable and a grain.

LOOK FOR	WHAT IT MEANS
Safety	Thermometer calibrated; every portion reached its USDA temperature; raw and cooked kept separate; safe hot-oil and broiler handling.
Fair test	Same protein, size, seasoning and starting weight; only the method changed.
Data	Complete table with times, temperatures and percent cooking loss; clear graph.
Explanation	Differences explained correctly with conduction, convection, radiation, evaporation and browning.
Meal and reflection	A complete meal served; family ratings recorded; one honest improvement planned.

UNIT 4

Cooking Methods: Moist Heat and Combination

Moist-heat cooking surrounds food with water or steam. Because water at sea level cannot rise above 212 °F, moist heat is gentle, steady and forgiving, and it is the key to tender pot roasts, clear stocks, bright vegetables and soft beans. In this unit you will learn boiling, simmering and poaching; steaming; braising and stewing; stocks and soups; and the pressure cooker.

The science runs from Joseph Black's discovery of latent heat and James Watt's measurements of steam to the way collagen melts into gelatin in a slow braise. The history includes Abraham Darby's cast-iron pots, Escoffier's foundation stocks and Denis Papin's steam digester. The labs make family meals: pasta with broccoli, steamed fish, a pot roast, chicken noodle soup from your own stock, and black beans and rice.

PREREQUISITES

- Units 1–3: food safety, knife skills, measurement, dry-heat cooking and thermometer use
- Comfort with $q = mc\Delta T$ (Lesson 2.4) and the two-stage cooling rule (Lesson 1.5)

MASTERY CHECKLIST

- ☐ I can poach, simmer, boil, blanch and shock, and explain why water caps at 212 °F.
- ☐ I can steam safely and explain why steam cooks quickly and burns badly.
- ☐ I can braise a tough cut until fork-tender and explain collagen and gelatin.
- ☐ I can make a clear stock and use it in a soup, cooling it safely.
- ☐ I can explain how a pressure cooker works and use one safely with a parent present.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **National Center for Home Food Preservation**: Free. The University of Georgia's tested guidance on canning and preserving, including why low-acid foods need a pressure canner. Read before any canning project.
- **A heavy Dutch oven (enameled or bare cast iron)**: Useful for braises, stews, soups and bread all year. Any heavy oven-safe pot with a tight lid works.
- **A stovetop or electric pressure cooker**: Optional, and used only with a parent present. Every recipe in this unit also has a stovetop method.

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 Boiling, Simmering and Blanching: Joseph Black's Latent Heat
3 sessions of 50 minutes

4.2 Steaming: James Watt and the Power of Steam — 3 sessions of 50 minutes

4.3 Braising: Abraham Darby's Iron Pot and Collagen to Gelatin
3 sessions of 50–90 minutes

4.4 Stocks and Soups: Escoffier's Foundations — 3 sessions of 50–90 minutes

4.5 The Pressure Cooker: Denis Papin's Steam Digester — 3 sessions of 50–90 minutes

Unit 4 Test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. Use $c_{\text{water}} = 4.186\ \text{J/(g}\cdot^\circ\text{C)}$ and $L_v = 2260\ \text{J/g}$. The test is worth 100 points.

1. **6 pts**
   Give the temperature ranges for poaching, simmering and boiling, and one food cooked by each.

2. **6 pts**

   What did Joseph Black discover, and why does it make water a gentle cooking medium?

3. **8 pts**

   How much energy heats 3 kg of water from 20 °C to 100 °C? How long at 1,800 W?

4. **6 pts**

   Why does salting pasta water not make it cook faster?

5. **8 pts**

   Compare the heat released to the skin by 2 g of steam at 100 °C condensing and cooling to 40 °C with 2 g of water cooling from 100 °C to 40 °C.

6. **6 pts**

   What did James Watt measure, and how did Black explain it?

7. **6 pts**

   Explain collagen and gelatin and why a pot roast cooks to about 200 °F.

8. **8 pts**

   A 4-lb chuck roast at $5.99/lb yields 65% cooked. How many 4-oz servings, and what is the cost per serving?

9. **6 pts**

   What did Abraham Darby patent in 1707, and why did it matter for home cooking?

10. **6 pts**

    Give the mirepoix ratio and the amount of each vegetable in 1½ lb (24 oz) of mirepoix.

11. **6 pts**

    Why is stock started in cold water and simmered, not boiled?

12. **6 pts**

    Stock reduced from 8 cups to 2 cups is how many times as concentrated? Why is stock unsalted?

13. **6 pts**

    Explain why a pressure cooker cooks faster, giving the approximate temperature inside.

14. **6 pts**

    Predict: dried beans are simmered with a can of tomatoes from the start. What will happen, and why?

15. **6 pts**

    Give three pressure-cooker safety rules.

16. **4 pts**

    Essay (one paragraph): Choose one moist-heat method from this unit and explain, with its science and one story, why it is the right method for a particular food.

ANSWER KEY

1. Poach 160–180 °F (eggs, fish); simmer 185–205 °F (soup, stock, braise); boil 212 °F (pasta, blanching).
2. Latent heat: water absorbs heat while boiling without getting hotter, so at sea level it cannot exceed 212 °F.
3. $3000 \times 4.186 \times 80 = 1.0 \times 10^6$ J; $1.0 \times 10^6 / 1800 \approx 558$ s ≈ 9.3 min.
4. The salt raises the boiling point by only a small fraction of a degree; it is for flavor.
5. Steam: $2(2260) + 2(4.186)(60) = 5022$ J; water: 502 J; about 10 times more.
6. That condensing steam heated about six times its weight of cold water to boiling; Black explained it with the latent heat carried by steam.
7. Collagen is tough connective-tissue protein; long, moist heat converts it to soft gelatin; reaching about 200 °F over hours gives time for that conversion, making the meat tender.
8. Cooked $4 \times 0.65 = 2.6$ lb $= 41.6$ oz ≈ 10 servings; $\$23.96 / 10 = \$2.40$.
9. Casting thin iron pots in sand molds; it made sturdy cooking pots cheap enough for ordinary households.
10. 2:1:1; 12 oz onion, 6 oz carrot, 6 oz celery.
11. Cold start lets proteins coagulate slowly into skimmable foam; a simmer keeps fat and particles from emulsifying into a cloudy, greasy stock.
12. 4 times; salt would be concentrated too.
13. Trapped steam raises the pressure to about 2 atm, raising water's boiling point to about 250 °F (121 °C); hotter water cooks faster.
14. They will take much longer to soften or stay firm, because acid slows the breakdown of the bean's cell walls; add acid near the end.
15. Any three: parent present; check gasket and valve; fill no more than two-thirds (half for beans); lock the lid; never force it open; release pressure as directed, venting away from people.
16. Answers vary. A strong answer names the method, the food, the physical reason (latent heat, gentle temperature cap, collagen to gelatin, raised boiling point) and connects a story (Black, Watt, Darby, Escoffier or Papin).

UNIT PROJECT: ONE CHICKEN, THREE MEALS

Plan and cook three meals from one whole chicken using moist and dry heat: roast or braise the chicken for the first meal, make stock from the carcass, and use the stock and leftover meat in a soup or stew for a second meal and a rice or bean dish for a third.

Write a plan and timeline, a grocery list with prices, and a cost-per-serving calculation for all three meals. Keep logs of temperatures (cooking, cooling and reheating) and record family ratings. Finish with a one-page reflection on how much food and money one chicken provided and what you would change.

LOOK FOR	WHAT IT MEANS
Planning	Clear three-meal plan, timeline and grocery list with prices.
Technique and safety	Correct methods; chicken to 165 °F; stock simmered and cooled by the two-stage rule; leftovers reheated to 165 °F.
Cost	Accurate cost-per-serving calculations for all three meals.
Records	Complete temperature logs and family ratings.
Reflection	Honest assessment of results, waste avoided and one improvement.

4.1 Boiling, Simmering and Blanching: Joseph Black's Latent Heat

OBJECTIVES

- Tell how Joseph Black discovered latent heat at the University of Glasgow around 1761–62.
- Distinguish boiling, simmering and poaching by temperature and by what the water looks like.
- Calculate the energy and time to heat a pot of water, and show that salting pasta water barely changes its boiling point.
- Blanch and shock a green vegetable, and cook pasta al dente, in a pasta-with-broccoli supper.

> **Warm-up.** Put a thermometer in a pot of water on high heat and read it every minute until the water has boiled hard for 3 minutes. Graph it. What happens to the temperature once the water boils, even though the burner is still on?

WATCH

Blanching and Shocking, Ep. 21

Culinary Arts Management at Cosumnes River College · 6:04

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

> **WHEN TO WATCH**
> After the kitchen-science paragraph, before the lab.

Note: From the culinary arts program of Cosumnes River College in California, part of its series on foundational cooking methods.

BACKUP VIDEO

Blanching and Shocking - Basic Kitchen Skills with Dietetics & Nutrition

Keiser University · 3:23

https://www.youtube.com/watch?v=G1V_4BTmh_A

A second short look at blanching from a university dietetics kitchen.

KEY TERMS

latent heat

Heat absorbed or released when a substance changes state (melting, boiling) without changing temperature.

boil

Large, rolling bubbles breaking the surface; 212 °F (100 °C) at sea level. Used for pasta and blanching.

simmer

Small bubbles rising gently, about 185–205 °F (85–96 °C). Used for soups, stocks, sauces and braises.

poach

Cooking in liquid that barely moves, about 160–180 °F (71–82 °C). Used for eggs, fish and delicate foods.

blanch and shock

Boiling a vegetable briefly, then plunging it into ice water to stop the cooking and keep its color and crunch.

CORE IDEAS

The story. Joseph Black was a physician and chemistry professor at the University of Glasgow in Scotland. Around 1761–62 he puzzled over a simple question: why does a pan of ice take so long to melt on a warm day, and why does a kettle take so long to boil away, if heat simply raises temperature? He measured carefully and found that melting ice soaks up a great deal of heat while staying at the freezing point, and boiling water soaks up even more while staying at the boiling point. He called this hidden heat **latent heat** (from the Latin for "hidden").

How he figured it out. Black compared equal amounts of ice and ice-cold water warming in the same room. The water warmed several degrees while the ice stayed at the freezing point until it had melted, even though both were absorbing heat from the room. He did similar experiments with boiling water and timed how long it took to boil away compared with how long it took to come to a boil. He concluded that changing state takes heat that does not show up on a thermometer.

The kitchen science. Black's discovery is why water is such a gentle, predictable cooking medium: at sea level it *cannot* get hotter than 212 °F (100 °C) no matter how high the burner; more heat only makes it boil harder. Cooks control moist heat by choosing the temperature below that ceiling: **poaching** (160–180 °F) for delicate eggs

and fish, **simmering** (185–205 °F) for soups and stews, and a rolling **boil** (212 °F) for pasta and blanching, where a large volume of water keeps its temperature when food goes in. Salt in pasta water seasons the pasta but barely raises the boiling point. **Blanching** sets the bright green of vegetables; a quick **shock** in ice water stops the cooking.

Let's cook. You will blanch broccoli in boiling salted water, shock part of it, and cook pasta in the same pot, then toss everything with garlic, olive oil and Parmesan. The technique standard: a full rolling boil, water salted to taste like mild seawater, broccoli bright green and tender-crisp, pasta al dente (tender with a slight bite), and the hot pot drained safely away from your body.

PICTURE STUDY



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

Image: Wikimedia Commons, public domain

Vincent van Gogh painted a Dutch farm family eating their supper of boiled potatoes, potatoes they had dug with their own hands. He wanted to show that they had honestly earned their food. The dish on the table steams in the lamplight.

Look closely

- Find the dish of potatoes. How were they cooked, and how can you tell they are hot?
- Look at the hands. What do they tell you about this family's work?
- Find the lamp. Why is the room so dark?

Talk about it

1. Boiled potatoes are one of the simplest moist-heat foods. How would you know when they are done?
2. Why might a poor family in 1885 boil rather than roast or fry their potatoes?
3. What would you want to say or do at this table?

> **Safety first.** Turn pot handles inward and lift a full pot of water with two dry mitts. Drain pasta by pouring away from you into a colander in the sink, letting the steam rise away from your face. Lower vegetables into boiling water with a spider or slotted spoon, never by dropping them.

KITCHEN LAB

Moist-Heat Lab: Pasta with Broccoli, Garlic and Parmesan

You will log the temperature of water at poach, simmer and boil, blanch and shock broccoli, and cook pasta al dente in the same pot.

You will need

- A large pot (6 quarts or more) with a lid
- A spider or slotted spoon, a colander and a large bowl of ice water
- An instant-read thermometer and a timer
- A large skillet
- A liquid measuring cup to save pasta water

Pasta with Broccoli, Garlic and Parmesan

Serves 6 · Prep 15 min · Cook 20 min

Ingredients

- 1 lb (450 g) short pasta such as orecchiette, penne or shells
- 1 large head broccoli (about 1¼ lb), cut into small florets; stem peeled and sliced
- 4 quarts water and 1½ tablespoons kosher salt
- ⅓ cup (80 mL) olive oil
- 4 cloves garlic, thinly sliced
- ¼ teaspoon red pepper flakes (optional)
- ½ cup (40 g) grated Parmesan cheese, plus more to serve
- 1 tablespoon lemon juice and black pepper to taste

Method

1. Bring the water to a rolling boil with the lid on; add the salt.
2. Add the broccoli and blanch 2 minutes. Lift out about one-third with the spider into the ice water (to compare later); lift the rest into a bowl.
3. Return the water to a boil and cook the pasta, stirring the first minute, until al dente. Taste from 2 minutes before the package time. Save 1 cup

of pasta water, then drain.

4. Meanwhile, warm the oil and garlic in the skillet over medium-low heat until the garlic is pale gold, 2–3 minutes. Add the pepper flakes and the broccoli from the bowl and cook 2 minutes, mashing a few florets.
5. Add the pasta, ½ cup pasta water and the Parmesan and toss until glossy, adding more water if dry. Finish with lemon juice and pepper. Serve the shocked broccoli on the side or tossed in at the end.

Allergy check: Contains wheat (pasta) and milk (Parmesan). Use gluten-free pasta and omit the cheese (or use a dairy-free alternative) as needed.

Steps

1. **Temperature ladder.** As the water heats, record the temperature when you see the first tiny bubbles on the bottom (poach), steady small bubbles rising (simmer) and a full rolling boil. Photograph each.
2. Record how long the water takes to boil with the lid on. (For comparison, time 1 quart without a lid on another day.)
3. Blanch the broccoli; shock one-third and leave the rest warm. After 10 minutes compare their color and crunch.
4. Cook the pasta, tasting every minute in the last few minutes; record the time when it was al dente versus the package time.
5. **Technique check.** Score 1–3: rolling boil, well-salted water, bright green broccoli, al dente pasta, sauce coating every piece, safe draining.
6. Clean up: let the pot cool, wash and dry everything, wipe the stove.
7. **Repeat round.** Blanch green beans or asparagus with the same method and serve them with a vinaigrette.

Tips

- Use plenty of water so it returns to a boil quickly after the food goes in.
- Salt the water after it boils; salt added to cold water can pit some pans.
- Save pasta water before draining; its starch helps the sauce cling.

Check your work

☐ I can tell Joseph Black's story and explain why boiling water stays at 212 °F.

- ☐ I can recognize poaching, simmering and boiling by temperature and appearance.
- ☐ I blanched broccoli and cooked pasta al dente.

LAB NOTEBOOK

1. Graph your warm-up data (temperature against time) and label the plateau at boiling.
2. Draw three pots showing what poaching, simmering and boiling water look like, with their temperatures.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$q = mc\Delta T, \quad c_{\text{water}} = 4.186\ \text{J/(g}\cdot{}^\circ\text{C)}$
$t = \dfrac{q}{P}$
$\Delta T_b = iK_b m$ (boiling-point rise; for water $K_b = 0.512\ {}^\circ\text{C}\cdot\text{kg/mol}$, salt $i = 2$)

> **From history.** Joseph Black also discovered carbon dioxide, which he called “fixed air,” in the 1750s. One of his friends at Glasgow was the instrument maker James Watt, whose work on steam engines drew on Black’s idea of latent heat (Lesson 4.2).

WORKED EXAMPLES

Example 1. How much energy heats 4 quarts (3.79 kg) of tap water from 15 °C to 100 °C? If the burner delivers 2,000 W to the pot, how long does it take?

Show solution

1. $q = 3790\ \text{g} \times 4.186\ \frac{\text{J}}{\text{g}\cdot{}^\circ\text{C}} \times 85\ {}^\circ\text{C} = 1.35 \times 10^6\ \text{J}.$
2. $t = \dfrac{1.35 \times 10^6\ \text{J}}{2000\ \text{J/s}} = 675\ \text{s} \approx 11\ \text{min}.$

Answer: About 1.35 million joules and 11 minutes (longer in practice, since heat escapes; a lid helps).

Example 2. You add 1 tablespoon of table salt (about 18 g) to 4 quarts (about 3.8 kg) of pasta water. By how much does the boiling point rise? (NaCl: 58.4 g/mol)

Show solution

1. Moles of salt: $18/58.4 = 0.31$ mol.
2. Molality: $0.31/3.8 = 0.081$ mol/kg.
3. $\Delta T_b = 2 \times 0.512 \times 0.081 = 0.083\ ^\circ\text{C}$.

Answer: Less than a tenth of a degree. Salt is for flavor, not for cooking faster.

Example 3. A pot holds 4 quarts of water at 100 °C. You add 1 lb (454 g) of broccoli at 5 °C. Ignoring the burner, about what temperature does the water drop to? (Take broccoli's specific heat as about 3.9 J/(g·°C).)

Show solution

1. Heat lost by water = heat gained by broccoli:
   $3790(4.186)(100 - T) = 454(3.9)(T - 5)$.
2. $15{,}865(100 - T) = 1771(T - 5) \Rightarrow 1{,}586{,}500 + 8855 = 17{,}636\,T$.
3. $T \approx 90.5\ ^\circ\text{C}$.

Answer: About 90 °C (195 °F): a big pot of water recovers quickly. In a small pot the drop would be much larger, which is why blanching uses plenty of water.

PRACTICE

1. Easy Give the temperature ranges for poaching, simmering and boiling.

   Show answer

   Poach 160–180 °F; simmer 185–205 °F; boil 212 °F at sea level.

2. Easy What is latent heat, and who named it?

   Show answer

   Heat absorbed or released during a change of state without a temperature change; Joseph Black.

3. Easy Why do we shock blanched vegetables in ice water?

   Show answer

   To stop the cooking quickly so they stay bright green and crisp.

4. **Medium** How much energy heats 2 L (2,000 g) of water from 20 °C to 100 °C?

   Show answer

   $2000 \times 4.186 \times 80 = 670{,}000$ J

5. **Medium** Why does turning the burner from medium-high to high not make boiling pasta cook faster?

   Show answer

   Boiling water stays at 212 °F; extra heat only makes it boil harder (evaporating water faster), not hotter.

6. **Medium** Why does a lid help water come to a boil faster?

   Show answer

   It keeps hot water vapor and its latent heat in the pot and reduces evaporation and heat loss from the surface.

7. **Medium** What does al dente mean, and how do you test for it?

   Show answer

   “To the tooth”: tender but with a slight firmness in the center; taste a piece starting a minute or two before the package time.

8. **Hard** Find the boiling-point rise of 1 L of water with 30 g of salt.

   Show answer

   Molality $30/58.4 = 0.51$ mol/kg; $\Delta T_b = 2(0.512)(0.51) = 0.53$ °C.

9. **Hard** At 2,000 W, how long does it take to boil away 1 L (1,000 g) of water that is already at 100 °C? (latent heat 2,260 J/g)

   Show answer

   $q = 2.26 \times 10^6$ J; $t = 1130$ s ≈ 19 min. Boiling away takes far longer than coming to a boil, exactly Black’s observation.

10. **Challenge** Black noticed ice and cold water behaved differently in a warm room. Describe how you could repeat his experiment at home with two identical cups, a thermometer and a clock, and what results you would expect.

    Show answer

    Put equal masses of crushed ice (at 32 °F) and ice-cold water (just above 32 °F) in identical cups in the same room; record temperatures every 5 minutes. The water warms steadily; the ice cup stays at 32 °F until the ice is gone, showing it absorbs heat without warming.

COMMON MISTAKES

- Adding pasta before the water is fully boiling.
- Using too little water, so it stops boiling when food goes in.
- Boiling a soup or stock hard instead of simmering it, which clouds and toughens it.
- Rinsing cooked pasta, which washes away the starch that helps sauce cling (except for a cold pasta salad).

> **Make it a game · Boil, Simmer, Poach.** Your parent shows photos in their mind: tiny bubbles, rolling bubbles, barely moving water. Describe each stage with its approximate temperature and name the technique. Do six rounds, then explain latent heat as Joseph Black discovered it. Finally name the steps of blanch and shock and why the ice water matters.

4.2 Steaming: James Watt and the Power of Steam

OBJECTIVES

- Explain why steaming cooks quickly and gently, using the latent heat released when steam condenses.
- Compare the energy in a steam burn with a hot-water burn.
- Tell how James Watt's measurements on steam at Glasgow in the 1760s connected to Black's latent heat.
- Steam fish and vegetables to their proper doneness with a home steamer setup.

> **Warm-up.** Hold a cold metal spoon about 6 inches above a pot of simmering water (use an oven mitt and keep your hand out of the steam). What forms on the spoon? Is the spoon getting warmer? Where is that heat coming from?

WATCH

How to Steam Vegetables | Cook Vegetables

SIKANA English · 3:54

https://www.youtube.com/watch?v=dV0ss0Y_X6o

> **WHEN TO WATCH**
> Before the lab. Notice the three steamer setups: a steamer pot, a bamboo basket and a colander.

Note: From Sikana, a nonprofit that makes free how-to lessons.

KEY TERMS

steaming

Cooking food in the hot vapor above boiling water, usually in a covered basket or on a rack.

condensation

The change of water vapor back into liquid, which releases its latent heat (about 2,260 J per gram) into whatever it touches.

en papillote

Cooking food sealed in a parchment or foil packet so it steams in its own moisture.

carryover steaming

Fish and vegetables keep cooking from trapped steam after the heat is off; lift the lid promptly.

water-soluble vitamins

Vitamins such as vitamin C and several B vitamins that dissolve in water and can leach into cooking water; steaming loses less than boiling.

CORE IDEAS

The story. In 1763–64 James Watt, an instrument maker at the University of Glasgow, was asked to repair a small working model of a Newcomen steam engine used in lectures. The model ran poorly and used an astonishing amount of steam. Watt measured how much cold water a given amount of steam could heat to boiling and was amazed: condensing steam heated about five to six times its own weight of water from cold to boiling. When he told Joseph Black, Black explained it with his own discovery: steam carries a large latent heat, released when it turns back into water.

How they figured it out. Watt measured the steam used, the cooling water, and the temperatures, and found the numbers would not balance unless the steam carried hidden heat. That insight led him in 1765 to his greatest invention, the separate condenser, which made steam engines far more efficient. The same physics is in your kitchen whenever steam rises from a pot.

The kitchen science. When steam at 212 °F touches cooler food, it condenses on the surface and releases about 2,260 joules for every gram, far more heat than the same gram of boiling water gives up as it cools. That is why steaming cooks fish and vegetables quickly and evenly without moving them, and why a puff of steam can burn your hand worse than a splash of hot water. Steamed food never gets hotter than 212 °F, so it does not brown; it stays moist and tender. Because the food is not sitting in water, steaming keeps more of the water-soluble vitamins than boiling does. Fish is safe at 145 °F, when it turns opaque and flakes.

Let's cook. You will steam cod fillets with ginger and green onions and steam green beans or bok choy, served with rice. You can use a bamboo steamer, a metal steamer

basket, or a heatproof plate on a rack in a covered skillet. The technique standard: water simmering steadily below the food, never touching it; lid opened away from you; fish steamed to 145 °F and just flaking; vegetables bright and tender-crisp.

PICTURE STUDY



Mariko: Famous Tea Shop (from The Fifty-three Stations of the Tōkaidō), Utagawa Hiroshige, c. 1833–34 · Woodblock print · The Metropolitan Museum of Art, New York (impression shown)

Image: Wikimedia Commons, public domain

Hiroshige made prints of the stations along the Tōkaidō, the great road between Edo (Tokyo) and Kyoto. At Mariko, travelers stopped at a roadside shop famous for *tororo-jiru*, a warm soup of grated yam served over rice. Simple, hot, moist food fed tired travelers.

Look closely

- Find the travelers eating. What are they eating from?
- Find the woman serving. What is she carrying?
- Look at the season. What tells you it is early spring?

Talk about it

1. Why would warm, moist foods like soup, rice and steamed dishes suit travelers?
2. Rice in Japan is often steamed. How does cooking rice use both boiling and steaming?
3. What would a roadside food stall in your town serve?

> **Safety first.** Keep the water below the steamer basket so it does not touch the food, and check that the pot does not boil dry. Open lids away from you with a mitt and let the first cloud of steam clear before reaching in. Use a long spatula or mitts to lift plates out of a steamer.

KITCHEN LAB

Steaming Lab: Ginger-Scallion Steamed Cod with Vegetables and Rice

You will steam fish and vegetables, compare steamed and boiled vegetables for color, texture and taste, and observe condensation at work.

You will need

- A bamboo steamer over a wok or skillet, a steamer basket in a pot, or a heatproof plate on a rack in a covered 12-inch skillet
- A medium saucepan with lid for rice
- An instant-read thermometer and a timer
- Mitts, tongs and a long spatula
- A small saucepan for comparison boiling

Ginger-Scallion Steamed Cod with Steamed Vegetables

Serves 4 · Prep 15 min · Cook 25 min (with rice)

Ingredients

- 1½ cups long-grain white rice and 2¼ cups water, ½ teaspoon salt
- 4 cod or other mild white fish fillets, 5–6 oz each, about 1 inch thick
- ½ teaspoon salt
- 1 two-inch piece fresh ginger, peeled and cut in thin matchsticks
- 4 green onions, cut in 2-inch lengths, then thin strips
- **Sauce:** 3 tablespoons soy sauce, 1 tablespoon water, 2 teaspoons sugar, 1 teaspoon toasted sesame oil
- 2 tablespoons neutral oil
- 1 lb green beans or 4 heads baby bok choy, trimmed

Method

1. Rinse the rice until the water runs nearly clear. Bring rice, water and salt to a boil, cover, reduce to low and cook 18 minutes; rest covered 10 minutes.

2. Set up the steamer with 1–2 inches of water below the rack. Bring to a steady boil.
3. Pat the fish dry, season with salt and lay on a heatproof plate that fits the steamer with an inch of space around it. Scatter half the ginger on top. Steam, covered, 7–10 minutes, until 145 °F and flaking.
4. Steam the vegetables in a second layer or after the fish, 3–5 minutes, until bright and tender-crisp.
5. Warm the sauce ingredients in a small pan. Carefully lift out the fish plate with mitts, pour off its liquid, top with the rest of the ginger and the green onions, and spoon over the warm sauce. Heat the neutral oil until shimmering and spoon it slowly over the green onions (a parent present; it will sizzle).
6. Serve with rice and vegetables.

Allergy check: Contains fish, soy and wheat (soy sauce) and sesame (sesame oil). Use gluten-free tamari for wheat-free and omit the sesame oil if needed.

Steps

1. **Condensation demo.** Hold a cold lid over the steam briefly (mitt on) and watch drops form. Explain in your notebook where the heat goes.
2. Cook the rice and set up the steamer. Record the time for the water to come to a boil.
3. Steam the fish; record its temperature at 6, 8 and 10 minutes.
4. **Steam versus boil.** Boil a handful of the green beans in the small pan for the same time as the steamed ones. Compare color, texture and flavor and the color of the leftover water.
5. **Technique check.** Score 1–3: water level correct, steady steam, lid opened safely, fish 145 °F and moist, vegetables bright and crisp-tender, rice fluffy.
6. Clean up: let the steamer cool before washing; dry bamboo steamers thoroughly to prevent mold.
7. **Repeat round.** Cook salmon or chicken breast en papillote (in a sealed parchment or foil packet in a 400 °F oven) and compare with stovetop steaming.

Tips

- Thin tail ends cook faster; fold them under for even steaming.
- Do not let the water touch the plate or basket; the food should steam, not boil.
- Add boiling water from a kettle if the pot runs low, so the steam does not stop.

Check your work

- ☐ I can explain steaming with latent heat and tell James Watt's story.
- ☐ I can compare the heat of steam and hot water by calculation.
- ☐ I steamed fish to 145 °F and vegetables to tender-crisp safely.

LAB NOTEBOOK

1. Draw your steamer setup in cross-section, labeling water, steam, condensation on the food and the lid.
2. Record your steam-versus-boil comparison table.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$q_{\text{steam}} = mL_v + mc\Delta T$$
$$q_{\text{water}} = mc\Delta T$$

From history. Watt's improved steam engines, patented in 1769, powered mills, mines and later ships and locomotives. The unit of power, the watt, is named for him; your kitchen burner and microwave are rated in watts.

WORKED EXAMPLES

Example 1. Compare the heat released to your skin by 1 g of steam at 100 °C that condenses and cools to 40 °C with 1 g of water at 100 °C cooling to 40 °C.

Show solution

1. Steam: $q = 2260 + 1(4.186)(60) = 2260 + 251 = 2511$ J.
2. Water: $q = 1(4.186)(60) = 251$ J.
3. Ratio: $2511/251 \approx 10$.

Answer: The steam delivers about 10 times as much heat as the same mass of boiling water. Open lids away from you.

Example 2. Watt found condensing steam could heat about 6 times its weight of cold water to boiling. Check this with Black's numbers: how much water at 10 °C can 1 g of steam heat to 100 °C?

Show solution

1. Heat from 1 g of steam condensing (staying at 100 °C): 2,260 J.
2. Heat needed per gram of water: $4.186 \times 90 = 377$ J.
3. $2260 / 377 = 6.0$ g.

Answer: About 6 g, just as Watt measured.

Example 3. A steamer pot holds 1.5 L of water. Steaming for 25 minutes boils away water at about 1 g per second. Will it run dry?

Show solution

1. Water used: $25 \times 60 \times 1 = 1500$ g $= 1.5$ L.
2. That is all of it, which would scorch the pot.

Answer: It would run dry at the very end. Use more water, lower the heat to a steady simmer, or check and add boiling water halfway.

PRACTICE

1. Easy Why does steamed food not brown?

   Show answer

   Steam cannot heat the surface above 212 °F, too low for fast browning.

2. Easy Why should a steamer lid be opened away from you?

   Show answer

   A cloud of steam escapes toward whoever is in front of the lid, and steam burns are severe.

3. Easy What was James Watt repairing when he began measuring steam?

   Show answer

   A model Newcomen steam engine at the University of Glasgow, in 1763–64.

4. **Medium** How much heat does 5 g of steam release when it condenses at 100 °C?

   Show answer

   $5 \times 2260 = 11{,}300$ J

5. **Medium** Why does steaming keep more vitamin C in broccoli than boiling?

   Show answer

   Vitamin C dissolves in water; in steaming the broccoli is not immersed, so less leaches out.

6. **Medium** Name three ways to steam without a steamer basket.

   Show answer

   A heatproof plate on a rack or upturned bowl in a covered skillet; a metal colander in a covered pot; a sealed foil or parchment packet in the oven (en papillote); a microwave-safe covered dish.

7. **Medium** What is the safe internal temperature for fish, and how does steamed fish look when done?

   Show answer

   145 °F; opaque and flaking easily.

8. **Hard** How much water at 20 °C can 10 g of steam heat to 100 °C?

   Show answer

   Per gram of water $4.186 \times 80 = 335$ J; $22{,}600 / 335 = 67$ g.

9. **Hard** Steamed broccoli takes 5 minutes for 1-inch florets. Estimate for ½-inch florets and explain.

   Show answer

   About 1¼–2 minutes; by the square rule, half the size takes about a quarter of the time (heat still must travel inward), though real times are a bit longer.

10. **Challenge** Explain why a burn from steam escaping a pressure cooker or a covered pot can be worse than a splash of boiling water, using the idea of latent heat.

    Show answer

    Steam that touches skin condenses, releasing 2,260 J per gram before it even starts to cool, about ten times the heat of the same mass of boiling water, and it spreads over the skin as a cloud.

COMMON MISTAKES

- Letting the steamer boil dry.
- Lifting the lid often; each time, the steam and heat escape.
- Leaning over the pot when opening the lid.
- Overcooking fish until it is dry and rubbery.

> **Make it a game · Steam Burn Estimate.** Explain to your parent why steam at 212 degrees Fahrenheit burns worse than water at the same temperature. Each of you writes an estimate of how many times more energy steam carries. Then compare with the latent heat idea. Add one safety rule for lifting a steamer lid. Closest estimate wins, and each safety rule counts.

4.3 Braising: Abraham Darby's Iron Pot and Collagen to Gelatin

OBJECTIVES

- Explain how slow, moist heat converts tough collagen into gelatin, and why tough cuts become tender when braised.
- Tell how Abraham Darby's 1707 patent for casting iron pots in sand made heavy cooking pots affordable.
- Compare cost per serving of tough and tender cuts and plan a long braise backward from dinner time.
- Braise a beef pot roast with vegetables until fork-tender.

> **Warm-up.** Look at a package of beef chuck and a package of beef tenderloin or sirloin at the store (or online prices). Which costs more per pound? Which do you think is tougher, and why would anyone buy the tough one?

WATCH

A Tasting of Culinary Science—Collagen

The Culinary Institute of America · 3:57

https://www.youtube.com/watch?v=Fb_NVHUl1b8

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Pause at the animation of collagen unwinding into gelatin and sketch it.

Note: From the Culinary Institute of America's culinary-science series.

KEY TERMS

braise

To brown food, then cook it slowly, covered, in a small amount of liquid at a low simmer, usually in the oven.

stew

Like braising, but with smaller pieces fully covered in liquid.

collagen

The tough protein of connective tissue (tendons, the sheaths around muscle). It dissolves into gelatin with long, moist heat.

gelatin

The soft, water-holding protein formed from collagen; it gives braises a silky, rich texture and sets when chilled.

Dutch oven

A heavy, lidded cast-iron (often enameled) pot used on the stove and in the oven for braising, stewing and baking.

CORE IDEAS

The story. In the early 1700s cooking pots were often made of brass, which was costly. Abraham Darby, a Quaker ironmaster in Bristol, England, had seen how Dutch founders cast brass pots in sand molds. In 1707 he patented a method for casting thin-walled *iron* pots in sand, and at his works in Coalbrookdale he went on to smelt iron with coke instead of charcoal. His cheap, sturdy cast-iron pots spread into kitchens across Britain and its colonies. The heavy lidded pot that cooks still call a "Dutch oven" carries the memory of that Dutch casting method.

How they figured it out. Generations of cooks learned that the toughest, cheapest cuts of meat, the hardworking shoulder, shank and brisket, became meltingly tender if cooked very slowly in a covered pot with a little liquid. A heavy iron pot held a steady, gentle heat at the edge of a fire, perfect for this. Food scientists later explained what cooks had discovered.

The kitchen science. Muscles that work hard are wrapped in a lot of **collagen**, a rope-like protein that makes meat tough. Muscle fibers themselves firm up and squeeze out moisture as they heat (above about 140 °F), but collagen begins to melt into **gelatin** only with long, moist heat around 160–180 °F and above, and it takes hours. So a braise is cooked far beyond "done" for safety, to about 195–205 °F inside, until the collagen has turned to gelatin, which coats the fibers and makes the meat seem juicy and tender. Browning first adds flavor (Maillard reaction); a low oven (about 300 °F) keeps the liquid at a gentle simmer so the meat does not dry out at the surface.

Let's cook. You will braise a beef chuck pot roast with onions, carrots and potatoes. The technique standard: meat patted dry and well browned on all sides, aromatics softened, liquid reaching about one-third to halfway up the meat, pot covered and braised at a low simmer until a fork slides in with no resistance, and the sauce skimmed of fat and seasoned.

PICTURE STUDY



Coalbrookdale by Night, Philip James de Loutherbourg, 1801 · Oil on canvas · Science Museum, London

Image: Wikimedia Commons, public domain

Coalbrookdale, in Shropshire, England, is where Abraham Darby built his ironworks. By 1801 the valley glowed all night with furnaces. This painting shows the industry that made iron pots, kettles and stoves cheap enough for ordinary kitchens.

Look closely

- Find the brightest part of the painting. What is happening there?
- Look for the people and the cart. How small are they next to the works?
- Find the smoke. What does it tell you about the fuel being burned?

Talk about it

1. How did cheap cast-iron pots change what ordinary families could cook?
2. Why is iron a good material for a slow-braising pot?
3. What does this painting suggest about the work and the dangers behind everyday tools?

Safety first. Lay the roast into the hot oil away from you and use tongs and a fork to turn it. The Dutch oven and its lid will be very hot and heavy: use two dry mitts, lift with both hands, and tell anyone nearby before you carry it. Cool leftovers by the two-stage rule.

KITCHEN LAB

Braising Lab: Beef Pot Roast with Vegetables

You will brown and braise a tough cut until tender, testing it with a fork and a thermometer, and chill some of the sauce to see the gelatin set.

You will need

- A Dutch oven or heavy oven-safe pot with lid (5–7 quarts)
- Tongs, a meat fork, a wooden spoon and a ladle
- An instant-read thermometer
- A fat separator or a spoon for skimming
- A small dish for the gelatin test

Beef Pot Roast with Carrots and Potatoes

Serves 6–8 · Prep 30 min · Braise 3–3½ hr

Ingredients

- 1 boneless beef chuck roast, 3–3½ lb (1.4–1.6 kg)
- 2 teaspoons kosher salt and 1 teaspoon black pepper
- 2 tablespoons neutral oil
- 2 onions, sliced
- 2 cloves garlic, smashed
- 2 tablespoons tomato paste
- 2 cups (480 mL) beef broth
- 1 tablespoon Worcestershire sauce (optional; check the label for fish)
- 2 bay leaves and 3 sprigs fresh thyme (or 1 teaspoon dried)
- 1½ lb carrots, cut in 2-inch pieces
- 1½ lb small potatoes, halved
- Chopped parsley

Method

1. Heat the oven to 300 °F (150 °C). Pat the roast dry and season it all over with salt and pepper.

2. Heat the oil in the Dutch oven over medium-high heat. Brown the roast well on all sides, 10–12 minutes. Move to a plate.
3. Lower the heat to medium. Add the onions and cook 5 minutes, scraping up the browned bits. Add the garlic and tomato paste and stir 1 minute.
4. Add the broth, Worcestershire, bay and thyme, and return the roast with any juices. The liquid should come about one-third of the way up. Bring to a simmer, cover and move to the oven.
5. Braise 2 hours. Add the carrots and potatoes around the meat, cover and braise 1–1½ hours more, until a fork slides into the meat with no resistance (about 200 °F inside) and the vegetables are tender.
6. Move the meat and vegetables to a platter. Skim the fat from the liquid, remove the herbs, and simmer to thicken slightly if you like. Season, slice or pull the meat apart, and serve with the sauce and parsley.

Allergy check: Worcestershire sauce usually contains fish (anchovies); omit it if needed. Check the broth label for wheat or soy.

Steps

1. **Plan backward.** Write the timeline from your dinner hour back to your start time.
2. Weigh the raw roast. Brown and braise it.
3. **Tenderness log.** At 1½, 2½ and 3 hours (and at the end), record the internal temperature and how easily a fork slides in (1 = tough, 5 = slides right in).
4. Weigh the cooked meat and calculate the cooked yield percentage and the cost per serving.
5. **Gelatin test.** Refrigerate ¼ cup of the strained braising liquid overnight. Does it set? What does that show?
6. **Technique check.** Score 1–3: deep browning, proper liquid level, gentle oven braise, fork-tender meat, skimmed and seasoned sauce, safe handling of the hot pot.
7. Cool and store leftovers safely. Clean up.
8. **Repeat round.** Make a beef or chicken-thigh stew with the same principles.

Tips

- Do not rush the browning; it is where the flavor starts.
- Braising liquid should barely bubble; adjust the oven down 25 °F if it boils hard.
- Chill overnight and lift off the hardened fat for the cleanest sauce.

Check your work

- ☐ I can explain collagen and gelatin and why tough cuts suit braising.
- ☐ I can tell Abraham Darby's story.
- ☐ I braised a fork-tender pot roast and calculated its cost per serving.

LAB NOTEBOOK

1. Draw a muscle with fibers and collagen sheaths before and after braising.
2. Graph your tenderness log (fork score and temperature against time).
3. Write the lab record with yield, cost per serving, a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{cost per serving} = \frac{\text{total cost}}{\text{servings}}$$

$$\text{cooked yield } \% = \frac{\text{cooked weight}}{\text{raw weight}} \times 100$$

From history. Abraham Darby's grandson, Abraham Darby III, built the famous Iron Bridge over the River Severn near Coalbrookdale in 1779, the first major bridge in the world made of cast iron. It still stands.

WORKED EXAMPLES

Example 1. A 3.5-lb chuck roast costs $6.49/lb and loses 35% of its weight during braising. Each serving is 4 oz cooked. How many servings, and what is the meat cost per serving?

Show solution

1. Cost: $3.5 \times \$6.49 = \$22.72$.
2. Cooked weight: $3.5 \text{ lb} \times 0.65 = 2.28 \text{ lb} = 36.4 \text{ oz}$.
3. Servings: $36.4 / 4 \approx 9$.
4. Per serving: $\$22.72 / 9 = \$2.52$.

Answer: About 9 servings at about $2.52 each for the meat.

Example 2. Beef tenderloin costs $19.99/lb and loses 20% when roasted. Find the meat cost per 4-oz cooked serving and compare with the chuck.

Show solution

1. 1 lb raw gives $16 \times 0.80 = 12.8$ oz cooked, or 3.2 servings.
2. Per serving: $\$19.99 / 3.2 = \$6.25$.

Answer: About $6.25 per serving, roughly 2½ times the chuck. Braising turns an inexpensive cut into a feast.

Example 3. Dinner is at 6:00 p.m. The roast needs 30 minutes of prep and browning, 3½ hours in the oven, and 20 minutes to rest and finish the sauce. When must you start?

Show solution

1. Total: $0.5 + 3.5 + 0.33 = 4.33 \text{ h} = 4 \text{ h } 20 \text{ min}$.
2. 6:00 p.m. − 4 h 20 min = 1:40 p.m.

Answer: Start by 1:40 p.m. (Braises reheat beautifully, so many cooks make them a day ahead.)

PRACTICE

1. Easy What is the difference between braising and stewing?

Show answer

Braising cooks larger pieces partly covered in liquid; stewing cooks smaller pieces fully covered.

2. Easy What protein makes tough cuts tough, and what does it become when braised?

Show answer

Collagen; gelatin.

3. Easy What did Abraham Darby patent in 1707?

Show answer

A method of casting thin iron pots in sand molds.

4. Medium Why is a pot roast cooked to about 200 °F when beef is safe at 145 °F?

Show answer

Not for safety but for tenderness: collagen needs long cooking at high internal temperatures to turn into gelatin.

5. Medium Why brown the meat before braising?

Show answer

Browning (Maillard reaction) builds deep flavor and color in the meat and the fond, which flavors the sauce.

6. Medium Why braise in a 300 °F oven rather than on a high burner?

Show answer

The oven surrounds the pot with gentle, even heat, keeping the liquid at a low simmer; high direct heat can boil the liquid hard and scorch the bottom.

7. Medium A 4-lb roast loses 30% when braised. What does it weigh cooked?

Show answer

2.8 lb.

8. Hard Pork shoulder costs $2.99/lb and yields 60% cooked. What is the cost per 4-oz cooked serving?

Show answer

1 lb gives 9.6 oz = 2.4 servings; $\$2.99 / 2.4 = \$1.25$.

9. Hard Why does a braise taste and feel better the next day?

Show answer

Flavors meld; gelatin sets the sauce, which can be skimmed of hardened fat; reheating gently keeps meat moist. (Cool quickly and refrigerate within 2 hours.)

10. Challenge A cook takes a pot roast out at 170 °F after 1½ hours and finds it tough and dry. Explain in terms of muscle fibers and collagen what happened, and what to do.

Show answer

The muscle fibers had already tightened and squeezed out moisture, but the collagen had not yet had time to dissolve into gelatin, so the meat was both dry and tough. Keep braising, covered, at a low simmer until it is fork-tender (often 3 hours or more); the gelatin will make it succulent.

COMMON MISTAKES

- Taking a braise out as soon as it reaches a “safe” temperature; it needs time for the collagen.
- Covering the meat completely with liquid, which boils it instead of braising.
- Boiling the braise hard on the stovetop, which makes the meat stringy and dry.
- Crowding the pot while browning.

> **Make it a game · Collagen Countdown.** Set a one-minute timer. Name everything that happens to a tough cut during braising, from collagen to gelatin, low heat, covered pot and why a Dutch oven is ideal. Then tell Abraham Darby's 1707 story. Your parent keeps a tally of facts. Repeat the minute twice, trying to beat your own count.

4.4 Stocks and Soups: Escoffier's Foundations

OBJECTIVES

- Explain why Escoffier began *Le Guide Culinaire* with stocks, which he called the foundations of cooking.
- Make a clear chicken stock by simmering bones and mirepoix, skimming, and never boiling hard.
- Calculate mirepoix ratios, stock yield and the concentration from reduction.
- Turn your stock into a chicken noodle soup.

> **Warm-up.** Taste a spoonful of boxed chicken broth and a spoonful of water with a pinch of salt. Then read the broth label. What makes broth taste like more than salty water?

WATCH

Our Favorite Way to Make Homemade Chicken Stock

America's Test Kitchen · 10:42

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

> **WHEN TO WATCH**
> Before the lab. ATK uses a quick browned-chicken method; compare it with the long-simmered classic stock in our recipe.

Note: America's Test Kitchen browns chicken pieces for a faster stock; both methods are good.

BACKUP VIDEO

60-Second Video Tips: 3 Easy Ways to De-Fat Stock

America's Test Kitchen · 1:26

https://www.youtube.com/watch?v=UwsX0IzN46o

After straining: three ways to remove fat from your stock.

KEY TERMS

stock

A flavorful liquid made by simmering bones (and sometimes meat) with vegetables and herbs; the base for soups and sauces.

mirepoix

A mix of diced onion, carrot and celery, classically 2 parts onion to 1 part each carrot and celery by weight.

sachet d'épices

A small bundle of herbs and spices (bay leaf, thyme, parsley stems, peppercorns) added to stocks and removed later.

skimming

Removing foam and fat that rise to the surface as stock simmers, so it stays clear and clean-tasting.

reduction

Simmering a liquid to evaporate water, concentrating its flavor and gelatin.

CORE IDEAS

The story. When Auguste Escoffier published *Le Guide Culinaire* in 1903, he did not open with a famous dish. He opened with *fonds de cuisine*, the stocks, and he called them the foundation of all good cooking: the white and brown stocks, fish stock and the essences from which the great sauces and soups were built. A kitchen with good stock, he taught, could make almost anything; a kitchen without it could make little of value.

How he figured it out. Escoffier had worked in kitchens where stocks simmered all day at the back of the stove. He saw that the quality of every sauce and soup depended on them, so he set down exact methods: bones blanched or roasted, cold water brought slowly to a simmer, careful skimming, a measured mirepoix, and long, gentle cooking. Home cooks have always made a humbler version from the bones of a Sunday roast.

The kitchen science. Starting bones in cold water and heating slowly lets proteins dissolve and then clump into a foam that rises and can be skimmed off. A gentle simmer extracts flavor and dissolves collagen into gelatin, which gives stock body. A hard boil churns fat and tiny particles into the liquid and makes it cloudy and greasy. Chicken stock simmers about 3–4 hours; beef stock longer. Salt is left out, because

stock is reduced later and would become too salty. Hot stock must be cooled quickly by the two-stage rule (Lesson 1.5).

Let's cook. You will make chicken stock from the roast-chicken carcass of Lesson 3.2 (or from chicken wings or backs) and use it in chicken noodle soup. The technique standard: cold-water start, slow simmer never boiling, regular skimming, strained clear, cooled by the two-stage rule, fat removed, and a soup with evenly cut vegetables, tender noodles and good seasoning.

PICTURE STUDY



The Soup for the Poor (Die Armensuppe), Albert Anker, 1893 · Oil on canvas · Private collection, Switzerland

Image: Wikimedia Commons, public domain

Albert Anker, a Swiss painter and the son of a veterinarian, loved to paint village life. In this scene, soup is ladled out to children and needy families in winter. A pot of soup made from bones, vegetables and grain fed many people cheaply and warmly.

Look closely

- Find the kettle and the ladle. How big is the pot? How many people might it feed?
- Look at the children's bowls and pots. How will they carry the soup home?
- Look at the season. Why is hot soup especially welcome?

Talk about it

1. Why is soup one of the best ways to feed many people on a small budget?
2. What might be in this soup? How would a stock make it more nourishing?
3. Who in your community might be blessed by a pot of homemade soup?

> **Safety first.** Lift and strain a pot of hot stock with two mitts and a parent's help, pouring away from you through a strainer set over a bowl in the sink. Do not rinse raw chicken. Cool the stock by the two-stage rule and refrigerate within 2 hours; use within 3–4 days or freeze.

KITCHEN LAB

Stock Lab: Chicken Stock to Chicken Noodle Soup

You will make chicken stock from bones, measure its yield and gelatin, cool it safely, and turn it into soup.

You will need

- A large stockpot (8 quarts or more)
- A ladle, a skimmer or large spoon, a fine-mesh strainer and a large heatproof bowl
- An ice bath and shallow containers for cooling
- An instant-read thermometer
- A chef's knife and board

Homemade Chicken Stock and Chicken Noodle Soup

Serves 6 (about 10 cups stock; soup serves 6) · Stock: prep 15 min · simmer 3–4 hr. Soup: 30 min

Ingredients

- **Stock:** 1 roast-chicken carcass plus 2 lb (900 g) chicken wings or backs (or 3–4 lb wings and backs)
- 4 quarts (3.8 L) cold water
- 12 oz (340 g) mirepoix: 6 oz onion, 3 oz carrot, 3 oz celery, roughly chopped
- 1 bay leaf, 4 sprigs thyme, 6 parsley stems, 8 black peppercorns
- **Soup:** 8 cups stock
- 2 carrots and 2 celery ribs in small dice, 1 onion in small dice
- 1 tablespoon oil or butter
- 2 cups (about 3 oz) dry egg noodles
- 2 cups cooked chicken, diced or pulled into pieces
- Salt and pepper to taste; 2 tablespoons chopped parsley; lemon juice

Method

1. Put the bones in the stockpot and cover with the cold water. Bring slowly to a simmer over medium heat (30–40 minutes), skimming the

foam as it rises.

2. When it simmers, add the mirepoix and herbs. Keep it at a bare simmer, a bubble every second or two, uncovered, 3–4 hours, skimming now and then. Add a little water if the bones become exposed.
3. Strain into a bowl in the sink, pressing lightly. Cool by the two-stage rule. Refrigerate overnight, then lift off the hardened fat.
4. For the soup, cook the diced onion, carrot and celery in the oil over medium heat 6–8 minutes until soft. Add 8 cups stock and simmer 10 minutes.
5. Add the noodles and cook 6–8 minutes until tender. Add the chicken and heat to 165 °F. Season with salt, pepper, parsley and a squeeze of lemon.

Allergy check: Egg noodles contain wheat and eggs; butter contains milk. Use rice or gluten-free noodles and oil as needed.

Steps

1. **Weigh the mirepoix** and check the 2:1:1 ratio.
2. **Simmer log.** Record the temperature of the stock every 30 minutes (aim for about 185–200 °F) and how much foam you skimmed.
3. Strain and measure the yield in cups; calculate the percentage of water lost.
4. **Cooling log.** Record temperatures to prove the two-stage rule was met.
5. **Gelatin test.** After chilling, describe the set: liquid, soft jelly or firm jelly.
6. Make the soup. Taste a spoonful of plain stock, then the seasoned soup, and note the difference salt and lemon make.
7. **Technique check.** Score 1–3: cold start, steady simmer, skimmed, clear, cooled correctly, soup vegetables evenly diced and tender, noodles not mushy, seasoning balanced.
8. **Repeat round.** Make a vegetable stock (no bones, 45–60 minutes) and compare.

Tips

- Cook noodles separately if you plan leftovers; they soak up broth and turn soft.
- Freeze stock in 1- and 2-cup containers for recipes all year.

- Roasting the bones first makes a darker, richer brown stock.

Check your work

- ☐ I can explain why stocks are the foundation of cooking.
- ☐ I made a clear, gelatin-rich stock and cooled it safely.
- ☐ I made a well-seasoned chicken noodle soup from my stock.

LAB NOTEBOOK

1. Draw a stockpot cross-section labeling bones, mirepoix, sachet, foam and fat.
2. Record your simmer, yield and cooling logs.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

Mirepoix $= 2:1:1$ onion : carrot : celery by weight

$C_2 = C_1 \times \dfrac{V_1}{V_2}$ (concentration after reducing from volume V_1 to V_2)

From history. Escoffier's *Le Guide Culinaire* was translated into English in 1907 as *A Guide to Modern Cookery*. Professional cooking schools around the world still begin with the stocks.

WORKED EXAMPLES

Example 1. Your stock needs 12 oz of mirepoix. How much onion, carrot and celery do you use?

Show solution

1. Parts: 2 + 1 + 1 = 4; each part $12/4 = 3$ oz.
2. Onion $2 \times 3 = 6$ oz, carrot 3 oz, celery 3 oz.

Answer: 6 oz onion, 3 oz carrot, 3 oz celery.

Example 2. You start with 4 quarts of water and end with 2½ quarts of strained stock. What percentage evaporated or was absorbed? If you reduce the stock further to 1¼ quarts for a sauce, how many times more concentrated is it?

Show solution

1. Loss: $\dfrac{4 - 2.5}{4} \times 100 = 37.5\%$.
2. Concentration factor: $2.5 / 1.25 = 2$.

Answer: 37.5% lost; the reduced stock is twice as concentrated (in flavor, gelatin and any salt, which is why stock is not salted).

Example 3. Homemade stock: carcass (free, saved), vegetables $1.40, herbs $0.50, for 10 cups. Boxed broth costs $3.29 per 4 cups. Compare cost per cup.

Show solution

1. Homemade: $\$1.90 / 10 = \$0.19$ per cup.
2. Boxed: $\$3.29 / 4 = \$0.82$ per cup.

Answer: About 19¢ versus 82¢ per cup, and homemade has more gelatin and no added salt.

PRACTICE

1. Easy What is the classic mirepoix ratio?

   Show answer

   2 parts onion, 1 part carrot, 1 part celery, by weight.

2. Easy Why is stock started in cold water?

   Show answer

   Proteins dissolve slowly and coagulate into foam that rises and can be skimmed, giving a clearer stock.

3. Easy Why should stock simmer, not boil?

   Show answer

   Boiling emulsifies fat and stirs up particles, making stock cloudy and greasy.

4. Medium How much onion is in 1 lb (16 oz) of mirepoix?

Show answer

8 oz.

5. Medium Why is salt left out of stock?

Show answer

Stock is often reduced later, which concentrates salt; it is seasoned when used.

6. Medium What does it mean if cold stock sets into a jelly?

Show answer

It contains plenty of gelatin dissolved from collagen in the bones and skin, a sign of good body.

7. Medium What did Escoffier call stocks, and where are they in his book?

Show answer

The foundations of cooking (fonds de cuisine); they open *Le Guide Culinaire*.

8. Hard Stock reduced from 6 cups to 1½ cups is how many times as concentrated?

Show answer

4 times.

9. Hard You have 3 quarts of hot stock. Describe exactly how you will cool it to meet the two-stage rule.

Show answer

Strain into a metal bowl or pot set in an ice bath, stir often until below 70 °F within 2 hours, then divide into shallow containers (2 inches deep or less) and refrigerate to 41 °F within 4 more hours; log temperatures.

10. Challenge A cook boils stock hard for 2 hours to save time. Predict the stock's appearance, flavor and body compared with one simmered 4 hours, and explain.

Show answer

Cloudy and greasy (emulsified fat and particles), flatter in flavor, and with less gelatin, because collagen needs long, gentle extraction; much water also boils away, concentrating any bitterness.

COMMON MISTAKES

- Boiling stock hard.
- Salting stock before reducing it.
- Leaving a big pot of stock to cool on the stove overnight.
- Overcooking noodles in the soup.

Make it a game · Stock Quiz Duel. Your parent quizzes you in a fast duel on stock: why Escoffier began with it, the mirepoix ratio, sachet d'épices, why you skim, and what reduction does. Each right answer scores a point; each wrong answer scores one for your parent. Then explain why the stock should simmer and not boil. First to ten wins.

Scripture. “And Jacob sod pottage: and Esau came from the field, and he was faint:” (Genesis 25:29, KJV)

“Sod pottage” means Jacob had boiled a thick soup. Esau was so hungry that he traded his birthright for a bowl of it. Good soup is a great comfort, but hunger of the moment should never cost us what matters most.

4.5 The Pressure Cooker: Denis Papin's Steam Digester

OBJECTIVES

- Tell how Denis Papin showed his steam digester to the Royal Society in 1679 and why he added a safety valve.
- Explain how higher pressure raises the boiling point of water, and estimate how much faster food cooks.
- Operate a pressure cooker safely with a parent present, or cook the same recipe on the stovetop.
- Cook dried black beans from scratch and serve them with rice.

> **Warm-up.** Look up the boiling point of water at the top of Pikes Peak (14,115 feet) or estimate it with the rule from Lesson 3.5. Why might mountain hikers find that beans and pasta never seem to cook through?

WATCH

The Science Behind Pressure Cookers

America's Test Kitchen · 1:50

https://www.youtube.com/watch?v=wMEAl-uRnbg

> **WHEN TO WATCH**
> After the story. Write down the boiling temperature shown inside the cooker.

Note: Short; watch the backup too for the physics of pressure and boiling.

BACKUP VIDEO

Atmospheric Pressure and Boiling

Wayne Breslyn (Dr. B.) · 2:52

https://www.youtube.com/watch?v=aiwynTBdln8

After the primary: a chemistry teacher shows why lower pressure lowers the boiling point, and the syringe demonstration.

KEY TERMS

pressure cooker

A sealed pot that traps steam, raising the pressure inside and so the boiling point of water, to about 250 °F (121 °C) at full pressure.

gauge pressure

Pressure above the surrounding air pressure; most pressure cookers reach about 15 pounds per square inch (psi) gauge, roughly twice normal air pressure in total.

safety valve

A valve that releases steam if the pressure rises too high; Denis Papin invented an early form of it.

natural release

Letting a pressure cooker cool until the pressure drops by itself, rather than venting steam quickly.

legume

A plant with seeds in pods, such as beans, peas and lentils; dried beans are rich in protein and fiber.

CORE IDEAS

The story. Denis Papin was a French physicist who worked in London with Robert Boyle on air pressure. In 1679 he showed the Royal Society his "steam digester," a strong iron pot with a tightly clamped lid. Heated, it trapped the steam and cooked bones until they were soft enough to eat. In 1681 he published a book describing how his digester could soften bones and tough meat cheaply. Because a sealed pot of steam can burst, Papin fitted it with a weighted valve that let steam escape when the pressure grew too high: an early safety valve, an idea later used on steam engines.

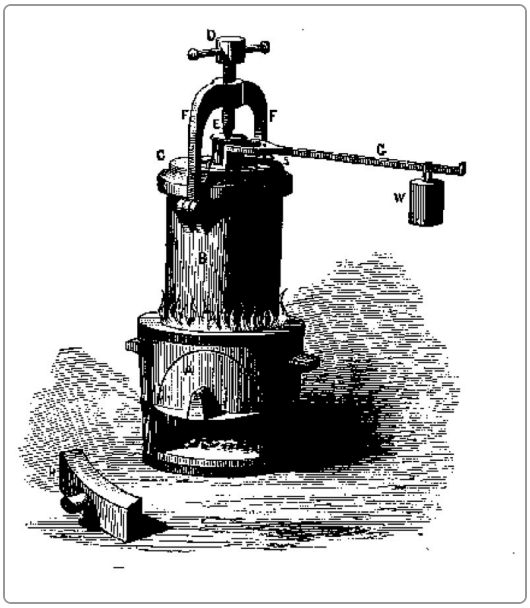
How he figured it out. Papin and Boyle had studied how air pressure changes the behavior of water. Papin reasoned that if steam could not escape, the pressure would rise and water would have to get hotter before it could boil. He tested it with stronger and stronger vessels, and he learned from the failures that a pressure vessel needs a way to let off steam. Home pressure cookers became common in the twentieth century; one of the first popular models for home kitchens was introduced at the 1939 New York World's Fair.

The kitchen science. Water boils when its vapor pressure equals the pressure around it. At sea level that happens at 212 °F. In a pressure cooker at about 15 psi

above the air outside, water must reach about 250 °F (121 °C) to boil. A rough cook's rule is that cooking reactions such as softening beans and dissolving collagen go about twice as fast for every 18 °F (10 °C) hotter, so dried beans, stocks and tough cuts cook in a third of the time or less. Pressure cookers are safe when used correctly: never fill past two-thirds (half for beans, which foam), keep the valve clean, never force the lid, and let the pressure fall before opening.

Let's cook. You will cook dried black beans with onion, garlic and cumin, either in a pressure cooker with a parent present or on the stovetop, and serve them with rice. The technique standard: beans sorted and rinsed, cooker filled no more than half full, correct pressure and release, beans fully tender and creamy (no chalky centers), and seasoning balanced with salt, acid and a little fat.

PICTURE STUDY



Papin's Steam Digester, Unknown engraver, Late 17th century (published engraving) · Engraving · Wikimedia Commons

Image: Wikimedia Commons, public domain

This old engraving shows Denis Papin's steam digester: a strong vessel with a lid screwed down by a frame and a weighted lever on top, the safety valve. It is the ancestor of the pressure cooker and of the pressure canner that home canners use for low-acid foods.

Look closely

- Find the lid and the clamp. Why must the lid be held down so firmly?
- Look for a valve or weight on top. What is its job?
- Find the fire. How would they control the heat?

Talk about it

1. What would happen if steam could not escape at all?
2. Why did people in Papin's time want to soften bones and tough meat?
3. Which modern kitchen tools descend from this invention?

Safety first. Use a pressure cooker only with a parent present and follow its manual: check the gasket and valve, fill beans no more than halfway, lock the lid, never force it open, and release pressure as directed with the valve pointed away from everyone. Without a pressure cooker, simmer the beans on the stovetop instead.

KITCHEN LAB

Pressure Lab: Black Beans and Rice

You will cook dried black beans, compare the time with stovetop cooking (by your own test or a published time), and calculate the savings of cooking beans from scratch.

You will need

- A stovetop or electric pressure cooker (optional; used with a parent present) or a large pot with lid
- A colander and a large bowl
- A medium saucepan with lid for rice
- A timer and a kitchen scale
- A wooden spoon and a potato masher

Black Beans and Rice

Serves 6–8 · Pressure: 50 min total. Stovetop: soak overnight, simmer 1–1½ hr

Ingredients

- 1 lb (450 g) dried black beans, sorted and rinsed
- 1 tablespoon olive oil
- 1 onion, diced; 1 green bell pepper, diced
- 4 cloves garlic, minced
- 2 teaspoons ground cumin and 1 teaspoon dried oregano
- 2 bay leaves
- 6 cups water (pressure cooker) or 8 cups (stovetop)
- 1½ teaspoons salt, more to taste
- 1–2 tablespoons lime juice or vinegar
- **Rice:** 2 cups long-grain rice, 3 cups water, 1 teaspoon salt
- To serve: chopped cilantro, diced onion, sour cream or grated cheese

Method

1. **Pressure cooker (parent present):** Heat the oil in the cooker on sauté or medium heat. Cook the onion and pepper 5 minutes; add garlic, cumin and oregano for 30 seconds. Add the beans, bay leaves and 6 cups water (no more than half full). Lock the lid and cook at high pressure 30–35 minutes for unsoaked beans (10–12 for soaked). Let the pressure release naturally, about 20 minutes, before opening.
2. **Stovetop:** Soak the beans overnight in plenty of water and drain. Cook the vegetables and spices in a large pot, add the beans, bay leaves and 8 cups water, bring to a boil, then simmer partly covered 1–1½ hours, stirring now and then, until creamy.
3. Taste a few beans: they must be creamy all the way through. Stir in the salt and simmer 10 minutes more, mashing a cup of beans to thicken the liquid.
4. Meanwhile cook the rice: bring rice, water and salt to a boil, cover, cook on low 18 minutes and rest 10.
5. Finish the beans with lime juice, taste and adjust. Remove the bay leaves. Serve over rice with toppings.

Allergy check: Contains none of the nine major allergens; sour cream and cheese toppings contain milk.

Steps

1. Sort the beans on a sheet pan, removing any small stones, and rinse them. Weigh them.
2. **Safety check.** With your parent, read the cooker's manual and check the gasket and valve. Write down the maximum fill line.
3. Cook the beans by the pressure method or the stovetop method, recording each stage's time (heat-up, at pressure or simmer, release).
4. **Doneness test.** Bite 5 beans and record whether each is creamy throughout.
5. Measure the cooked beans in cups and calculate the cost per cup against canned beans at your store.
6. **Technique check.** Score 1–3: beans sorted, cooker filled correctly, safe pressure and release (or steady simmer), beans fully tender, seasoned with salt and acid.

7. Cool and refrigerate or freeze leftover beans within 2 hours. Clean the cooker's lid, gasket and valve.
8. **Repeat round.** Cook chickpeas or pinto beans and compare time and cost.

Tips

- Old dried beans cook more slowly; buy from a store that sells many.
- Salt does not keep beans from softening; add it during cooking for better-seasoned beans.
- Acid (tomato, vinegar, lime) slows softening, so add it near the end.

Check your work

- ☐ I can tell Denis Papin's story and explain the safety valve.
- ☐ I can explain why pressure raises the boiling point and estimate the time saved.
- ☐ I cooked tender, well-seasoned black beans safely and served them with rice.

LAB NOTEBOOK

1. Draw a cross-section of a pressure cooker, labeling the lid lock, gasket, valve, steam space and maximum fill line.
2. Record your timing and cost data.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

rate factor $\approx 2^{\Delta T/10\,^{\circ}\mathrm{C}}$ (rough rule of thumb)
$1\ \mathrm{atm} = 14.7\ \mathrm{psi}$

From history. Papin also worked on early steam-powered machines and, in 1707, built a paddle boat in Germany. Although it is uncertain whether it ever ran by steam, his ideas about pressure, steam and safety valves influenced the engineers who followed him.

WORKED EXAMPLES

Example 1. A pressure cooker runs at 15 psi gauge. What is the total pressure in atmospheres? About what is water's boiling point there?

Show solution

1. Total $= 14.7 + 15 = 29.7$ psi ≈ 2.0 atm.
2. From steam tables, water boils at about 121 °C (250 °F) at 2 atm.

Answer: About 2 atmospheres and 121 °C (250 °F).

Example 2. Use the rough rule that cooking goes twice as fast for every 10 °C rise. If soaked beans simmer tender in 75 minutes at 100 °C, estimate the time at 121 °C.

Show solution

1. Rise: 21 °C; factor $2^{21/10} = 2^{2.1} \approx 4.3$.
2. Time $\approx 75 / 4.3 \approx 17$ min.

Answer: About 17 minutes at pressure, plus time to come to pressure and release, close to the 10–15 minutes many guides give for soaked black beans.

Example 3. One pound of dried black beans ($1.89) makes about 6 cups cooked. A 15-oz can ($1.09) holds about 1½ cups drained. Compare cost per cup.

Show solution

1. Dried: $\$1.89 / 6 = \$0.32$ per cup.
2. Canned: $\$1.09 / 1.5 = \$0.73$ per cup.

Answer: Dried beans cost less than half as much per cup, and a pressure cooker makes them nearly as quick.

PRACTICE

1. Easy Who invented the steam digester, and when did he show it to the Royal Society?

   Show answer

   Denis Papin, 1679.

2. Easy About what temperature does water boil inside a pressure cooker at full pressure?

Show answer

About 250 °F (121 °C).

3. Easy What is the purpose of a safety valve?

Show answer

To release steam if the pressure becomes too high, preventing the vessel from bursting.

4. Medium Why do beans take longer to cook at high altitude?

Show answer

Lower air pressure lowers the boiling point, so the water is cooler and cooking reactions are slower.

5. Medium Why may beans fill a pressure cooker only halfway?

Show answer

They foam as they cook, and foam can clog the valve.

6. Medium A pressure cooker reaches 115 °C. Using the rough doubling rule, how much faster than boiling at 100 °C?

Show answer

$2^{1.5} \approx 2.8$ times faster.

7. Medium What does “natural release” mean, and why is it used for beans?

Show answer

Letting the pressure drop on its own; it prevents foamy liquid from spraying through the valve and lets beans finish gently without bursting.

8. Hard At 5,000 feet, water boils at about 203 °F. In a pressure cooker at 15 psi gauge (outside air about 12.2 psi there), is the boiling point higher or lower than at sea level? Explain.

Show answer

Slightly lower: total pressure is about 27.2 psi instead of 29.7, so the boiling point is a few degrees below 250 °F; cooking times at altitude are lengthened slightly.

9. Hard A recipe cooks 2 cups of dried beans (about 13 oz). How many cups cooked will it make, using 1 lb ≈ 6 cups?

   Show answer

   $13/16 \times 6 \approx 4.9$ cups.

10. Challenge Papin learned from failures that a pressure vessel must have a way to release steam. Write a short safety checklist for using a modern home pressure cooker, with the reason for each rule.

    Show answer

    Example: parent present (supervision); check the gasket and valve are clean (so pressure can release); fill no more than two-thirds, half for beans (room for steam and foam); lock the lid fully (seal); never force the lid open (pressure inside); release pressure as the recipe says, venting away from people (steam burns); clean the valve after use.

COMMON MISTAKES

- Overfilling the cooker with beans or grains that foam.
- Forcing the lid open before the pressure has dropped.
- Using a pressure cooker as a canner; home canning of low-acid foods needs a tested pressure-canner process and an adult.
- Adding acid at the start, so the beans stay hard.

> **Make it a game · Pressure Scenarios.** Your parent poses pressure cooker scenarios: dry black beans, steam escaping, lid that will not open, cooking at altitude. For each, give the correct step and why the safety valve and gauge pressure matter. Explain natural release for beans. Tell how Papin showed the Royal Society his digester in 1679. Five scenarios, no hints.

UNIT 4

Cooking Methods: Moist Heat and Combination

Moist-heat cooking surrounds food with water or steam. Because water at sea level cannot rise above 212 °F, moist heat is gentle, steady and forgiving, and it is the key to tender pot roasts, clear stocks, bright vegetables and soft beans. In this unit you will learn boiling, simmering and poaching; steaming; braising and stewing; stocks and soups; and the pressure cooker.

The science runs from Joseph Black's discovery of latent heat and James Watt's measurements of steam to the way collagen melts into gelatin in a slow braise. The history includes Abraham Darby's cast-iron pots, Escoffier's foundation stocks and Denis Papin's steam digester. The labs make family meals: pasta with broccoli, steamed fish, a pot roast, chicken noodle soup from your own stock, and black beans and rice.

PREREQUISITES

- Units 1–3: food safety, knife skills, measurement, dry-heat cooking and thermometer use
- Comfort with $q = mc\Delta T$ (Lesson 2.4) and the two-stage cooling rule (Lesson 1.5)

MASTERY CHECKLIST

- ☐ I can poach, simmer, boil, blanch and shock, and explain why water caps at 212 °F.
- ☐ I can steam safely and explain why steam cooks quickly and burns badly.
- ☐ I can braise a tough cut until fork-tender and explain collagen and gelatin.
- ☐ I can make a clear stock and use it in a soup, cooling it safely.
- ☐ I can explain how a pressure cooker works and use one safely with a parent present.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **National Center for Home Food Preservation**: Free. The University of Georgia's tested guidance on canning and preserving, including why low-acid foods need a pressure canner. Read before any canning project.
- **A heavy Dutch oven (enameled or bare cast iron)**: Useful for braises, stews, soups and bread all year. Any heavy oven-safe pot with a tight lid works.
- **A stovetop or electric pressure cooker**: Optional, and used only with a parent present. Every recipe in this unit also has a stovetop method.

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 Boiling, Simmering and Blanching: Joseph Black's Latent Heat
3 sessions of 50 minutes

4.2 Steaming: James Watt and the Power of Steam — 3 sessions of 50 minutes

4.3 Braising: Abraham Darby's Iron Pot and Collagen to Gelatin
3 sessions of 50–90 minutes

4.4 Stocks and Soups: Escoffier's Foundations — 3 sessions of 50–90 minutes

4.5 The Pressure Cooker: Denis Papin's Steam Digester — 3 sessions of 50–90 minutes

Unit 4 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. Use $c_{\text{water}} = 4.186\ \text{J/(g}\cdot^\circ\text{C)}$ and $L_v = 2260\ \text{J/g}$. The test is worth 100 points.

1. **6 pts**
   Give the temperature ranges for poaching, simmering and boiling, and one food cooked by each.

2. **6 pts**

   What did Joseph Black discover, and why does it make water a gentle cooking medium?

3. **8 pts**

   How much energy heats 3 kg of water from 20 °C to 100 °C? How long at 1,800 W?

4. **6 pts**

   Why does salting pasta water not make it cook faster?

5. **8 pts**

   Compare the heat released to the skin by 2 g of steam at 100 °C condensing and cooling to 40 °C with 2 g of water cooling from 100 °C to 40 °C.

6. **6 pts**

   What did James Watt measure, and how did Black explain it?

7. **6 pts**

   Explain collagen and gelatin and why a pot roast cooks to about 200 °F.

8. **8 pts**

   A 4-lb chuck roast at $5.99/lb yields 65% cooked. How many 4-oz servings, and what is the cost per serving?

9. **6 pts**

   What did Abraham Darby patent in 1707, and why did it matter for home cooking?

10. **6 pts**

    Give the mirepoix ratio and the amount of each vegetable in 1½ lb (24 oz) of mirepoix.

11. **6 pts**

    Why is stock started in cold water and simmered, not boiled?

12. **6 pts**

    Stock reduced from 8 cups to 2 cups is how many times as concentrated? Why is stock unsalted?

13. **6 pts**

    Explain why a pressure cooker cooks faster, giving the approximate temperature inside.

14. **6 pts**

    Predict: dried beans are simmered with a can of tomatoes from the start. What will happen, and why?

15. **6 pts**

    Give three pressure-cooker safety rules.

16. **4 pts**

    Essay (one paragraph): Choose one moist-heat method from this unit and explain, with its science and one story, why it is the right method for a particular food.

ANSWER KEY

1. Poach 160–180 °F (eggs, fish); simmer 185–205 °F (soup, stock, braise); boil 212 °F (pasta, blanching).
2. Latent heat: water absorbs heat while boiling without getting hotter, so at sea level it cannot exceed 212 °F.
3. $3000 \times 4.186 \times 80 = 1.0 \times 10^6$ J; $1.0 \times 10^6 / 1800 \approx 558$ s ≈ 9.3 min.
4. The salt raises the boiling point by only a small fraction of a degree; it is for flavor.
5. Steam: $2(2260) + 2(4.186)(60) = 5022$ J; water: 502 J; about 10 times more.
6. That condensing steam heated about six times its weight of cold water to boiling; Black explained it with the latent heat carried by steam.
7. Collagen is tough connective-tissue protein; long, moist heat converts it to soft gelatin; reaching about 200 °F over hours gives time for that conversion, making the meat tender.
8. Cooked $4 \times 0.65 = 2.6$ lb $= 41.6$ oz ≈ 10 servings; $\$23.96 / 10 = \$2.40$.
9. Casting thin iron pots in sand molds; it made sturdy cooking pots cheap enough for ordinary households.
10. 2:1:1; 12 oz onion, 6 oz carrot, 6 oz celery.
11. Cold start lets proteins coagulate slowly into skimmable foam; a simmer keeps fat and particles from emulsifying into a cloudy, greasy stock.
12. 4 times; salt would be concentrated too.
13. Trapped steam raises the pressure to about 2 atm, raising water's boiling point to about 250 °F (121 °C); hotter water cooks faster.
14. They will take much longer to soften or stay firm, because acid slows the breakdown of the bean's cell walls; add acid near the end.
15. Any three: parent present; check gasket and valve; fill no more than two-thirds (half for beans); lock the lid; never force it open; release pressure as directed, venting away from people.
16. Answers vary. A strong answer names the method, the food, the physical reason (latent heat, gentle temperature cap, collagen to gelatin, raised boiling point) and connects a story (Black, Watt, Darby, Escoffier or Papin).

UNIT PROJECT: ONE CHICKEN, THREE MEALS

Plan and cook three meals from one whole chicken using moist and dry heat: roast or braise the chicken for the first meal, make stock from the carcass, and use the stock and leftover meat in a soup or stew for a second meal and a rice or bean dish for a third.

Write a plan and timeline, a grocery list with prices, and a cost-per-serving calculation for all three meals. Keep logs of temperatures (cooking, cooling and reheating) and record family ratings. Finish with a one-page reflection on how much food and money one chicken provided and what you would change.

LOOK FOR	WHAT IT MEANS
Planning	Clear three-meal plan, timeline and grocery list with prices.
Technique and safety	Correct methods; chicken to 165 °F; stock simmered and cooled by the two-stage rule; leftovers reheated to 165 °F.
Cost	Accurate cost-per-serving calculations for all three meals.
Records	Complete temperature logs and family ratings.
Reflection	Honest assessment of results, waste avoided and one improvement.

UNIT 5

Sauces, Eggs and Breakfast

Sauces turn simple food into a meal, and eggs are the most versatile ingredient in the kitchen. In this unit you will learn the classical mother sauces in their family-kitchen forms: a béchamel and cheese sauce, a tomato sauce from Naples, and a pan gravy built on the fond of seared meat. Then you will cook eggs four ways and finish with a family breakfast served hot and on time.

The stories run from Marie-Antoine Carême, the poor boy who became the "king of chefs," and Antonio Latini's 1692 tomato sauce, to Annette Poulard's omelettes at Mont-Saint-Michel and Amelia Simmons's 1796 *American Cookery*. The science covers starch gelatinization, pH and acidity, Maillard browning in the fond, protein denaturation in eggs and the chemistry of baking soda.

PREREQUISITES

- Units 1–4: safety, knife skills, measurement, dry and moist heat, and stock making
- Comfort with ratios, °F/°C conversion and simple chemical equations

MASTERY CHECKLIST

- ☐ I can make a roux and a smooth béchamel, and name the five mother sauces.
- ☐ I can make and balance a tomato sauce, explaining acidity with pH.
- ☐ I can deglaze a pan and thicken a gravy with a roux or a slurry.
- ☐ I can cook eggs scrambled, fried, poached and as an omelet, safely and to standard.
- ☐ I can plan and serve a hot family breakfast on time, explaining chemical leavening.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **Library of Congress: *American Cookery* by Amelia Simmons (1796)**: Free. Search the Library of Congress website (loc.gov) for the title to read the first American cookbook online; look for the recipes that call for pearlash.
- **An 8-inch nonstick skillet**: For omelets and eggs. Keep it for eggs only and it will last for years.
- **pH test strips**: Optional and inexpensive; used to test tomato sauce and other foods in Lesson 5.2.

Not required. Every recipe in this unit works in an ordinary home kitchen.
School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

5.1 The Mother Sauces: Carême, Escoffier and the Béchamel 3 sessions of 50 minutes

5.2 Tomato Sauce: Antonio Latini and the Neapolitan Tomato
3 sessions of 50 minutes

5.3 Pan Sauces and Gravy: Escoffier's Brown Sauce at Home 3 sessions of 50 minutes

5.4 Egg Cookery: Mère Poulard's Omelette 3 sessions of 50 minutes

5.5 The Family Breakfast: Amelia Simmons, Pearlash and Pancakes
3 sessions of 50–90 minutes

Unit 5 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Name the five mother sauces and the family-kitchen substitute used in this course for espagnole.

2. **6 pts**
   Who was Carême, and what did Escoffier change about his list of sauces?

3. **8 pts**

   How much butter and flour make 5 cups of medium béchamel? Of thin?

4. **6 pts**

   Explain why flour stirred straight into hot milk makes lumps but a roux does not.

5. **6 pts**

   Tomatoes are about pH 4.4 and milk about pH 6.6. How many times more acidic are tomatoes?

6. **6 pts**

   Give three ways to balance a sharp tomato sauce.

7. **6 pts**

   What did Antonio Latini publish, where and when?

8. **6 pts**

   Explain fond and deglazing, and how much cornstarch thickens 2 cups of gravy.

9. **6 pts**

   Why is hollandaise made only with pasteurized eggs in this course?

10. **8 pts**

    Describe denaturation and coagulation in egg cookery, and why eggs overcooked on high heat turn rubbery.

11. **6 pts**

    Give the USDA rule for egg dishes and for fried eggs.

12. **6 pts**

    A breakfast for 9 needs 2 eggs each plus 2 for the pancakes. Eggs cost $3.89 a dozen. How many dozen and what cost for the eggs used?

13. **6 pts**

    Write the reaction of baking soda with an acid and name an acid in buttermilk pancakes.

14. **6 pts**

    Predict: a cook replaces buttermilk with plain milk in a recipe leavened only with baking soda. What happens, and how would you fix it?

15. **6 pts**

    Who was Amelia Simmons, and what was pearlash?

16. **6 pts**

    Essay (one paragraph): Explain how planning a timeline is as much a part of cooking as technique, using the family breakfast as your example.

ANSWER KEY

1. Béchamel, velouté, espagnole, tomato, hollandaise; a pan sauce or gravy built on fond.
2. Marie-Antoine Carême (1784–1833), who first organized French sauces into families; Escoffier revised the list to five mother sauces in 1903.
3. Medium: 10 Tbsp each; thin: 5 Tbsp each.
4. Starch on the outside of a flour clump gelatinizes at once and seals dry flour inside; in a roux, fat coats each grain so the flour disperses before it swells.
5. $10^{2.2} \approx 160$ times.
6. Salt, fat (olive oil or butter), a little sweetness (sugar, onion, carrot); longer simmering.
7. *Lo Scalco alla Moderna*, Naples, 1692 and 1694, with one of the earliest European tomato-sauce recipes.
8. Fond is browned bits from searing; deglazing dissolves them with liquid; about 2 tablespoons cornstarch in ¼ cup cold liquid.
9. Its yolks are warmed gently and never reach 160 °F, so ordinary eggs might carry live bacteria.
10. Heat unfolds egg proteins (denaturation), which bond into a network (coagulation) that holds water; too much heat tightens the network, squeezing out water and making eggs rubbery and weepy.
11. Egg dishes to 160 °F; fried and poached eggs cooked until whites and yolks are firm (unless pasteurized).
12. 20 eggs; buy 2 dozen; cost of eggs used $20 \times \$3.89/12 = \$6.48$.
13. $\mathrm{NaHCO_3 + H^+ \rightarrow Na^+ + H_2O + CO_2}$; lactic acid in buttermilk.
14. Little gas forms and the leftover soda tastes soapy; pancakes are flat and bitter. Add lemon juice or vinegar to the milk, or use baking powder.
15. Author of *American Cookery* (1796), the first American cookbook; pearlash was refined potash from wood ashes, the first chemical leavener in American recipes.
16. Answers vary. A strong answer explains working backward from serving time, cooking items that hold well first (pancakes in a 200 °F oven) and fast or fragile items last (eggs), preparing cold items ahead, and how timing affects safety, quality and the family gathering together.

UNIT PROJECT: SAUCE AND BRUNCH SERVICE

Plan and serve a weekend brunch for your family or guests that includes at least one mother-sauce-based dish (for example, eggs on biscuits with a velouté gravy, a vegetable gratin with Mornay sauce, or shakshuka-style eggs cooked firm in your marinara), an egg dish cooked to standard, a quick bread, and fruit.

Write the menu, a shopping list with prices and the cost per serving, and a timeline from shopping to cleanup. Record temperatures for every egg dish, and photograph the table. Afterward, ask each guest for a rating and one comment, and write a reflection on what went well and what you would change.

LOOK FOR	WHAT IT MEANS
Menu and planning	Complete menu meeting the requirements; shopping list, cost per serving and a realistic timeline.
Technique	Smooth sauce of correct thickness; eggs to standard and 160 °F; quick bread properly risen.
Service	Food served hot and together near the planned time; table set.
Safety and cleanup	Safe egg handling and cooking; kitchen cleaned.
Reflection	Guest ratings recorded and one honest improvement planned.

5.1 The Mother Sauces: Carême, Escoffier and the Béchamel

OBJECTIVES

- Name Escoffier's five mother sauces and the family-kitchen versions used in this course.
- Tell how Marie-Antoine Carême first organized French sauces into families in the early 1800s.
- Make a roux and use roux ratios to thicken a sauce to a chosen consistency.
- Make a béchamel, turn it into a cheese (Mornay) sauce, and bake macaroni and cheese.

> **Warm-up.** Whisk 1 tablespoon of flour straight into 1 cup of hot milk. Then, in a second pan, cook 1 tablespoon of butter and 1 tablespoon of flour together for 2 minutes before whisking in 1 cup of milk. Compare the two after 5 minutes of simmering. Which is smooth, and why?

WATCH

Traditional Bechamel | Bechamel | How to Make a Bechamel Sauce | Bechamel Sauce | White Sauce

The Sauce and Gravy Channel · 4:57

https://www.youtube.com/watch?v=Pka0G0BHABY

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Watch how he adds the milk to the roux a little at a time.

BACKUP VIDEO

How To Make A Roux, Bechamel, & Cheese Sauce ~ Chef@Home

Chef Perry (MYKITCHEN) · 6:35

https://www.youtube.com/watch?v=9UmtN0NDZUQ

Before the lab: roux to béchamel to cheese sauce to macaroni, in one pan.

KEY TERMS

mother sauce

One of the five basic sauces of classical French cooking from which many others are made: béchamel, velouté, espagnole (brown), tomato and hollandaise.

roux

Equal weights of fat and flour cooked together; used to thicken sauces, soups and gravies without lumps.

béchamel

Milk thickened with a white roux; the base of cheese sauces, creamed dishes and lasagna.

velouté

Light stock (chicken, fish or vegetable) thickened with a blond roux; the base of many gravies and cream soups.

Mornay sauce

Béchamel with cheese melted in.

CORE IDEAS

The story. Marie-Antoine Carême (1784–1833) was abandoned as a child in Paris during hard times, found work in a cook-shop, and rose to become the most famous chef of his age, cooking for statesmen and royalty and designing towering sugar centerpieces. He wrote books that organized French cooking for the first time, and he grouped the many sauces of his day into families, each descending from a few great "mother" sauces. Seventy years later Auguste Escoffier revised the list in *Le Guide Culinaire* (1903) to five mothers: **béchamel**, **velouté**, **espagnole** (brown sauce), **tomato** and **hollandaise**.

How they figured it out. Carême saw that hundreds of sauces were really variations: a white sauce plus cheese, a stock sauce plus mushrooms, a brown sauce plus herbs. Teaching the few bases first meant a cook could make any variation. In a family kitchen we use the same idea: béchamel and its cheese sauce (this lesson), velouté as the base of gravies and cream soups, a tomato sauce (5.2), and a pan sauce or gravy in place of the long-cooked espagnole (5.3). Hollandaise, an emulsion of egg yolks and butter, is made only with pasteurized eggs, or left out.

The kitchen science. Flour thickens because its starch granules absorb liquid and swell when heated, a process called **gelatinization**; thickening begins around 140–160 °F and is complete near a simmer. Raw flour stirred into hot milk clumps: the

outside of each clump gelatinizes and seals dry flour inside. Cooking flour in fat first coats each grain so it disperses smoothly, and it cooks away the raw-flour taste. The more roux per cup of liquid, the thicker the sauce: about 1 tablespoon each of butter and flour per cup makes a thin sauce, 2 a medium sauce, and 3 a thick one. A sauce is fully thickened only after it simmers a minute or two.

Let's cook. You will make a medium béchamel, melt cheese into it for a Mornay sauce, and bake macaroni and cheese with a crisp crumb topping. The technique standard: roux cooked 2 minutes without browning, milk whisked in gradually with no lumps, sauce simmered until it coats the back of a spoon, cheese added off the heat so it melts smoothly, pasta slightly underdone before baking, and a golden top.

PICTURE STUDY



Portrait of Marie-Antoine Carême, After Charles de Steuben, Early 19th century · Print after a painted portrait · Wikimedia Commons

Image: Wikimedia Commons, public domain

Marie-Antoine Carême was called “the king of chefs and the chef of kings.” He came from nothing and became famous through study, drawing and hard work: he studied architecture in libraries to design his great sugar centerpieces, and he wrote careful books so others could learn.

Look closely

- Look at how Carême chose to be shown. Is he dressed as a cook or as a gentleman?
- What does his expression suggest about him?
- Compare this portrait with the photograph of Escoffier in Lesson 1.1.

Talk about it

1. Why might a chef in 1820 want to be painted like a gentleman?
2. Carême taught himself by reading. What could you teach yourself about cooking from books?
3. How does organizing knowledge into families (like the mother sauces) help someone learn?

> **Safety first.** Whisk hot milk into the roux slowly, and stir with a long-handled whisk so splashes do not reach your hands; a starch sauce sticks and spits as it thickens, so lower the heat once it bubbles. Bake the mac and cheese on a sheet pan to catch drips and lift it with dry mitts.

KITCHEN LAB

Sauce Lab: Béchamel to Baked Macaroni and Cheese

You will make thin, medium and thick béchamel test samples, then a Mornay sauce for a family-size baked macaroni and cheese.

You will need

- A heavy saucepan and a whisk
- A large pot and colander for pasta
- A 9 × 13-inch baking dish and a sheet pan
- A grater, measuring cups and spoons, a kitchen scale
- A spoon for the coating test

Baked Macaroni and Cheese (Mornay Sauce)

Serves 8 · Prep 20 min · Cook 15 min · Bake 20 min

Ingredients

- 1 lb (450 g) elbow macaroni or shells
- 6 tablespoons (84 g) butter
- 6 tablespoons (45 g) all-purpose flour
- 3 cups (720 mL) whole milk, warmed
- 1 teaspoon dry mustard and ¼ teaspoon paprika
- 1 teaspoon salt and ¼ teaspoon black pepper
- 12 oz (340 g) sharp cheddar cheese, grated (about 3 cups)
- ½ cup (40 g) grated Parmesan
- **Topping:** ¾ cup panko crumbs tossed with 1 tablespoon melted butter

Method

1. Heat the oven to 375 °F (190 °C). Butter the baking dish.
2. Cook the pasta in boiling salted water 2 minutes less than the package says. Drain.
3. Melt the butter in the saucepan over medium heat. Whisk in the flour and cook, whisking, 2 minutes without browning.

4. Whisk in the warm milk a little at a time, smoothing out the roux after each addition. Add the mustard, paprika, salt and pepper. Simmer 2–3 minutes, whisking, until it coats the back of a spoon.
5. Take the pan off the heat and stir in the cheddar a handful at a time until smooth, then the Parmesan. Fold in the pasta.
6. Spread in the dish, sprinkle with the topping, set on the sheet pan and bake 20 minutes, until bubbling and golden. Rest 5 minutes before serving.

Allergy check: Contains milk and wheat. Use gluten-free pasta and a gluten-free flour blend for wheat-free; milk-free versions need a dairy-free milk, fat and cheese and taste quite different.

Steps

1. **Ratio test.** Make three ½-cup samples of béchamel: thin (1½ tsp each butter and flour), medium (1 Tbsp each) and thick (1½ Tbsp each). Simmer each 2 minutes.
2. **Spoon and line test.** Dip a spoon in each, draw a finger line across the back, and record whether the line holds. Photograph them side by side.
3. Make the full recipe, recording the time the roux cooked and the time to thicken.
4. **Technique check.** Score 1–3: pale roux, no lumps, proper thickness, smooth (not grainy) cheese sauce, pasta not mushy after baking, golden topping.
5. Calculate the cost per serving from your receipt.
6. Clean up: soak the sauce pan right away in warm water; starch sauces set like glue.
7. **Repeat round.** Make a velouté with chicken stock and use it in a chicken pot pie filling or a cream of mushroom soup.

Tips

- Warm milk lumps less than cold milk.
- Grate your own cheese; bagged pre-grated cheese is coated with starch and melts less smoothly.
- If lumps form, whisk hard or pour the sauce through a strainer.

Check your work

- ☐ I can name the five mother sauces and tell Carême's story.
- ☐ I can make a roux and choose a ratio for thin, medium or thick sauce.
- ☐ I made a smooth Mornay sauce and a golden baked mac and cheese.

LAB NOTEBOOK

1. Draw a family tree of the mother sauces with two daughters each.
2. Record your ratio test with photos or sketches.
3. Write the lab record with cost per serving, a family rating and one change for the repeat round.

KEY FORMULAS

Roux per cup (240 mL) of liquid: thin 1 Tbsp each fat and flour; medium 2 Tbsp each; thick 3 Tbsp each

$1\ \text{Tbsp butter} \approx 14\ \text{g}, \quad 1\ \text{Tbsp flour} \approx 7.5\ \text{g}$

From history. By tradition, béchamel is named for Louis de Béchameil, a steward at the court of Louis XIV, though cooks were making white sauces before him. Carême died in 1833 at only 48, worn out, it was said, by years of work over charcoal fires.

WORKED EXAMPLES

Example 1. You need a medium béchamel from 3 cups of milk. How much butter and flour, in tablespoons and grams?

Show solution

1. Medium: 2 Tbsp each per cup; $3 \times 2 = 6$ Tbsp each.
2. Butter: $6 \times 14 = 84$ g; flour: $6 \times 7.5 = 45$ g.

Answer: 6 tablespoons each: about 84 g butter and 45 g flour. (By volume they are equal; by weight a roux is often given as equal weights, which is close.)

Example 2. Your béchamel is too thick for a sauce over vegetables. You made 2 cups at medium (4 Tbsp each of butter and flour). How much more milk makes it thin (1 Tbsp each per cup)?

Show solution

1. Thin ratio: 1 Tbsp each per cup, so 4 Tbsp of roux suits 4 cups.
2. Add $4 - 2 = 2$ cups of milk, whisking in gradually and simmering again.

Answer: Add about 2 more cups of milk.

Example 3. Mac and cheese: pasta \$1.29, milk (3 cups) \$0.90, butter \$0.75, cheddar (12 oz) \$4.49, Parmesan \$1.00, panko \$0.40. It serves 8. Find the cost per serving.

Show solution

1. Total $= 1.29 + 0.90 + 0.75 + 4.49 + 1.00 + 0.40 = \$8.83$.
2. Per serving $= \$8.83 / 8 = \$1.10$.

Answer: About \$1.10 per serving.

PRACTICE

1. Easy Name Escoffier's five mother sauces.

   Show answer

   Béchamel, velouté, espagnole, tomato, hollandaise.

2. Easy What is a roux, and why is the flour cooked in fat first?

   Show answer

   Fat and flour cooked together; coating the flour with fat lets it disperse without lumps and cooks off the raw taste.

3. Easy What is the difference between béchamel and velouté?

   Show answer

   Béchamel uses milk; velouté uses light stock.

4. Medium How much roux for 4 cups of thick sauce?

   Show answer

   12 Tbsp (¾ cup) each of butter and flour.

5. Medium Why add cheese off the heat?

Show answer

Very hot sauce can make cheese proteins tighten and squeeze out fat, giving a grainy, greasy sauce; gentle heat melts it smoothly.

6. Medium Who was Marie-Antoine Carême, and what did he contribute to sauces?

Show answer

A French chef (1784–1833) who organized French cooking and grouped sauces into families descended from a few mother sauces.

7. Medium Why must a roux-thickened sauce simmer a minute or two before you judge its thickness?

Show answer

Starch gelatinization finishes near the boil; the sauce thickens fully only then.

8. Hard A recipe calls for 2 cups of medium velouté for chicken pot pie. Write the ingredients and method.

Show answer

4 Tbsp butter, 4 Tbsp flour, 2 cups chicken stock: cook the roux 2 minutes (blond), whisk in warm stock gradually, simmer 2–3 minutes until it coats a spoon, season.

9. Hard You must make béchamel for 30 servings of lasagna, needing 3 quarts of medium sauce. How much butter and flour in cups?

Show answer

12 cups of milk × 2 Tbsp = 24 Tbsp each = 1½ cups each.

10. Challenge Carême organized sauces into families. Draw (in words) a family tree with béchamel at the top and at least four “daughter” sauces or dishes, explaining what is added to each.

Show answer

Example: béchamel → Mornay (cheese) → macaroni and cheese; béchamel → cream sauce (cream) → creamed spinach; béchamel → soubise (puréed onion); béchamel → lasagna white layer; béchamel → sausage gravy (sausage drippings as the fat).

COMMON MISTAKES

- Adding all the milk at once to a hot roux, which makes lumps.
- Browning the roux for a white sauce.
- Boiling the sauce after the cheese goes in, so it turns grainy.
- Fully cooking the pasta before baking, so it turns soft.

> **Make it a game · Sauce Family Tree.** Your parent reads a sauce clue: milk and roux, stock and roux, butter and egg yolk, tomato, brown stock. You name the mother sauce and one daughter, such as Mornay from béchamel. Do ten clues against the clock. Then tell how Carême first sorted sauces into families and what a roux is made of.

5.2 Tomato Sauce: Antonio Latini and the Neapolitan Tomato

OBJECTIVES

- Tell how the tomato came from the Americas to Europe and how Antonio Latini printed an early tomato-sauce recipe in Naples in 1692.
- Explain tomato acidity using pH, and how cooks balance acid with fat, salt and a little sweetness.
- Calculate reduction and cost per serving for a homemade sauce.
- Make a marinara sauce from canned tomatoes and serve it over spaghetti.

> **Warm-up.** Taste a little canned crushed tomato straight from the can. Then stir a pinch of salt into a spoonful, a drop of olive oil into another, and a pinch of sugar into a third. Which change made the biggest difference?

WATCH

How To Make Homemade Marinara Sauce

Sugar Spun Run · 4:16

https://www.youtube.com/watch?v=a4fsHkb-5Mw

> **WHEN TO WATCH**
> Before the lab. Compare her seasoning with ours, and notice how long she simmers the sauce.

BACKUP VIDEO

How to Make Marinara Sauce Using Fresh or Canned Tomatoes

Mary's Nest · 12:31

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

Optional: a longer lesson showing marinara from fresh tomatoes as well as canned.

KEY TERMS

pH

A scale of acidity: 7 is neutral, lower is acidic. Each step down is ten times more acidic. Tomatoes are about pH 4.2–4.9.

marinara

A quick Italian tomato sauce of tomatoes, garlic, olive oil and herbs, simmered briefly.

reduction

Simmering to evaporate water and concentrate flavor and body.

non-reactive pan

Stainless steel, enameled cast iron or glass, which does not react with acidic foods.

umami

The savory taste of glutamate; ripe and cooked tomatoes are rich in it.

CORE IDEAS

The story. Tomatoes came to Europe from the Americas in the 1500s. For many years Europeans grew them as curiosities, and some feared they were unwholesome. Naples, then ruled by Spain, was one of the first places where cooks embraced them. Antonio Latini, steward to a Spanish official in Naples, published *Lo Scalco alla Moderna* ("The Modern Steward") in 1692 and 1694. It contains one of the earliest printed European recipes for a tomato sauce, which he called "in the Spanish style": tomatoes roasted on coals, peeled and chopped with onion, peppers, thyme, salt, oil and vinegar.

How they figured it out. Neapolitan cooks learned by cooking that tomatoes, cooked down with oil and salt, became a rich sauce that went with everything, and by the 1800s tomato sauce on pasta was the everyday food of Naples. Italian families who came to America in great numbers around 1900 brought the sauce with them, and canned tomatoes put it on tables all year.

The kitchen science. Tomatoes are acidic, about pH 4.2–4.9; on the log scale, pH 4 is ten times as acidic as pH 5. Acid makes a sauce taste bright; too much makes it sharp. Cooks balance it with fat (olive oil coats the tongue), salt (which reduces the perception of bitterness and sharpness) and a little sweetness (a sautéed onion, a grated carrot or a pinch of sugar). Simmering evaporates water and concentrates the tomatoes' natural glutamate, the source of their savory umami. Acid reacts with bare aluminum and iron, so tomato sauce is made in stainless steel or enameled pans.

Let's cook. You will make a marinara from canned whole tomatoes crushed by hand, with garlic, olive oil, basil and a pinch of red pepper, and serve it over spaghetti. The technique standard: garlic gently golden (never brown), tomatoes simmered until

the sauce thickens and the oil glistens on top, balanced to taste in salt, acid and sweetness, and pasta finished in the sauce with a little pasta water.

PICTURE STUDY



Still Life with Cucumbers and Tomatoes, Luis Egidio Meléndez, 1772 · Oil on canvas · Museo del Prado, Madrid

Image: Wikimedia Commons, public domain

Luis Meléndez painted this still life in Spain, about eighty years after Latini's tomato sauce was printed in Spanish-ruled Naples. By then tomatoes were common in Spanish kitchens. Meléndez painted their ribbed shapes and glossy skins with great care.

Look closely

- Find the tomatoes. How ripe do they look? How can you tell?
- Look at their shapes. How are they different from round supermarket tomatoes?
- Find the pot and jug. What might the cook make with these ingredients?

Talk about it

1. What sauce or dish could you make from everything in this painting?
2. Why do canned tomatoes often make a better winter sauce than fresh out-of-season tomatoes?
3. How would you choose the best tomatoes at a market?

> **Safety first.** Crush whole tomatoes by hand in a bowl, not in the hot pan, so the juice does not spatter. Add tomatoes to hot oil carefully, standing back, and use a splatter screen or partly cover the simmering sauce. Drain pasta away from you.

KITCHEN LAB

Sauce Lab: Marinara over Spaghetti

You will make a marinara, measure its reduction, balance it by taste in rounds, and finish pasta in the sauce.

You will need

- A wide stainless or enameled sauté pan or Dutch oven
- A large pot and colander
- A large bowl for crushing tomatoes
- A measuring cup for reduction checks and for pasta water
- A wooden spoon

Marinara Sauce with Spaghetti

Serves 6 · Prep 10 min · Simmer 30 min

Ingredients

- 2 cans (28 oz each) whole peeled tomatoes
- ⅓ cup (80 mL) olive oil
- 1 small onion, finely diced (optional)
- 5 cloves garlic, thinly sliced
- ¼ teaspoon red pepper flakes
- 1 teaspoon salt, more to taste
- 1 teaspoon dried oregano (optional)
- 10 fresh basil leaves, torn, or 1 teaspoon dried
- Pinch of sugar if needed
- 1 lb (450 g) spaghetti
- Grated Parmesan to serve

Method

1. Pour the tomatoes into the bowl and crush them with your hands to small pieces (or pulse briefly in a blender).

2. Warm the oil in the pan over medium heat. If using onion, cook it 5 minutes until soft. Add the garlic and pepper flakes and cook gently 1–2 minutes, until the garlic is pale gold.
3. Stand back and add the tomatoes, salt and oregano. Bring to a simmer and cook, stirring now and then, 20–30 minutes, until thickened and the oil glistens on the surface.
4. Stir in the basil. Taste and balance: more salt if flat, a pinch of sugar if sharp.
5. Cook the spaghetti in salted boiling water 1 minute short of al dente. Save 1 cup of pasta water; drain.
6. Toss the pasta in the sauce over low heat with a splash of pasta water for 1 minute. Serve with Parmesan.

Allergy check: Contains wheat (pasta) and milk (Parmesan, optional). Use gluten-free pasta and skip the cheese as needed.

Steps

1. **Measure.** Measure the volume of sauce at the start of the simmer and at the end; calculate the percentage reduced.
2. **Balance rounds.** Taste at 10, 20 and 30 minutes. Record the flavor (sharp, flat, rich) and each adjustment you make.
3. **pH check (optional).** If you have pH strips, test the sauce at the start and end.
4. Finish the pasta in the sauce.
5. **Technique check.** Score 1–3: garlic pale gold, proper thickness, balanced seasoning, pasta al dente and coated, no splatter burns.
6. Cost the sauce per cup and compare with a jar at your store.
7. Freeze extra sauce in labeled containers. Clean up.
8. **Repeat round.** Use the same sauce base for a different dish: pizza sauce, shakshuka (eggs cooked to firm in sauce), or meatballs simmered in it.

Tips

- Whole canned tomatoes are often better quality than crushed or diced.
- A wide pan reduces faster than a deep pot.

- A Parmesan rind simmered in the sauce adds umami; remove it before serving.

Check your work

- ☐ I can tell the story of the tomato and Latini's 1692 recipe.
- ☐ I can explain tomato acidity with pH and balance a sauce.
- ☐ I made a well-balanced marinara and finished pasta in it.

LAB NOTEBOOK

1. Draw a pH scale from 0 to 14 and mark lemon juice, tomatoes, milk, water and baking soda.
2. Record your reduction and balance rounds.
3. Write the lab record with cost per cup, a family rating and one change for the repeat round.

KEY FORMULAS

$\mathrm{pH} = -\log_{10}[\mathrm{H}^+]$ (each pH unit is a factor of 10 in acidity)

$\%\ \text{reduced} = \dfrac{V_{\text{start}} - V_{\text{end}}}{V_{\text{start}}} \times 100$

From history. Neapolitans were once nicknamed "leaf eaters" for their vegetables, and later "macaroni eaters" as dried pasta became cheap in the 1700s. Street vendors sold plates of pasta with tomato sauce that customers ate with their hands.

WORKED EXAMPLES

Example 1. Tomatoes are about pH 4.3 and lemon juice about pH 2.3. How many times more acidic is lemon juice?

Show solution

1. Difference: 2 pH units.
2. $10^2 = 100$.

Answer: About 100 times more acidic (in hydrogen-ion concentration).

Example 2. You start with 7 cups of tomatoes and simmer the sauce down to 5 cups. What percentage was evaporated?

Show solution

1. $\dfrac{7-5}{7} \times 100 = 28.6\%$.

Answer: About 29% of the volume evaporated, concentrating the flavor.

Example 3. Two 28-oz cans of tomatoes cost $2.29 each; oil, garlic and basil $1.60. The sauce makes 5 cups. A 24-oz jar (about 2¾ cups) of marinara costs $4.99. Compare cost per cup.

Show solution

1. Homemade: $(2 \times 2.29 + 1.60)/5 = \$6.18/5 = \$1.24$ per cup.
2. Jar: $\$4.99/2.75 = \$1.81$ per cup.

Answer: Homemade is about $1.24 per cup versus $1.81 for the jar, and you control the salt and sweetness.

PRACTICE

1. Easy Where did tomatoes come from, and when did they reach Europe?

   Show answer

   The Americas; the 1500s.

2. Easy Name Antonio Latini's book and its dates.

   Show answer

   Lo Scalco alla Moderna, Naples, 1692 and 1694.

3. Easy Why make tomato sauce in stainless steel rather than bare aluminum or cast iron?

   Show answer

   Acid reacts with bare aluminum and iron, giving a metallic taste and damaging seasoning.

4. Medium How many times more acidic is pH 3 than pH 5?

   Show answer

   100 times.

5. Medium Name three ways to balance a sauce that tastes too sharp.

Show answer

A little more salt; more olive oil or butter; a pinch of sugar, a sautéed onion or grated carrot; simmer longer.

6. Medium Why should garlic be cooked only until pale gold?

Show answer

Browned garlic turns bitter.

7. Medium 8 cups of sauce reduced to 6 cups: what percentage evaporated?

Show answer

25%.

8. Hard Your sauce serves 6 with 1 lb of spaghetti. How many cups of sauce and pounds of pasta for 15 people?

Show answer

Factor 2.5: 12½ cups of sauce (if 5 cups serve 6) and 2½ lb of pasta.

9. Hard Explain why a tomato sauce simmered 30 minutes tastes more savory than raw crushed tomatoes.

Show answer

Evaporation concentrates glutamate (umami), sugars and flavor compounds, and gentle cooking blends the garlic and herbs into the sauce.

10. Challenge Tomato pH (4.2–4.9) is close to 4.6, the line used in home canning. Explain why home-canned tomatoes need added lemon juice or citric acid by tested recipes.

Show answer

Some tomatoes are above pH 4.6, where the bacterium that causes botulism can grow in a sealed jar; adding a measured acid, as tested USDA/NCHFP recipes require, ensures every jar is safely acidic.

COMMON MISTAKES

- Browning or burning the garlic.
- Adding sugar before tasting.
- Simmering in a bare aluminum or cast-iron pan for a long time.

- Drowning pasta in sauce instead of tossing to coat.

> **Make it a game · Tomato Truths.** Give your parent three statements about tomato sauce: two true, one false. Include pH, acid, a non-reactive pan, umami and Latini's 1692 recipe. Your parent names the false one. Then swap. Keep score across five rounds. End by predicting where a tomato sits on the pH scale.

5.3 Pan Sauces and Gravy: Escoffier's Brown Sauce at Home

OBJECTIVES

- Explain how a pan sauce or gravy uses the fond, the browned bits left after searing or roasting.
- Thicken a gravy with a roux or a cornstarch slurry, and calculate amounts for a given volume.
- Explain why hollandaise is made only with pasteurized eggs in this course.
- Cook pan-seared pork chops with pan gravy and mashed potatoes.

> **Warm-up.** Look at a pan after you have seared meat in it. What is stuck to the bottom? Pour in a few tablespoons of hot water (with a parent present) and scrape with a wooden spoon. What happens to the water's color and smell?

WATCH

How to Make Gravy from Turkey Drippings | Thanksgiving Turkey Gravy | Turkey with Gravy | Easy Gravy

The Sauce and Gravy Channel · 4:47

https://www.youtube.com/watch?v=z66z_nXmyks

> **WHEN TO WATCH**
> After the story. Watch the fond dissolve when he deglazes the roasting pan, then the roux and the broth.

Note: Made with turkey drippings; the method is the same for the pan gravy after pork chops.

KEY TERMS

espagnole
The classical brown mother sauce, made from brown stock and a brown roux, cooked for hours in restaurant kitchens.

fond
The browned, caramelized bits stuck to a pan after searing or roasting.

deglaze

To pour liquid (broth, water or juice) into a hot pan and scrape up the fond so it dissolves into a sauce.

monter au beurre

Swirling a little cold butter into a finished pan sauce to make it glossy and rich.

slurry

Cornstarch (or flour) stirred into cold liquid, then whisked into a simmering liquid to thicken it.

CORE IDEAS

The story. In Escoffier's kitchens the brown mother sauce, espagnole, took days: veal bones were roasted, simmered into brown stock, thickened with a brown roux, simmered again with browned vegetables and tomato, skimmed and strained. A great restaurant could afford the time; a family could not. Home cooks found their own way to the same flavors, using the browned bits left in the pan after a roast or a skillet of chops: the pan gravy that appears in American cookbooks from Mary Randolph's in 1824 onward.

How they figured it out. Every cook who has scrubbed a roasting pan has seen the dark, sticky fond. Cooks learned that a little liquid dissolves it into a deeply flavored sauce in minutes, and that a little flour cooked in the drippings, or a cornstarch slurry, thickens it. Escoffier's brown sauce and Grandmother's gravy rest on the same chemistry: browning first, then dissolving and thickening.

The kitchen science. The fond is concentrated Maillard browning: proteins and sugars from the meat that have reacted and stuck to the hot pan. Deglazing with broth dissolves those flavorful compounds. The sauce is thickened with a roux (flour cooked in the drippings) or a slurry (cornstarch mixed into cold liquid; about 1 tablespoon cornstarch per cup of liquid for a medium gravy). Cornstarch gives a glossy, clear sauce and thickens at a simmer; flour gives an opaque, homey gravy. Hollandaise, the fifth mother sauce, is an emulsion thickened by egg yolks that are only gently warmed, not cooked to 160 °F, so in this course it is made only with pasteurized eggs, or left out.

Let's cook. You will pan-sear boneless pork chops to 145 °F, then make a pan gravy in the same skillet and serve it with mashed potatoes. The technique standard: chops

browned with a good fond (not burned), deglazed with broth, gravy thickened smooth and seasoned, and mashed potatoes cooked tender and mashed fluffy.

PICTURE STUDY



Still Life with Coffee Pot, Milk Jug, Cup, Bread and Potatoes, Albert Anker, 1902 · Oil on canvas · Private collection, Switzerland

Image: Wikimedia Commons, public domain

Albert Anker painted simple still lifes of a Swiss farmhouse table: potatoes, bread, milk and coffee, the everyday food of village families. Nothing is fancy, and everything is painted with respect.

Look closely

- Find the potatoes. How were they cooked?
- Find the bread and the milk jug. Which foods here came from the family's own farm?
- Look at the light. What time of day might this be?

Talk about it

1. How would a gravy or sauce turn these plain potatoes into a richer supper?
2. Why do simple foods like potatoes and bread appear again and again in paintings of thankful, ordinary life?
3. What simple supper could you make for your family from what is in your pantry today?

> **Safety first.** Pour broth into the hot pan off the heat or with the burner turned low, standing back, because it will steam and spatter at once. Cook pork chops to 145 °F with a 3-minute rest. Drain potatoes by pouring away from you.

KITCHEN LAB

Sauce Lab: Pork Chops with Pan Gravy and Mashed Potatoes

You will build fond by searing, deglaze it, thicken a gravy two ways in test batches, and serve a classic family supper.

You will need

- A 12-inch stainless or cast-iron skillet (nonstick makes little fond)
- A large pot, colander and potato masher or ricer
- A whisk and wooden spoon
- An instant-read thermometer
- Small cups for the slurry

Pan-Seared Pork Chops with Pan Gravy and Mashed Potatoes

Serves 4–6 · Prep 20 min · Cook 35 min

Ingredients

- **Potatoes:** 3 lb (1.4 kg) russet or Yukon Gold potatoes, peeled and cut in 2-inch chunks
- 1 tablespoon salt for the water
- 1 cup (240 mL) warm milk and 6 tablespoons butter
- **Chops:** 4–6 boneless pork chops, about ¾ inch thick
- 1½ teaspoons salt, ½ teaspoon pepper, ½ teaspoon garlic powder
- 1 tablespoon neutral oil
- **Gravy:** 1 tablespoon butter, 1 small shallot or ¼ onion, minced
- 1½ tablespoons flour
- 1½ cups (360 mL) chicken broth
- ½ teaspoon fresh thyme or ¼ teaspoon dried; salt and pepper to taste

Method

1. Put the potatoes in a pot of cold water with the salt, bring to a boil and simmer 15–20 minutes, until a knife slides in easily. Drain well, return

to the pot over low heat for 1 minute to dry, then mash with the warm milk and butter. Season and keep warm.

2. Pat the chops dry and season. Heat the oil in the skillet over medium-high heat until shimmering. Sear the chops 3–4 minutes per side, until browned and 145 °F in the center. Move to a plate to rest.
3. Lower the heat to medium. Add the butter and shallot to the pan and cook 1 minute. Sprinkle in the flour and stir 1 minute.
4. Off the heat, whisk in the broth gradually, scraping up the fond. Return to the heat, add the thyme and any juices from the resting chops, and simmer 2–3 minutes until thickened. Season.
5. Serve the chops with the potatoes and spoon the gravy over both.

Allergy check: Contains milk (butter, milk) and wheat (flour). For wheat-free gravy use a cornstarch slurry (1½ Tbsp in 3 Tbsp cold broth); for milk-free use oil and an unsweetened plant milk.

Steps

1. Make the mashed potatoes first and keep them warm over very low heat.
2. Sear the chops; photograph the fond before deglazing.
3. **Two thickeners.** Make the gravy with the roux as written. In a small saucepan, thicken ½ cup more broth with 1½ teaspoons cornstarch slurry. Compare look, texture and taste.
4. Record the chops' final temperatures after resting.
5. **Technique check.** Score 1–3: good fond without burning, safe deglazing, smooth gravy of the right thickness, chops at 145 °F, fluffy potatoes.
6. Clean up: deglaze the empty skillet with water while warm to make washing easy.
7. **Repeat round.** Make a pan sauce after searing chicken thighs, using broth and lemon juice and finishing with a teaspoon of cold butter.

Tips

- A stainless or cast-iron pan makes the best fond; nonstick pans leave little.
- If the fond darkens too fast, lower the heat; black fond is bitter.
- Warm the milk before adding it to potatoes so they stay hot and fluffy.

Check your work

- ☐ I can explain fond, deglazing and thickening with a roux or slurry.
- ☐ I can explain why hollandaise is made only with pasteurized eggs.
- ☐ I made a smooth pan gravy and fluffy mashed potatoes with chops at 145 °F.

LAB NOTEBOOK

1. Draw the three steps of a pan sauce: brown, deglaze, thicken, with what happens chemically in each.
2. Record your two-thickener comparison.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

Slurry: about 1 Tbsp cornstarch per cup liquid (medium), mixed with 2 Tbsp cold liquid
Gravy roux: about 2 Tbsp fat + 2 Tbsp flour per cup

From history. Pasteurized eggs in the shell, gently heated in warm water to kill bacteria without cooking them, became available in some American stores in the early 2000s. They are the safe choice for any recipe in which eggs stay soft, such as hollandaise or homemade mayonnaise.

WORKED EXAMPLES

Example 1. You will make 1½ cups of gravy with a cornstarch slurry. How much cornstarch and cold water for the slurry?

Show solution

1. 1.5 cups × 1 Tbsp/cup = 1.5 Tbsp cornstarch.
2. Mix with about 3 tablespoons cold water or broth.

Answer: 1½ tablespoons cornstarch in 3 tablespoons cold liquid.

Example 2. Mashed potatoes: 3 lb potatoes ($2.49), ½ cup butter ($1.25), 1 cup milk ($0.30). Serves 8. A box of instant potatoes serving 8 costs $2.99. Compare cost per serving.

Show solution

1. Homemade: $\$4.04/8 = \$0.51$.
2. Instant: $\$2.99/8 = \$0.37$ (plus the milk and butter it also calls for).

Answer: About 51¢ versus 37¢ plus the extras, so very close, and homemade is fresher with more potato flavor.

Example 3. A pan sauce starts with 1 cup of broth and must reduce by half before thickening. If it evaporates about 2 tablespoons per minute at a hard simmer, how long will it take?

Show solution

1. Remove ½ cup = 8 Tbsp.
2. $8/2 = 4$ min.

Answer: About 4 minutes.

PRACTICE

1. Easy What is fond?

   Show answer

   The browned bits stuck to the pan after searing or roasting.

2. Easy What does deglaze mean?

   Show answer

   To add liquid to a hot pan and scrape up the fond to dissolve it.

3. Easy Why is a cornstarch slurry mixed with cold liquid first?

   Show answer

   Cold liquid separates the starch granules so they do not clump when they hit the hot sauce.

4. Medium How much cornstarch thickens 3 cups of gravy?

Show answer

About 3 tablespoons.

5. Medium Compare gravy thickened with flour and with cornstarch.

Show answer

Flour: opaque, homey, needs cooking to lose raw taste. Cornstarch: glossy and clear, thickens quickly at a simmer, can thin out if boiled long or stirred hard.

6. Medium Why is hollandaise made only with pasteurized eggs in this course?

Show answer

The yolks are only gently warmed and do not reach 160 °F, so ordinary eggs could carry live bacteria.

7. Medium What happens to fond that is burned black?

Show answer

It tastes bitter and will make the sauce bitter; discard it and start the sauce fresh.

8. Hard Your gravy is too thin after simmering. Give two fixes and the amount for one of them for 2 cups.

Show answer

Simmer to reduce, or add a slurry (2 Tbsp cornstarch in ¼ cup cold liquid for 2 cups), or whisk in a little beurre manié (equal parts soft butter and flour).

9. Hard Why do starchy (russet) potatoes mash fluffier than waxy (red) ones, and why should mashed potatoes not be beaten in a blender?

Show answer

Russets have more starch and less water, so they fall apart into fluffy cells; overworking ruptures the swollen starch cells and releases sticky starch, making them gluey.

10. **Challenge** Explain how Escoffier's espagnole and a quick home pan gravy rely on the same three steps, and what the home cook gives up for speed.

    Show answer

    Both brown (Maillard flavor), dissolve the browned flavors into liquid (stock or deglazing), and thicken (roux or slurry). The home cook gives up the depth and body of long-simmered brown stock rich in gelatin, though homemade stock (Lesson 4.4) recovers much of it.

COMMON MISTAKES

- Burning the fond, which makes a bitter sauce.
- Dumping cornstarch powder straight into hot liquid.
- Overworking mashed potatoes into glue.
- Using a nonstick pan and wondering where the fond went.

> **Make it a game · Deglaze Drill.** Your parent calls steps in scrambled order for making a pan sauce: sear, remove meat, deglaze, reduce, thicken, monter au beurre. Put them in the right order aloud in under fifteen seconds. Then calculate how much cornstarch slurry thickens two cups of gravy by using your course ratio. Record your best time for the order.

5.4 Egg Cookery: Mère Poulard's Omelette

OBJECTIVES

- Explain how egg proteins set at different temperatures, and why egg dishes are cooked to 160 °F.
- Cook eggs scrambled, fried, poached and as a French omelet, each to its standard.
- Tell the story of Annette Poulard's omelettes at Mont-Saint-Michel.
- Calculate egg quantities and costs for a family breakfast.

> **Warm-up.** Crack an egg onto a plate. Find the thick white, the thin white, the yolk and the two twisted cords (chalazae). Which part do you think will set first when heated?

WATCH

How to Make Omelets Like a Pro

America's Test Kitchen · 9:06

https://www.youtube.com/watch?v=CBlTBg7tq9k

> **WHEN TO WATCH**
> Before the lab. Watch the pan heat, the stirring and the rolling closely, then copy them for your omelet.

Note: About two-thirds of the way through there is a short promotional break for the channel; skip ahead to the drawings that explain why eggs stick.

KEY TERMS

denaturation

The unfolding of protein molecules by heat, acid or beating; unfolded proteins can bond together (coagulate) and set.

coagulation

Unfolded proteins linking into a network, turning liquid egg into a soft solid.

French omelet

Eggs stirred quickly in butter over medium heat until barely set, then rolled into a smooth, pale cylinder.

poach

To cook eggs out of the shell in water at about 180 °F, just below a simmer.

carryover

Eggs keep cooking on a hot plate; take them off the heat just before they look done.

CORE IDEAS

The story. Mont-Saint-Michel is a rocky island abbey off the coast of Normandy, France, reached at low tide across the sands. In 1888 Annette Poulard and her husband opened an inn there for pilgrims and travelers, who often arrived hungry and could not wait for a long meal before the tide turned. She became famous for her omelettes, beaten with a rhythmic clatter in copper bowls and cooked over an open wood fire in long-handled pans. Her inn, La Mère Poulard, still serves them, and visitors still hear the whisks beating as they arrive.

How she figured it out. Madame Poulard needed something quick, filling and delicious from ingredients on hand: Normandy eggs and butter. By long practice she learned exactly how hard to beat the eggs, how hot the fire should be and when to take the pan off, so that each omelette came out puffed and tender. Her secret, if she had one, was skill repeated thousands of times.

The kitchen science. Eggs are mostly water and protein. Heat unfolds (denatures) the proteins, which then link together (coagulate) into a soft network that holds the water. Different proteins set at different temperatures: some egg-white proteins begin to set around 144–149 °F (62–65 °C), the yolk thickens around 149–158 °F (65–70 °C), and the whole egg is firm near 160–170 °F. Cooked too hot or too long, the network tightens and squeezes out water, and eggs turn rubbery and weepy. The USDA says egg dishes should reach **160 °F**, and fried and poached eggs should be cooked until the whites and yolks are firm, unless you use pasteurized eggs. Low, steady heat gives tender eggs that are still fully cooked.

Let's cook. You will practice four egg techniques and then make a French omelet with herbs. The technique standard: scrambled eggs soft and moist with no visible liquid; fried eggs with set whites and firm yolks; poached eggs with compact whites and firm yolks; and an omelet that is smooth, pale gold, fully set and neatly rolled.

PICTURE STUDY



Kitchen Utensils with Leeks, Fish and Eggs, Jean-Siméon Chardin, c. 1734 · Oil on canvas · Cleveland Museum of Art

Image: Wikimedia Commons, public domain

Chardin painted plain kitchen goods on a stone shelf: pots, leeks, a fish and eggs, the makings of a simple supper or a quick omelette. He took months to paint what a cook could cook in minutes, studying the way light falls on a smooth egg.

Look closely

- Count the eggs. How does Chardin make them look round and smooth?
- Find the pots. Which would you use to cook the eggs, and why?
- Find the leeks and the fish. What dishes do these suggest with the eggs?

Talk about it

1. What could you make with exactly these ingredients?
2. Why are eggs so useful to a busy cook?
3. How would you store eggs today to keep them safe?

Safety first. Cook egg dishes to 160 °F and fried or poached eggs until the whites and yolks are firm, unless you use pasteurized eggs. Wash hands after cracking eggs. Lower eggs into poaching water with a cup or small bowl, and lift them out with a slotted spoon.

KITCHEN LAB

Egg Lab: Four Techniques and a French Omelet

You will cook eggs four ways, record setting times and temperatures, and finish with an herb omelet.

You will need

- An 8-inch nonstick skillet and a rubber spatula
- A medium saucepan for poaching, a slotted spoon, small cups
- A fork or whisk and bowls
- An instant-read thermometer
- A timer

French Herb Omelet

Serves 1 (make one per person) · Prep 3 min · Cook 2 min

Ingredients

- 3 large eggs
- Pinch of salt and pepper
- 1 tablespoon butter
- 1 tablespoon chopped fresh herbs: chives, parsley or tarragon
- 2 tablespoons grated cheese (optional)

Method

1. Beat the eggs, salt and pepper with a fork until no streaks of white remain. Stir in the herbs.
2. Melt the butter in the skillet over medium heat until foaming but not brown.
3. Pour in the eggs. Immediately stir in small circles with the spatula while shaking the pan, 30–60 seconds, until the eggs form soft, small curds but are still a bit wet on top.
4. Spread the eggs evenly, stop stirring, and cook 30 seconds more until the bottom sets and the top is just set with no liquid egg (add cheese now if using).

5. Tilt the pan, roll the omelet from the handle side toward the far edge with the spatula, and turn it onto a warm plate seam-side down. The center should reach 160 °F.

Allergy check: Contains eggs and milk (butter, cheese). Use oil for milk-free.

Steps

1. **Scrambled.** Cook 2 eggs over medium-low heat, stirring slowly. Record time and final temperature.
2. **Fried.** Fry 1 egg in butter over medium-low heat, covered for the last minute, until white and yolk are firm. Record time.
3. **Poached.** Heat water with a teaspoon of vinegar to about 180 °F (bubbles on the bottom, barely moving). Slide in an egg from a cup and cook 4–5 minutes until the yolk is firm. Record time.
4. **Omelet.** Make the French omelet. Make a second one and aim for a smoother, paler surface.
5. **Compare.** Rate each technique for texture, appearance and difficulty.
6. **Technique check.** Score 1–3 for each egg against its standard.
7. Clean up: wash the nonstick pan gently; wipe up egg spills promptly.
8. **Repeat round.** Make omelets for the whole family, one after another, timing how long each takes.

Tips

- Use a dedicated small nonstick pan for eggs.
- Fresh eggs hold together best for poaching.
- Have the plate ready before the omelet goes in; it cooks in two minutes.

Check your work

- ☐ I can explain how egg proteins set and why egg dishes reach 160 °F.
- ☐ I can cook eggs scrambled, fried, poached and as an omelet to standard.
- ☐ I can tell Mère Poulard's story.

LAB NOTEBOOK

1. Draw a temperature bar from 140 to 180 °F, marking when white proteins begin to set, when yolk thickens, the USDA 160 °F line, and when eggs turn rubbery.

2. Record your four-technique comparison table.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

1 large egg $\approx$ 50 g without shell (about 33 g white, 17 g yolk)

$$\text{cost per egg} = \frac{\text{carton price}}{12}$$

From history. Mont-Saint-Michel's abbey was begun in the 700s and rebuilt over centuries. Pilgrims crossed the sands on foot at low tide, and many were caught by the fast-rising water; a good, quick meal at the inn was a welcome thing.

WORKED EXAMPLES

Example 1. A family breakfast for 6 needs 2 eggs per person scrambled plus a 3-egg omelet to test. How many eggs, and what is the cost if a dozen costs \$3.49?

Show solution

1. Eggs: $6 \times 2 + 3 = 15$.
2. Cost per egg: $\$3.49 / 12 = \$0.29$.
3. Total: $15 \times \$0.29 = \$4.36$.

Answer: 15 eggs (buy 18 or two dozen), about \$4.36.

Example 2. Convert the setting temperatures 62 °C and 70 °C to °F.

Show solution

1. $\frac{9}{5}(62) + 32 = 143.6\ ^\circ\text{F}$;
2. $\frac{9}{5}(70) + 32 = 158\ ^\circ\text{F}$.

Answer: About 144 °F and 158 °F; 160 °F is just above the yolk's setting range, which is why egg dishes are cooked to 160 °F.

Example 3. A recipe for 8 calls for 10 large eggs (about 500 g). You have only medium eggs (about 44 g each without shell). How many do you need?

Show solution

1. $500\ \text{g} \div 44\ \text{g} = 11.4$.

Answer: About 11–12 medium eggs. Weighing beaten eggs is the most accurate method for baking.

PRACTICE

1. Easy What temperature should egg dishes reach?

   Show answer

   160 °F.

2. Easy Why do overcooked scrambled eggs turn rubbery and weepy?

   Show answer

   The protein network tightens too much and squeezes out its water.

3. Easy Where is Mont-Saint-Michel, and what did Annette Poulard open there in 1888?

   Show answer

   Off the coast of Normandy, France; an inn famous for omelettes.

4. Medium Why cook eggs over low to medium heat?

   Show answer

   Gentle heat sets the proteins evenly without overtightening, giving tender, moist eggs.

5. Medium How do you know scrambled eggs are done safely?

   Show answer

   No visible liquid egg remains; they are set but still moist (and reach 160 °F).

6. Medium Why add a little vinegar to poaching water?

   Show answer

   Acid helps the egg white proteins set faster, keeping the white compact.

7. Medium How many large eggs are in 300 g of beaten egg?

Show answer

About 6.

8. Hard Eggs are $4.29 a dozen. Compare the cost of a 3-egg omelet with cheese ($0.40) and a bowl of cereal with milk ($0.85).

Show answer

Omelet $3 \times 0.3575 + 0.40 = \$1.47$; cereal $0.85.

9. Hard Explain why the whites of a fried egg set before the yolk, even though the yolk is in the middle of the heat.

Show answer

The white is in direct contact with the hot pan and many white proteins set at lower temperatures; the yolk is thicker and insulated, and needs higher temperatures to set.

10. Challenge Design a test to compare scrambled eggs cooked on low heat and on high heat. What would you measure, and what do you predict?

Show answer

Same eggs, butter, pan and amount; measure time to set, final temperature, weight of liquid that weeps out after 5 minutes, and a texture rating. Predict: high heat is faster but tougher and weepier; low heat is tender.

COMMON MISTAKES

- Cooking eggs over high heat.
- Serving runny eggs from ordinary (unpasteurized) eggs.
- Using a pan too large for an omelet, so it spreads thin and overcooks.
- Leaving cooked eggs in the hot pan, so carryover overcooks them.

> **Make it a game · Egg Temperature Ladder.** Draw a ladder of temperatures on paper. Without notes, place where egg white starts to set, where yolk sets, and the 160 degrees Fahrenheit safety mark. Your parent then calls scrambled, fried, poached or French omelet and you describe the pan heat and doneness. Check against your lab notes and count the corrections.

> **Scripture.** “Can that which is unsavoury be eaten without salt? or is there any taste in the white of an egg?” (Job 6:6, KJV)
>
> Job, in his suffering, compares the hard words of his friends to tasteless food. Cooks know what he means: a pinch of salt brings eggs to life. Our words, too, should be “seasoned with salt” (Colossians 4:6).

5.5 The Family Breakfast: Amelia Simmons, Pearlash and Pancakes

OBJECTIVES

- Tell how Amelia Simmons's *American Cookery* (1796) introduced chemical leavening to American recipes.
- Explain how baking soda and baking powder make carbon dioxide, and balance soda with an acidic ingredient.
- Plan a breakfast timeline so pancakes, eggs and fruit reach the table hot and together.
- Cook and serve a family breakfast of buttermilk pancakes, scrambled eggs and fruit.

> **Warm-up.** Put ½ teaspoon of baking soda in a glass and add 2 tablespoons of vinegar. In another glass, stir ½ teaspoon of baking powder into 2 tablespoons of warm water. Compare the fizz. Then add 2 tablespoons of water to plain baking soda. What does baking soda need to fizz?

WATCH

How to Make the Easiest Pancakes Ever

America's Test Kitchen · 8:05

https://www.youtube.com/watch?v=Lm2dq55phHo

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Notice the lumpy batter and how they judge when to flip.

KEY TERMS

chemical leavener

An ingredient that makes gas (carbon dioxide) in a batter or dough by a chemical reaction, rather than by yeast.

baking soda

Sodium bicarbonate, a base that releases carbon dioxide when it reacts with an acid such as buttermilk, yogurt, lemon juice or molasses.

baking powder

Baking soda already mixed with a dry acid (and starch). Double-acting powder makes some gas when wet and more when heated.

holding temperature

A low oven (about 200 °F) used to keep finished food hot (above 140 °F) while the rest of the meal is cooked.

pearlash

Potassium carbonate refined from wood ashes; the first chemical leavener used in American recipes.

CORE IDEAS

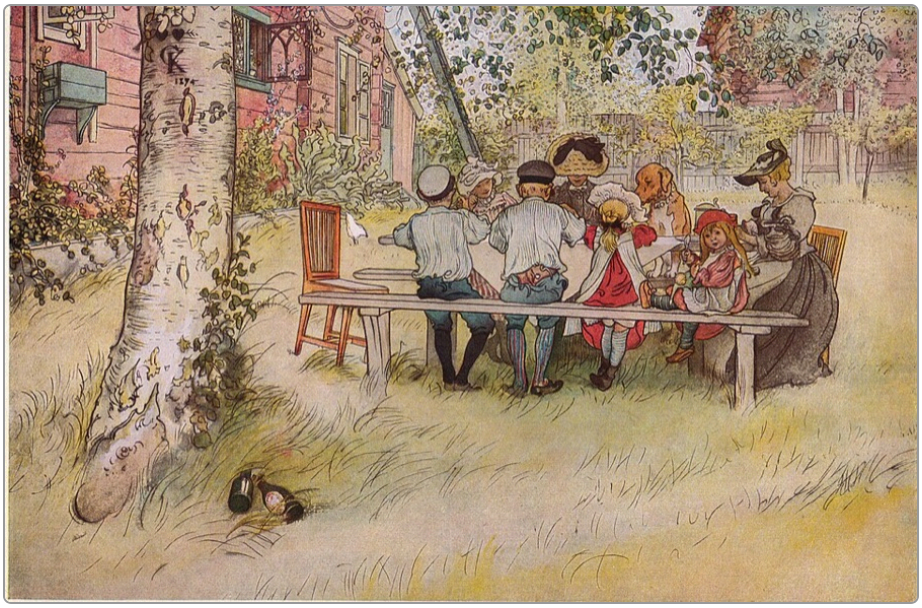
The story. In 1796 a small book appeared in Hartford, Connecticut: *American Cookery*, by Amelia Simmons, "an American orphan." It was the first cookbook written by an American and published in the new United States, and it used American foods such as cornmeal, pumpkin and cranberries. It also did something new: several recipes called for *pearlash*, a refined form of potash from wood ashes, to make cookies and cakes rise. Until then, baked goods were raised with yeast or with eggs beaten for an hour. Pearlash was the first chemical leavener in American cooking.

How they figured it out. American cooks had pearlash on hand because it was made from wood ashes for soap and glass. Someone noticed that, mixed with sour milk or molasses, it made dough puff. Chemists later produced purer leaveners: baking soda (sodium bicarbonate) became common in the 1800s, and baking powder, with its own built-in acid, followed in the mid-1800s. Quick breads, biscuits and pancakes, "quick" because they need no rising time, became everyday American breakfasts.

The kitchen science. Baking soda is a base. With an acid, it releases bubbles of carbon dioxide: $\mathrm{NaHCO_3 + H^+ \rightarrow Na^+ + H_2O + CO_2}$. In buttermilk pancakes, the lactic acid in buttermilk reacts with the soda; baking powder adds a second, heat-triggered lift on the griddle. About ¼ teaspoon of soda neutralizes 1 cup of buttermilk; too much soda leaves a soapy, metallic taste. Lumpy batter is good: overmixing develops gluten and makes pancakes tough and flat. A family breakfast is also a lesson in timing: a 200 °F oven holds pancakes hot while the eggs cook.

Let's cook. You will plan and cook a family breakfast: buttermilk pancakes, soft scrambled eggs cooked to 160 °F and cut fruit, with everything on the table at once. The technique standard: a written timeline, batter mixed just until combined, griddle at the right heat (a drop of water dances), pancakes flipped once when bubbles pop and edges set, eggs tender and fully cooked, and the table set before the food is done.

PICTURE STUDY



Breakfast under the Big Birch, Carl Larsson, 1896 · Watercolor · Nationalmuseum, Stockholm

Image: Wikimedia Commons, public domain

Carl Larsson painted his own family's life at their home in Sundborn, Sweden, in a famous series of watercolors. On a summer morning the whole household gathers at a long table under the birch tree for breakfast. The painting shows how a simple meal becomes a time to be together.

Look closely

- Count the people at the table. Who are they?
- Look at the table. How was it set, and what is being served?
- Find the dog and the youngest children. What are they doing?

Talk about it

1. What had to happen in the kitchen before this table could be set?
2. How would you plan a breakfast so that everyone sits down together?
3. What makes a family meal more than just eating?

Safety first. Heat the griddle to medium (about 375 °F for an electric griddle) and keep the handle turned in; lift pancakes with a wide spatula. Scramble eggs to 160 °F with no visible liquid. Do not taste the uncooked batter, which contains raw flour and egg.

KITCHEN LAB

Service Lab: A Family Breakfast on Time

You will plan a breakfast timeline, cook buttermilk pancakes, scrambled eggs and fruit, and serve everything hot at a set time.

You will need

- A griddle or two large skillets
- A sheet pan with a wire rack and a 200 °F oven
- Mixing bowls, a whisk, a ¼-cup measure and a wide spatula
- A nonstick skillet for eggs, an instant-read thermometer
- A clock or timer and your written timeline

Buttermilk Pancakes with Scrambled Eggs and Fruit

Serves 6 (16 pancakes) · Prep 20 min · Cook 30 min

Ingredients

- **Pancakes:** 2 cups (240 g) all-purpose flour
- 2 tablespoons sugar
- 1½ teaspoons baking powder and ½ teaspoon baking soda
- ½ teaspoon salt
- 2 cups (480 mL) buttermilk (or 2 cups milk plus 2 tablespoons lemon juice, rested 5 minutes)
- 2 large eggs
- 3 tablespoons melted butter, plus butter or oil for the griddle
- **Eggs:** 10 large eggs, ½ teaspoon salt, 2 tablespoons butter
- **Fruit:** 4 cups mixed fruit (berries, bananas, oranges), washed and cut
- Maple syrup to serve

Method

1. Heat the oven to 200 °F with a rack-lined sheet pan inside.
2. Whisk the flour, sugar, baking powder, soda and salt in a large bowl. In another bowl whisk the buttermilk, eggs and melted butter.

3. Pour the wet into the dry and fold just until no dry flour remains; leave lumps. Rest 5–10 minutes.
4. Heat the griddle over medium heat and grease lightly. Pour ¼-cup portions. Cook until bubbles pop and edges set, 2–3 minutes; flip and cook 1–2 minutes more. Move to the oven rack in one layer.
5. When the last pancakes are in the oven, beat the eggs with salt. Melt the butter in the nonstick skillet over medium-low heat, add the eggs and stir slowly until softly set with no liquid remaining (160 °F), 4–6 minutes.
6. Serve the pancakes, eggs and fruit together with syrup.

Allergy check: Contains wheat, milk and eggs. Use a gluten-free flour blend for wheat-free; plant milk with lemon juice and oil for milk-free.

Steps

1. **Timeline.** Write a timeline working backward from your serving time; post it on the counter.
2. Set the table and prepare the fruit first (or the night before).
3. Mix the batter and cook the pancakes, holding them in the oven. Record the griddle setting and time per batch.
4. Cook the eggs last; record their final temperature.
5. **On-time check.** Record the time the food reached the table versus your planned time, and the temperature of a pancake from the first batch when served.
6. **Technique check.** Score 1–3: timeline followed, lumpy batter not overmixed, even golden pancakes, eggs tender at 160 °F, everything served hot together, kitchen cleaned after.
7. Clean up with the family: everyone takes one job.
8. **Repeat round.** Serve the breakfast again with a different quick bread (biscuits or muffins from Unit 6) and beat your on-time score.

Tips

- The first pancake is a test: adjust the heat after it.
- Do not press pancakes with the spatula.

- Spread finished pancakes on a rack, not in a stack, so they stay crisp at the edges.

Check your work

- ☐ I can tell Amelia Simmons's story and explain chemical leavening.
- ☐ I can balance baking soda with an acid.
- ☐ I planned and served a hot family breakfast on time.

LAB NOTEBOOK

1. Copy your breakfast timeline and mark where it slipped and why.
2. Draw a pancake in cross-section showing bubbles of CO_2 and the set crumb.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$NaHCO_3 + H^+ \rightarrow Na^+ + H_2O + CO_2$$

Rule of thumb: $\frac{1}{4}$ tsp baking soda per cup buttermilk; about 1 tsp baking powder per cup flour

From history. *American Cookery* includes early printed recipes for "Johny Cake" and "Indian Slapjack," griddle cakes of cornmeal, and for pumpkin pie. The Library of Congress has digitized a copy you can read online.

WORKED EXAMPLES

Example 1. Your pancake recipe uses 2 cups of buttermilk and 2 cups of flour. How much baking soda neutralizes the buttermilk, and how much baking powder adds lift by the rules of thumb?

Show solution

1. Soda: $2 \times \frac{1}{4} = \frac{1}{2}$ tsp.
2. Powder: $2 \times 1 = 2$ tsp.

Answer: ½ teaspoon baking soda and about 2 teaspoons baking powder (the recipe uses 1½–2).

Example 2. Breakfast is at 8:00 a.m. Pancakes take 20 minutes to cook in batches; eggs take 6 minutes; fruit prep takes 10 minutes; batter takes 10 minutes to mix and rest; setting the table takes 5. Plan a timeline for one cook.

Show solution

1. Work backward: eggs 7:54–8:00 (last, so they are freshest).
2. Pancakes 7:34–7:54, held in a 200 °F oven.
3. Batter 7:24–7:34; preheat oven and griddle at 7:24.
4. Fruit and table 7:09–7:24 (or the night before).

Answer: Start at about 7:10: fruit and table, then batter, then pancakes into the warm oven, then eggs last. Everything reaches the table hot at 8:00.

Example 3. One batch of pancakes (16) costs: flour $0.40, buttermilk $1.10, eggs $0.58, butter $0.40, sugar and leaveners $0.15. What is the cost per pancake, and per serving of 3?

Show solution

1. Total $= \$2.63$.
2. Per pancake $= \$2.63/16 = \$0.16$.
3. Per serving $= 3 \times \$0.16 = \$0.49$.

Answer: About 16¢ per pancake, 49¢ per 3-pancake serving.

PRACTICE

1. Easy What did Amelia Simmons publish in 1796, and why is it important?

   Show answer

   American Cookery, the first cookbook by an American published in the United States; it used American ingredients and the first chemical leavener, pearlash.

2. Easy What does baking soda need to make carbon dioxide?

   Show answer

   An acid (such as buttermilk, yogurt, lemon juice, vinegar or molasses).

3. Easy Why is lumpy pancake batter better than smooth?

Show answer

Overmixing develops gluten, making pancakes tough and flat.

4. Medium How much baking soda for 1½ cups of buttermilk?

Show answer

About ⅜ teaspoon (a scant ½ teaspoon).

5. Medium What is double-acting baking powder?

Show answer

Baking powder that makes some gas when moistened and more when heated.

6. Medium How do you know when to flip a pancake?

Show answer

Bubbles on the top pop and stay open, and the edges look set and dry.

7. Medium Why hold pancakes in a 200 °F oven rather than stacking them on the counter?

Show answer

To keep them hot (above 140 °F) and serve everything together without sogginess from steam in a tight stack; spread them on a rack on a sheet pan.

8. Hard Write the balanced equation for baking soda reacting with an acid (H^+) and explain where the bubbles in a pancake come from.

Show answer

$NaHCO_3 + H^+ \rightarrow Na^+ + H_2O + CO_2$; the CO_2 gas forms bubbles that expand with heat and are set in place as the batter cooks.

9. Hard A recipe for 16 pancakes must serve 10 people at 4 pancakes each. Find the yield factor and the cups of flour if the original uses 2 cups.

Show answer

Need 40 pancakes; factor 2.5; 5 cups of flour.

10. **Challenge** Plan a breakfast for 6 with pancakes, eggs, a fruit salad and a hot drink, for one cook and one helper. Write a timeline that brings everything to the table at 7:30 a.m.

    Show answer

    Answers vary. A strong plan sets the table and cuts fruit the night before or first, mixes batter about 30 minutes ahead, cooks pancakes into a 200 °F oven, cooks eggs last, assigns the helper the drink and the table, and lists exact clock times.

COMMON MISTAKES

- Overmixing the batter.
- A griddle that is too hot (burnt outsides, raw centers) or too cold (pale, tough pancakes).
- Using baking soda with no acid in the recipe.
- Cooking eggs first so they are cold by the time the pancakes are done.

Make it a game · Leavener Showdown. Your parent names a recipe: buttermilk pancakes, plain-milk pancakes, biscuits, a fresh baking powder test. You choose baking soda or baking powder and justify it with chemistry. Add the carbon dioxide step. Then tell how Amelia Simmons put pearlash in American Cookery in 1796. Five rounds, one point each.

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)

Getting up early to feed a household is a picture of love and diligence in Proverbs. A breakfast planned and served on time is a small way to serve your own family.

UNIT 5

Sauces, Eggs and Breakfast

Sauces turn simple food into a meal, and eggs are the most versatile ingredient in the kitchen. In this unit you will learn the classical mother sauces in their family-kitchen forms: a béchamel and cheese sauce, a tomato sauce from Naples, and a pan gravy built on the fond of seared meat. Then you will cook eggs four ways and finish with a family breakfast served hot and on time.

The stories run from Marie-Antoine Carême, the poor boy who became the "king of chefs," and Antonio Latini's 1692 tomato sauce, to Annette Poulard's omelettes at Mont-Saint-Michel and Amelia Simmons's 1796 *American Cookery*. The science covers starch gelatinization, pH and acidity, Maillard browning in the fond, protein denaturation in eggs and the chemistry of baking soda.

PREREQUISITES

- Units 1–4: safety, knife skills, measurement, dry and moist heat, and stock making
- Comfort with ratios, °F/°C conversion and simple chemical equations

MASTERY CHECKLIST

- ☐ I can make a roux and a smooth béchamel, and name the five mother sauces.
- ☐ I can make and balance a tomato sauce, explaining acidity with pH.
- ☐ I can deglaze a pan and thicken a gravy with a roux or a slurry.
- ☐ I can cook eggs scrambled, fried, poached and as an omelet, safely and to standard.
- ☐ I can plan and serve a hot family breakfast on time, explaining chemical leavening.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **Library of Congress: *American Cookery* by Amelia Simmons (1796)**: Free. Search the Library of Congress website (loc.gov) for the title to read the first American cookbook online; look for the recipes that call for pearlash.
- **An 8-inch nonstick skillet**: For omelets and eggs. Keep it for eggs only and it will last for years.
- **pH test strips**: Optional and inexpensive; used to test tomato sauce and other foods in Lesson 5.2.

Not required. Every recipe in this unit works in an ordinary home kitchen.
School Launch has no ties to these authors, publishers or companies.

LESSONS IN THIS UNIT

5.1 The Mother Sauces: Carême, Escoffier and the Béchamel 3 sessions of 50 minutes

5.2 Tomato Sauce: Antonio Latini and the Neapolitan Tomato
3 sessions of 50 minutes

5.3 Pan Sauces and Gravy: Escoffier's Brown Sauce at Home 3 sessions of 50 minutes

5.4 Egg Cookery: Mère Poulard's Omelette 3 sessions of 50 minutes

5.5 The Family Breakfast: Amelia Simmons, Pearlash and Pancakes
3 sessions of 50–90 minutes

Unit 5 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Name the five mother sauces and the family-kitchen substitute used in this course for espagnole.

2. **6 pts**
   Who was Carême, and what did Escoffier change about his list of sauces?

3. **8 pts**

   How much butter and flour make 5 cups of medium béchamel? Of thin?

4. **6 pts**

   Explain why flour stirred straight into hot milk makes lumps but a roux does not.

5. **6 pts**

   Tomatoes are about pH 4.4 and milk about pH 6.6. How many times more acidic are tomatoes?

6. **6 pts**

   Give three ways to balance a sharp tomato sauce.

7. **6 pts**

   What did Antonio Latini publish, where and when?

8. **6 pts**

   Explain fond and deglazing, and how much cornstarch thickens 2 cups of gravy.

9. **6 pts**

   Why is hollandaise made only with pasteurized eggs in this course?

10. **8 pts**

    Describe denaturation and coagulation in egg cookery, and why eggs overcooked on high heat turn rubbery.

11. **6 pts**

    Give the USDA rule for egg dishes and for fried eggs.

12. **6 pts**

    A breakfast for 9 needs 2 eggs each plus 2 for the pancakes. Eggs cost $3.89 a dozen. How many dozen and what cost for the eggs used?

13. **6 pts**

    Write the reaction of baking soda with an acid and name an acid in buttermilk pancakes.

14. **6 pts**

    Predict: a cook replaces buttermilk with plain milk in a recipe leavened only with baking soda. What happens, and how would you fix it?

15. **6 pts**

    Who was Amelia Simmons, and what was pearlash?

16. **6 pts**

    Essay (one paragraph): Explain how planning a timeline is as much a part of cooking as technique, using the family breakfast as your example.

ANSWER KEY

1. Béchamel, velouté, espagnole, tomato, hollandaise; a pan sauce or gravy built on fond.
2. Marie-Antoine Carême (1784–1833), who first organized French sauces into families; Escoffier revised the list to five mother sauces in 1903.
3. Medium: 10 Tbsp each; thin: 5 Tbsp each.
4. Starch on the outside of a flour clump gelatinizes at once and seals dry flour inside; in a roux, fat coats each grain so the flour disperses before it swells.
5. $10^{2.2} \approx 160$ times.
6. Salt, fat (olive oil or butter), a little sweetness (sugar, onion, carrot); longer simmering.
7. *Lo Scalco alla Moderna*, Naples, 1692 and 1694, with one of the earliest European tomato-sauce recipes.
8. Fond is browned bits from searing; deglazing dissolves them with liquid; about 2 tablespoons cornstarch in ¼ cup cold liquid.
9. Its yolks are warmed gently and never reach 160 °F, so ordinary eggs might carry live bacteria.
10. Heat unfolds egg proteins (denaturation), which bond into a network (coagulation) that holds water; too much heat tightens the network, squeezing out water and making eggs rubbery and weepy.
11. Egg dishes to 160 °F; fried and poached eggs cooked until whites and yolks are firm (unless pasteurized).
12. 20 eggs; buy 2 dozen; cost of eggs used $20 \times \$3.89/12 = \$6.48$.
13. $\mathrm{NaHCO_3 + H^+ \rightarrow Na^+ + H_2O + CO_2}$; lactic acid in buttermilk.
14. Little gas forms and the leftover soda tastes soapy; pancakes are flat and bitter. Add lemon juice or vinegar to the milk, or use baking powder.
15. Author of *American Cookery* (1796), the first American cookbook; pearlash was refined potash from wood ashes, the first chemical leavener in American recipes.
16. Answers vary. A strong answer explains working backward from serving time, cooking items that hold well first (pancakes in a 200 °F oven) and fast or fragile items last (eggs), preparing cold items ahead, and how timing affects safety, quality and the family gathering together.

UNIT PROJECT: SAUCE AND BRUNCH SERVICE

Plan and serve a weekend brunch for your family or guests that includes at least one mother-sauce-based dish (for example, eggs on biscuits with a velouté gravy, a vegetable gratin with Mornay sauce, or shakshuka-style eggs cooked firm in your marinara), an egg dish cooked to standard, a quick bread, and fruit.

Write the menu, a shopping list with prices and the cost per serving, and a timeline from shopping to cleanup. Record temperatures for every egg dish, and photograph the table. Afterward, ask each guest for a rating and one comment, and write a reflection on what went well and what you would change.

LOOK FOR	WHAT IT MEANS
Menu and planning	Complete menu meeting the requirements; shopping list, cost per serving and a realistic timeline.
Technique	Smooth sauce of correct thickness; eggs to standard and 160 °F; quick bread properly risen.
Service	Food served hot and together near the planned time; table set.
Safety and cleanup	Safe egg handling and cooking; kitchen cleaned.
Reflection	Guest ratings recorded and one honest improvement planned.

UNIT 6

Baking and Pastry

Baking is cooking by formula. In this unit you will learn to read and write recipes the way professional bakers do, in baker's percentages, and you will bake the main families of baked goods: a high-hydration focaccia, a kneaded sandwich loaf, quick breads made by the muffin method, a flaky pastry crust, and a pound cake made by the creaming method.

The history runs from Hannah Glasse's pound cake and Amelia Simmons's pearlash to the Fleischmann brothers' yeast, Eben Horsford's baking powder, Ruth Wakefield's tested recipes and Raymond Calvel's autolyse. The science covers gluten, yeast fermentation, chemical leavening, fat and flakiness, and the air cells of a creamed batter. Every lab is weighed in grams, and every bake ends with an internal temperature and a crumb study.

PREREQUISITES

- Units 1–5, especially measuring by weight (2.5) and chemical leavening (5.5)
- A digital scale that reads grams
- Comfort with percentages and area scaling

MASTERY CHECKLIST

- ☐ I can write and scale a formula in baker's percentages and calculate hydration.
- ☐ I can knead a yeast dough to a windowpane and bake bread to the right internal temperature.
- ☐ I can make quick breads by the muffin method without overmixing.
- ☐ I can make a flaky, tender pie crust by the 3-2-1 ratio.
- ☐ I can cream butter and sugar properly and bake a pound cake by the classic ratio.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- King Arthur Baking: Baker's Percentage: Free. King Arthur's professional reference page explaining baker's percentages, for Lesson 6.1.
- **A bench scraper and a 9 × 5-inch loaf pan:** Inexpensive tools used throughout the unit.
- **A stand or hand mixer:** Optional; every recipe in this unit can be mixed by hand.

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 **Baker's Percentages: Raymond Calvel and the Focaccia**
3 sessions of 50–90 minutes

6.2 **The Home Loaf: Fleischmann's Yeast, Kneading and Gluten**
3 sessions of 50–90 minutes

6.3 **Quick Breads: Eben Horsford's Baking Powder and the Muffin Method**
3 sessions of 50–90 minutes

6.4 **Pie Crust and Cookies: Fat, Flour and Flakiness** 3 sessions of 50–90 minutes

6.5 **The Pound Cake and the Creaming Method** 3 sessions of 50–90 minutes

Unit 6 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **8 pts**
   A dough uses 500 g flour, 350 g water, 10 g salt and 5 g yeast. Write the baker's percentages and the hydration.

2. **8 pts**
   Make 1,200 g of dough at flour 100%, water 65%, salt 2%, yeast 1.0%. How much of each ingredient?

3. **6 pts**

   What is an autolyse, and why did Raymond Calvel promote it?

4. **6 pts**

   Explain how gluten and yeast together make bread rise.

5. **6 pts**

   What internal temperatures show that a sandwich loaf, a lean crusty bread and a pound cake are done?

6. **4 pts**

   Dough rises from 4.0 cm to 7.4 cm. What is the rise factor? Is it ready to shape?

7. **6 pts**

   Tell the Fleischmann story in two sentences.

8. **6 pts**

   Describe the muffin method and predict what 60 strokes of mixing will do to a muffin.

9. **6 pts**

   Who was Eben Horsford, and what problem did his baking powder solve?

10. **8 pts**

    Using 3-2-1, how much butter and water go with 210 g flour? Explain how cold butter makes crust flaky.

11. **6 pts**

    How much more dough does a 14-inch round need than a 12-inch round of the same thickness?

12. **6 pts**

    Who was Ruth Wakefield, and what does her story teach about recipe writing?

13. **8 pts**

    A pound cake is to use 5 large eggs (250 g). Give the weights of flour, butter and sugar, and explain the role of creaming.

14. **6 pts**

    Predict: a pound cake batter is made with melted butter and cold eggs. What will the cake be like, and why?

15. **6 pts**

    Muffins for 12 cost $4.80. What is the cost for 36, and the cost per muffin?

16. **4 pts**

    Essay (one paragraph): Explain why bakers say “baking is chemistry,” using at least three examples from this unit.

ANSWER KEY

1. Flour 100%, water 70%, salt 2%, yeast 1.0%; hydration 70%.
2. Total 168%; flour $1200/1.68 = 714$ g; water 464 g; salt 14 g; yeast 7 g.
3. A rest of flour and water before adding salt and yeast; it hydrates flour and starts gluten, so less mixing is needed and bread has better flavor and color.
4. Kneaded gluten forms an elastic network; yeast produces CO_2, which the network traps in bubbles that expand, raising the dough.
5. About 190 °F; 200–210 °F; 205–210 °F.
6. 1.85; not quite doubled; give it more time.
7. Charles and Maximilian Fleischmann, with James Gaff, began making pure compressed yeast in Cincinnati in 1868. Reliable yeast, shown off at the 1876 Centennial Exhibition, made light home-baked bread dependable.
8. Mix dry and wet separately, then fold together briefly. Overmixing develops gluten, causing tunnels, peaked tops and toughness.
9. A Harvard chemist who developed calcium-phosphate baking powder; it supplied a measured acid with the soda, giving consistent rising instead of relying on variable sour milk.
10. Butter 140 g, water 70 g. Cold butter pieces flatten into layers; in the oven their water turns to steam and separates the layers.
11. $(14/12)^2 = 1.36$: 36% more.
12. Creator of the chocolate chip cookie at the Toll House Inn in the late 1930s; precise, tested recipes let others repeat results.
13. 250 g each. Creaming beats air cells into butter with sugar crystals; they expand in the oven to lighten the cake.
14. Dense and heavy, possibly greasy: melted butter cannot hold air, and cold eggs break the emulsion.
15. $14.40; 40¢ each.
16. Answers vary. Strong answers cite gluten formation, yeast fermentation producing CO_2, chemical leaveners reacting with acids, fat and steam creating flaky layers, starch setting, Maillard browning, and the need for exact ratios measured by weight.

UNIT PROJECT: A BAKER'S WEEK

Bake three different products in one week for your family or to share with neighbors: one yeast bread, one quick bread and one pastry or cake. For each, write the formula in baker's percentages and grams, keep a log (temperatures, rise times, bake times and internal temperatures), and photograph the crumb.

Calculate the ingredient cost and cost per serving for each, and compare one with a store-bought equivalent. Give at least one of your bakes away with a handwritten card, and write a one-page reflection on what you learned about baking science and about generosity.

LOOK FOR	WHAT IT MEANS
Formulas	Accurate baker's percentages and gram weights for all three products.
Technique	Each product meets its technique standard (rise, crumb, flakiness or fine grain) and correct internal temperature.
Records	Complete logs and crumb photos.
Cost	Correct cost per serving and a fair comparison with a store product.
Reflection and generosity	A bake shared with others and a thoughtful reflection.

6.1 Baker's Percentages: Raymond Calvel and the Focaccia

OBJECTIVES

- Write a bread formula in baker's percentages and calculate hydration.
- Scale a dough formula to any total weight or pan size.
- Tell how the French baking teacher Raymond Calvel developed the autolyse rest in the 1970s.
- Bake a high-hydration focaccia, measured entirely by weight.

> **Warm-up.** Look at two bread recipes, one in cups and one in grams. Which would be easier to double, halve, or change from a loaf into rolls? Why do you think professional bakers write recipes as percentages of the flour?

WATCH

What is Baker's Percentage? - Bread School

King Arthur Baking Company · 12:00

https://www.youtube.com/watch?v=fohAKf3gdSg

> **WHEN TO WATCH**
> Before the worked examples. Copy the whiteboard formula into your notebook as he builds it.

Note: From King Arthur Baking's Bread School series.

BACKUP VIDEO

Breaking Down Baker's Percentages | Baker's math, dough hydration, baking formulas

Baker Bettie · 9:22

https://www.youtube.com/watch?v=l4A1PecP91g

A second explanation, including the pound cake written in baker's percentages (Lesson 6.5).

KEY TERMS

baker's percentage

Each ingredient's weight expressed as a percentage of the total flour weight, which is always 100%.

hydration

Water (and other liquids) as a percentage of flour weight. Sandwich bread is about 60–65%; focaccia 75–85%.

autolyse

A rest of flour and water (before salt and yeast) that lets the flour hydrate and gluten begin to form on its own.

gluten

The stretchy network formed when two wheat proteins, glutenin and gliadin, are hydrated and worked.

fermentation

The work of yeast as it feeds on sugars in dough, producing carbon dioxide gas and flavor.

CORE IDEAS

The story. By the mid-twentieth century many French bakeries were mixing dough hard and fast in powerful machines, and their bread was turning white, fluffy and bland. Raymond Calvel (1913–2005), a professor at the French national milling school in Paris, set out to restore the flavor of traditional bread. In the 1970s he introduced the **autolyse**: mix only flour and water and let them rest 20–30 minutes before adding the yeast and salt. He taught bakers all over the world, including in Japan and the United States, and wrote *Le Goût du Pain* ("The Taste of Bread," 1990).

How he figured it out. Calvel compared doughs made with and without the rest, keeping everything else the same, and found that the rested dough needed less mixing to become smooth, took in water better and baked into bread with better flavor and color, because over-mixing pumped in air that bleached the flour's natural pigments. He wrote his formulas the way professional bakers do, in **baker's percentages**, so that any baker could make his dough at any size.

The kitchen science. In baker's percentages, flour is always 100% and everything else is a percentage of the flour's weight. A lean bread might be flour 100%, water 65%, salt 2%, yeast 1.0%. The water percentage is the **hydration**: more water makes a stickier dough, a more open crumb and a crisper crust. Focaccia is very wet, around

80%, so it is folded rather than kneaded, and the water turns to steam in the oven to puff the big holes. Salt near 2% seasons the bread and tightens gluten; much more slows the yeast.

Let's cook. You will mix a focaccia by weight from its baker's percentages, rest it (autolyse), fold it, let it rise in the pan, dimple it with olive oil and bake it until deep golden. The technique standard: every ingredient weighed within 1–2 g, hydration calculated correctly, dough folded (not kneaded) until it holds its shape, fully risen and bubbly before baking, baked to about 205 °F inside with a crisp bottom.

PICTURE STUDY



The Milkmaid, Johannes Vermeer, c. 1657–58 · Oil on canvas · Rijksmuseum, Amsterdam

Image: Wikimedia Commons, public domain

Vermeer painted a kitchen maid pouring milk with complete attention. On the table lie pieces of bread; many scholars think she is making a bread pudding from stale bread, wasting nothing. The light falls on the crusty loaves so that you can almost feel their texture.

Look closely

- Find the stream of milk. Why is she pouring so slowly?
- Look at the bread on the table. How does Vermeer show its crust and crumb?
- Find the foot warmer on the floor and the basket on the wall. What do they tell you about this household?

Talk about it

1. If she is making bread pudding, what would she add next?
2. Why would a careful cook measure as slowly as she pours?
3. How would a baker in Vermeer's time have measured flour and water without a scale?

Safety first. Use dry oven mitts for the hot pan, which will be oily and very hot at 450 °F; slide the focaccia out onto a rack with a wide spatula. Do not taste the unbaked dough, which contains raw flour.

KITCHEN LAB

Baking Lab: Focaccia by Baker's Percentages

You will write a focaccia formula in baker's percentages, weigh it exactly, and bake it in a 9 × 13 pan, logging the dough's rise.

You will need

- A digital scale reading in grams
- A large bowl, a bowl scraper or spatula and plastic wrap
- A 9 × 13-inch metal baking pan
- An instant-read thermometer and a timer
- A cooling rack

Olive Oil Focaccia

Serves 12 pieces · Mix 15 min · Rest and fold 2 hr · Pan rise 45–60 min · Bake 22–28 min

Ingredients

- 500 g (about 4 cups) bread flour or all-purpose flour (100%)
- 400 g (1⅔ cups) lukewarm water, about 95 °F (80%)
- 10 g (1¾ teaspoons) fine salt (2%)
- 4 g (1¼ teaspoons) instant yeast (0.8%)
- 50 g (¼ cup) olive oil, divided: 25 g in the pan, 25 g on top
- Flaky salt and 1 teaspoon dried rosemary or 1 tablespoon fresh, chopped

Method

1. **Autolyse:** Mix the flour and 380 g of the water until no dry flour remains. Cover and rest 20–30 minutes.
2. Sprinkle the salt and yeast over the dough, add the remaining 20 g water, and squeeze and fold with a wet hand until combined, 2–3 minutes.
3. Cover. Every 30 minutes for the next 1½ hours, do a set of folds: with a wet hand, lift one side of the dough, stretch it up and fold it over; turn

the bowl and repeat four times. The dough will become smoother and stronger.

4. Pour 25 g oil into the pan. Turn the dough into the pan, turn it to coat and gently stretch it toward the corners. If it springs back, wait 10 minutes and stretch again. Cover and rise 45–60 minutes, until puffy and bubbly. Heat the oven to 450 °F (230 °C).
5. Drizzle the rest of the oil on top. With oiled fingers, press deep dimples all over. Sprinkle with rosemary and flaky salt.
6. Bake 22–28 minutes, until deep golden and about 205 °F inside. Slide onto a rack and cool 10 minutes before cutting.

Allergy check: Contains wheat. No common substitute gives the same result; gluten-free focaccia needs a dedicated recipe.

Steps

1. **Formula sheet.** Write the formula in a table: ingredient, baker's %, grams. Check that the percentages and grams agree.
2. Weigh every ingredient and record actual weights.
3. **Rise log.** Photograph the dough at mixing, after the folds and before baking. Mark its height in the pan with a ruler.
4. Bake and record the internal temperature and bake time.
5. **Crumb study.** Cut a slice and photograph the crumb. Describe the holes and the crust.
6. **Technique check.** Score 1–3: accurate weighing, correct hydration, folds done on time, fully risen, deep golden, 205 °F, crisp bottom.
7. Clean up: scrape dough off tools before washing (cold water first loosens it).
8. **Repeat round.** Make the formula at 70% hydration and compare crumb and handling.

Tips

- Wet hands, not floured hands, for sticky dough.
- A cold kitchen slows rising; give the dough more time rather than more yeast.

- For more flavor, refrigerate the covered dough overnight after the folds, then pan it the next day.

Check your work

- ☐ I can write and use baker's percentages and calculate hydration.
- ☐ I can tell Raymond Calvel's story and explain the autolyse.
- ☐ I baked a well-risen focaccia measured by weight.

LAB NOTEBOOK

1. Copy your formula sheet and scale it to a half-sheet pan.
2. Paste or sketch your rise and crumb photos with notes.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{baker's } \% = \frac{\text{ingredient mass}}{\text{flour mass}} \times 100$$

$$\text{flour mass} = \frac{\text{total dough mass}}{\text{sum of all baker's } \%/100}$$

From history. Professional bakers have used percentages for over a century because a formula in percentages works at any size, from one loaf to a thousand. Many bakeries call the sheet a "formula," not a recipe.

WORKED EXAMPLES

Example 1. A dough uses 500 g flour, 400 g water, 10 g salt and 4 g instant yeast. Write the baker's percentages and the hydration.

Show solution

1. Flour $= 100\%$.
2. Water $= 400/500 \times 100 = 80\%$ (this is the hydration).
3. Salt $= 10/500 \times 100 = 2\%$; yeast $= 4/500 \times 100 = 0.8\%$.

Answer: Flour 100%, water 80% (hydration 80%), salt 2%, yeast 0.8%.

Example 2. You want 1,500 g of dough with the formula flour 100%, water 75%, salt 2%, yeast 1.0%, olive oil 5%. How much of each?

Show solution

1. Total percentage: $100 + 75 + 2 + 1 + 5 = 183\%$.
2. Flour $= 1500 / 1.83 = 820$ g.
3. Water $0.75 \times 820 = 615$ g; salt 16 g; yeast 8 g; oil 41 g.

Answer: Flour 820 g, water 615 g, salt 16 g, yeast 8 g, olive oil 41 g (total 1,500 g).

Example 3. Your focaccia formula fills a 9 × 13-inch pan with 918 g of dough. How much dough for a half-sheet pan (13 × 18 inches) at the same thickness?

Show solution

1. Area ratio $= \dfrac{13 \times 18}{9 \times 13} = \dfrac{234}{117} = 2$.
2. Dough $= 2 \times 918 = 1836$ g.

Answer: Double the dough: about 1,836 g.

PRACTICE

1. Easy In baker's percentages, what is flour always?

   Show answer

   100%.

2. Easy A dough has 300 g flour and 195 g water. What is the hydration?

   Show answer

   65%.

3. Easy What is an autolyse, and who popularized it?

   Show answer

   A rest of flour and water before adding salt and yeast; Raymond Calvel, in the 1970s.

4. **Medium** Write baker's percentages for 1,000 g flour, 700 g water, 20 g salt, 5 g yeast.

Show answer

100%, 70%, 2%, 0.5%.

5. **Medium** You want a 70% hydration dough with 450 g flour. How much water?

Show answer

315 g.

6. **Medium** Why does a high-hydration dough like focaccia have bigger holes?

Show answer

More water makes a looser dough that expands easily, and more water turns to steam in the oven, inflating larger bubbles.

7. **Medium** Why is salt usually about 2% of flour weight?

Show answer

It seasons the bread and strengthens gluten; much more slows yeast and tastes too salty.

8. **Hard** Make 2,000 g of dough at flour 100%, water 68%, salt 2%, yeast 1.0%. How much of each?

Show answer

Total 171%; flour 1,170 g; water 795 g; salt 23 g; yeast 12 g.

9. **Hard** A recipe uses 3 cups flour (360 g) and 1⅓ cups water (315 g). Is this a lean sandwich dough or a wet focaccia-style dough? Show why.

Show answer

Hydration $315/360 = 87.5\%$: very wet, focaccia-style.

10. **Challenge** Calvel compared doughs with and without an autolyse. Design a home experiment to test whether an autolyse changes a dough, naming the variable, the controls and three things you would measure.

    Show answer

    Make two identical doughs; one rests flour and water 30 minutes before adding salt and yeast (variable), the other is mixed at once (control). Keep flour, water, temperature, rise times and baking identical. Measure mixing time to a windowpane, loaf volume or height, and crumb photos and a blind taste rating.

COMMON MISTAKES

- Measuring flour by cups for a percentage formula.
- Adding extra flour to a wet dough because it is sticky; it is meant to be.
- Underproofing, which gives a dense focaccia.
- Pulling it pale; bake until deep golden.

Make it a game · Baker's Percent Race. Your parent names a flour weight, such as 800 grams. Calculate water at 75, salt at 2 and yeast at 1 percent as fast as you can, then hydration. Race a timer for six rounds with different flour weights. Log the fastest set. Name two things autolyse does to dough.

Scripture. “Take thou also unto thee wheat, and barley, and beans, and lentiles, and millet, and fitches, and put them in one vessel, and make thee bread thereof,” (Ezekiel 4:9, KJV)

God gave Ezekiel a bread formula of grains and beans together. Bakers have always worked from formulas; ours simply write the amounts in grams and percentages.

6.2 The Home Loaf: Fleischmann's Yeast, Kneading and Gluten

OBJECTIVES

- Tell how the Fleischmann brothers made reliable compressed yeast available to American bakers from 1868.
- Explain how kneading develops gluten and how yeast fermentation raises dough.
- Use the windowpane test and an internal temperature to judge dough and bread.
- Bake a soft sandwich loaf with a rise log.

> **Warm-up.** Stir 1 teaspoon of sugar and ½ teaspoon of yeast into ½ cup of warm water (about 100 °F) in a narrow glass, and another into ice water. Mark the foam level every 5 minutes for 20 minutes. What does the yeast need?

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**
> Before the lab, all the way through. Note his shaping steps and how he judges the proof.

Note: From King Arthur Baking; a longer video worth watching before your first loaf.

BACKUP VIDEO

How to Knead Bread Dough by Hand | Detailed Instructions | Baking Tips

ChainBaker · 8:35

https://www.youtube.com/watch?v=T8FK5apuL40

If kneading by hand is new: watch his hands and copy the motion.

KEY TERMS

yeast

A living single-celled fungus (*Saccharomyces cerevisiae*) that feeds on sugars in dough and releases carbon dioxide gas.

kneading

Pushing, folding and turning dough to develop gluten into a strong, elastic network that traps gas.

windowpane test

Stretching a small piece of dough thin enough to let light through without tearing; a sign of well-developed gluten.

proofing

The final rise of shaped dough before baking.

oven spring

The quick rise of bread in the first minutes of baking, as gas expands and the yeast makes a last burst of carbon dioxide.

CORE IDEAS

The story. In the 1860s American home bakers raised bread with homemade "starters" or with leftover yeast from other trades that gave uneven results. Charles Fleischmann, who came from a family of yeast makers in the Austrian Empire, saw the problem on a visit to the United States. In 1868, with his brother Maximilian and the businessman James Gaff, he began producing compressed cake yeast in Cincinnati, a pure, reliable yeast sold fresh to bakers and households. At the 1876 Centennial Exhibition in Philadelphia the company ran a model Viennese bakery, and crowds lined up for its bread. Reliable yeast made a light home loaf something any family could bake.

How they figured it out. The Fleischmanns grew yeast carefully, kept it pure and pressed it into cakes that stayed active for days if kept cool. Louis Pasteur had shown in the late 1850s that fermentation was caused by living yeast cells, and the yeast makers put that science to work: healthy, uncontaminated yeast in the right amount gives a predictable rise every time.

The kitchen science. When flour meets water, two proteins, glutenin and gliadin, link into **gluten**. Kneading lines up and strengthens this network until it is smooth and elastic and passes the windowpane test. Meanwhile, yeast feeds on sugars and produces carbon dioxide, which the gluten traps in thousands of tiny balloons; the dough rises. Yeast works best around 75–85 °F and is killed above about 140 °F. In the oven the gas expands (oven spring), steam forms, the starch sets and the crust browns. Sandwich bread is done at about 190 °F inside; lean, crusty breads at 200–210 °F.

Let's cook. You will knead a soft milk-and-butter sandwich loaf by hand, shape it, and bake it in a loaf pan, keeping a rise log. The technique standard: dough kneaded to a windowpane, first rise until doubled, tight shaping with a smooth top, proofed until it crowns about 1 inch above the pan, baked to 190 °F, and cooled completely before slicing.

PICTURE STUDY



Woman Baking Bread, Jean-François Millet, 1854 · Oil on canvas · Kröller-Müller Museum, Otterlo, Netherlands

Image: Wikimedia Commons, public domain

Jean-François Millet, who grew up on a farm in Normandy, painted the hard, honorable work of country people. Here a woman bakes the family's bread in a wood-fired brick oven, sliding the dough in on a long wooden paddle called a peel.

Look closely

- Find the oven mouth and the peel. How does she keep her arms out of the heat?
- Look at her posture. What does it say about the weight of the dough and the work?
- Look for the loaves. How many might she bake at once?

Talk about it

1. How would she know her oven was hot enough without a thermometer?
2. How many days of bread might one baking provide for a farm family?
3. What does it mean to pray "Give us this day our daily bread" when you bake your own?

> **Safety first.** Handle the hot loaf pan with dry mitts and turn the bread out onto a rack, away from your face. Do not taste unbaked dough. If you use a stand mixer for kneading, keep hands and spatulas out of the bowl while it runs.

KITCHEN LAB

Baking Lab: Soft Sandwich Loaf with a Rise Log

You will knead a sandwich loaf by hand, test gluten with the windowpane test, and record the rise and the bake.

You will need

- A digital scale, a large bowl and a straight-sided container (or tape to mark the bowl)
- A 9 × 5-inch or 8½ × 4½-inch loaf pan
- An instant-read thermometer
- A clean counter for kneading and a bench scraper
- A cooling rack

Soft Sandwich Loaf

Serves 1 loaf (about 16 slices) · Mix and knead 20 min · Rise 1–1½ hr · Proof 45–60 min · Bake 35–40 min

Ingredients

- 425 g (3½ cups) all-purpose or bread flour
- 227 g (1 cup) warm milk, about 100 °F
- 57 g (¼ cup) warm water
- 28 g (2 tablespoons) butter, softened
- 25 g (2 tablespoons) sugar or honey
- 8 g (1½ teaspoons) salt
- 7 g (2¼ teaspoons, 1 packet) instant yeast
- A little oil for the bowl

Method

1. Mix the flour, sugar, salt and yeast in the bowl. Add the milk, water and butter and stir to a shaggy dough.
2. Knead on a lightly floured counter 10–12 minutes, pushing away with the heel of your hand, folding back and turning, until smooth and elastic and it passes the windowpane test. Add flour only a tablespoon at a time if very sticky.

3. Place in an oiled container, cover and let rise in a warm spot until doubled, 1–1½ hours.
4. Press the dough into an 8 × 10-inch rectangle. Roll it up tightly from the short side, pinch the seam and set it seam-down in the greased pan. Cover and proof until it crowns about 1 inch above the rim, 45–60 minutes. Heat the oven to 350 °F (175 °C).
5. Bake 35–40 minutes, until golden brown and 190 °F in the center. Tent with foil after 20 minutes if it browns too fast.
6. Turn out onto a rack and cool completely, at least 1 hour, before slicing.

Allergy check: Contains wheat and milk. Use a plant milk and oil for milk-free.

Steps

1. **Yeast test.** Run the warm-up yeast test and record the foam heights.
2. **Kneading log.** Try the windowpane test at 4, 8 and 12 minutes of kneading; photograph each.
3. **Rise log.** Mark the dough's starting height on the container and record height every 15 minutes until doubled. Note the room temperature.
4. Shape, proof and bake. Record the proof height above the pan and the final internal temperature.
5. **Crumb study.** Photograph a slice. Is the crumb even? Any large holes or dense streaks?
6. **Technique check.** Score 1–3: windowpane passed, doubled rise, tight shaping, proper proof, 190 °F, cooled before slicing.
7. Clean up: scrape the counter with the bench scraper before wiping.
8. **Repeat round.** Bake the loaf with half whole-wheat flour and compare rise, crumb and taste.

Tips

- A warm (not hot) spot, like an oven with only the light on, speeds rising.
- Shape tightly: a loose roll makes holes and a lopsided loaf.
- The poke test: a gently floured finger dent that springs back slowly means ready to bake.

Check your work

- ☐ I can tell the Fleischmann story and explain yeast fermentation and gluten.
- ☐ I can judge dough by the windowpane test and bread by internal temperature.
- ☐ I baked a soft, even sandwich loaf and kept a rise log.

LAB NOTEBOOK

1. Draw gluten as a net trapping CO_2 bubbles, before and after kneading.
2. Graph your rise log (height against time).
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

Sandwich bread hydration (including milk): about 60–65%

$$\text{rise factor} = \frac{\text{volume after rise}}{\text{starting volume}}$$

From history. Active dry yeast, which keeps for months without refrigeration, was developed by Fleischmann's during the Second World War so that soldiers could have fresh bread. Instant (rapid-rise) yeast followed later and can be mixed directly with flour.

WORKED EXAMPLES

Example 1. The loaf uses 425 g flour, 227 g milk (about 87% water) and 57 g water. What is its effective hydration?

Show solution

1. Water in milk: $0.87 \times 227 = 197$ g.
2. Total water: $197 + 57 = 254$ g.
3. Hydration $= 254/425 \times 100 = 60\%$.

Answer: About 60%: a soft, easy-to-knead sandwich dough.

Example 2. Dough in a straight-sided container starts 3.0 cm high and is 6.4 cm high after 70 minutes. What is its rise factor? Has it doubled?

Show solution

1. $6.4/3.0 = 2.13$.

Answer: A rise factor of about 2.1: it has doubled and is ready to shape.

Example 3. Water for activating yeast should be about 105–110 °F. Your thermometer reads in Celsius. What range is that?

Show solution

1. $\frac{5}{9}(105 - 32) = 40.6\ ^\circ\text{C}$;
2. $\frac{5}{9}(110 - 32) = 43.3\ ^\circ\text{C}$.

Answer: About 41–43 °C. (Instant yeast can be mixed straight into flour with warm liquid around 95–100 °F.)

PRACTICE

1. Easy What gas makes bread rise, and what produces it?

   Show answer

   Carbon dioxide, produced by yeast feeding on sugars.

2. Easy What is the windowpane test?

   Show answer

   Stretching a small piece of dough thin enough to see light through without tearing, showing well-developed gluten.

3. Easy When did the Fleischmanns start making compressed yeast, and where?

   Show answer

   1868, Cincinnati.

4. Medium Why does water that is too hot ruin a dough?

   Show answer

   Yeast dies above about 140 °F, so the dough will not rise.

5. Medium What two proteins form gluten?

   Show answer

   Glutenin and gliadin.

6. Medium What internal temperature shows a sandwich loaf is done?

   Show answer

   About 190 °F.

7. Medium Why must bread cool before slicing?

Show answer

The crumb is still setting as steam escapes; cutting early makes it gummy.

8. Hard A dough has 500 g flour, 300 g milk (87% water) and 30 g butter (16% water). What is its hydration?

Show answer

Water $261 + 4.8 = 266$ g; 53%.

9. Hard Dough rises from 1.5 L to 2.7 L. What is the rise factor? Has it doubled?

Show answer

1.8; not yet doubled.

10. Challenge Explain, using gluten and gas, why bread made from low-protein cake flour rises poorly.

Show answer

Less glutenin and gliadin make a weaker gluten network that cannot stretch and hold the gas; bubbles burst and escape, so the loaf is dense and low.

COMMON MISTAKES

- Adding too much flour while kneading, which makes dry, dense bread.
- Using water hot enough to kill the yeast.
- Slicing hot bread.
- Underbaking: a golden crust is not proof; check for 190 °F.

Make it a game · Windowpane Challenge. Make a mock dough from flour and water, enough for a small ball. Knead for two minutes and test stretching a thin piece to see light through it. Predict how many minutes it takes you to reach windowpane. Explain gluten and yeast fermentation. Then tell how the Fleischmann brothers changed American baking in 1868.

Scripture. “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)

Jesus used a home baker’s everyday work to teach how God’s kingdom grows: quietly, from within, until it fills everything. Watch your dough rise and remember the parable.

6.3 Quick Breads: Eben Horsford's Baking Powder and the Muffin Method

OBJECTIVES

- Tell how Eben Horsford developed a calcium-phosphate baking powder at Harvard in the 1850s.
- Explain the muffin method and why overmixing makes tough, tunneled muffins.
- Use baker's percentages to compare a muffin formula with a bread formula.
- Bake blueberry muffins and run a mixing experiment.

> **Warm-up.** Look at a muffin cut in half from a bakery or a package. Do you see tall, narrow holes running up through it (tunnels)? What do you think causes them?

WATCH

Muffin Method, Ep. 41

Culinary Arts Management at Cosumnes River College · 4:52

https://www.youtube.com/watch?v=Zamf3t-ilUk

> **WHEN TO WATCH**
> Before the lab. Count how many strokes he uses to combine wet and dry.

BACKUP VIDEO

Pastry Foundations - Muffin Method

Hospitality Education Foundation of Georgia · 6:02

https://www.youtube.com/watch?v=ZLgVuz4PuDM

A culinary-school lesson on the same method, with a close look at tunneling.

KEY TERMS

quick bread

Bread or cake raised with chemical leaveners (baking soda or powder) or steam instead of yeast, so it needs no rising time.

muffin method

Whisk the dry ingredients in one bowl and the wet (including liquid fat) in another, then fold them together briefly, just until moistened.

tunneling

Long holes in a muffin caused by overmixing, which develops gluten that traps gas in channels.

baking powder

A mix of baking soda, a dry acid and starch that releases carbon dioxide when wet and (if double-acting) again when hot.

quick-bread doneness

Golden, springs back when pressed, a toothpick in the center comes out with no wet batter, and about 200–205 °F inside.

CORE IDEAS

The story. Eben Norton Horsford (1818–1893) studied chemistry in Germany with the great Justus von Liebig and became a professor at Harvard. Liebig had studied how bread nourishes, and Horsford became interested in the leavening of bread. In the 1850s and 1860s he developed and patented a baking powder made with calcium phosphate (rather than cream of tartar, which was costly and imported) and, with a partner, founded the Rumford Chemical Works in Rhode Island, named for Count Rumford. In 1861 he wrote *The Theory and Art of Bread-Making*. His baking powder made reliable biscuits, muffins and cakes possible for any household.

How he figured it out. Horsford knew that baking soda needed an acid, and that home cooks' sour milk varied from day to day, so results varied too. He combined the soda with a measured dry acid in one powder, so the right amount of gas was produced every time water was added. The powder only had to be kept dry until use. Cooks then developed simple mixing methods for quick breads, of which the muffin method is the quickest.

The kitchen science. In the muffin method, dry and wet ingredients are mixed separately and then combined with only 10–15 strokes, leaving a lumpy batter. Each extra stroke develops gluten. A little gluten holds the muffin together; too much makes it tough, with tunnels where gas pushed up through tough channels and peaked tops. Liquid fat (oil or melted butter) coats flour and keeps muffins tender. Compared with bread (flour 100%, water about 65%, sugar 0–5%), a muffin formula is rich: sugar 60% or more and fat 30% or more of the flour, which is why it is so tender.

Let's cook. You will bake blueberry muffins by the muffin method and test the effect of mixing: 12 strokes versus 50 strokes. The technique standard: dry and wet mixed separately, folded just until moistened, blueberries tossed in a little flour so they do not sink, cups filled ¾ full, baked until golden and a toothpick comes out clean.

PICTURE STUDY



The Baker Arent Oostwaard and His Wife Catharina Keizerswaard, Jan Steen, 1658 · Oil on panel · Rijksmuseum, Amsterdam

Image: Wikimedia Commons, public domain

Jan Steen painted the baker Arent Oostwaard of Leiden and his wife at their shop window. On the sill lie loaves, rolls, pretzel-shaped krakelingen and pastries. The boy blows a horn to tell the neighborhood that the bread is fresh from the oven.

Look closely

- Count the different kinds of bread and pastry. Which might be yeast breads and which quick, rich pastries?
- Find the boy with the horn. Why announce fresh bread?
- Look at the baker's clothes and arms. What do they tell you about his work?

Talk about it

1. Which breads on this sill would need hours to rise, and which could be made quickly?
2. Why would a baker need to be up long before dawn?
3. If you ran a bakery, which quick bread would you sell first, and why?

> **Safety first.** Do not taste the uncooked batter, which contains raw flour and egg. Lift the hot muffin tin with dry mitts and let muffins cool in the pan 5 minutes before turning them out.

KITCHEN LAB

Baking Lab: Blueberry Muffins and the Mixing Test

You will bake a batch of blueberry muffins by the muffin method, dividing the batter to test how mixing changes texture.

You will need

- A 12-cup muffin tin and paper liners
- Two mixing bowls, a whisk and a rubber spatula
- A digital scale, a ⅓-cup scoop
- A toothpick and an instant-read thermometer
- A cooling rack

Blueberry Muffins

Serves 12 muffins · Prep 15 min · Bake 18–22 min

Ingredients

- 240 g (2 cups) all-purpose flour, plus 1 tablespoon for the berries
- 150 g (¾ cup) sugar, plus 1 tablespoon for the tops
- 2½ teaspoons baking powder
- ½ teaspoon salt and ½ teaspoon cinnamon (optional)
- 240 g (1 cup) milk
- 70 g (⅓ cup) neutral oil or melted butter
- 1 large egg
- 1 teaspoon vanilla extract
- 1½ cups (about 225 g) blueberries, fresh or frozen (not thawed)

Method

1. Heat the oven to 400 °F (205 °C) and line the tin.
2. Whisk the flour, sugar, baking powder, salt and cinnamon in a large bowl.
3. Whisk the milk, oil, egg and vanilla in another bowl.
4. Toss the blueberries with 1 tablespoon flour.

5. Pour the wet into the dry and fold with a spatula about 10–12 strokes, until just moistened; fold in the berries with 2–3 more strokes. (For the mixing test, see the lab steps.)
6. Fill the cups about ¾ full, sprinkle with sugar and bake 18–22 minutes, until golden, springy, and a toothpick comes out clean (about 200–205 °F). Cool 5 minutes in the pan, then on a rack.

Allergy check: Contains wheat, milk and eggs. Use a gluten-free flour blend, plant milk and oil as needed.

Steps

1. **Plan the test.** After folding the batter 12 strokes, scoop 6 muffins (Batch A). Stir the remaining batter 40 more strokes and scoop 6 more (Batch B). Mark which liners are which.
2. Bake together and record the bake time and internal temperature.
3. **Compare.** Measure the height of 3 muffins from each batch. Cut one of each in half and photograph the crumb. Look for tunnels and peaked tops.
4. **Taste.** Rate tenderness for each batch (blind, if a family member serves them).
5. Write a conclusion explaining your results with gluten.
6. **Technique check.** Score 1–3: separate dry and wet mixing, minimal folding in Batch A, berries well distributed, correct fill, baked to doneness.
7. **Repeat round.** Make banana bread or cornbread muffins by the same method.

Tips

- Frozen blueberries go in straight from the freezer to limit purple streaks.
- Room-temperature milk and egg keep melted butter from clumping.
- A spoonful of batter in empty cups is not needed; empty cups are fine in most tins.

Check your work

- ☐ I can tell Horsford's story and explain baking powder.
- ☐ I can explain the muffin method and the effect of overmixing.
- ☐ I baked tender blueberry muffins and ran a fair mixing test.

LAB NOTEBOOK

1. Draw cross-sections of a tender muffin and an overmixed one, labeling tunnels and peaks.
2. Record your mixing test data and photos.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{baker's } \% = \frac{\text{ingredient mass}}{\text{flour mass}} \times 100$$

About 1–$1\frac{1}{4}$ tsp baking powder per cup of flour for muffins

From history. Horsford's baking powder company also printed popular cookbooks to teach cooks how to use it. Rumford baking powder, named for Count Rumford, is still sold today.

WORKED EXAMPLES

Example 1. The muffin recipe uses 240 g flour, 150 g sugar, 70 g oil, 240 g milk and 50 g egg. Find the baker's percentages for sugar, oil and milk.

Show solution

1. Sugar $150/240 = 62.5\%$; oil $70/240 = 29\%$; milk $240/240 = 100\%$.

Answer: Sugar about 63%, oil about 29%, milk 100% of the flour: a rich, tender formula compared with bread.

Example 2. The recipe makes 12 muffins. You need 30 for a bake sale. Find the yield factor and the flour and sugar.

Show solution

1. Factor $30/12 = 2.5$.
2. Flour $240 \times 2.5 = 600$ g; sugar $150 \times 2.5 = 375$ g.

Answer: Factor 2.5: 600 g flour and 375 g sugar (and 2.5 times everything else).

Example 3. Ingredients for 12 muffins cost $4.20 (blueberries $2.50 of it). You sell them at a bake sale for $1.25 each. What is the cost per muffin and the profit per dozen?

Show solution

1. Cost per muffin $= \$4.20 / 12 = \$0.35$.
2. Revenue per dozen $= 12 \times \$1.25 = \$15.00$; profit $= \$15.00 - \$4.20 = \$10.80$.

Answer: 35¢ per muffin; $10.80 profit per dozen (not counting paper liners and oven energy).

PRACTICE

1. Easy Describe the muffin method in two sentences.

   Show answer

   Whisk the dry ingredients in one bowl and the wet ingredients (with liquid fat) in another. Pour the wet into the dry and fold just until moistened, leaving lumps.

2. Easy What causes tunnels in muffins?

   Show answer

   Overmixing, which develops too much gluten.

3. Easy Who was Eben Horsford?

   Show answer

   A Harvard chemistry professor who developed a calcium-phosphate baking powder in the 1850s–60s and founded the Rumford Chemical Works.

4. Medium Why toss blueberries in a little flour before folding them in?

   Show answer

   The flour coating helps them grip the batter so they sink less, and it absorbs some juice.

5. Medium How much baking powder for 3 cups of flour at 1¼ tsp per cup?

   Show answer

   3¾ teaspoons.

6. Medium Why does oil make muffins more tender than solid butter in the muffin method?

Show answer

Liquid fat coats flour proteins and limits gluten formation, and it stays liquid at room temperature, keeping the crumb moist.

7. Medium How do you test a muffin for doneness?

Show answer

Golden top that springs back, a toothpick in the center comes out without wet batter, about 200–205 °F inside.

8. Hard A bread formula has sugar at 4% and a muffin formula at 63%. What does sugar do in the muffin besides sweeten?

Show answer

It holds moisture (keeps it tender and moist), interferes with gluten, browns the crust, and helps the batter hold air.

9. Hard Batter for 12 muffins weighs 850 g. How much batter per cup? If you use a ⅓-cup scoop that holds 80 g, how many muffins?

Show answer

About 71 g per cup; 850/80 ≈ 10–11 muffins.

10. Challenge Horsford wanted bakers to get the same result every time. Explain why a powder with a built-in acid gives more consistent results than baking soda plus sour milk.

Show answer

Sour milk varies in acidity day to day, so the amount of gas (and leftover soda) varied; baking powder contains a measured acid matched to the soda, so the reaction is the same every time water and heat are added.

COMMON MISTAKES

- Beating muffin batter smooth.
- Using expired baking powder; test it in hot water (it should fizz).
- Overfilling the cups, so muffins spill and stick.
- Opening the oven in the first 10 minutes, which can make them fall.

Make it a game · Overmix Detective. Your parent plays a baker with five complaints: tough muffins, tunnels, flat tops, dry crumb, pale crust. Diagnose each with the muffin method and baking powder facts. Defend your answer in twenty seconds. Then explain Eben Horsford's calcium-phosphate baking powder. A wrong diagnosis hands your parent a point.

6.4 Pie Crust and Cookies: Fat, Flour and Flakiness

OBJECTIVES

- Explain how cold fat and minimal gluten make a flaky, tender pie crust, using the 3-2-1 ratio.
- Tell how Ruth Wakefield's careful recipe testing at the Toll House Inn produced the chocolate chip cookie in the 1930s.
- Calculate crust ratios and scale a pastry to different pans.
- Bake an apple galette with an all-butter crust.

> **Warm-up.** Put a pat of cold butter and a pat of soft butter side by side on a plate. Press each with a fork. What happens to each? Which do you think would make separate layers in a dough?

WATCH

How To Make Flaky All Butter Pie Pastry — The Tried and Tested Method

Glen And Friends Cooking · 4:42

https://www.youtube.com/watch?v=kzwSTJQK9-g

> **WHEN TO WATCH**
> Before the lab. Look for the size of the butter pieces before the water goes in.

BACKUP VIDEO

All Butter Pie Crust | Sally's Baking

Sally's Baking Recipes · 3:22

https://www.youtube.com/watch?v=0fHZl_noN5s

A second method using a pastry cutter by hand.

KEY TERMS

flaky

Made of thin, separate layers, from flattened pieces of cold fat that melt and release steam in the oven.

tender

Easily broken or cut, because fat coats flour and limits gluten.

3-2-1 dough

Pie dough made of 3 parts flour, 2 parts fat and 1 part water by weight.

galette

A free-form tart: pastry rolled into a round, filled, and folded up around the edges.

blind tasting

Tasting without knowing which sample is which, so expectations do not affect the judgment.

CORE IDEAS

The story. Ruth Graves Wakefield (1903–1977) trained in household arts at the Framingham State Normal School in Massachusetts and worked as a dietitian and teacher. In 1930 she and her husband opened the Toll House Inn in Whitman, Massachusetts, where she cooked for guests and became known for her desserts. She was a careful, exacting cook who tested recipes until they worked every time. In the late 1930s she added chopped bars of semisweet chocolate to a butter cookie dough, and the chocolate held its shape: the chocolate chip cookie. Her *Toll House Tried and True Recipes* (1938) printed the recipe, and its fame spread across the country.

How she figured it out. Wakefield's training taught her to measure precisely and to change one thing at a time. Her cookbook gave exact amounts and times so that home cooks could repeat her results. Pastry rewards that same precision: the temperature of the butter, the amount of water and the handling of the dough decide whether a crust is flaky and tender or tough and greasy.

The kitchen science. Pie dough is 3 parts flour, 2 parts fat and 1 part water by weight. Keep the butter cold and leave it in pea-sized pieces: rolling flattens them into thin sheets between layers of dough. In the oven, the water in the butter turns to steam and puffs the layers apart, making the crust **flaky**; the fat that coats the flour limits gluten, making it **tender**. Too much water or handling develops gluten and makes a tough crust that shrinks. Cookies show fat in a different way: butter that is creamed holds air, and its melting temperature and the amount of sugar decide how far a cookie spreads.

Let's cook. You will make an all-butter crust by hand and bake an apple galette. The technique standard: butter cold and in pea-sized pieces, just enough ice water for

the dough to hold together, dough chilled at least 1 hour, rolled evenly to about ⅛ inch, filled and folded neatly, and baked until the crust is deep golden and the juices bubble.

PICTURE STUDY



Woman Churning Butter, Jean-François Millet, 1855–56 · Etching · The Metropolitan Museum of Art, New York

Image: Wikimedia Commons, public domain

Millet made this etching of a farm woman churning cream into butter, a long and tiring job done by hand. The butter she makes is the same fat that, kept cold and in pieces, gives a pie crust its flaky layers.

Look closely

- Find the churn and the dasher. How does she use her arms and body?
- Find the cat. What does it hope for?
- Look at the farmhouse around her. What does it tell you about her life?

Talk about it

1. How long do you think it took to make enough butter for a pie?
2. Why must butter for pastry be kept cold?
3. How would knowing the work behind butter change how you use it?

> **Safety first.** Do not taste raw pie dough or cookie dough, which contain raw flour (and, in cookies, uncooked egg). Place the galette on a parchment-lined rimmed sheet pan to catch hot, sugary juices, which can burn badly; let it cool 20 minutes before cutting.

KITCHEN LAB

Pastry Lab: All-Butter Apple Galette

You will make an all-butter crust by the 3-2-1 ratio, roll and fold a galette, and photograph the flaky layers.

You will need

- A digital scale, a large bowl, a pastry blender or two forks (or your fingertips)
- A rolling pin and plastic wrap
- A rimmed sheet pan and parchment paper
- A paring knife, peeler and apple corer
- A pastry brush and a cooling rack

All-Butter Apple Galette

Serves 8 · Dough 15 min + chill 1 hr · Assemble 20 min · Bake 40–45 min

Ingredients

- **Crust:** 150 g (1¼ cups) all-purpose flour
- 1 tablespoon sugar and ¼ teaspoon salt
- 100 g (7 tablespoons) cold unsalted butter, cut in ½-inch cubes
- 50–60 g (3½–4 tablespoons) ice water
- **Filling:** 1½ lb (680 g, about 3 medium) apples, peeled, cored and sliced ¼ inch thick
- ⅓ cup (65 g) sugar, plus 1 tablespoon for the crust
- 1 tablespoon lemon juice and 1 tablespoon flour
- ½ teaspoon cinnamon and a pinch of salt
- 1 tablespoon milk (or beaten egg) for brushing

Method

1. Whisk the flour, sugar and salt. Add the cold butter and cut it in with a pastry blender or fingertips until the pieces are pea-sized, with some larger flakes.

2. Sprinkle in 50 g of ice water and toss with a fork. Squeeze a handful: if it holds together, stop; if crumbly, add water a teaspoon at a time. Press into a disk, wrap and chill at least 1 hour.
3. Heat the oven to 400 °F (205 °C). Toss the apples with the sugar, lemon juice, flour, cinnamon and salt.
4. On a floured counter roll the dough into a 12–13-inch round about ⅛ inch thick, turning it often. Move to the parchment-lined pan.
5. Arrange the apples in the center, leaving a 2-inch border. Fold the border up over the fruit, pleating it. Brush the crust with milk and sprinkle with sugar.
6. Bake 40–45 minutes, until the crust is deep golden and the juices bubble. Cool on the pan 20 minutes before slicing.

Allergy check: Contains wheat and milk. A gluten-free flour blend can work with extra care; plant-based butter can replace butter for milk-free.

Steps

1. **Weigh** the crust ingredients and confirm the 3-2-1 ratio in your notebook.
2. **Butter check.** Photograph the butter pieces in the flour before adding water.
3. Record how much water you actually needed.
4. Roll, fill and bake. Measure the diameter of the dough round and of the finished galette.
5. **Layer study.** Break a piece of the edge and photograph the layers.
6. **Cookie comparison (optional).** Bake two cookies from any butter cookie dough, one from dough chilled 1 hour and one unchilled, and compare spread. Do not taste the dough.
7. **Technique check.** Score 1–3: cold butter in pieces, minimal water, chilled dough, even rolling, neat pleats, deep golden and flaky.
8. **Repeat round.** Bake a two-crust pie or a pear or berry galette with the same dough.

Tips

- Freeze the cubed butter 10 minutes first on a warm day.

- If dough cracks while rolling, let it warm 5 minutes; if it softens and sticks, chill it 10 minutes.
- Firm baking apples (Granny Smith, Honeycrisp, Braeburn) hold their shape.

Check your work

- ☐ I can explain flakiness and tenderness and the 3-2-1 ratio.
- ☐ I can tell Ruth Wakefield's story.
- ☐ I baked a flaky, golden apple galette.

LAB NOTEBOOK

1. Draw pie dough in cross-section before and after baking, showing butter layers and steam pockets.
2. Record your weights, water used and layer photos.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$\text{flour} : \text{fat} : \text{water} = 3 : 2 : 1$ by weight

$\text{dough} \propto \text{pan area} = \pi r^2$

From history. During the Second World War, families mailed Toll House cookies to soldiers overseas, and the recipe spread even further. Ruth Wakefield allowed the Nestlé company to print her recipe on its chocolate packages, which spread it into nearly every American kitchen.

WORKED EXAMPLES

Example 1. You have 180 g flour. Using 3-2-1, how much butter and water?

Show solution

1. One part $= 180/3 = 60$ g.
2. Butter $= 2 \times 60 = 120$ g; water $= 60$ g.

Answer: 120 g butter and about 60 g ice water (add the last bit only as needed).

Example 2. A 9-inch pie needs a 12-inch round of dough. How much more dough does a 10-inch pie needing a 13½-inch round require, if thickness is the same?

Show solution

1. Area ratio $= \left(\frac{13.5}{12}\right)^2 = 1.27$.

Answer: About 27% more dough.

Example 3. Butter is about 16% water. How much water is in 120 g of butter, and why does that water matter for flakiness?

Show solution

1. $0.16 \times 120 = 19$ g of water.

Answer: About 19 g. That water turns to steam in the hot oven and lifts the layers apart.

PRACTICE

1. Easy What is the 3-2-1 ratio for pie dough?

   Show answer

   3 parts flour, 2 parts fat, 1 part water, by weight.

2. Easy Why must butter for pie crust be cold?

   Show answer

   Cold butter stays in solid pieces that flatten into layers; soft butter blends in and makes a crumbly or greasy crust.

3. Easy Who was Ruth Wakefield?

   Show answer

   A trained dietitian and teacher who ran the Toll House Inn in Whitman, Massachusetts, and created the chocolate chip cookie in the late 1930s.

4. Medium With 240 g flour, how much butter and water for 3-2-1 dough?

   Show answer

   160 g butter, 80 g water.

5. Medium Why does a crust made with too much water turn tough and shrink?

Show answer

Extra water lets more gluten form, making the dough elastic so it springs back and shrinks, and baking it tough.

6. Medium Why chill pie dough before rolling?

Show answer

To firm the butter and relax the gluten, so it rolls easily without tearing or shrinking.

7. Medium What makes a cookie spread more?

Show answer

More sugar, warmer or melted butter, less flour, a hot sheet pan, or too little chilling.

8. Hard A recipe calls for 1¼ cups flour (150 g). Using 3-2-1, how much butter in tablespoons (1 Tbsp = 14 g)?

Show answer

100 g butter ≈ 7 tablespoons.

9. Hard Compare dough needed for an 11-inch galette round and a 13-inch round of the same thickness.

Show answer

$(13/11)^2 = 1.40$: 40% more dough.

10. Challenge Design a fair test to compare crust made with all butter and crust made with half butter, half shortening, naming what you keep the same and what you measure.

Show answer

Same flour, total fat weight, water, chilling, thickness, oven and bake time; vary only the fat type. Measure flakiness (photo of layers), tenderness (force to break or a blind rating), shrinkage (diameter before and after), color and flavor rating.

COMMON MISTAKES

- Overworking the dough or adding too much water.

- Skipping the chill.
- Rolling only in one direction, which makes an uneven, misshapen round.
- Cutting the galette hot, so the juices run.

> **Make it a game · 3-2-1 Challenge.** Your parent names a flour weight in grams. Compute the fat and water amounts for a 3-2-1 dough in ten seconds: 3 parts flour, 2 fat, 1 water. Run eight rounds. Then name three reasons a crust turns out tough and three that make it flaky. Finish with Ruth Wakefield and her testing at the Toll House Inn.

6.5 The Pound Cake and the Creaming Method

OBJECTIVES

- Tell the history of the pound cake, from Hannah Glasse (1747) and Amelia Simmons (1796) to today.
- Explain how creaming butter and sugar traps air, and how eggs and flour build the cake's structure.
- Use the 1:1:1:1 pound-cake ratio as baker's percentages and scale it to different pans.
- Bake a pound cake by weight using the creaming method.

> **Warm-up.** Beat 2 tablespoons of soft butter with 2 tablespoons of sugar with a fork for 3 minutes. Look at it and compare with plain soft butter. What changed in color and texture? Where did the change come from?

WATCH

The Science Behind Pound Cake - Kitchen Conundrums with Thomas Joseph

Everyday Food · 6:06

https://www.youtube.com/watch?v=dNMM9XPZ_3o

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Pause on the creamed butter and compare it with yours.

BACKUP VIDEO

How to cream butter and sugar

King Arthur Baking Company · 1:26

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

A short look at what properly creamed butter and sugar look like.

KEY TERMS

creaming method

Beating softened butter and sugar until light and fluffy, then adding eggs one at a time and dry ingredients at the end.

pound cake

A cake originally made with a pound each of flour, butter, sugar and eggs.

emulsion

A smooth mixture of fat and water; egg yolk helps the butter and the eggs' water stay blended in cake batter.

curdled batter

A broken emulsion that looks grainy, usually from adding cold eggs too quickly.

structure builders

Ingredients that set and hold a baked good's shape: flour (starch and gluten) and eggs (protein).

CORE IDEAS

The story. The pound cake is one of the oldest recipes still baked in the same way. Hannah Glasse's *The Art of Cookery* (1747) gives a pound cake of a pound each of butter, sugar, flour and eggs, beaten by hand for an hour, and Amelia Simmons's *American Cookery* (1796) printed one for the new nation. The recipe was easy to remember in a time when many people could not read: a pound of each. The long beating was the only leavening; there was no baking powder yet.

How they figured it out. Cooks learned that the beating mattered as much as the ingredients. Beaten long enough, butter and sugar turned pale and fluffy, and the cake rose high and fine-grained; beaten carelessly, it was heavy. Food science later explained it: the sugar crystals were cutting countless tiny air pockets into the butter.

The kitchen science. In **creaming**, sharp sugar crystals carve tiny air cells into soft butter (about 65–68 °F, cool but bendable). Eggs, added one at a time, form an emulsion with the butter; egg yolk helps hold fat and water together. In the oven, those air cells expand with heat and with steam and carbon dioxide (if baking powder is used), and the egg proteins and flour starch set around them. The pound-cake ratio in baker's percentages is flour 100%, butter 100%, sugar 100%, eggs 100%. Butter too warm cannot hold air; too cold, it will not cream. Cold eggs can curdle the batter.

Let's cook. You will bake a classic pound cake by weight. The technique standard: butter at about 65–68 °F, creamed with sugar 4–5 minutes until pale and fluffy, eggs at room temperature added one at a time, flour folded in gently just until combined,

baked low and slow until a toothpick comes out clean and the center reads about 205–210 °F.

PICTURE STUDY



Still Life with Tea Service, Albert Anker, Late 19th century · Oil on canvas · Private collection, Switzerland
Image: Wikimedia Commons, public domain

Albert Anker painted a Swiss tea table: a copper kettle, teacups, sugar and a plate of golden sponge biscuits. Light cakes and biscuits like these depend on air beaten into eggs or butter, the same idea as creaming for a pound cake.

Look closely

- Find the cakes. How can you tell they are light and airy?
- Find the kettle and teapot. How does the painting suggest warmth?
- Look at the cloth and cups. Who might be coming to tea?

Talk about it

1. What gives a sponge cake or pound cake its light texture?
2. Why are cakes so often part of welcoming guests?
3. What would you bake for a family tea?

Safety first. Do not taste uncooked batter. If you use a stand mixer, keep hands and spatulas out of the bowl while it runs and turn it off to scrape. Lift the heavy, hot pan with two dry mitts and cool the cake 15 minutes before turning it out.

KITCHEN LAB

Baking Lab: Classic Pound Cake by Weight

You will measure the classic 1:1:1:1 ratio by weight, cream by hand or mixer, and check the cake's rise and crumb.

You will need

- A digital scale, a large mixing bowl and a hand or stand mixer (or a sturdy wooden spoon)
- A 9 × 5-inch loaf pan, greased and floured or lined with parchment
- An instant-read thermometer for the butter and the cake
- A rubber spatula, a toothpick and a cooling rack
- A ruler

Classic Pound Cake

Serves 10–12 slices · Prep 20 min · Bake 60–75 min

Ingredients

- 225 g (1 cup) unsalted butter, at 65–68 °F
- 225 g (1 cup + 2 tablespoons) sugar
- 225 g beaten eggs (4 large eggs plus 1 yolk), at room temperature
- 225 g (1¾ cups + 1 tablespoon) all-purpose or cake flour
- ½ teaspoon salt
- ½ teaspoon baking powder (optional, for a slightly lighter cake)
- 1½ teaspoons vanilla extract
- 1 tablespoon lemon zest (optional)

Method

1. Heat the oven to 325 °F (165 °C). Prepare the pan.
2. Whisk the flour, salt and baking powder together.
3. Beat the butter 1 minute, then add the sugar and beat 4–5 minutes until pale and fluffy, scraping the bowl twice.

4. Add the eggs a little at a time (about one egg's worth), beating well after each. Beat in the vanilla and zest.
5. On low speed (or by hand), add the flour in three parts, mixing just until no streaks remain. Scrape into the pan and smooth the top.
6. Bake 60–75 minutes, until golden, a toothpick in the center comes out clean and the center reads 205–210 °F. Cool 15 minutes in the pan, then turn out onto a rack.

Allergy check: Contains wheat, milk and eggs. Gluten-free flour blends can work; the eggs and butter are essential to this cake.

Steps

1. **Weigh** the four main ingredients and confirm the 1:1:1:1 ratio.
2. **Butter temperature.** Record the butter's temperature before creaming.
3. **Creaming check.** Photograph the butter and sugar at 0, 2 and 5 minutes. Note the color change.
4. **Batter volume.** Mark the batter height in the pan with a ruler before baking, and measure the cake's height after baking. Calculate the rise.
5. Record the bake time and final internal temperature.
6. **Crumb study.** Slice and photograph. Describe the crumb (fine and even, or coarse).
7. **Technique check.** Score 1–3: correct butter temperature, full creaming, eggs added gradually, gentle flour folding, baked to temperature.
8. **Repeat round.** Bake a creamed-method sheet cake or cookies and compare.

Tips

- If the top cracks down the middle, that is normal and traditional for pound cake.
- Cake flour makes a finer, more tender crumb than all-purpose.
- Wrap leftovers well; pound cake keeps for days and freezes beautifully.

Check your work

☐ I can tell the history of the pound cake.

☐ I can explain creaming and the 1:1:1:1 ratio.

- [ ] I baked a fine-crumbed pound cake to 205–210 °F.

LAB NOTEBOOK

1. Draw creamed butter under a “microscope,” showing sugar crystals and air cells.
2. Record your creaming photos, batter and cake heights, and crumb.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

Pound cake: flour : butter : sugar : eggs $= 1 : 1 : 1 : 1$ (each 100% in baker’s percentages)

$$\text{scale factor} = \frac{\text{new pan volume}}{\text{old pan volume}}$$

From history. Later bakers added baking powder and changed the ratios to make lighter cakes, but the old pound cake survives in many family recipe boxes. The French call a similar cake *quatre-quarts*, “four quarters,” for its four equal parts.

WORKED EXAMPLES

Example 1. A “pound of each” is 454 g. You want a smaller cake with 225 g flour. How much butter, sugar and egg, and about how many large eggs (50 g each without shell)?

Show solution

1. 1:1:1:1: butter 225 g, sugar 225 g, eggs 225 g.
2. Eggs: $225/50 = 4.5$ large eggs (use 4 eggs plus 1 yolk, or weigh 225 g of beaten egg).

Answer: 225 g each of butter, sugar and egg (about 4½ large eggs).

Example 2. Your 9 × 5 × 3-inch loaf pan holds the 225-g recipe. How much more batter does a 10-inch Bundt pan holding 12 cups need, if the loaf pan holds 8 cups?

Show solution

1. Factor $= 12/8 = 1.5$.
2. Flour $= 225 \times 1.5 = 338$ g (and the same for butter, sugar and eggs).

Answer: 1.5 times: about 338 g of each ingredient.

Example 3. Creaming works best with butter at 65–68 °F. Convert to °C. Your kitchen is 77 °F; is room-temperature butter too warm?

Show solution

1. $\frac{5}{9}(65 - 32) = 18.3\ ^\circ\text{C}$; $\frac{5}{9}(68 - 32) = 20\ ^\circ\text{C}$.
2. At 77 °F (25 °C), butter left out for hours will be too soft to hold air.

Answer: 18–20 °C. In a warm kitchen, take butter out only 30–45 minutes ahead and check that it bends without being greasy.

PRACTICE

1. Easy What does “pound cake” mean?

   Show answer

   A cake made with a pound each of flour, butter, sugar and eggs.

2. Easy What does creaming do?

   Show answer

   Sugar crystals cut tiny air cells into soft butter, lightening the batter and helping the cake rise.

3. Easy Why add eggs one at a time?

   Show answer

   To keep the butter-egg emulsion from breaking (curdling).

4. Medium Write the pound-cake formula in baker’s percentages.

   Show answer

   Flour 100%, butter 100%, sugar 100%, eggs 100%.

5. Medium How much butter, sugar and eggs go with 300 g flour in a pound cake?

   Show answer

   300 g each.

6. Medium Why is a pound cake baked at a lower temperature (325 °F) than muffins (400 °F)?

Show answer

It is a large, dense cake; lower heat lets the center bake through before the outside overbrowns.

7. Medium What happens if the butter is melted instead of creamed?

Show answer

It cannot hold air; the cake is dense and heavy.

8. Hard A pound cake uses 4 eggs (200 g). How much flour, butter and sugar for the classic ratio?

Show answer

200 g each.

9. Hard Your batter looks curdled after adding eggs. Explain why and give a fix.

Show answer

The emulsion broke, often from cold eggs added too fast; beat in a spoonful of the flour, or warm the bowl slightly, and keep going; the cake will usually still bake well.

10. Challenge Hannah Glasse's cooks beat the batter for an hour by hand. Estimate why a stand mixer creams in 5 minutes, and explain what both are trying to achieve.

Show answer

A mixer beats hundreds of times per minute with a consistent motion, creating and dividing air cells far faster than a tiring arm; both aim to fill the butter with many small, stable air cells that expand into a fine, light crumb.

COMMON MISTAKES

- Butter too soft or melted.
- Adding cold eggs all at once.
- Overmixing after the flour goes in, which makes the cake tough.
- Opening the oven early; the cake may sink.

Make it a game · Creaming Judge. Cream a stick of butter with sugar in a bowl, stopping to describe how it looks at one, three and five minutes. Predict the volume change. Explain how creaming traps air, why cold eggs curdle batter, and how a pound cake came from Hannah Glasse's era. Your parent judges your explanation like a baking competition.

UNIT 6

Baking and Pastry

Baking is cooking by formula. In this unit you will learn to read and write recipes the way professional bakers do, in baker's percentages, and you will bake the main families of baked goods: a high-hydration focaccia, a kneaded sandwich loaf, quick breads made by the muffin method, a flaky pastry crust, and a pound cake made by the creaming method.

The history runs from Hannah Glasse's pound cake and Amelia Simmons's pearlash to the Fleischmann brothers' yeast, Eben Horsford's baking powder, Ruth Wakefield's tested recipes and Raymond Calvel's autolyse. The science covers gluten, yeast fermentation, chemical leavening, fat and flakiness, and the air cells of a creamed batter. Every lab is weighed in grams, and every bake ends with an internal temperature and a crumb study.

PREREQUISITES

- Units 1–5, especially measuring by weight (2.5) and chemical leavening (5.5)
- A digital scale that reads grams
- Comfort with percentages and area scaling

MASTERY CHECKLIST

- ☐ I can write and scale a formula in baker's percentages and calculate hydration.
- ☐ I can knead a yeast dough to a windowpane and bake bread to the right internal temperature.
- ☐ I can make quick breads by the muffin method without overmixing.
- ☐ I can make a flaky, tender pie crust by the 3-2-1 ratio.
- ☐ I can cream butter and sugar properly and bake a pound cake by the classic ratio.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **King Arthur Baking: Baker's Percentage**: Free. King Arthur's professional reference page explaining baker's percentages, for Lesson 6.1.
- **A bench scraper and a 9 × 5-inch loaf pan**: Inexpensive tools used throughout the unit.
- **A stand or hand mixer**: Optional; every recipe in this unit can be mixed by hand.

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 Baker's Percentages: Raymond Calvel and the Focaccia
3 sessions of 50–90 minutes

6.2 The Home Loaf: Fleischmann's Yeast, Kneading and Gluten
3 sessions of 50–90 minutes

6.3 Quick Breads: Eben Horsford's Baking Powder and the Muffin Method
3 sessions of 50–90 minutes

6.4 Pie Crust and Cookies: Fat, Flour and Flakiness 3 sessions of 50–90 minutes

6.5 The Pound Cake and the Creaming Method 3 sessions of 50–90 minutes

Unit 6 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **8 pts**
   A dough uses 500 g flour, 350 g water, 10 g salt and 5 g yeast. Write the baker's percentages and the hydration.

2. **8 pts**
   Make 1,200 g of dough at flour 100%, water 65%, salt 2%, yeast 1.0%. How much of each ingredient?

3. **6 pts**

   What is an autolyse, and why did Raymond Calvel promote it?

4. **6 pts**

   Explain how gluten and yeast together make bread rise.

5. **6 pts**

   What internal temperatures show that a sandwich loaf, a lean crusty bread and a pound cake are done?

6. **4 pts**

   Dough rises from 4.0 cm to 7.4 cm. What is the rise factor? Is it ready to shape?

7. **6 pts**

   Tell the Fleischmann story in two sentences.

8. **6 pts**

   Describe the muffin method and predict what 60 strokes of mixing will do to a muffin.

9. **6 pts**

   Who was Eben Horsford, and what problem did his baking powder solve?

10. **8 pts**

    Using 3-2-1, how much butter and water go with 210 g flour? Explain how cold butter makes crust flaky.

11. **6 pts**

    How much more dough does a 14-inch round need than a 12-inch round of the same thickness?

12. **6 pts**

    Who was Ruth Wakefield, and what does her story teach about recipe writing?

13. **8 pts**

    A pound cake is to use 5 large eggs (250 g). Give the weights of flour, butter and sugar, and explain the role of creaming.

14. **6 pts**

    Predict: a pound cake batter is made with melted butter and cold eggs. What will the cake be like, and why?

15. **6 pts**

    Muffins for 12 cost $4.80. What is the cost for 36, and the cost per muffin?

16. **4 pts**

    Essay (one paragraph): Explain why bakers say “baking is chemistry,” using at least three examples from this unit.

ANSWER KEY

1. Flour 100%, water 70%, salt 2%, yeast 1.0%; hydration 70%.
2. Total 168%; flour $1200/1.68 = 714$ g; water 464 g; salt 14 g; yeast 7 g.
3. A rest of flour and water before adding salt and yeast; it hydrates flour and starts gluten, so less mixing is needed and bread has better flavor and color.
4. Kneaded gluten forms an elastic network; yeast produces CO_2, which the network traps in bubbles that expand, raising the dough.
5. About 190 °F; 200–210 °F; 205–210 °F.
6. 1.85; not quite doubled; give it more time.
7. Charles and Maximilian Fleischmann, with James Gaff, began making pure compressed yeast in Cincinnati in 1868. Reliable yeast, shown off at the 1876 Centennial Exhibition, made light home-baked bread dependable.
8. Mix dry and wet separately, then fold together briefly. Overmixing develops gluten, causing tunnels, peaked tops and toughness.
9. A Harvard chemist who developed calcium-phosphate baking powder; it supplied a measured acid with the soda, giving consistent rising instead of relying on variable sour milk.
10. Butter 140 g, water 70 g. Cold butter pieces flatten into layers; in the oven their water turns to steam and separates the layers.
11. $(14/12)^2 = 1.36$: 36% more.
12. Creator of the chocolate chip cookie at the Toll House Inn in the late 1930s; precise, tested recipes let others repeat results.
13. 250 g each. Creaming beats air cells into butter with sugar crystals; they expand in the oven to lighten the cake.
14. Dense and heavy, possibly greasy: melted butter cannot hold air, and cold eggs break the emulsion.
15. $14.40; 40¢ each.
16. Answers vary. Strong answers cite gluten formation, yeast fermentation producing CO_2, chemical leaveners reacting with acids, fat and steam creating flaky layers, starch setting, Maillard browning, and the need for exact ratios measured by weight.

UNIT PROJECT: A BAKER'S WEEK

Bake three different products in one week for your family or to share with neighbors: one yeast bread, one quick bread and one pastry or cake. For each, write the formula in baker's percentages and grams, keep a log (temperatures, rise times, bake times and internal temperatures), and photograph the crumb.

Calculate the ingredient cost and cost per serving for each, and compare one with a store-bought equivalent. Give at least one of your bakes away with a handwritten card, and write a one-page reflection on what you learned about baking science and about generosity.

LOOK FOR	WHAT IT MEANS
Formulas	Accurate baker's percentages and gram weights for all three products.
Technique	Each product meets its technique standard (rise, crumb, flakiness or fine grain) and correct internal temperature.
Records	Complete logs and crumb photos.
Cost	Correct cost per serving and a fair comparison with a store product.
Reflection and generosity	A bake shared with others and a thoughtful reflection.

UNIT 7

Flavor, Spice and the Grill

This is the unit where cooking becomes an art. You will learn the five basic tastes and how to balance a dish with salt, acid, fat, sweetness and heat; the spice trade that sent Vasco da Gama around Africa to India; how cooks pair flavors by harmony and by contrast; how to build and control a two-zone grill fire; and how to plate food so that it looks as good as it tastes.

The stories include Kikunae Ikeda's discovery of umami, da Gama's voyage of 1497–1499, a 2011 study that mapped 56,000 recipes as a flavor network, George Stephen's 1952 kettle grill, and the change from service à la française to plated courses. Grill labs follow strict safety rules and always offer an indoor method.

PREREQUISITES

- Units 1–6, especially dry-heat cooking (Unit 3) and safe temperatures
- A grill is optional; every grill lab has an indoor method
- Comfort with percentages, ratios and simple combinatorics

MASTERY CHECKLIST

- ☐ I can name the five tastes and balance a dish in measured rounds.
- ☐ I can toast, grind and bloom spices and tell the story of the spice trade.
- ☐ I can design dishes with complementary and contrasting pairings.
- ☐ I can set up a two-zone fire, follow every grill safety rule, and cook chicken to a safe, juicy finish.
- ☐ I can slice against the grain and plate food with balance, color and contrast.

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 7.4.
- **A chimney starter (for the adult) and long-handled tongs**: A chimney lights charcoal without liquid starter. Not needed for gas grills or the indoor methods.
- **A spice grinder or mortar and pestle**: For toasting and grinding whole spices in Lesson 7.2. A cheap blade coffee grinder kept only for spices works well.

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	**The Five Tastes and Balancing a Dish: Ikeda's Umami**	3 sessions of 50 minutes
7.2	**Herbs, Spices and Vasco da Gama's Voyage**	3 sessions of 50–90 minutes
7.3	**Complementary and Contrasting Flavors: The Flavor Network**	3 sessions of 50 minutes
7.4	**The Grill: George Stephen's Kettle and the Two-Zone Fire**	3 sessions of 50–90 minutes
7.5	**Texture and Plating: Service à la Russe**	3 sessions of 50–90 minutes

Unit 7 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Name the five basic tastes and tell how Ikeda discovered umami.

2. **8 pts**
   Soup weighs 2,400 g. How much salt makes it 0.9% salt, in grams and teaspoons of table salt (6 g/tsp)?

3. **6 pts**

   A dish is flat, too rich, and slightly bitter. Name the element to add for each problem.

4. **6 pts**

   Give the plant part of cinnamon, cloves, pepper, nutmeg and ginger.

5. **8 pts**

   Tell the story of Vasco da Gama's voyage and why it mattered for cooks.

6. **6 pts**

   Why toast whole spices and bloom ground spices?

7. **4 pts**

   A spice blend uses parts 3:3:2:1:1. How many grams of each in 40 g?

8. **8 pts**

   How many ingredient pairs are possible among 8 ingredients? Explain complementary and contrasting pairing with one example of each.

9. **6 pts**

   What did the 2011 flavor-network study find?

10. **6 pts**

    Give the quick-pickle brine for 2 cups.

11. **8 pts**

    List six grill safety rules from this course.

12. **6 pts**

    Explain a two-zone fire and how to cook bone-in chicken on it.

13. **6 pts**

    Who built the first kettle grill, from what, and when?

14. **6 pts**

    Flank steak loses 25% when grilled. How much raw steak for 8 servings of 4 oz cooked?

15. **6 pts**

Explain service à la russe and two plating principles.

16. **4 pts**

Essay (one paragraph): Describe a complete dinner you would plan using at least three ideas from this unit (balance, spice, pairing, grilling, plating), and explain why each makes the meal better.

ANSWER KEY

1. Sweet, salty, sour, bitter, umami. In 1908 Kikunae Ikeda isolated glutamate from kombu seaweed broth and showed it caused the savory taste.
2. $0.009 \times 2400 = 21.6$ g ≈ 3.6 tsp.
3. Flat: salt. Too rich: acid. Bitter: salt (and a touch of sweetness).
4. Bark; flower bud; berry; seed; rhizome.
5. He sailed from Lisbon in 1497, rounded Africa and, with an Indian Ocean pilot from Malindi, reached Calicut in May 1498, returning in 1499 with spices; the sea route made spices cheaper and changed world trade.
6. Toasting releases and deepens volatile aromas; blooming in oil dissolves fat-soluble flavors into the dish.
7. One part 4 g: 12, 12, 8, 4, 4 g.
8. 28 pairs. Complementary: tomato and basil (shared flavors). Contrasting: salt and caramel, or lemon and salmon (opposites balance).
9. Western recipes tend to pair ingredients that share many flavor compounds; East Asian recipes tend to pair ingredients that share few.
10. 1 cup vinegar, 1 cup water, 2 Tbsp sugar, 1 Tbsp salt.
11. Any six: adult lights charcoal; no liquid starter; outdoors on a flat surface away from house, railings, overhangs, dry leaves; long tongs; lid and hose or extinguisher ready; never leave lit grill; children and pets back; coals cool 24–48 hours before an adult disposes of them in a metal can.
12. Hot side and cool side; sear over direct heat, then finish over indirect heat with the lid closed until at least 165 °F (175–185 °F for tender thighs).
13. George Stephen, from a metal buoy at Weber Brothers Metal Works, 1952.
14. $32 / 0.75 = 42.7$ oz ≈ 2.7 lb.
15. Courses brought one at a time, plated for each guest. Any two plating principles: clean rim, height, color and texture contrast, odd numbers, balanced proportions.
16. Answers vary; a strong answer names specific dishes and connects each to a principle from the unit with a reason.

UNIT PROJECT: A FAMILY GRILLED DINNER WITH A SIGNATURE RUB

Plan, prepare and serve a family dinner cooked on the grill (or by the indoor methods): a protein cooked by the two-zone method, at least one grilled vegetable, a sauce or relish that adds contrast (chimichurri, salsa, pickled onions or a yogurt sauce), and a side. Create and name your own spice rub, write its recipe by weight, and label a jar of it as a gift.

Write a menu, a shopping list with costs, a timeline from lighting the fire to serving, and a flavor chart showing at least four complementary or contrasting pairings. Plate the meal for each family member and photograph it. Record every safe temperature and the grill safety checklist.

LOOK FOR	WHAT IT MEANS
Safety	Grill safety checklist completed and followed; adult lit charcoal; all temperatures safe and recorded; raw and cooked kept separate.
Flavor design	Original rub recorded by weight; flavor chart with at least four well-explained pairings; dish balanced to taste.
Technique	Two-zone cooking done well; vegetables charred not burned; meat sliced and served properly.
Planning and plating	Menu, costed shopping list, realistic timeline; plates balanced and attractive.
Reflection	Family ratings and one honest improvement for next time.

7.1 The Five Tastes and Balancing a Dish: Ikeda's Umami

OBJECTIVES

- Name the five basic tastes and tell how Kikunae Ikeda identified umami in 1908.
- Balance a dish by adjusting salt, acid, fat, sweetness and heat in measured rounds.
- Calculate salt as a percentage of a dish's weight and convert between kinds of salt.
- Make a roasted tomato soup and season it to balance.

> **Warm-up.** Taste a spoonful of plain unsalted broth, then add a tiny pinch of salt and taste again; then a drop of lemon juice; then a little grated Parmesan. Describe how each changed the taste. Which made it taste "more like itself"?

WATCH

Why Does Salt Make Food Taste Better?

SciShow · 4:11

https://www.youtube.com/watch?v=ATrSoMlx5PE

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Note the three things salt does besides taste salty.

Note: From SciShow. It ends with a sponsor message; stop when the science ends.

KEY TERMS

five basic tastes
Sweet, salty, sour, bitter and umami, sensed by taste receptor cells all over the tongue.

umami
The savory taste of glutamate and certain other compounds, found in tomatoes, aged cheese, mushrooms, soy sauce, seaweed and meat broths.

flavor
The whole impression of a food: taste plus aroma (smelled through the back of the nose), texture, temperature and the tingle or burn of spices.

balance
Adjusting salt, acid, fat, sweetness and heat so no one element overwhelms and the dish tastes complete.

seasoning to taste

Adding salt and other seasonings in small amounts, tasting after each, until the dish is right.

CORE IDEAS

The story. In 1907–1908 Kikunae Ikeda, a chemistry professor at Tokyo Imperial University, wondered why his wife's dashi, a broth made from kombu seaweed, tasted so deeply savory. It was not sweet, salty, sour or bitter. He evaporated large amounts of kombu broth and isolated crystals of glutamic acid, then found that its salt, glutamate, gave the same savory taste. He named the taste *umami*, from the Japanese word for "delicious," and published his findings in 1908.

How he figured it out. Ikeda worked like a careful chemist: he isolated the substance, tested it on its own, and showed it produced the taste. For decades Western scientists doubted a fifth taste, but in the early 2000s researchers identified taste receptors on the tongue that respond specifically to glutamate, confirming what Ikeda and generations of cooks already knew. (The old "tongue map" that put each taste on a different part of the tongue is a myth; every taste is sensed all over the tongue.)

The kitchen science. A balanced dish engages several tastes at once. **Salt** makes food taste more like itself and softens bitterness. **Acid** (lemon, vinegar, tomato) brightens and cuts richness. **Fat** carries aromas and rounds sharp edges. **Sweetness** tames acid and bitterness. **Heat** from chiles adds excitement. **Umami** from tomatoes, cheese, mushrooms or broth adds depth. Most soups taste well seasoned at roughly 0.8–1.2% salt by weight. Because kinds of salt differ in crystal size, a teaspoon of table salt holds about twice as much salt as a teaspoon of flaky kosher salt; weigh salt or taste as you go.

Let's cook. You will roast tomatoes, onion and garlic and purée them into soup, then balance it in rounds, adding salt, acid, fat and a touch of sweetness or heat in measured amounts and recording what each did. The technique standard: vegetables roasted until browned at the edges, soup puréed safely and smooth, and seasoning built in small, recorded steps until the family agrees it is balanced.

PICTURE STUDY



Still Life with Oranges and Walnuts, Luis Egidio Meléndez, 1772 · Oil on canvas · The National Gallery, London

Image: Wikimedia Commons, public domain

Meléndez painted foods that offer different tastes and textures side by side: tart, juicy oranges; rich, slightly bitter walnuts; boxes of sweets. A thoughtful cook combines such contrasts on the table and in a single dish.

Look closely

- Find something sour, something sweet and something rich or bitter.
- Look at the textures: smooth peel, ridged shells, wooden boxes. How does Meléndez show each?
- Find the jugs and pots. What might they hold?

Talk about it

1. Which two foods here would you combine in one dish, and why?
2. How does each taste here balance the others?
3. Why might a painter choose foods of contrasting color and texture?

Safety first. Roasted vegetables and hot soup can burn: let the pan cool a few minutes before scraping it, fill a blender only halfway with hot soup and vent the lid under a towel, or use an immersion blender. Check for food allergies before any family tasting.

KITCHEN LAB

Balance Lab: Roasted Tomato Soup

You will make roasted tomato soup and season it in measured rounds, recording family ratings after each round.

You will need

- A rimmed sheet pan and a large pot
- A blender or immersion blender
- A kitchen scale, measuring spoons and small tasting cups
- A ladle
- A tasting score sheet

Roasted Tomato Soup

Serves 6 · Prep 15 min · Roast 40 min · Simmer 15 min

Ingredients

- 3 lb (1.4 kg) Roma tomatoes, halved (or two 28-oz cans whole tomatoes, drained, juice saved)
- 1 large onion, cut in wedges
- 6 cloves garlic, peeled
- 3 tablespoons olive oil
- 1 teaspoon salt to start (more in the balance rounds)
- ½ teaspoon black pepper
- 3 cups (720 mL) chicken or vegetable broth (low-sodium)
- Balance shelf: lemon juice, extra salt, olive oil or a splash of cream, sugar or honey, red pepper flakes, grated Parmesan
- Fresh basil to garnish

Method

1. Heat the oven to 425 °F (220 °C). Toss the tomatoes, onion and garlic with the oil, 1 teaspoon salt and the pepper on the sheet pan, tomatoes cut-side up.

2. Roast 35–45 minutes, until the tomatoes collapse and brown at the edges.
3. Scrape everything into the pot with the broth. Simmer 10 minutes.
4. Purée until smooth (blender half full and vented, or immersion blender). Weigh the soup.
5. Run the balance rounds (see the lab steps). Serve hot with basil.

Allergy check: Contains none of the nine major allergens unless you add cream or Parmesan (milk) in the balance rounds.

Steps

1. Weigh the finished soup and calculate the salt already in it from the 1 teaspoon added.
2. **Round 1: salt.** Add salt to bring the soup to about 0.9% total. Taste and rate.
3. **Round 2: acid.** Add 1 teaspoon lemon juice. Taste and rate.
4. **Round 3: fat.** Add 1 tablespoon olive oil (or cream). Taste and rate.
5. **Round 4: sweet or heat.** Add a pinch of sugar or of red pepper flakes to a cup only. Taste and rate.
6. Record every addition by weight or volume and the family's ratings, and decide your final recipe.
7. **Technique check.** Score 1–3: well-roasted vegetables, safe puréeing, smooth soup, measured and recorded seasoning, balanced final soup.
8. **Repeat round.** Balance a different dish the same way: a vinaigrette, a pot of beans, or a stir-fry sauce.

Tips

- Season in small steps; you can add salt but not take it out.
- Taste from a clean spoon each time.
- If you oversalt, add more unsalted broth or tomatoes, not sugar.

Check your work

- ☐ I can name the five tastes and tell Ikeda's story.
- ☐ I can calculate salt percentage and convert kinds of salt.
- ☐ I balanced a soup in recorded rounds.

LAB NOTEBOOK

1. Draw a “balance wheel” with salt, acid, fat, sweet, heat and umami, with two ingredients for each.
2. Record your balance rounds and ratings in a table.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{salt } \% = \frac{\text{salt mass}}{\text{total mass}} \times 100$$

1 tsp table salt ≈ 6 g; 1 tsp Morton kosher ≈ 5 g; 1 tsp Diamond Crystal kosher ≈ 3 g

From history. In 1909 Ikeda helped found the company Ajinomoto to sell monosodium glutamate (MSG) as a seasoning. Scientific reviews have found MSG safe for the general public at normal levels of use; it is simply the sodium salt of the glutamate already found in tomatoes and cheese.

WORKED EXAMPLES

Example 1. Your soup weighs 1,800 g. How much salt makes it 1.0% salt? How many teaspoons of table salt is that?

Show solution

1. $0.010 \times 1800 \text{ g} = 18 \text{ g}$.
2. $18 \text{ g} \div 6 \text{ g/tsp} = 3 \text{ tsp}$.

Answer: 18 g, about 3 teaspoons of table salt. If your broth was already salted, much of this is already there, so add salt gradually and taste.

Example 2. A recipe written for Diamond Crystal kosher salt calls for 2 teaspoons. You have table salt. How much do you use?

Show solution

1. Salt needed: $2 \times 3 \text{ g} = 6 \text{ g}$.
2. Table salt: $6 \text{ g} \div 6 \text{ g/tsp} = 1 \text{ tsp}$.

Answer: About 1 teaspoon of table salt: half the volume.

Example 3. Your tasters rate the soup 1–5 after each round: plain 2.1; +salt 3.4; +lemon 3.9; +olive oil 4.2; +pinch of sugar 4.1. Which adjustment helped most, and which should you undo next time?

Show solution

1. Changes: salt +1.3, lemon +0.5, oil +0.3, sugar −0.1.

Answer: Salt made the biggest improvement; the sugar did not help this batch (the tomatoes were sweet enough), so leave it out next time.

PRACTICE

1. Easy Name the five basic tastes.

   Show answer

   Sweet, salty, sour, bitter, umami.

2. Easy Who identified umami, and from what food?

   Show answer

   Kikunae Ikeda, from kombu seaweed broth (dashi), in 1908.

3. Easy Is the tongue map true?

   Show answer

   No; all tastes are sensed all over the tongue.

4. Medium How many grams of salt make 1,200 g of soup 0.9% salt?

   Show answer

   10.8 g.

5. Medium Name three foods rich in umami.

   Show answer

   Any three: tomatoes, aged cheese (Parmesan), mushrooms, soy sauce, miso, seaweed, meat broth, anchovies.

6. Medium A sauce tastes flat. What do you add first, and why?

   Show answer

   Salt, in small amounts, because it brings out the existing flavors and reduces bitterness.

7. Medium A dish is too rich and heavy. What element balances it?

Show answer

Acid (lemon juice or vinegar).

8. Hard A recipe uses 1 tablespoon Morton kosher salt. How many grams, and how many teaspoons of table salt?

Show answer

15 g; 2½ teaspoons table salt.

9. Hard Explain the difference between taste and flavor, with an example.

Show answer

Taste is the five basic sensations from the tongue; flavor adds aroma, texture and temperature. A pinched nose makes an apple and a raw potato taste nearly the same, because their flavors differ mostly in aroma.

10. Challenge Design a fair tasting test to find the best salt level for your soup, from 0.6% to 1.4%.

Show answer

Divide the soup into five equal portions by weight; add salt for 0.6, 0.8, 1.0, 1.2 and 1.4%; label with codes; serve blind in random order at the same temperature; have tasters rate each and choose a favorite; average the results.

COMMON MISTAKES

- Adding all the salt at once.
- Using sugar to fix a dish that needs salt or acid.
- Tasting only at the end.
- Measuring kosher and table salt as if they were the same.

> **Make it a game · Fix the Soup.** Your parent mixes a plain cup of broth, a pinch at a time. Each of you adds salt, acid, fat, sugar or heat in measured rounds, tasting after each and naming which of the five tastes you corrected. Try to reach balance in four rounds. Tell how Ikeda named umami in 1908 before you finish.

> **Scripture.** “Let your speech be alway with grace, seasoned with salt, that ye may know how ye ought to answer every man.” (Colossians 4:6, KJV)
>
> Paul uses seasoning as a picture of gracious speech: not bland, not harsh, but rightly balanced, as a good cook balances a dish.

7.2 Herbs, Spices and Vasco da Gama's Voyage

OBJECTIVES

- Tell the story of Vasco da Gama's voyage to Calicut (1497–1499) and why spices were worth the risk.
- Identify the plant parts that common spices come from and explain why whole spices keep their aroma longer.
- Toast and grind whole spices into a blend, and scale and cost a spice blend.
- Cook a chickpea and spinach curry with your own spice blend.

> **Warm-up.** Smell a jar of pre-ground cumin. Then toast a teaspoon of whole cumin seeds in a dry pan for a minute (with a parent present), crush them and smell again. Describe the difference.

WATCH

The Spice Of Empires

Townsends · 16:44

https://www.youtube.com/watch?v=BPCpLm-as-Y

> **WHEN TO WATCH**
> After the story. Listen for why pepper was worth sailing around the world for.

Note: Townsends presents 18th-century food history; this episode is about black pepper and the spice trade.

BACKUP VIDEO

Toasting and Grinding Spices - Cooking With Melissa Clark | The New York Times

The New York Times · 2:43

https://www.youtube.com/watch?v=L0UOkH9UfiY

Before the lab: how to toast whole spices and grind them by machine or mortar.

KEY TERMS

spice

A dried seed, fruit, bark, root, bud or other plant part used for flavor, such as pepper, cinnamon, cloves, nutmeg, cumin and ginger.

volatile oils

Aromatic compounds in spices that evaporate easily and carry their scent; heat releases them, and time and air fade them.

blooming

Cooking spices briefly in hot oil so their fat-soluble flavors dissolve into the oil.

garam masala

A warm North Indian spice blend, often of cumin, coriander, cardamom, cinnamon, cloves and black pepper.

the spice trade

The long-distance trade in spices from South and Southeast Asia to the Middle East and Europe, by land and sea, over many centuries.

CORE IDEAS

The story. For centuries pepper, cinnamon, cloves and nutmeg reached Europe only after passing through many hands overland and by sea, so they were costly. In July 1497 the Portuguese navigator Vasco da Gama sailed from Lisbon with four ships to find a sea route to India. His fleet rounded the Cape of Good Hope, sailed up the coast of East Africa, and, guided across the Indian Ocean by an experienced pilot taken on at Malindi, reached Calicut (Kozhikode) on India's Malabar Coast in May 1498. The voyage home was terrible; more than half the crew died, many of scurvy. But the pepper and spices he brought back to Lisbon in 1499 were worth a fortune, and the sea route changed world trade.

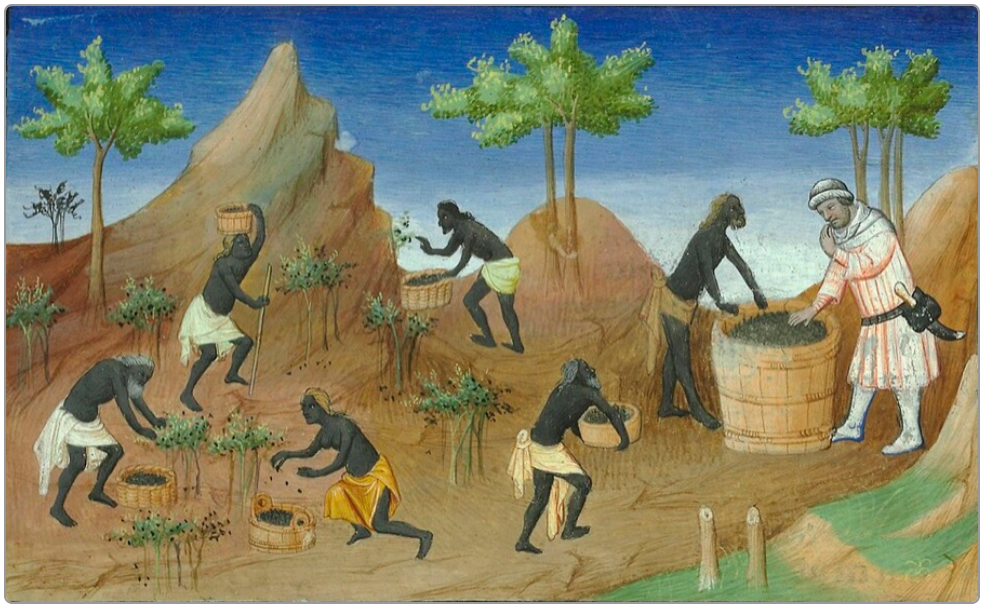
How they figured it out. Da Gama built on decades of Portuguese exploration down the African coast and on the knowledge of Indian Ocean sailors, who had long used the monsoon winds to cross between Africa, Arabia and India. Navigators learned which winds to wait for and which coasts to follow. Cooks in Europe, meanwhile, had learned over centuries how a little spice could transform plain food.

The kitchen science. Spices come from many plant parts: black pepper is the dried berry of a vine; cinnamon is bark; cloves are dried flower buds; nutmeg is a seed and

mace the lacy covering around it; ginger and turmeric are rhizomes (underground stems); cumin and coriander are seeds. Their aromas are **volatile oils**, which escape and oxidize once the spice is ground, so whole spices keep their aroma for years while ground spices fade within months. Toasting whole spices in a dry pan releases and deepens their aroma; **blooming** ground spices in hot oil dissolves fat-soluble flavors into the dish.

Let's cook. You will toast and grind your own warm spice blend and use it in a chickpea and spinach curry with tomatoes and a little coconut milk or yogurt, served with rice. The technique standard: spices toasted just until fragrant (not smoking), ground fine, bloomed briefly in oil, curry simmered to blend, and finished with salt and acid to balance.

PICTURE STUDY



The Pepper Harvest (from The Book of Marvels), Workshop of the Boucicaut Master (illuminators), c. 1410–1412 · Manuscript illumination · Bibliothèque nationale de France, Paris

Image: Wikimedia Commons, public domain

This illumination comes from a French manuscript of Marco Polo's travels made around 1410. The painters had never seen India, so their picture of the pepper harvest at "Coilum" (Kollam, near Calicut) is imaginative. It shows how precious and mysterious pepper seemed to Europeans less than a century before da Gama sailed.

Look closely

- Find the pepper plants and the workers. What are they doing?
- Find the merchant. What is being traded?
- What details show that the painters were imagining a place they had never seen?

Talk about it

1. What does this picture suggest about how Europeans thought of spices?
2. Pepper actually grows on a climbing vine. How would you correct this picture?
3. Which spice in your cupboard came the farthest to reach you?

> **Safety first.** Toast spices in a dry pan over medium-low heat and stir constantly; they scorch quickly, and dried chiles can release stinging fumes. Use a dedicated spice grinder or mortar and pestle and unplug the grinder before cleaning it. Wash hands after handling chiles.

KITCHEN LAB

Spice Lab: Toasted Spice Blend and Chickpea-Spinach Curry

You will compare toasted and untoasted spices, grind your own blend, and cook a curry with it.

You will need

- A dry skillet, a spice grinder or mortar and pestle
- A kitchen scale
- A large skillet or Dutch oven
- A medium saucepan for rice
- Small jars for the blend

Chickpea and Spinach Curry with a Toasted Spice Blend

Serves 6 · Blend 15 min · Curry 35 min

Ingredients

- **Blend (about 50 g):** 16 g cumin seeds, 16 g coriander seeds, 8 g black peppercorns, 4 g cinnamon stick (broken), 4 g green cardamom pods (seeds only), 2 g whole cloves
- **Curry:** 2 tablespoons oil
- 1 large onion, diced
- 4 cloves garlic and 1 tablespoon ginger, minced
- 2 tablespoons of your spice blend plus ½ teaspoon ground turmeric
- 1 can (15 oz) diced tomatoes
- 2 cans (15 oz each) chickpeas, drained and rinsed
- 1 can (13.5 oz) coconut milk, or 1 cup plain yogurt stirred in at the end off the heat
- 5 oz (140 g) fresh spinach
- 1 teaspoon salt, more to taste; 1 tablespoon lemon juice
- Cooked rice to serve

Method

1. Toast the whole blend spices in a dry skillet over medium-low heat, stirring, 1–2 minutes, until fragrant. Cool, then grind fine. Store extra in a labeled jar.
2. Heat the oil in the large skillet over medium heat. Cook the onion 6–8 minutes until golden. Add the garlic and ginger for 1 minute.
3. Add 2 tablespoons of the blend and the turmeric and stir 30 seconds to bloom.
4. Add the tomatoes and chickpeas and simmer 10 minutes, mashing a few chickpeas. Stir in the coconut milk and simmer 5 minutes.
5. Stir in the spinach until wilted. Season with salt and lemon juice. (If using yogurt, take the pan off the heat first.) Serve over rice.

Allergy check: Contains none of the nine major allergens with coconut milk (coconut is not listed among the nine), or milk if made with yogurt. Check the spice blend's ingredients if you buy one instead.

Steps

1. **Smell test.** Compare untoasted whole, toasted whole and pre-ground cumin. Rank aroma strength.
2. Weigh and toast the blend spices; grind and weigh the finished blend.
3. **Plant parts.** Make a chart of each spice in your blend with its plant part and where it grows.
4. Cook the curry, recording when you bloomed the spices.
5. **Balance.** Taste before and after the salt and lemon, and record the change.
6. **Technique check.** Score 1–3: spices toasted not scorched, fine grind, bloomed briefly, balanced seasoning.
7. Clean the grinder by grinding a spoonful of dry rice, then wiping it (unplugged).
8. **Repeat round.** Make a different blend (a taco seasoning or a pumpkin-pie spice) by weight and use it in a dish.

Tips

- Buy whole spices in small amounts and grind as you need them.
- Label blends with the date; use within 3–6 months.
- Bloom ground spices only 30 seconds; they burn fast in hot oil.

Check your work

- ☐ I can tell the story of da Gama's voyage and the spice trade.
- ☐ I can name spice plant parts and explain volatile oils.
- ☐ I toasted and ground a blend and cooked a balanced curry.

LAB NOTEBOOK

1. Draw a map of da Gama's route from Lisbon around Africa to Calicut, labeling the Cape of Good Hope and Malindi.
2. Record your smell test and blend weights.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{cost per gram} = \frac{\text{price}}{\text{grams in package}}$$

$$\text{scale factor} = \frac{\text{amount wanted}}{\text{recipe yield}}$$

From history. After da Gama, the Portuguese, then the Dutch and the English, fought for control of the spice islands. Today black pepper is grown in India, Vietnam, Brazil and Indonesia, and costs only pennies a serving.

WORKED EXAMPLES

Example 1. Your blend uses, by weight, cumin 4 parts, coriander 4, black pepper 2, cinnamon 1, cardamom 1, cloves ½. How many grams of each for 50 g of blend?

Show solution

1. Total parts: $4 + 4 + 2 + 1 + 1 + 0.5 = 12.5$.
2. One part $= 50 / 12.5 = 4$ g.
3. Cumin 16 g, coriander 16 g, pepper 8 g, cinnamon 4 g, cardamom 4 g, cloves 2 g.

Answer: 16, 16, 8, 4, 4 and 2 g (total 50 g).

Example 2. Whole cumin costs $3.99 for 70 g; ground cumin costs $2.99 for 40 g. Which is cheaper per gram?

Show solution

1. Whole: $\$3.99/70 = \$0.057$ per g.
2. Ground: $\$2.99/40 = \$0.075$ per g.

Answer: Whole cumin is about 5.7¢ per gram versus 7.5¢, cheaper and it keeps its aroma longer.

Example 3. Da Gama sailed from Lisbon on July 8, 1497, and reached Calicut on about May 20, 1498. About how many days was the outward voyage?

Show solution

1. July 8 to July 8 is 365 days; from July 8, 1497, back to May 20, 1498, is 49 days short of a year.
2. $365 - 49 = 316$ days.

Answer: About 316 days, more than ten months at sea.

PRACTICE

1. Easy From what plant part does each come: cinnamon, cloves, black pepper, nutmeg, ginger?

   Show answer

   Bark; flower buds; berry; seed; rhizome (underground stem).

2. Easy Where and when did Vasco da Gama reach India?

   Show answer

   Calicut, on the Malabar Coast, in May 1498.

3. Easy Why do whole spices keep their aroma longer than ground spices?

   Show answer

   Their volatile oils are sealed inside; grinding exposes them to air, where they evaporate and oxidize.

4. **Medium** What does blooming spices in oil do?

Show answer

Dissolves fat-soluble flavor compounds into the oil, spreading them through the dish.

5. **Medium** How do you know toasted spices are ready?

Show answer

They become fragrant and slightly darker, often within 1–2 minutes; remove them before they smoke.

6. **Medium** Scale the 50-g blend recipe to 30 g. How much cumin?

Show answer

$16 \times 0.6 = 9.6$ g

7. **Medium** Why were spices so expensive in Europe before 1498?

Show answer

They passed through many traders over long land and sea routes, with taxes and profits added at every step.

8. **Hard** Ground cinnamon costs $4.49 for 68 g. A 1-lb (454 g) bag from a bulk store costs $12.99. Compare the cost per gram and say when the bulk bag is a bad buy.

Show answer

Jar 6.6¢/g; bulk 2.9¢/g. The bulk bag is a bad buy if you cannot use it before it loses its aroma (within about a year).

9. **Hard** Explain why the voyage home cost so many sailors their lives, using what you know about nutrition.

Show answer

Long months without fresh fruits and vegetables meant no vitamin C, causing scurvy.

10. **Challenge** Indian Ocean sailors had crossed between Africa and India for centuries before da Gama. Explain how the monsoon winds made such voyages possible and why timing mattered.

    Show answer

    Monsoon winds reverse seasonally, blowing toward India in one season and back toward Africa and Arabia in another; ships sailed with the favorable wind and waited months for it to turn. Sailing at the wrong time meant headwinds and storms.

COMMON MISTAKES

- Burning spices while toasting or blooming.
- Keeping ground spices for years.
- Adding yogurt to a boiling curry, so it curdles.
- Grinding spices in a coffee grinder still used for coffee; keep one for spices.

Make it a game · Spice Source Quiz. Gather six spices. Your parent covers the labels and you identify each by smell, naming the plant part it comes from, such as bark, seed, bud or root. Score one point per correct pair. Then tell Vasco da Gama's route to Calicut and why spices justified such danger. Explain why spices bloom in hot oil.

Scripture. “and of spices very great store, and precious stones: there came no more such abundance of spices as these which the queen of Sheba gave to king Solomon.” (1 Kings 10:10, KJV)

In Solomon’s day spices were gifts fit for a king. What was once a royal treasure now sits in our cupboards: a good reason to use it well and give thanks.

7.3 Complementary and Contrasting Flavors: The Flavor Network

OBJECTIVES

- Distinguish complementary pairings (shared flavors) from contrasting pairings (salt and sweet, acid and fat, heat and cool, crunchy and creamy).
- Describe the 2011 “flavor network” study of recipes from many cuisines.
- Count possible ingredient pairs and calculate a quick-pickle brine.
- Make black bean tacos with quick-pickled onions and lime crema, built on contrasts.

> **Warm-up.** Taste a slice of apple alone, then with a sliver of sharp cheddar, then with a pinch of salt, then with a few drops of lemon. Which pairing did you like best? Was it because the flavors were alike or because they were opposite?

WATCH

Exploring the HIDDEN Science Behind Flavor Pairings

Abbey the Food Scientist · 8:32

https://www.youtube.com/watch?v=qV4t8nWbeiM

> **WHEN TO WATCH**
> After the story. Watch for the 2011 flavor-network study and its diagrams.

Note: A food scientist explains the food-pairing idea and the 2011 Scientific Reports study.

KEY TERMS

complementary pairing

Ingredients that share some flavor compounds or qualities and reinforce each other, such as tomato and basil, or apple and cinnamon.

contrasting pairing

Ingredients with opposite qualities that balance each other: salty and sweet, acid and fat, hot and cool, crunchy and creamy.

quick pickle

Vegetables soaked in a hot vinegar-and-water brine and refrigerated; ready in an hour, not shelf-stable.

crema

A thin, tangy cream sauce; here, sour cream or yogurt thinned with lime juice.

flavor compound

A molecule that contributes to a food's aroma or taste; foods contain hundreds.

CORE IDEAS

The story. In 2011 a team of scientists, Yong-Yeol Ahn, Sebastian Ahnert, James Bagrow and Albert-László Barabási, published a study called "Flavor network and the principles of food pairing." They gathered about 56,000 recipes from online collections and a reference list of the flavor compounds found in hundreds of ingredients. Then they asked a question cooks had argued about: do ingredients that share flavor compounds tend to be used together?

How they figured it out. The team built a network map in which each ingredient was a point and lines joined ingredients that shared compounds. Comparing real recipes with random combinations, they found that North American and Western European recipes tended to combine ingredients that *share* many compounds (like milk, butter, egg and vanilla), while East Asian recipes tended to combine ingredients that share *few*. In other words, cooks around the world build good dishes in two ways: with harmony and with contrast.

The kitchen science. Complementary pairings reinforce each other: tomato and basil, apple and cinnamon, chocolate and coffee-like roasted flavors. **Contrasting** pairings balance each other: **salt and sweet** (salted caramel, watermelon and feta), **acid and fat** (lemon on fish, vinegar on rich pork, pickles with cheese), **heat and cool** (chiles with yogurt or sour cream), and **crunchy and creamy.** A taco is a lesson in contrast: rich beans, sharp pickled onion, cool tangy crema, crunchy cabbage, and a hit of chile.

Let's cook. You will make black bean tacos with quick-pickled red onions and lime crema, and chart every pairing on the plate. The technique standard: onions pickled at least 30 minutes, beans seasoned and mashed to a spreadable texture, crema balanced in tang, tortillas warmed until pliable, and each taco built with at least three contrasts.

PICTURE STUDY



Apples and Oranges, Paul Cézanne, c. 1899 · Oil on canvas · Musée d'Orsay, Paris

Image: Wikimedia Commons, public domain

Paul Cézanne painted apples and oranges again and again, studying how colors, shapes and fabrics balance one another. In this crowded still life, warm reds and oranges contrast with the cool white cloth and the patterned drapery.

Look closely

- Find the warm colors and the cool colors. Where do they meet?
- Look for contrasts in texture: smooth fruit, folded cloth, patterned fabric.
- Find the highest and lowest fruit. How does Cézanne lead your eye across the picture?

Talk about it

1. How is balancing colors in a painting like balancing flavors in a dish?
2. Would you pair these two fruits in a salad? What would you add for contrast?
3. What does Cézanne's patience with the same subject teach a cook?

Safety first. Bring the brine just to a simmer and pour it over the onions in a heatproof jar, standing back from the steam. Refrigerate quick pickles and use within 2–3 weeks. Check the crema ingredients and toppings for milk allergies.

KITCHEN LAB

Pairing Lab: Black Bean Tacos with Pickled Onions and Lime Crema

You will make quick-pickled onions, lime crema and seasoned black beans, then build tacos and chart the contrasts.

You will need

- A small saucepan and a heatproof pint jar
- A medium skillet and a potato masher or fork
- A chef’s knife and board
- Small bowls for toppings
- A skillet or griddle for tortillas

Black Bean Tacos with Quick-Pickled Onions and Lime Crema

Serves 4–6 (12 tacos) · Prep 25 min (pickles need 30 min) · Cook 15 min

Ingredients

- **Pickled onions:** 1 large red onion, thinly sliced
- ¾ cup vinegar (cider or white), ¾ cup water, 1½ tablespoons sugar, 2¼ teaspoons salt
- **Lime crema:** ¾ cup sour cream or plain yogurt, 2 tablespoons lime juice, ¼ teaspoon salt, 1–2 tablespoons water
- **Beans:** 1 tablespoon oil, ½ onion diced, 2 cloves garlic
- 2 cans (15 oz each) black beans, drained (save ¼ cup liquid)
- 1 teaspoon cumin, 1 teaspoon chili powder, ½ teaspoon salt, 1 tablespoon lime juice
- 12 corn tortillas
- Toppings: thinly sliced cabbage, crumbled cotija or feta, cilantro, sliced jalapeño, avocado

Method

1. Put the onion slices in the jar. Bring the vinegar, water, sugar and salt to a simmer, stirring to dissolve, and pour over the onions. Cool, then

refrigerate at least 30 minutes.

2. Whisk the crema ingredients, adding water until pourable.
3. Heat the oil in the skillet over medium heat. Cook the onion 5 minutes, add the garlic, cumin and chili powder for 30 seconds, then the beans and reserved liquid. Simmer 5 minutes, mashing about half the beans. Season with salt and lime.
4. Warm the tortillas in a dry skillet 30 seconds per side, stacking them in a clean towel.
5. Build each taco: beans, cabbage, pickled onions, cheese, crema, cilantro and jalapeño.

Allergy check: Contains milk (sour cream or yogurt, cheese). For milk-free, use a dairy-free yogurt and skip the cheese. Corn tortillas are wheat-free; check the label.

Steps

1. **Pairing chart.** Before cooking, list each component and its main quality: salty, sour, sweet, rich, hot, cool, crunchy, creamy.
2. Make the pickles, crema and beans.
3. **Subtraction test.** Build one taco with everything, and others missing one element at a time (no onions; no crema; no cabbage). Taste and rate each.
4. Record which missing element hurt the taco most, and explain with complementary or contrasting pairing.
5. **Technique check.** Score 1–3: pickled onions bright and tangy, beans well seasoned, crema balanced, tortillas pliable, at least three contrasts in each taco.
6. Clean up and store the pickles in the refrigerator, labeled and dated.
7. **Repeat round.** Use the pickled onions on a different dish (grain bowls, sandwiches, grilled meats) and note the contrast they add.

Tips

- Slice onions thin and evenly so they pickle evenly.
- Warm tortillas just before serving; cold corn tortillas crack.
- Taste the beans after adding lime; acid often fixes “flat” beans.

Check your work

- ☐ I can explain complementary and contrasting pairings and the 2011 flavor-network study.
- ☐ I can count pairs and calculate a pickling brine.
- ☐ I built tacos with at least three contrasts and tested them.

LAB NOTEBOOK

1. Draw a small “flavor network” for your taco: each component as a circle, with lines labeled “contrast” or “complement.”
2. Record your subtraction-test ratings.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{number of pairs} = \frac{n(n-1)}{2}$$

Quick-pickle brine: about $1:1$ vinegar to water, with about 1 Tbsp sugar and 1½ tsp salt per cup

From history. Before the flavor-network study, some chefs had already experimented with pairing foods that share flavor compounds, sometimes in surprising combinations. The study showed that cooks’ traditions differ, and that both harmony and contrast can make a dish delicious.

WORKED EXAMPLES

Example 1. Your taco has 7 components. How many different two-ingredient pairings are on the plate?

Show solution

1. $\dfrac{7 \times 6}{2} = 21.$

Answer: 21 pairings. Even a simple dish contains many flavor relationships.

Example 2. You need 1½ cups of quick-pickle brine at 1:1 vinegar to water, 1 Tbsp sugar and 1½ tsp salt per cup. How much of each?

Show solution

1. Vinegar 0.75 cup, water 0.75 cup.
2. Sugar $1.5 \times 1 = 1.5$ Tbsp; salt $1.5 \times 1.5 = 2.25$ tsp.

Answer: ¾ cup vinegar, ¾ cup water, 1½ Tbsp sugar, 2¼ tsp salt.

Example 3. The 2011 study used about 56,000 recipes. If 381 ingredients appeared, how many possible ingredient pairs exist?

Show solution

1. $\dfrac{381 \times 380}{2} = 72{,}390$.

Answer: 72,390 possible pairs, far too many to test by tasting, which is why the scientists used a network map.

PRACTICE

1. Easy Give one example each of salt + sweet, acid + fat, heat + cool, and crunchy + creamy.

   Show answer

   Examples: salted caramel; lemon on salmon; salsa with sour cream; crisp tortilla chips with guacamole.

2. Easy What is the difference between complementary and contrasting pairings?

   Show answer

   Complementary ingredients share flavors and reinforce each other; contrasting ingredients have opposite qualities and balance each other.

3. Easy Why must quick pickles be refrigerated?

   Show answer

   They are not processed for shelf storage; refrigeration keeps them safe, and they keep about 2–3 weeks.

4. **Medium** How many pairs among 5 ingredients? Among 10?

   Show answer

   10; 45.

5. **Medium** What did the 2011 flavor-network study find about Western and East Asian recipes?

   Show answer

   Western recipes tended to pair ingredients that share many flavor compounds; East Asian recipes tended to pair ingredients that share few.

6. **Medium** Why does a squeeze of lime improve rich black beans?

   Show answer

   Acid cuts and brightens the richness and makes the flavors seem clearer.

7. **Medium** Make 2 cups of quick-pickle brine.

   Show answer

   1 cup vinegar, 1 cup water, 2 Tbsp sugar, 1 Tbsp salt.

8. **Hard** A pickled onion recipe uses 1 cup brine for 1 large onion. How much brine for 3 onions, and what does it cost if vinegar is $2.49 per 32 oz?

   Show answer

   3 cups brine: 1½ cups (12 oz) vinegar ≈ $12/32 \times \$2.49 = \$0.93$.

9. **Hard** Design a dessert using one complementary pairing and one contrasting pairing, and explain each.

   Show answer

   Example: baked apples with cinnamon (complementary warm, sweet aromas) topped with a pinch of flaky salt and tangy yogurt (contrasts: salt with sweet, acid and cool with warm).

10. **Challenge** The 2011 study counted shared compounds, but taste also depends on texture and temperature. Explain one limitation of judging pairings only by shared chemistry.

    Show answer

    Shared aroma compounds do not capture texture, temperature, basic tastes, amounts or cultural familiarity; two foods may share compounds yet clash in texture, or share few and still balance beautifully by contrast.

COMMON MISTAKES

- Piling on so many toppings that no flavor stands out.
- Skipping acid in rich dishes.
- Keeping quick pickles at room temperature.
- Adding crema to a hot skillet, where it can separate.

> **Make it a game · Pairing Rally.** Take turns naming food pairs in a rally. Your parent says an ingredient, you reply with a partner and label it complementary or contrasting, then your parent must top it with a different pair. No repeats. First one stuck for ten seconds loses. Work in crunchy and creamy, acid and fat, heat and cool.

7.4 The Grill: George Stephen's Kettle and the Two-Zone Fire

OBJECTIVES

- Tell how George Stephen built the Weber kettle grill in 1952 from a metal buoy.
- Set up a two-zone fire and explain direct and indirect heat with the fire triangle.
- Follow the grill safety rules exactly, including who lights the grill.
- Grill bone-in chicken by the two-zone method (or roast it indoors) to a safe and juicy finish.

Warm-up. With a parent in charge, light a candle and cover it with a glass jar. Time how long the flame lasts. Then think about a grill lid and its vents. How does a griller control a fire without touching it?

WATCH

How to Cook a Whole Meal on Your Grill (2-Zone)

Weber Grills · 2:43

https://www.youtube.com/watch?v=PKIItO05vC8

WHEN TO WATCH
After the kitchen-science paragraph. Notice which foods go on the hot side and which on the cool side.

Note: From Weber, the company George Stephen founded. Shown on a gas grill; the two-zone idea is the same for charcoal.

BACKUP VIDEO

Setting Up a Two-Zone Charcoal Fire | Weber Grills

Weber Grills · 1:26

https://www.youtube.com/watch?v=V-21tnf6tHk

For the adult who lights the charcoal: the chimney starter and two-zone setup, with no liquid starter.

KEY TERMS

fire triangle

Heat, fuel and oxygen: the three things a fire needs. Remove any one and it goes out.

two-zone fire

A grill set up with a hot side (coals or burners on) and a cooler side (no coals or burners off).

direct heat

Cooking right over the coals or flame, for searing and for thin, quick-cooking foods.

indirect heat

Cooking beside the fire with the lid closed, so the grill works like an oven, for thick or bone-in foods.

chimney starter

A metal cylinder that lights charcoal with crumpled paper or a fire-starter cube, so no liquid starter is needed.

CORE IDEAS

The story. In 1952 George Stephen worked at Weber Brothers Metal Works near Chicago, which made metal buoys for harbors. Frustrated with his open backyard brazier, where wind blew ashes on the food and rain put out the fire, he cut a buoy in half, put legs and vents on the bottom half and a handle on the top half for a lid. The round "kettle" grill held heat like an oven and let him control the fire with its vents. Neighbors wanted their own, and the kettle grill became one of the best-known grills in the world.

How he figured it out. Stephen tested and adjusted: closing the vents starved the fire of oxygen and cooled it; opening them fed it and made it hotter. The lid trapped hot air so food cooked from above as well as below. He was applying the fire triangle and convection without needing to name them. Cooks soon learned to bank the coals to one side, creating a hot zone and a cool zone in the same grill.

The kitchen science. A grill cooks by radiation from the glowing coals, conduction through the hot grate (the grill marks) and convection when the lid is closed. A **two-zone fire** lets you sear food over **direct** heat for browning and flavor, then move it to the **indirect** side to finish cooking through without burning, exactly how thick, bone-in chicken pieces should be cooked. Fat dripping onto coals causes flare-ups; the cool zone and a closed lid control them. Chicken is safe at 165 °F; bone-in thighs

and drumsticks are juicier and more tender at 175–185 °F, because their connective tissue softens.

Let's cook. You will season bone-in chicken thighs and drumsticks with a dry rub and cook them on a two-zone grill (or sear them and roast them in the oven for the indoor way). **Grill rules:** an adult lights charcoal (you may light a gas grill only with a parent present and the lid open); never use liquid charcoal starter; grill outdoors on a flat surface away from the house, railings, overhangs and dry leaves; keep a lid, a hose or extinguisher nearby; use long tongs; never leave a lit grill; and let coals cool 24–48 hours before an adult empties them into a metal can.

PICTURE STUDY



Cowboys Eating Out on the Range, Chuck Wagon in Background, Erwin E. Smith, c. 1908–1910 · Photograph · Library of Congress, Washington, D.C.

Image: Wikimedia Commons, public domain

Erwin E. Smith photographed working cowboys on Texas ranches in the early 1900s. On a cattle drive, the cook drove the chuck wagon and fed the crew over open fires with Dutch ovens and coffee pots, cooking with coals, wind and dust.

Look closely

- Find the chuck wagon. What do you think is stored in its box?
- Look at how the men are eating. What are they eating from?
- Look for the fire or cooking area. How would the cook control the heat outdoors?

Talk about it

1. How did a chuck-wagon cook use the same ideas as a two-zone grill?
2. What fire-safety rules would matter on dry prairie grass?
3. Why was the cook one of the most important people on a cattle drive?

Safety first. An adult lights charcoal with a chimney starter; you may light a gas grill only with a parent present and the lid open. Grill outdoors on a flat surface away from the house, railings, overhangs and dry leaves, with a hose or extinguisher nearby; use long tongs, never leave a lit grill, and smother flare-ups by closing the lid. Cook chicken to at least 165 °F and keep raw chicken separate.

KITCHEN LAB

Grill Lab: Two-Zone Spice-Rubbed Chicken

You will mix a dry rub, help set a two-zone fire, map the zones with the hand test, and cook chicken safely to a juicy finish (or use the indoor sear-and-roast method).

You will need

- A charcoal or gas grill with a lid, long tongs, a grill brush and heat-resistant gloves
- A chimney starter (for charcoal, used by an adult)
- An instant-read thermometer
- Two platters (one for raw, one for cooked) and a raw-meat board
- For the indoor way: a 12-inch oven-safe skillet

Two-Zone Grilled Spice-Rubbed Chicken

Serves 6 · Prep 15 min · Fire 25 min · Grill 30–40 min

Ingredients

- 3 lb (1.4 kg) bone-in, skin-on chicken thighs and drumsticks
- **Rub:** 1 tablespoon brown sugar, 2 teaspoons smoked paprika
- 2 teaspoons kosher salt, 1 teaspoon black pepper
- 1 teaspoon garlic powder, 1 teaspoon onion powder
- 1 teaspoon ground cumin, ½ teaspoon chili powder
- 1 tablespoon oil for the grate or pan

Method

1. Pat the chicken dry. Mix the rub and season all sides. Refrigerate while the fire heats. Wash hands, board and anything that touched raw chicken.
2. **Charcoal:** An adult lights a full chimney of briquettes and, when they are covered with gray ash, pours them onto one side of the grill. **Gas:** Heat all burners on high with the lid closed 10 minutes, then turn one side off. Clean and oil the grate.

3. Sear the chicken skin-side down over the hot side 3–4 minutes per side, moving pieces to the cool side if flare-ups start.
4. Move all pieces to the cool side, skin-side up, close the lid (vents half open) and cook 25–35 minutes, until the thickest pieces read at least 165 °F, ideally 175–185 °F for tender thighs.
5. **Indoor way:** Heat the oven to 400 °F. Sear the chicken skin-side down in the oiled skillet over medium-high heat 6–8 minutes, turn, and roast 25–30 minutes to the same temperatures.
6. Move to a clean platter and rest 5 minutes. An adult closes the vents (or turns off the gas) and lets the grill cool.

Allergy check: Contains none of the nine major allergens. Check spice blends and chili powders for added ingredients.

Steps

1. **Safety briefing.** Before the fire, walk the grill area with your parent and check the safety list: location, extinguisher or hose, lid, long tongs, no liquid starter.
2. Make the rub and season the chicken; record the weight of chicken and rub.
3. **Zone map.** When the grill is hot, have the adult do the hand test over each zone and record the seconds.
4. Grill (or sear and roast) the chicken. Record times on each side of the grill and the final temperatures of three pieces.
5. **Taste test.** Compare a piece pulled at 165 °F with one at 180 °F for juiciness and tenderness.
6. **Technique check.** Score 1–3: safety rules followed, good sear without burning, flare-ups controlled, safe final temperatures, raw and cooked kept separate.
7. Clean up: brush the grate while warm (adult), wash platters and tongs; coals cool 24–48 hours before an adult empties them into a metal can.
8. **Repeat round.** Cook a thicker food (a pork shoulder steak or a whole spatchcocked chicken) on the two-zone fire.

Tips

- Sugar in a rub burns over direct heat; keep the sear short.

- Leave space between pieces so heat can circulate.
- Do not press chicken with the tongs; it pushes out juices and causes flare-ups.

Check your work

- ☐ I can tell George Stephen's story and explain the fire triangle and two-zone fire.
- ☐ I followed every grill safety rule.
- ☐ I cooked spice-rubbed chicken to a safe, juicy finish.

LAB NOTEBOOK

1. Draw your grill from above showing the hot zone, cool zone, vents and where each piece cooked.
2. Record your zone map, times and temperatures.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

Hand test (5 inches above the grate): 2–4 s = high, 5–7 s = medium, 8–10 s = low

$$\text{cooking time} \approx \text{sear time} + \text{indirect time}$$

From history. The fire-safety association NFPA reports that grill fires are most common in the summer months. Most could be prevented by keeping grills away from houses and railings and by cleaning grease from grates and trays.

WORKED EXAMPLES

Example 1. Bone-in thighs sear 4 minutes per side over direct heat, then need about 25 minutes on the indirect side. Dinner is at 6:30 p.m. and the coals need 20 minutes in the chimney plus 5 minutes to heat the grate. When should the adult light the chimney?

Show solution

1. Cooking: $8 + 25 = 33$ min; resting 5 min.
2. Fire: 25 min.
3. Total: $33 + 5 + 25 = 63$ min.
4. 6:30 p.m. − 63 min ≈ 5:27 p.m.

Answer: Light the chimney by about 5:25 p.m. Check the chicken with a thermometer starting at about 6:10.

Example 2. A gas grill has a 20-lb propane tank (about 430,000 BTU). Two burners on high use about 24,000 BTU per hour. How many hours of cooking does a full tank give, and what is the fuel cost per hour if a refill costs $22?

Show solution

1. $430{,}000 / 24{,}000 \approx 18$ h.
2. $\$22 / 18 \approx \$1.22$ per hour.

Answer: About 18 hours of two-burner cooking, roughly $1.22 per hour.

Example 3. Chicken thighs cost $1.99/lb, bone-in. You need 3 lb for 6 people. What is the cost, and the cost per serving?

Show solution

1. $3 \times \$1.99 = \$5.97$; $\$5.97 / 6 = \$1.00$.

Answer: $5.97, about $1.00 per serving for the chicken.

PRACTICE

1. Easy Name the three parts of the fire triangle and how a grill lid controls a flare-up.

Show answer

Heat, fuel, oxygen; closing the lid cuts off oxygen.

2. Easy Who may light a charcoal grill in this course, and what may never be used?

Show answer

Only an adult lights charcoal; liquid charcoal starter is never used.

3. Easy What is a two-zone fire?

Show answer

A grill with one hot side and one cooler side, for direct and indirect cooking.

4. Medium Why cook bone-in chicken mostly over indirect heat?

Show answer

It is thick and needs time to cook through; direct heat alone would burn the outside before the inside was safe.

5. Medium List five grill safety rules.

Show answer

Any five: adult lights charcoal; no liquid starter; outdoors away from the house, railings and overhangs; flat surface; long tongs; hose or extinguisher and lid nearby; never leave a lit grill; coals cool 24–48 hours before disposal in a metal can; keep children and pets back.

6. Medium Your hand test over the hot side lasts 3 seconds and over the cool side 9 seconds. Classify each zone.

Show answer

Hot side high; cool side low.

7. Medium What happened in 1952 near Chicago that changed backyard grilling?

Show answer

George Stephen made the first kettle grill from a metal buoy at Weber Brothers Metal Works.

8. Hard Chicken thighs are at 155 °F after 20 minutes on the indirect side and rise about 1 °F per minute. How much longer to reach 175 °F?

   Show answer

   About 20 minutes.

9. Hard Explain why opening the bottom vents makes a charcoal fire hotter.

   Show answer

   More oxygen reaches the coals, so they burn faster and release more heat.

10. Challenge Describe how to cook the same chicken indoors so that it matches the two-zone method, explaining which part of the oven method matches each zone.

    Show answer

    Sear the pieces skin-side down in a hot oven-safe skillet on the stove (direct heat), then move the skillet to a 400 °F oven to finish to 175 °F (indirect, convection heat, like a closed grill).

COMMON MISTAKES

- Cooking bone-in chicken only over direct heat.
- Using a fork to turn meat, which pierces it and drips fat into flare-ups.
- Putting cooked chicken back on the raw platter.
- Leaving a lit grill unattended.

Make it a game · Two-Zone Setup. Draw an aerial plan of a grill on paper. Mark where coals go for direct and indirect heat, where chicken skin side goes first, and where the lid vents sit. Explain the fire triangle and a chimney starter's job. Your parent points to a spot and you name what belongs there. A grill expert must also tell the George Stephen buoy story.

Scripture. “As soon then as they were come to land, they saw a fire of coals there, and fish laid thereon, and bread.” (John 21:9, KJV)

After a long night of fishing, the risen Jesus had breakfast ready on a fire of coals for His tired disciples. Cooking over a fire for others is an old and loving act.

7.5 Texture and Plating: Service à la Russe

OBJECTIVES

- Explain the change from service à la française to service à la russe and how it made plating part of cooking.
- Use the principles of plating: a clean rim, height, color contrast, texture contrast and balanced portions.
- Plan plate proportions using MyPlate guidelines and calculate cost per plate.
- Grill (or broil) flank steak with chimichurri and grilled vegetables, sliced and plated.

> **Warm-up.** Put the same food on two plates: on one, piled in the middle; on the other, arranged with space, color and height. Ask a family member which they would rather eat. Why do you think appearance changes how we expect food to taste?

WATCH

Food Styling: Chef Michael Laiskonis' 4 Essential Elements of Plating

Institute of Culinary Education · 6:51

https://www.youtube.com/watch?v=O1ARyw1G7Ng

> **WHEN TO WATCH**
> Before you sketch your plate. Write down the four elements and one tip for each.

BACKUP VIDEO

Basic Food Plating Techniques

WebstaurantStore · 1:40

https://www.youtube.com/watch?v=r2tuI8uyzA8

A quick look at classic and free-form plating of a steak dinner.

KEY TERMS

service à la française

The older style of dining in which many dishes were set on the table at once and guests served themselves.

service à la russe

Service in courses, each dish brought to the guest in turn, already portioned or plated.

plating

Arranging food on the plate for appearance, balance and ease of eating.

against the grain

Slicing across the direction of the muscle fibers so each slice has short fibers and is tender.

chimichurri

An Argentine sauce of chopped parsley, garlic, oil, vinegar and spices, served with grilled meat.

CORE IDEAS

The story. For centuries, a formal European dinner was served *à la française*: dozens of dishes set on the table at once in a grand pattern, as Carême drew in his books, and guests helped themselves to whatever was within reach while much grew cold. Around 1810 the Russian ambassador in Paris, Prince Alexander Kurakin, served dinners *à la russe*: one course at a time, carved and portioned in the kitchen and brought to each guest hot. The style spread through the 1800s, and Escoffier's restaurants made it the standard: each plate was composed in the kitchen.

How they figured it out. Once each guest received a plate, the cook decided what the guest would see and taste first. Chefs began to think about the plate as a small composition: the protein, the vegetable, the starch and the sauce in balance. Food scientists have since shown that appearance changes how people rate the taste of food; we eat first with our eyes.

The kitchen science. Texture is part of flavor: a tender steak, a crisp-charred vegetable and a bright, loose sauce contrast pleasingly. Slicing flank steak thin **against the grain** shortens its long muscle fibers so it is tender. Plating principles: wipe the rim clean; use an odd number of pieces; build a little height; contrast colors (green chimichurri on brown meat, red peppers and yellow squash); keep sauces from flooding crisp foods; and follow MyPlate proportions, about half vegetables, a quarter protein and a quarter grain or starch.

Let's cook. You will grill (or broil) flank steak and vegetables, make chimichurri, slice the steak against the grain and plate four identical plates as if serving à la russe. The technique standard: steak seared to 145 °F and rested, sliced thin against the

grain, vegetables charred and tender-crisp, sauce bright and balanced, and plates matched, clean-rimmed and balanced in color, height and proportion.

PICTURE STUDY



Still Life with Fruit and Jug, Luis Egidio Meléndez, 1773 · Oil on canvas · See the image source page

Image: Wikimedia Commons, public domain

Luis Meléndez arranged simple fruit and a jug with the care of a chef plating a dish: varied heights, contrasting colors and textures, a clear center of attention and space around each object. A still-life painter and a cook who plates food solve the same problem: how to make simple things inviting.

Look closely

- Find the tallest object. How does it give the arrangement height?
- Find contrasts of color and texture. Which objects are smooth and which rough?
- Find the empty space. Why does Meléndez leave it?

Talk about it

1. Which plating principles from this lesson can you see in the painting?
2. How would you arrange tonight's plate the way Meléndez arranged this ledge?
3. Why do we enjoy food more when it is arranged with care?

> **Safety first.** Follow every grill rule from Lesson 7.4; for the indoor way, broil with the rack 4 inches from the element and stay at the oven. Cook the steak to 145 °F with a 3-minute rest. Keep raw-meat boards and platters separate from plates and cutting boards for cooked food.

KITCHEN LAB

Plating Lab: Flank Steak with Chimichurri and Grilled Vegetables

You will grill (or broil) a steak and vegetables, slice against the grain, and plate four matching plates with a sketch first.

You will need

- A grill and long tongs (or a broiler pan for the indoor way)
- An instant-read thermometer
- A chef's knife and a cutting board for cooked meat
- Four dinner plates, a clean towel for wiping rims, spoons for sauce
- A food processor or knife for the chimichurri

Grilled Flank Steak with Chimichurri and Vegetables

Serves 6 · Prep 25 min · Marinate 30 min · Grill 20 min

Ingredients

- 2 lb (900 g) flank steak
- 1½ teaspoons kosher salt and 1 teaspoon black pepper
- **Chimichurri:** 1 cup packed parsley, finely chopped
- 3 cloves garlic, minced; ½ teaspoon dried oregano; ¼ teaspoon red pepper flakes
- ½ cup (120 mL) olive oil, 3 tablespoons cider or white vinegar, ½ teaspoon salt
- **Vegetables:** 2 bell peppers, 2 zucchini, 1 red onion, cut in large pieces
- 2 tablespoons olive oil, ½ teaspoon salt
- Cooked rice to serve

Method

1. Stir the chimichurri ingredients together; let stand 20 minutes for the flavors to blend.
2. Season the steak with salt and pepper and rest 30 minutes in the refrigerator. Toss the vegetables with oil and salt.

3. Grill the vegetables over direct medium-high heat until charred and tender-crisp, 8–12 minutes, turning with tongs. Move to a clean platter.
4. Grill the steak over direct high heat 4–6 minutes per side, until 145 °F in the thickest part. (Indoor way: broil 4 inches from the element, 5–7 minutes per side.) Rest on a clean board at least 5 minutes.
5. Slice thinly against the grain at a slight angle.
6. Plate: rice, fanned steak slices, vegetables, and chimichurri spooned over the steak. Wipe the rims and serve.

Allergy check: Contains none of the nine major allergens.

Steps

1. **Plate sketch.** Draw your plate from above before cooking: where each food goes, the colors, and where the sauce lands.
2. Make the chimichurri and cook the vegetables and steak. Record temperatures.
3. **Grain test.** Cut one slice with the grain and one against it; taste and compare.
4. **Plate four.** Plate four matching plates à la russe. Photograph them together. Are they consistent?
5. **Family judging.** Ask the family to rate appearance before tasting and flavor after. Record both.
6. **Technique check.** Score 1–3: safe grilling, 145 °F with rest, thin slices against the grain, matching plates, clean rims, color and texture contrast.
7. Clean up: cooked-meat board and raw-meat platters washed separately; grill brushed when cool enough.
8. **Repeat round.** Plate a dessert from Unit 6 with a sauce and a garnish using the same principles.

Tips

- Find the grain before cooking (long lines on the steak) so you remember which way to slice.
- Warm the plates in a low oven for hot food; chill them for salads.
- Less sauce than you think: you can always pass more at the table.

Check your work

- ☐ I can explain service à la russe and the principles of plating.
- ☐ I can plan plate proportions and cost per plate.
- ☐ I cooked and plated four matching steak dinners.

LAB NOTEBOOK

1. Paste your plate sketch next to a photo of the real plate and note what changed.
2. Record your grain test and family ratings for appearance and flavor.
3. Write the lab record with cost per plate, a family rating and one change for the repeat round.

KEY FORMULAS

MyPlate plate: about $\frac{1}{2}$ vegetables and fruit, $\frac{1}{4}$ protein, $\frac{1}{4}$ grains

$$\text{cost per plate} = \frac{\text{total cost}}{\text{number of plates}}$$

From history. Service à la russe also made printed menus common, so guests knew which courses were coming. Today's family-style service, with platters passed around the table, is a friendly middle way between the two old styles.

WORKED EXAMPLES

Example 1. A dinner plate's food area is a circle 9 inches across. About how many square inches should hold vegetables, protein and grain by MyPlate proportions?

Show solution

1. Area $= \pi(4.5)^2 = 63.6$ in^2.
2. Vegetables ≈ 31.8 in^2; protein ≈ 15.9 in^2; grain ≈ 15.9 in^2.

Answer: About 32, 16 and 16 square inches.

Example 2. Flank steak: 1.75 lb at $9.99/lb. Vegetables $5.40; chimichurri $2.10; rice $0.80. The meal makes 6 plates. What is the cost per plate?

Show solution

1. Steak $= 1.75 \times 9.99 = \$17.48$.
2. Total $= 17.48 + 5.40 + 2.10 + 0.80 = \$25.78$.
3. Per plate $= \$25.78/6 = \$4.30$.

Answer: About $4.30 per plate.

Example 3. Each plate gets 4 oz of cooked steak. Flank steak loses about 25% of its weight when grilled. How much raw steak do you need for 6 plates?

Show solution

1. Cooked needed: $6 \times 4 = 24$ oz.
2. Raw: $24/0.75 = 32$ oz $= 2$ lb.

Answer: About 2 lb raw.

PRACTICE

1. Easy What is the difference between service à la française and à la russe?

   Show answer

   À la française: many dishes on the table at once, guests serve themselves. À la russe: courses brought one at a time, portioned or plated for each guest.

2. Easy Why slice flank steak against the grain?

   Show answer

   To shorten the long muscle fibers so each slice is tender.

3. Easy Name four plating principles.

   Show answer

   Any four: clean rim; odd numbers; height; color contrast; texture contrast; sauce placed so it does not make crisp food soggy; balanced proportions.

4. Medium By MyPlate, what fraction of the plate is vegetables and fruit?

   Show answer

   About half.

5. Medium Who is credited with bringing service à la russe to Paris, and about when?

Show answer

Prince Alexander Kurakin, the Russian ambassador, around 1810.

6. Medium A steak loses 20% when cooked. How much raw steak gives 30 oz cooked?

Show answer

37.5 oz (about 2.3 lb).

7. Medium Why add the chimichurri at the table or just before serving rather than long before?

Show answer

Fresh herbs darken and the vinegar softens crisp foods; adding it last keeps colors bright and textures crisp.

8. Hard Total meal cost $31.50 for 7 plates. What is the cost per plate, and what would a restaurant charge at a 30% food-cost percentage?

Show answer

$4.50 per plate; price $4.50 / 0.30 = \$15.00$.

9. Hard Explain why a plate with only brown foods (steak, potatoes, mushrooms) may seem less appetizing, and how to fix it.

Show answer

Appearance shapes expectations; a single color looks heavy and dull. Add green herbs or vegetables, a red or yellow vegetable, and a bright sauce.

10. Challenge Plan and sketch a plate for this lesson's dinner that follows MyPlate proportions and at least four plating principles, and explain each choice.

Show answer

Answers vary. A strong plan places sliced steak (¼) fanned against a mound of rice (¼) for height, with grilled peppers, zucchini and onions (½) on the open side, chimichurri spooned over the steak, odd numbers of slices, color contrast and a wiped rim.

COMMON MISTAKES

- Slicing with the grain, so steak is chewy.

- Flooding the plate with sauce.
- Plates that do not match when serving several people.
- Cutting the steak without resting it.

> **Make it a game · Plate It Fast.** Set a four-minute timer. Plate any simple food from your kitchen, such as bread, cheese and fruit, using a clean rim, height, color and odd-numbered groupings. Your parent judges each principle out of five. Then explain how service à la russe made plating part of cooking. Beat your own total next time.

UNIT 7

Flavor, Spice and the Grill

This is the unit where cooking becomes an art. You will learn the five basic tastes and how to balance a dish with salt, acid, fat, sweetness and heat; the spice trade that sent Vasco da Gama around Africa to India; how cooks pair flavors by harmony and by contrast; how to build and control a two-zone grill fire; and how to plate food so that it looks as good as it tastes.

The stories include Kikunae Ikeda's discovery of umami, da Gama's voyage of 1497–1499, a 2011 study that mapped 56,000 recipes as a flavor network, George Stephen's 1952 kettle grill, and the change from service à la française to plated courses. Grill labs follow strict safety rules and always offer an indoor method.

PREREQUISITES

- Units 1–6, especially dry-heat cooking (Unit 3) and safe temperatures
- A grill is optional; every grill lab has an indoor method
- Comfort with percentages, ratios and simple combinatorics

MASTERY CHECKLIST

- ☐ I can name the five tastes and balance a dish in measured rounds.
- ☐ I can toast, grind and bloom spices and tell the story of the spice trade.
- ☐ I can design dishes with complementary and contrasting pairings.
- ☐ I can set up a two-zone fire, follow every grill safety rule, and cook chicken to a safe, juicy finish.
- ☐ I can slice against the grain and plate food with balance, color and contrast.

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 7.4.
- **A chimney starter (for the adult) and long-handled tongs**: A chimney lights charcoal without liquid starter. Not needed for gas grills or the indoor methods.
- **A spice grinder or mortar and pestle**: For toasting and grinding whole spices in Lesson 7.2. A cheap blade coffee grinder kept only for spices works well.

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	**The Five Tastes and Balancing a Dish: Ikeda's Umami**	3 sessions of 50 minutes
7.2	**Herbs, Spices and Vasco da Gama's Voyage**	3 sessions of 50–90 minutes
7.3	**Complementary and Contrasting Flavors: The Flavor Network**	3 sessions of 50 minutes
7.4	**The Grill: George Stephen's Kettle and the Two-Zone Fire**	3 sessions of 50–90 minutes
7.5	**Texture and Plating: Service à la Russe**	3 sessions of 50–90 minutes

Unit 7 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Name the five basic tastes and tell how Ikeda discovered umami.

2. **8 pts**
   Soup weighs 2,400 g. How much salt makes it 0.9% salt, in grams and teaspoons of table salt (6 g/tsp)?

3. **6 pts**

   A dish is flat, too rich, and slightly bitter. Name the element to add for each problem.

4. **6 pts**

   Give the plant part of cinnamon, cloves, pepper, nutmeg and ginger.

5. **8 pts**

   Tell the story of Vasco da Gama’s voyage and why it mattered for cooks.

6. **6 pts**

   Why toast whole spices and bloom ground spices?

7. **4 pts**

   A spice blend uses parts 3:3:2:1:1. How many grams of each in 40 g?

8. **8 pts**

   How many ingredient pairs are possible among 8 ingredients? Explain complementary and contrasting pairing with one example of each.

9. **6 pts**

   What did the 2011 flavor-network study find?

10. **6 pts**

    Give the quick-pickle brine for 2 cups.

11. **8 pts**

    List six grill safety rules from this course.

12. **6 pts**

    Explain a two-zone fire and how to cook bone-in chicken on it.

13. **6 pts**

    Who built the first kettle grill, from what, and when?

14. **6 pts**

    Flank steak loses 25% when grilled. How much raw steak for 8 servings of 4 oz cooked?

15. **6 pts**

Explain service à la russe and two plating principles.

16. **4 pts**

Essay (one paragraph): Describe a complete dinner you would plan using at least three ideas from this unit (balance, spice, pairing, grilling, plating), and explain why each makes the meal better.

ANSWER KEY

1. Sweet, salty, sour, bitter, umami. In 1908 Kikunae Ikeda isolated glutamate from kombu seaweed broth and showed it caused the savory taste.
2. $0.009 \times 2400 = 21.6$ g ≈ 3.6 tsp.
3. Flat: salt. Too rich: acid. Bitter: salt (and a touch of sweetness).
4. Bark; flower bud; berry; seed; rhizome.
5. He sailed from Lisbon in 1497, rounded Africa and, with an Indian Ocean pilot from Malindi, reached Calicut in May 1498, returning in 1499 with spices; the sea route made spices cheaper and changed world trade.
6. Toasting releases and deepens volatile aromas; blooming in oil dissolves fat-soluble flavors into the dish.
7. One part 4 g: 12, 12, 8, 4, 4 g.
8. 28 pairs. Complementary: tomato and basil (shared flavors). Contrasting: salt and caramel, or lemon and salmon (opposites balance).
9. Western recipes tend to pair ingredients that share many flavor compounds; East Asian recipes tend to pair ingredients that share few.
10. 1 cup vinegar, 1 cup water, 2 Tbsp sugar, 1 Tbsp salt.
11. Any six: adult lights charcoal; no liquid starter; outdoors on a flat surface away from house, railings, overhangs, dry leaves; long tongs; lid and hose or extinguisher ready; never leave lit grill; children and pets back; coals cool 24–48 hours before an adult disposes of them in a metal can.
12. Hot side and cool side; sear over direct heat, then finish over indirect heat with the lid closed until at least 165 °F (175–185 °F for tender thighs).
13. George Stephen, from a metal buoy at Weber Brothers Metal Works, 1952.
14. $32 / 0.75 = 42.7$ oz ≈ 2.7 lb.
15. Courses brought one at a time, plated for each guest. Any two plating principles: clean rim, height, color and texture contrast, odd numbers, balanced proportions.
16. Answers vary; a strong answer names specific dishes and connects each to a principle from the unit with a reason.

UNIT PROJECT: A FAMILY GRILLED DINNER WITH A SIGNATURE RUB

Plan, prepare and serve a family dinner cooked on the grill (or by the indoor methods): a protein cooked by the two-zone method, at least one grilled vegetable, a sauce or relish that adds contrast (chimichurri, salsa, pickled onions or a yogurt sauce), and a side. Create and name your own spice rub, write its recipe by weight, and label a jar of it as a gift.

Write a menu, a shopping list with costs, a timeline from lighting the fire to serving, and a flavor chart showing at least four complementary or contrasting pairings. Plate the meal for each family member and photograph it. Record every safe temperature and the grill safety checklist.

LOOK FOR	WHAT IT MEANS
Safety	Grill safety checklist completed and followed; adult lit charcoal; all temperatures safe and recorded; raw and cooked kept separate.
Flavor design	Original rub recorded by weight; flavor chart with at least four well-explained pairings; dish balanced to taste.
Technique	Two-zone cooking done well; vegetables charred not burned; meat sliced and served properly.
Planning and plating	Menu, costed shopping list, realistic timeline; plates balanced and attractive.
Reflection	Family ratings and one honest improvement for next time.

UNIT 8

Nutrition and the Balanced Diet

Good cooks feed people well. In this unit you will learn the science and history behind MyPlate and the Dietary Guidelines, the macronutrients and food energy, how to read a Nutrition Facts label, how the brain's reward system shapes cravings and habits, and how to cook safely for guests with food allergies. Calories appear only as a unit of energy; this course never discusses weight or appearance. Foods are nutrient-dense foods and treats, and both have their place.

The stories include the 1943 Basic Seven, Wilbur Atwater's respiration calorimeter, the 1990 label law and its 2016 Added Sugars line, Olds and Milner's 1954 discovery and the food-industry "bliss point," and the 2004 and 2021 allergen laws. The labs feed the family: stuffed peppers, grain bowls, oat bars, hummus, and a dinner safe for guests with allergies.

PREREQUISITES

- Units 1–7
- Comfort with percentages, unit rates and reading tables
- Willingness to keep honest food logs (never about body size)

MASTERY CHECKLIST

- ☐ I can describe MyPlate and the Dietary Guidelines and measure foods in cup- and ounce-equivalents.
- ☐ I can use the 4-4-9 factors to describe food energy and plan meals for growth and sport.
- ☐ I can read a Nutrition Facts label and convert grams of added sugar to teaspoons.
- ☐ I can explain the reward system, satiety and habits accurately.
- ☐ I can cook for guests with food allergies without cross-contact.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **MyPlate.gov**: Free at MyPlate.gov: the USDA's MyPlate site with food-group amounts by age and printable tip sheets.
- **FDA: How to Understand and Use the Nutrition Facts Label**: Free. The FDA's guide to every line of the label, for Lesson 8.3.
- **FDA: Food Allergies**: Free. The FDA's page on the nine major allergens and labeling, for Lesson 8.5.

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	**MyPlate and the Dietary Guidelines: From the Basic Seven to Today**	3 sessions of 50 minutes
8.2	**Macronutrients, Food Energy and Eating for Sport**	3 sessions of 50 minutes
8.3	**The Nutrition Facts Label and Added Sugar**	3 sessions of 50 minutes
8.4	**Cravings, Reward and Habits That Last**	3 sessions of 50 minutes
8.5	**Food Allergies: Cooking for Guests Safely**	3 sessions of 50–90 minutes

Unit 8 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Put in order and date: Food Guide Pyramid, MyPlate, Basic Seven, MyPyramid.

2. **6 pts**
   Describe MyPlate's proportions and name one nutrient each food group provides.

3. **6 pts**

   A dinner has 1 cup cooked pasta, 3 oz chicken, 2 cups raw spinach salad and 1½ oz cheese. Give the food-group amounts.

4. **8 pts**

   A meal has 85 g carbohydrate, 30 g protein and 22 g fat. Find its energy in kcal and kJ, and the percentage from fat.

5. **6 pts**

   Who was Wilbur Atwater, and what did he measure?

6. **6 pts**

   Give three guidelines for eating around a game or practice.

7. **6 pts**

   Why does this course's sport nutrition rely on ordinary meals and water rather than pills, powders or stimulant drinks?

8. **8 pts**

   A drink has 2 servings per bottle and 21 g added sugars per serving. How many grams and teaspoons in the bottle, and what %DV?

9. **6 pts**

   Explain total sugars versus added sugars, with an example of a food with sugars but no added sugars.

10. **6 pts**

    Describe accurately what dopamine does in the reward system.

11. **6 pts**

    What is satiety, how long does the fullness signal take, and what three things help it?

12. **6 pts**

    Compare the energy density of a 30-g snack with 150 kcal and a 180-g snack with 200 kcal.

13. **6 pts**

    List the nine major allergens and name the law that added sesame.

14. **6 pts**

    Explain cross-contact and four ways to prevent it.

15. **4 pts**

    Predict: a cook fries breaded shrimp, then fries potatoes in the same oil for a guest with a shellfish allergy. What could happen?

16. **8 pts**

    Essay (one paragraph): Describe a balanced way of eating that fits this unit's teaching about food and bodies, using at least three ideas from the unit and one from Scripture.

ANSWER KEY

1. Basic Seven 1943; Food Guide Pyramid 1992; MyPyramid 2005; MyPlate 2011.
2. About half fruits and vegetables, a quarter grains, a quarter protein, dairy on the side. Examples: vegetables/fruits vitamin C and fiber; grains B vitamins and fiber; protein iron and protein; dairy calcium.
3. Grains 2 oz-eq; protein 3 oz-eq; vegetables 1 cup-eq; dairy 1 cup-eq.
4. $340 + 120 + 198 = 658$ kcal; 2,753 kJ; fat $198/658 = 30\%$.
5. A Wesleyan chemist who, with Edward Rosa, built a respiration calorimeter in the 1890s and measured the energy people get from food (4, 4 and 9 kcal per gram).
6. Balanced meal 2–4 hours before; small carbohydrate snack and water if needed 30–60 minutes before; water during; carbohydrate and protein within an hour or two after.
7. Food provides the protein and energy teens need; pills and powders are unnecessary and loosely regulated, and stimulant drinks are unsuitable for teens.
8. 42 g; about 10½ tsp; 84% DV.
9. Total sugars include natural sugars in fruit and milk; added sugars are added in processing or cooking. Plain milk or an apple.
10. It is a messenger tied to wanting, motivation and learning what is rewarding; it rises when we expect or get something good. It is not pleasure itself.
11. The feeling of satisfaction that tells us to stop eating; about 20 minutes; fiber, protein and water (and eating slowly).
12. 5.0 kcal/g and 1.1 kcal/g.
13. Milk, eggs, fish, crustacean shellfish, tree nuts, peanuts, wheat, soybeans, sesame; the FASTER Act of 2021.
14. Transfer of an allergen protein to a safe food or surface. Read labels; wash hands; use freshly washed tools and pans; cook the safe dish first and cover it; separate serving spoons; label dishes.
15. Shellfish protein in the oil can transfer to the potatoes and cause an allergic reaction; frying does not destroy it.
16. Answers vary. A strong answer speaks of a pattern of mostly nutrient-dense foods covering the five groups, food as energy for growth and work, reading labels, eating slowly and attending to fullness, treats enjoyed in their place, care

for guests, thankfulness and self-control (e.g., 1 Corinthians 10:31; Galatians 5:22–23), and never judges bodies or calls foods good or bad.

UNIT PROJECT: A WEEK OF BALANCED FAMILY MEALS

Plan a week of family dinners (and one breakfast and one packed lunch) that follow MyPlate, use at least three recipes from this course, and include one meal safe for a guest with a food allergy of your choice. Check each meal against the five food groups and write it on a planning chart.

Cook at least three of the meals. For one, calculate the energy and macronutrients per serving and the added sugar. Write a one-page reflection on what you learned about balanced eating, keeping to the course's rule of talking about nourishment, skill and thankfulness, never about weight or appearance.

LOOK FOR	WHAT IT MEANS
Planning chart	Seven dinners, a breakfast and a lunch, each checked against the five food groups.
Cooking	Three meals cooked to standard with safe temperatures and family ratings.
Calculations	Accurate energy, macronutrient and added-sugar calculations for one meal.
Allergy-safe meal	A meal safe for a named allergy, with label audit and cross-contact plan.
Reflection	Thoughtful, kind and accurate, with no talk of weight or appearance.

8.1 MyPlate and the Dietary Guidelines: From the Basic Seven to Today

OBJECTIVES

- Trace the history of U.S. food guides from the 1943 Basic Seven to MyPlate (2011) and the Dietary Guidelines for Americans.
- Measure foods in MyPlate cup-equivalents and ounce-equivalents.
- Plan a dinner that includes all five food groups in balanced proportions.
- Cook stuffed bell peppers with a fruit side, a meal that covers the whole plate.

> **Warm-up.** Draw a plate and sketch what you ate for dinner last night on it. What fraction of the plate was vegetables and fruit? Protein? Grains? Was there dairy on the side?

WATCH

Choose My Plate Dietary Guidelines

AllOne Health · 3:03

https://www.youtube.com/watch?v=-J1hmmy1OB4

> **WHEN TO WATCH**
> After the story. Note one tip for each food group.

Note: A short overview of MyPlate's five food groups from a workplace-wellness program.

KEY TERMS

MyPlate

The USDA's food-guide icon since 2011: a plate divided into fruits, vegetables, grains and protein, with a cup of dairy beside it.

Dietary Guidelines for Americans

Science-based advice on eating patterns from the U.S. Departments of Agriculture and of Health and Human Services, issued every five years since 1980.

cup-equivalent

A MyPlate measure for fruits, vegetables and dairy; for example 1 cup raw or cooked vegetables, 2 cups raw leafy greens, or 1½ oz of natural cheese equals 1 cup.

ounce-equivalent

A MyPlate measure for grains and protein; for example 1 slice of bread or ½ cup cooked rice is 1 oz-eq of grains; 1 egg or ¼ cup cooked beans is 1 oz-eq of protein.

nutrient-dense food

A food that supplies vitamins, minerals and other nourishing substances in good amounts for its energy, such as vegetables, fruits, whole grains, beans, eggs, fish and milk.

CORE IDEAS

The story. During the Second World War, with food rationed and many young men found to be poorly nourished, the U.S. Department of Agriculture published the "Basic Seven" in 1943: seven food groups to eat from every day, printed on posters for kitchens and schools. It was simplified to the "Basic Four" in 1956, replaced by the Food Guide Pyramid in 1992 and by MyPyramid in 2005, and in June 2011 by **MyPlate**, a simple picture of a dinner plate. Since 1980 the USDA and the Department of Health and Human Services have also published the *Dietary Guidelines for Americans* every five years; the 2020–2025 edition gives advice for every stage of life.

How they figured it out. Each guide drew on the nutrition science of its time: which foods supply which nutrients, and in what amounts people of each age need them. The planners also learned that a guide only helps if people can remember and use it. A pyramid of servings proved confusing; a plate, the place where people actually eat, was easy to picture.

The kitchen science. MyPlate suggests making about half the plate fruits and vegetables, about a quarter grains (at least half of them whole grains), and about a quarter protein foods, with dairy (milk, yogurt, cheese or fortified soy milk) on the side. Different groups supply different nutrients: vegetables and fruits supply vitamins A and C, potassium and fiber; whole grains supply fiber and B vitamins; protein foods supply protein, iron and zinc; dairy supplies calcium and vitamin D. Teenagers need about 3 cup-equivalents of dairy a day because bones are growing

quickly. No single food is “good” or “bad”: the guidelines describe a balanced eating pattern built mostly from nutrient-dense foods, with room for treats in their place.

Let’s cook. You will make stuffed bell peppers filled with seasoned ground beef (or beans), brown rice, tomatoes and cheese, served with a fruit salad, and check the plate against MyPlate. The technique standard: peppers par-cooked so they are tender, filling cooked to 160 °F (ground beef) and reheated to 165 °F in the peppers, seasoned well, and a plate that covers all five food groups.

PICTURE STUDY



For Health… Eat Some Food from Each Group… Every Day! (The Basic Seven), U.S. Department of Agriculture, 1940s · Printed poster · Via the Digital Public Library of America

Image: Wikimedia Commons, public domain

The USDA printed posters like this one during and after the Second World War to teach the Basic Seven food groups. Families taped them in kitchens; schools hung them in lunchrooms. Compare its seven groups with today's five.

Look closely

- Count the groups and read their names. Which of them are now combined?
- Find the group that has no place on MyPlate today.
- Look at the drawings and colors. How did the poster try to catch attention?

Talk about it

1. Why might the government have cared so much about nutrition during a war?
2. What did the Basic Seven get right that MyPlate still teaches?
3. Design a modern kitchen poster that teaches MyPlate in one glance.

Safety first. Cook ground beef to 160 °F and reheat the stuffed peppers until the filling reaches 165 °F. Lower peppers into boiling water with tongs and drain them upside down away from you. Check every ingredient against family allergies; the cheese contains milk.

KITCHEN LAB

MyPlate Lab: Stuffed Bell Peppers with Fruit Salad

You will cook a complete MyPlate dinner and calculate the food-group amounts in one serving.

You will need

- A large pot, a large skillet and a 9 × 13-inch baking dish
- Tongs, a spoon and an instant-read thermometer
- A chef's knife and boards (one for raw meat)
- Measuring cups
- A MyPlate worksheet

Stuffed Bell Peppers with Rice, Beef and Beans

Serves 6 · Prep 25 min · Bake 30 min

Ingredients

- 6 large bell peppers, tops cut off and seeds removed
- 1 lb (450 g) lean ground beef (or 2 more cans of beans for a meatless version)
- 1 onion, diced; 2 cloves garlic, minced
- 1 teaspoon cumin, 1 teaspoon chili powder, 1 teaspoon dried oregano, 1 teaspoon salt
- 1 can (15 oz) black beans, drained
- 1 can (15 oz) diced tomatoes
- 3 cups cooked brown rice
- 1 cup (4 oz) grated cheddar or Monterey Jack
- **Fruit salad:** 6 cups mixed fruit (oranges, berries, grapes, apple) with 1 tablespoon lime juice

Method

1. Heat the oven to 375 °F (190 °C). Boil the peppers 3–4 minutes, lift out with tongs and drain upside down.

2. Cook the beef and onion in the skillet over medium-high heat, breaking up the meat, until no pink remains and it reads 160 °F. Drain excess fat. Add the garlic and spices for 1 minute.
3. Stir in the beans, tomatoes and rice; heat through and taste for salt.
4. Stand the peppers in the baking dish and fill them. Cover with foil and bake 20 minutes; uncover, top with cheese and bake 10 minutes more, until the filling reads 165 °F.
5. Meanwhile toss the fruit with lime juice. Serve the peppers with the fruit salad and a glass of milk or yogurt.

Allergy check: Contains milk (cheese). Omit the cheese for milk-free. Check spice blends and broth labels.

Steps

1. **Plan.** Sketch the plate and predict the fraction for each food group.
2. Cook the meal; record the beef's temperature and the final filling temperature.
3. **Measure.** Measure the rice, beans, beef and cheese that go into one pepper, and calculate the food-group amounts per serving.
4. Photograph a plated serving from above and estimate the fraction of the plate each group covers.
5. **Compare.** How close was your plate to MyPlate's proportions? What would you change?
6. **Technique check.** Score 1–3: peppers tender, filling well seasoned, safe temperatures, attractive plate, all five groups present.
7. **Repeat round.** Plan and cook another one-dish meal (a soup, casserole or stir-fry) that covers all five groups.

Tips

- Choose peppers that stand up on their own, or trim a thin slice from the bottom.
- Cook extra rice earlier in the week to save time.
- Lentils or extra beans make a fine meatless filling.

Check your work

☐ I can trace U.S. food guides from 1943 to MyPlate.

- ☐ I can measure foods in cup- and ounce-equivalents.
- ☐ I cooked a meal covering all five food groups and checked its proportions.

LAB NOTEBOOK

1. Make a timeline of U.S. food guides from 1943 to today with a small drawing of each.
2. Record your food-group calculation for one serving.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

Grains: 1 slice bread = ½ cup cooked rice or pasta = 1 oz-eq; Protein: 1 oz meat = 1 egg = ¼ cup cooked beans = 1 oz-eq
Vegetables: 1 cup raw or cooked = 2 cups raw leafy greens = 1 cup-eq; Dairy: 1 cup milk or yogurt = 1½ oz natural cheese = 1 cup-eq

From history. The 1943 Basic Seven included a group for butter and fortified margarine. Later guides dropped it as a group and treated oils as a separate allowance, since most people already ate plenty of fats.

WORKED EXAMPLES

Example 1. One stuffed pepper contains about ½ cup cooked brown rice, 2 oz cooked beef, ¼ cup black beans, ½ cup tomatoes, the pepper itself (about ¾ cup) and ½ oz cheese. Find the food-group amounts.

Show solution

1. Grains: ½ cup rice $= 1$ oz-eq.
2. Protein: 2 oz beef + ¼ cup beans $= 2 + 1 = 3$ oz-eq.
3. Vegetables: ½ + ¾ $= 1.25$ cup-eq.
4. Dairy: ½ oz cheese $= \frac{0.5}{1.5} = 0.33$ cup-eq.

Answer: About 1 oz-eq grains, 3 oz-eq protein, 1¼ cups vegetables and ⅓ cup dairy. Add 1 cup of fruit salad and a glass of milk to complete the plate.

Example 2. A teen aims for about 3 cup-equivalents of dairy a day. Breakfast has 1 cup of milk; lunch has 1½ oz cheddar. How much more is needed, and what could supply it?

Show solution

1. So far: $1 + 1 = 2$ cup-eq.
2. Remaining: $3 - 2 = 1$ cup-eq.

Answer: 1 more cup-equivalent: a cup of yogurt or milk at supper, or 1½ oz of cheese.

Example 3. Stuffed peppers for 6 cost $14.70 and the fruit salad $4.50. What is the cost per serving?

Show solution

1. $(14.70 + 4.50)/6 = \$3.20$.

Answer: About $3.20 per serving for a meal covering all five food groups.

PRACTICE

1. Easy Put these U.S. food guides in order: MyPlate, Food Guide Pyramid, Basic Seven, Basic Four.

   Show answer

   Basic Seven (1943), Basic Four (1956), Food Guide Pyramid (1992), MyPlate (2011).

2. Easy What are the five MyPlate food groups?

   Show answer

   Fruits, vegetables, grains, protein foods, dairy.

3. Easy How often are the Dietary Guidelines for Americans updated, and by whom?

   Show answer

   Every five years, by the USDA and the Department of Health and Human Services.

4. Medium How many oz-eq of grains are in 1 cup of cooked pasta?

Show answer

2 oz-eq.

5. Medium How many cup-equivalents of vegetables are in 3 cups of raw spinach?

Show answer

1½ cup-eq.

6. Medium Why do teenagers need about 3 cups of dairy (or fortified soy) a day?

Show answer

Bones grow rapidly in the teen years and need calcium and vitamin D.

7. Medium What does “nutrient-dense” mean? Give three examples.

Show answer

Supplying many nutrients for its energy; e.g., vegetables, beans, whole grains, fruit, eggs, fish, milk.

8. Hard A lunch has a sandwich (2 slices whole-wheat bread, 2 oz turkey, lettuce and tomato ½ cup), an apple (1 cup) and a cup of milk. List the food-group amounts.

Show answer

Grains 2 oz-eq; protein 2 oz-eq; vegetables ½ cup; fruit 1 cup; dairy 1 cup.

9. Hard Design a supper that fills half the plate with fruits and vegetables using at least three colors.

Show answer

Example: roasted carrots and broccoli with a side of berries alongside chicken and brown rice.

10. Challenge Why do you think the USDA switched from a pyramid to a plate? Evaluate one strength and one limitation of the plate.

Show answer

Strength: easy to picture at every meal and shows proportions simply. Limitation: does not show amounts per day, types of fat, or mixed dishes like soups and casseroles well, so the Dietary Guidelines add detail.

COMMON MISTAKES

- Calling foods “good” or “bad” instead of thinking about the whole pattern.
- Forgetting fruit and dairy when a main dish covers the other groups.
- Leaving peppers too firm; par-cook them first.
- Measuring leafy greens like dense vegetables; 2 cups raw greens count as 1 cup.

Make it a game · Cup-Equivalent Challenge. Your parent names foods: a banana, a cup of raw spinach, half a cup of beans, a slice of bread. State the MyPlate group and whether it equals a cup or ounce. Do twelve in ninety seconds. Then place the 1943 Basic Seven, 1916 food guide and 2011 MyPlate on a timeline you draw from memory.

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

Even ordinary eating can honor God when it is done with thanks and wisdom. A balanced plate is a small act of stewardship of the body He gave.

8.2 Macronutrients, Food Energy and Eating for Sport

OBJECTIVES

- Tell how Wilbur Atwater measured food energy with a respiration calorimeter in the 1890s.
- Use the factors 4, 4 and 9 kcal per gram to find the energy from carbohydrate, protein and fat, as a unit of energy and never as something to restrict.
- Plan meals and snacks that fuel growth and sport: timing, carbohydrate, protein and water.
- Cook a balanced grain bowl and calculate its energy and macronutrients from label data.

> **Warm-up.** Think about a day when you had a game, practice or long hike. What did you eat before and after? How did you feel during the activity? Write two sentences.

WATCH

Sports Nutrition for Youth Athletes

Phoenix Children's · 3:49

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

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Write down his advice on timing and on hydration.

Note: A sports-medicine physician at Phoenix Children's hospital answers common questions.

BACKUP VIDEO

Let's Learn Food Science - Atwater Factors for Determining Calories

Amy Proulx · 16:09

https://www.youtube.com/watch?v=tc8mddI-b8Y

Optional, after the story: a college food-science lecture on how Atwater measured food energy.

KEY TERMS

macronutrients

The nutrients the body needs in large amounts: carbohydrate, protein and fat (and water).

Atwater factors

Average energy values: about 4 kcal per gram of carbohydrate, 4 per gram of protein and 9 per gram of fat.

hydration

Having enough water in the body; plain water is the best drink for most practices and games.

Calorie (kilocalorie)

A unit of energy. One food Calorie (kcal) is the energy to warm 1 kg of water by 1 °C; 1 kcal = 4.184 kJ.

glycogen

The storage form of carbohydrate in muscles and liver; the main fuel for hard exercise.

CORE IDEAS

The story. Wilbur Olin Atwater (1844–1907), a chemistry professor at Wesleyan University in Connecticut, wanted to know how much energy people actually got from their food. In the 1890s, with the physicist Edward Rosa, he built a **respiration calorimeter**: a sealed, insulated room in which a volunteer lived for days while every bit of food, air, water and heat was measured. Atwater showed that the body obeys the law of conservation of energy, just like a machine, and he measured average energy values for the main nutrients that are still used on food labels today.

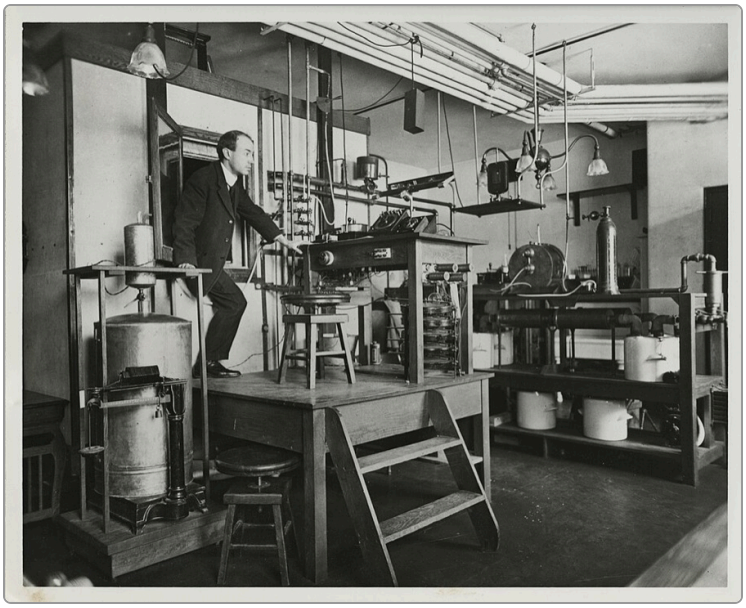
How he figured it out. Atwater burned samples of foods in a sealed, oxygen-filled calorimeter to measure their total energy, then measured how much was lost in digestion. He found that on average carbohydrate and protein supply about 4 kilocalories per gram and fat about 9. His careful bookkeeping of energy in and out laid the foundation of nutrition science.

The kitchen science. A Calorie is simply a unit of energy, like a mile is a unit of distance; growing teenagers and athletes need plenty of it. **Carbohydrates** (grains, fruit, potatoes, beans, milk) are the main fuel for hard exercise and are stored as glycogen. **Protein** (meat, fish, eggs, beans, dairy) builds and repairs muscle and every tissue; teens need it at every meal, but food supplies plenty, and pills, powders and stimulant drinks are not needed or recommended. **Fat** supplies concentrated

energy and carries vitamins A, D, E and K. For sport: eat a balanced meal 2–4 hours before, a small carbohydrate snack 30–60 minutes before if hungry, drink water before, during and after, and eat a meal or snack with carbohydrate and protein within an hour or two after.

Let's cook. You will build grain bowls with brown rice or quinoa, roasted vegetables, a protein (chicken thighs or chickpeas) and a yogurt-herb sauce, a meal that fuels a practice or game. Then you will use label data to calculate the energy and macronutrients in one bowl. The technique standard: grain cooked fluffy, vegetables roasted and browned, chicken to 165 °F (or chickpeas crisp), sauce balanced, and bowls assembled attractively.

PICTURE STUDY



The Atwater–Rosa Respiration Calorimeter, Photographer unknown, c. 1900 · Photograph · Wikimedia Commons

Image: Wikimedia Commons, public domain

This chamber at Wesleyan University let scientists measure everything a person ate and breathed and all the heat he gave off. Volunteers lived inside for days, reading, resting and exercising on a stationary bicycle, while the team kept careful records.

Look closely

- Find the window. How did food go in and records come out?
- Look at the pipes and instruments. What were they measuring?
- Imagine living inside for several days. What would you need?

Talk about it

1. Why did Atwater need a sealed room to measure food energy accurately?
2. What does “conservation of energy” mean for the food we eat?
3. How do food labels today still depend on Atwater’s work?

Safety first. Cook chicken to 165 °F and keep raw chicken separate from the vegetables. Roast at high heat with dry mitts and turn vegetables with tongs or a spatula. Check the yogurt sauce and toppings against family allergies.

KITCHEN LAB

Fuel Lab: Build-Your-Own Grain Bowls

You will cook the parts of a grain bowl, assemble bowls for the family, and calculate energy and macronutrients from labels.

You will need

- Two rimmed sheet pans and a medium saucepan
- An instant-read thermometer
- A kitchen scale and measuring cups
- Food labels or a nutrition database printout for each ingredient
- Bowls for serving

Grain Bowls with Roasted Vegetables, Chicken and Yogurt-Herb Sauce

Serves 6 · Prep 25 min · Cook 35 min

Ingredients

- 1½ cups brown rice or quinoa, cooked by the package directions
- 1½ lb (680 g) boneless chicken thighs (or 2 cans chickpeas, drained and dried)
- 1 teaspoon each salt, cumin and paprika; ½ teaspoon garlic powder
- 4 cups vegetables cut in 1-inch pieces: sweet potato, broccoli, red onion, bell pepper
- 3 tablespoons olive oil, divided
- **Sauce:** 1 cup plain yogurt, 2 tablespoons lemon juice, 2 tablespoons chopped herbs (dill, parsley or mint), 1 small clove garlic grated, ¼ teaspoon salt
- Toppings: cucumber, cherry tomatoes, toasted seeds

Method

1. Heat the oven to 425 °F (220 °C). Start the grain.
2. Toss the vegetables with 2 tablespoons oil and ½ teaspoon salt on one sheet pan. Toss the chicken (or chickpeas) with the remaining oil and

spices on the other.

3. Roast both, turning once: vegetables 25–30 minutes until browned; chicken 20–25 minutes until 165 °F (chickpeas 25–30 minutes until crisp).
4. Whisk the sauce. Slice the chicken.
5. Build bowls: grain, vegetables, chicken or chickpeas, toppings and a spoonful of sauce.

Allergy check: Contains milk (yogurt). Use a dairy-free yogurt or a tahini-lemon sauce (sesame) instead. Check the seed toppings.

Steps

1. Cook and assemble the bowls. Record the chicken's final temperature.
2. **Weigh one bowl's parts.** Weigh the grain, vegetables, protein and sauce in one bowl.
3. **Calculate.** Using labels or a database, find the grams of carbohydrate, protein and fat in each part. Add them and calculate total kcal and the percentage from each macronutrient.
4. **Sport plan.** Write a game-day eating plan that uses this bowl as the pre-game meal 3 hours before.
5. **Technique check.** Score 1–3: grain fluffy, vegetables browned, chicken 165 °F, sauce balanced, accurate calculations.
6. **Repeat round.** Build a breakfast bowl (oats, fruit, yogurt, seeds) and calculate it the same way.

Tips

- Spread vegetables in one layer so they roast instead of steaming.
- Cook a big batch of grain for several meals.
- A grain bowl is easy to adapt for different appetites: each person builds his own.

Check your work

☐ I can tell Atwater's story and use the 4-4-9 factors.

☐ I can plan eating and drinking around a game or practice.

- [ ] I cooked grain bowls and calculated their energy and macronutrients.

LAB NOTEBOOK

1. Draw Atwater's calorimeter and label what goes in and what comes out.
2. Record your bowl calculation in a table.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$E = 4C + 4P + 9F$ (kcal; C, P, F in grams)

$1 \text{ kcal} = 4.184 \text{ kJ}$

$$\%\text{ energy from a nutrient} = \frac{\text{kcal from that nutrient}}{\text{total kcal}} \times 100$$

From history. Atwater also tested how much energy volunteers used while resting, reading and exercising. His tables of food composition, published by the USDA, were the first of their kind in the United States.

WORKED EXAMPLES

Example 1. One grain bowl contains about 70 g carbohydrate, 35 g protein and 18 g fat. How much food energy does it supply, in kcal and kJ?

Show solution

1. $E = 4(70) + 4(35) + 9(18) = 280 + 140 + 162 = 582$ kcal.
2. $582 \times 4.184 = 2435$ kJ.

Answer: About 580 kcal (2,400 kJ): solid fuel for a practice.

Example 2. In that bowl, what percentage of the energy comes from carbohydrate, protein and fat?

Show solution

1. Carbohydrate $280/582 = 48\%$; protein $140/582 = 24\%$; fat $162/582 = 28\%$.

Answer: About 48% carbohydrate, 24% protein and 28% fat: a balanced meal.

Example 3. A runner drinks 16 oz of water 2 hours before a race and loses about 1.5 lb of body water during it, measured by weighing before and after. Sports dietitians suggest replacing about 16–24 oz of fluid per pound lost. How much should she drink afterward?

Show solution

1. $1.5 \times 16 = 24$ oz to $1.5 \times 24 = 36$ oz.

Answer: About 24–36 oz (3–4½ cups) of fluid over the next few hours, mostly water with her meal. (Weighing here measures sweat loss, not body size.)

PRACTICE

1. Easy Give the Atwater factors for carbohydrate, protein and fat.

   Show answer

   4, 4 and 9 kcal per gram.

2. Easy What did Atwater's respiration calorimeter show?

   Show answer

   That the human body obeys conservation of energy; it measured the energy people get from food.

3. Easy What is the best drink for most practices?

   Show answer

   Plain water.

4. Medium A snack has 30 g carbohydrate, 8 g protein and 6 g fat. How many kcal?

   Show answer

   $120 + 32 + 54 = 206$ kcal

5. Medium Convert 2,000 kcal to kJ.

   Show answer

   8,368 kJ.

6. Medium Why are carbohydrates important before a hard practice?

   Show answer

   They are the main fuel for intense exercise and refill muscle glycogen.

7. Medium Why does this course rely on ordinary food rather than pills, powders or stimulant drinks for young athletes?

Show answer

Ordinary meals supply plenty of protein and energy for growth and sport; pills and powders are unnecessary and loosely regulated, and stimulant drinks are unsuitable for teens.

8. Hard A lunch has 600 kcal, with 20 g fat. What percentage of the energy is from fat?

Show answer

$180/600 = 30\%$.

9. Hard Plan the timing of meals and snacks around a 4:00 p.m. game.

Show answer

Example: balanced lunch around 12:00–1:00 p.m. (grain, protein, fruit, vegetables); small carbohydrate snack and water around 3:00 p.m. (banana or crackers); water during the game; dinner with carbohydrate and protein by about 6:00–6:30 p.m.

10. Challenge Explain why Atwater's factors are averages, and give one reason a real food might differ.

Show answer

Different carbohydrates, proteins and fats vary slightly in energy, and some energy is not digested (for example, fiber or nuts with cell walls); the factors average across typical foods.

COMMON MISTAKES

- Thinking of Calories as something bad; they are the energy that fuels growth, school and sport.
- Skipping meals before practice.
- Relying on sports drinks, pills or powders instead of food and water.
- Forgetting to drink water on hot days.

Make it a game · Atwater Drill. Your parent reads a label with grams of carbohydrate, protein and fat. Compute total energy using 4, 4 and 9, in your head or on paper. Race a timer for six labels. Then explain what glycogen does for an athlete and one hydration habit. Tell how Atwater's calorimeter measured food in the 1890s.

8.3 The Nutrition Facts Label and Added Sugar

OBJECTIVES

- Explain the history of the Nutrition Facts label: the 1990 law, the 1994 label and the 2016 update with Added Sugars.
- Read a label for serving size, nutrients and % Daily Value, and convert grams of added sugar to teaspoons.
- Compare a homemade and a store-bought food by their labels.
- Bake chewy oat granola bars lower in added sugar and write their label information.

> **Warm-up.** Find three packaged foods in your kitchen: a cereal, a drink and a snack. Find the line “Includes … g Added Sugars” on each. Guess how many teaspoons that is before you calculate.

WATCH

The New Nutrition Facts Label: Q&A With FDA's Susan Mayne

U.S. Food and Drug Administration · 6:30

https://www.youtube.com/watch?v=DTI3yOtctw4

> **WHEN TO WATCH**
> After the story. Pause at each question and predict the answer before she gives it.

Note: From the FDA’s Center for Food Safety and Applied Nutrition.

BACKUP VIDEO

Added Sugar on the Food Label

Health and Human Sciences Extension and Outreach · 1:36

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

Before the label calculations: total sugars versus added sugars.

KEY TERMS

serving size

The amount of food all the label's numbers describe, based on the amount people typically eat.

% Daily Value (%DV)

How much of a day's reference amount of a nutrient one serving provides; 5% DV or less is low, 20% DV or more is high.

added sugars

Sugars and syrups added during processing or preparation, as opposed to sugars naturally in fruit and milk.

total sugars

All sugars in the food, both natural and added.

fiber

Plant carbohydrate the body does not digest; it helps digestion and helps people feel satisfied.

CORE IDEAS

The story. Before the 1990s, many packaged foods carried little or no nutrition information, and the information that existed came in many different formats. In 1990 Congress passed the Nutrition Labeling and Education Act, and by 1994 nearly all packaged foods carried a standard black-and-white "Nutrition Facts" panel. In 2016 the Food and Drug Administration updated it: serving sizes were made more realistic, Calories were printed larger, and a new line showed **Added Sugars**. Manufacturers had until 2020–2021 to adopt it.

How they figured it out. The FDA tested label designs with shoppers to see which formats people could read quickly and correctly. Research showed people could not tell how much sugar came from fruit or milk and how much was added, so the 2016 label separated them. The Dietary Guidelines advise that added sugars be less than 10% of daily food energy for everyone age 2 and older.

The kitchen science. Read a label in order: **serving size** first (all numbers depend on it), then food energy, then nutrients. Use **%DV** as a quick guide: 5% or less is low, 20% or more is high. To picture added sugar, remember that about 4 grams of sugar is 1 teaspoon. Sugar in baking does more than sweeten: it holds moisture, browns, tenderizes and helps bind, so reducing sugar changes texture; dried fruit, cinnamon

and vanilla can add sweetness and flavor in other ways. Homemade foods do not need to be sugar-free; the point is to know what you are eating and to choose wisely.

Let's cook. You will bake chewy oat bars bound with peanut butter (or sunflower butter), a little honey and mashed banana, then calculate their added sugar per bar and compare with a store-bought granola bar label. The technique standard: ingredients weighed, bars pressed firmly into the pan, baked until golden at the edges, cooled completely before cutting, and an accurate label calculation.

PICTURE STUDY



Beverly Ann Grimm, Eleven, Leaving the Store after Making the Family Purchases, Farm Security Administration / Office of War Information photographer, 1940s · Photograph · Library of Congress, Washington, D.C.

Image: Wikimedia Commons, public domain

A government photographer recorded an eleven-year-old girl doing her family's grocery shopping in the 1940s. Packages then carried brand names and pictures, but no Nutrition Facts panel: shoppers had to trust the grocer and the brand.

Look closely

- Look at what she is carrying. What kinds of foods might be in her bags?
- Look at the store behind her. What can you tell about it?
- Look at her face and posture. How does she seem to feel about her job?

Talk about it

1. What would you want to know about her groceries that the labels of the 1940s did not tell you?
2. How did the 1994 label change shopping?
3. Which foods today need no label at all, and why?

> **Safety first.** Never taste the unbaked bar mixture if it contains egg. Peanut butter is a major allergen: use sunflower-seed butter and check oats and chocolate labels for allergy warnings if anyone has a peanut or tree-nut allergy. Honey is never given to babies under one year.

KITCHEN LAB

Label Lab: Chewy Oat Bars and a Homemade Label

You will bake oat bars, calculate their added sugar per bar, and compare them side by side with a store-bought bar.

You will need

- An 8 × 8-inch pan lined with parchment
- A large bowl, a fork or masher, a spatula
- A kitchen scale
- A store-bought granola bar with its label
- A calculator

Chewy Banana Oat Bars

Serves 16 bars · Prep 15 min · Bake 25 min · Cool 1 hr

Ingredients

- 2 ripe bananas (about 225 g peeled), mashed
- ½ cup (128 g) peanut butter or sunflower-seed butter
- ⅓ cup (113 g) honey
- 1 teaspoon vanilla extract and ½ teaspoon cinnamon
- ¼ teaspoon salt
- 2½ cups (225 g) old-fashioned rolled oats
- ½ cup (75 g) raisins or chopped dried fruit
- ¼ cup (40 g) mini chocolate chips or seeds (optional)

Method

1. Heat the oven to 350 °F (175 °C) and line the pan.
2. Mash the bananas in the bowl. Stir in the nut or seed butter, honey, vanilla, cinnamon and salt until smooth.
3. Stir in the oats, dried fruit and chips until evenly coated.
4. Press firmly and evenly into the pan with the back of a spatula or damp hands.

5. Bake 22–27 minutes, until golden at the edges and set in the center.
6. Cool completely in the pan (at least 1 hour), lift out by the parchment and cut into 16 bars. Store airtight up to 5 days or freeze.

Allergy check: Contains peanuts (if peanut butter is used). Chocolate chips may contain milk and soy. Use sunflower-seed butter and allergen-free chips for a top-nine-free bar; check that the oats are processed without wheat if needed.

Steps

1. Weigh every ingredient and record it.
2. Bake and cut the bars; weigh one bar.
3. **Calculate.** Using labels, find the grams of added sugar in the batch (honey and chips) and per bar. Convert to teaspoons and %DV.
4. **Compare.** Make a side-by-side table: your bar and the store bar, with serving size, kcal, added sugars, fiber and protein.
5. **Taste.** Hold a blind family tasting of the two bars and record ratings.
6. **Technique check.** Score 1–3: accurate weighing, even pressing, properly baked, cooled before cutting, correct calculations.
7. **Repeat round.** Change one ingredient (more cinnamon and less honey, or dates instead of raisins) and recalculate.

Tips

- Very ripe bananas give more sweetness and moisture.
- Press hard; loose bars crumble.
- Cut with a large knife, pressing straight down.

Check your work

- ☐ I can explain the history of the Nutrition Facts label.
- ☐ I can read serving size and %DV and convert grams of sugar to teaspoons.
- ☐ I baked oat bars and wrote accurate label information for them.

LAB NOTEBOOK

1. Copy a Nutrition Facts label and annotate each part in your own words.
2. Record your bar comparison table.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{teaspoons of sugar} \approx \frac{\text{grams}}{4}$$

$$\%\text{DV} = \frac{\text{amount per serving}}{\text{Daily Value}} \times 100$$ (Daily Value for added sugars: 50 g)

From history. Before the standardized label, a few foods carried voluntary nutrition information. The 1994 label was designed by a team that tested many versions with shoppers; its simple black-and-white box was later copied by other countries.

WORKED EXAMPLES

Example 1. A 20-oz bottle of sweetened tea lists 2.5 servings per bottle and 18 g added sugars per serving. How many grams and teaspoons of added sugar are in the whole bottle? What %DV?

Show solution

1. Grams: $2.5 \times 18 = 45$ g.
2. Teaspoons: $45/4 \approx 11$.
3. %DV: $45/50 \times 100 = 90\%$.

Answer: 45 g, about 11 teaspoons, 90% of the Daily Value. Reading servings per container matters.

Example 2. Your batch of 16 bars contains ⅓ cup honey (about 113 g, roughly 82% sugar) and no other added sugar. How many grams of added sugar per bar?

Show solution

1. Sugar from honey: $0.82 \times 113 = 93$ g.
2. Per bar: $93/16 = 5.8$ g.

Answer: About 6 g of added sugar per bar (1½ teaspoons). Many store bars list 8–12 g.

Example 3. If a teen eats about 2,400 kcal in a day, how many grams of added sugar is 10% of that energy?

Show solution

1. 10% of energy $= 240$ kcal.
2. Sugar is 4 kcal/g: $240/4 = 60$ g.

Answer: About 60 g (15 teaspoons). This is a guide to balance, not a number to count anxiously.

PRACTICE

1. Easy In what years were the label law passed, the standard label required, and the Added Sugars line introduced?

   Show answer

   1990; 1994; 2016 (in use by 2020–2021).

2. Easy About how many grams of sugar are in 1 teaspoon?

   Show answer

   About 4 g.

3. Easy What is the first thing to read on a label, and why?

   Show answer

   The serving size, because all other numbers depend on it.

4. Medium A cereal has 12 g added sugars per serving. How many teaspoons? What %DV?

   Show answer

   3 tsp; 24% DV.

5. Medium What is the difference between total sugars and added sugars?

   Show answer

   Total sugars include natural sugars in fruit and milk; added sugars are those added in processing or cooking.

6. Medium Is 3% DV of fiber low or high? 25%?

Show answer

Low; high.

7. Medium Why might plain yogurt list sugars but no added sugars?

Show answer

Milk naturally contains lactose, a sugar; nothing was added.

8. Hard A bag of chips has 3 servings; you eat the whole bag. One serving has 160 kcal and 10 g fat. What did you eat in total?

Show answer

480 kcal and 30 g fat.

9. Hard A 12-oz soda has 39 g added sugar. What percentage of a 50-g Daily Value is that, and how many teaspoons?

Show answer

78% DV; about 10 tsp.

10. Challenge Reducing sugar in a cookie recipe by half changes more than sweetness. Predict three changes and explain each.

Show answer

Less spread and a cakier, drier texture (sugar holds moisture and liquefies in baking); paler color (less caramelization and browning); shorter shelf life and less tenderness (sugar keeps moisture and limits gluten).

COMMON MISTAKES

- Ignoring servings per container.
- Thinking “no added sugar” means no sugar (fruit and milk sugars remain).
- Cutting bars while warm.
- Treating any food as forbidden instead of thinking about balance.

> **Make it a game · Label Detective.** Pick two packaged foods from the pantry. Your parent names a question: which has more added sugar per serving, which has a higher percent Daily Value of fiber, what is the real serving size. Find the answer in thirty seconds. Run six questions. Then trace the label from 1990 to 2016.

8.4 Cravings, Reward and Habits That Last

OBJECTIVES

- Explain the brain's reward system accurately: dopamine as a messenger tied to wanting and learning, not pleasure itself.
- Tell the history of Olds and Milner's 1954 discovery and of Howard Moskowitz's "bliss point."
- Explain satiety and the roughly 20-minute fullness signal, and how fiber, protein and water help.
- Make hummus with vegetables and baked pita chips, a satisfying snack, and compare it with a packaged snack.

> **Warm-up.** Think of a food you sometimes keep eating even after you are no longer hungry. What is it like: sweet, salty, crunchy, rich? Write down when and where you usually eat it.

WATCH

2-Minute Neuroscience: Reward System

Neuroscientifically Challenged · 2:04

https://www.youtube.com/watch?v=f7E0mTJQ2KM

> **WHEN TO WATCH**
> After the story. Watch twice and sketch the pathway from the ventral tegmental area to the nucleus accumbens.

Note: A short, accurate neuroscience summary by a neuroscientist; it uses the brain terms named in the core ideas and mentions in passing that drugs of abuse act on the same pathway.

KEY TERMS

reward system

Brain circuits that help us learn what is worth seeking, such as food, water and companionship.

dopamine

A messenger chemical in the brain tied to wanting, motivation and learning what is rewarding; it rises when we expect or get something good.

bliss point

The level of an ingredient, often sugar or salt, at which a food is most appealing; the term is associated with the food researcher Howard Moskowitz.

habit

A behavior repeated so often in the same situation that it becomes nearly automatic; habits can be changed by changing cues and routines.

satiety

The feeling of being satisfied and full that tells us to stop eating.

CORE IDEAS

The story. In 1954 two researchers at McGill University in Montreal, James Olds and Peter Milner, discovered by accident that stimulating a certain area of a rat's brain made the animal return again and again to the place where it had happened. They had found part of what scientists now call the brain's **reward system.** Decades later, research showed that the messenger dopamine in this system is tied to *wanting* and to learning what is worth seeking. Meanwhile, in the food industry, the researcher Howard Moskowitz became known for testing many versions of products, such as sauces and soft drinks, to find the level of sweetness that people liked most, a level later called the "bliss point."

How they figured it out. Olds and Milner noticed an unexpected behavior and followed it with careful experiments. Food scientists, for their part, ran large taste tests and measured preferences. Together these lines of research explain something we all experience: foods that combine sweetness, salt, fat and crunch can be very appealing, and some packaged snacks are designed to be hard to stop eating.

The kitchen science. Dopamine does not make food delicious; it makes us *want* things the brain has learned are rewarding, and it helps us learn the cues that predict them (the sound of a bag opening, a commercial, a certain time of day). Foods that are very sweet, salty and rich, and that melt quickly in the mouth, make it easy to eat past full. Fullness takes time: the stomach and gut send satiety signals that take about 20 minutes to register. Fiber, protein and water slow eating and increase satisfaction. The good news is that habits and tastes can be retrained: when

people eat less added sugar or salt for a few weeks, their taste buds adjust and less tastes like enough. Treats are good gifts in their place; self-control is learning to enjoy them without being ruled by them.

Let's cook. You will make smooth hummus and serve it with crisp vegetables and homemade baked pita chips, a snack rich in fiber and protein, and run a fullness log comparing it with a packaged snack. The technique standard: chickpeas blended very smooth, hummus balanced with lemon, salt and garlic, chips baked crisp and golden, and an honest log.

PICTURE STUDY



The Land of Cockaigne, Pieter Bruegel the Elder, 1567 · Oil on panel · Alte Pinakothek, Munich

Image: Wikimedia Commons, public domain

In old European folk tales, Cockaigne was an imaginary land where food fell into your mouth without work: roofs made of pies, roasted birds flying to the table. Bruegel painted three men who have eaten so much that they cannot move. It is a picture with a warning: endless plenty without work or self-control does not make people happy.

Look closely

- Find the three men. Who are they, by their clothes?
- Find the roof made of pies and the egg with legs. What is Bruegel joking about?
- Look at the men's faces and bodies. Do they look satisfied or stuck?

Talk about it

1. What is the difference between enjoying a feast and the scene in this painting?
2. How does this old painting connect to the science of cravings and fullness?
3. What habits help you enjoy good food and still be ready for the day's work?

> **Safety first.** Preheat the oven and handle the pita-chip pans with dry mitts. Chickpeas and tahini: tahini is sesame, one of the nine major allergens; use the sesame-free version if needed. Wash and dry vegetables before cutting.

KITCHEN LAB

Satiety Lab: Hummus, Vegetables and Baked Pita Chips

You will make hummus and baked pita chips, then keep an honest snack and fullness log over two days.

You will need

- A food processor or blender
- A sheet pan and oven mitts
- A chef's knife and board
- A kitchen scale
- A snack log sheet

Smooth Hummus with Vegetables and Baked Pita Chips

Serves 8 (about 3 cups hummus) · Prep 20 min · Bake 10 min

Ingredients

- 2 cans (15 oz each) chickpeas, drained (save the liquid)
- ⅓ cup (80 g) tahini (sesame paste)
- ¼ cup (60 mL) lemon juice
- 1–2 cloves garlic
- ¾ teaspoon salt and ½ teaspoon cumin
- 3 tablespoons olive oil, plus more to drizzle
- ¼–½ cup ice water or chickpea liquid
- Paprika and parsley to garnish
- **Chips:** 4 pita breads, 2 tablespoons olive oil, ½ teaspoon salt
- **Vegetables:** carrots, cucumbers, bell peppers, snap peas

Method

1. Heat the oven to 375 °F (190 °C). Brush the pitas with oil, sprinkle with salt, cut each into 8 wedges and spread on the sheet pan. Bake 8–12 minutes, until crisp and golden.

2. Blend the tahini and lemon juice 1 minute until creamy. Add the garlic, salt and cumin.
3. Add the chickpeas and blend 2–3 minutes, scraping down, adding the oil and ice water a little at a time until very smooth.
4. Taste and adjust lemon, salt and garlic. Spread in a bowl, drizzle with oil and sprinkle with paprika and parsley.
5. Cut the vegetables into sticks and serve with the hummus and chips. Refrigerate leftovers up to 5 days.

Allergy check: Contains sesame (tahini) and wheat (pita). For sesame-free hummus, use 3 tablespoons olive oil and a little extra lemon instead of tahini; for wheat-free, serve with vegetables only.

Steps

1. Make the hummus and chips. Record the blending time and how you adjusted the seasoning.
2. **Energy density.** Using labels, calculate kcal per gram for a serving of your hummus plate and of a packaged snack you often eat.
3. **Fullness log.** On two afternoons, eat a planned snack (one day the hummus plate, one day the packaged snack) at the same time, sitting down, from a plate. Record how satisfied you felt at 0, 20 and 60 minutes (scale 1–5) and when you next felt hungry.
4. Write a short, honest conclusion. (This log is about learning, not about body size.)
5. **Technique check.** Score 1–3: smooth hummus, balanced seasoning, crisp chips, neat vegetables, complete log.
6. **Repeat round.** Make a different bean dip (white bean and herb, or black bean) and compare.

Tips

- Ice water makes hummus fluffier and lighter.
- Blend longer than you think for the smoothest hummus.
- Snacks eaten from a plate at the table, not from the bag, are easier to enjoy and stop.

Check your work

- ☐ I can explain the reward system and dopamine accurately.
- ☐ I can explain satiety and the 20-minute signal.
- ☐ I made a satisfying snack and kept an honest fullness log.

LAB NOTEBOOK

1. Draw a simple diagram of a habit loop: cue, routine, reward, and how you could change the routine.
2. Record your energy-density comparison and fullness log.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{energy density} = \frac{\text{kcal}}{\text{grams of food}}$$

$$\text{cost per serving} = \frac{\text{total cost}}{\text{servings}}$$

From history. Moskowitz is also known for showing that people's preferences fall into groups: some like a plain sauce, others chunky or spicy, which is why grocery shelves now hold many versions of the same product.

WORKED EXAMPLES

Example 1. A label says a 28-g serving of chips has 160 kcal. Hummus with carrots: 60 g hummus (150 kcal) and 100 g carrots (41 kcal). Compare energy density.

Show solution

1. Chips: $160/28 = 5.7$ kcal/g.
2. Hummus plate: $(150 + 41)/(60 + 100) = 191/160 = 1.2$ kcal/g.

Answer: The chips are nearly 5 times as energy-dense. The hummus plate gives a larger, slower snack with fiber, protein and water, so it is easier to feel satisfied.

Example 2. Homemade hummus: chickpeas $1.09 (two cans $2.18), tahini $1.20, lemon, garlic and oil $0.90, making about 3 cups. A 10-oz tub (about 1¼ cups) costs $4.29. Compare cost per cup.

Show solution

1. Homemade: $(2.18 + 1.20 + 0.90)/3 = \$1.43$ per cup.
2. Store: $\$4.29/1.25 = \$3.43$ per cup.

Answer: About $1.43 versus $3.43 per cup.

Example 3. If fullness takes about 20 minutes to register, and a person finishes a snack in 5 minutes, how long after finishing will the signal arrive? What does this suggest?

Show solution

1. $20 - 5 = 15$ min after finishing.

Answer: About 15 minutes later, so eating slowly, or waiting before a second helping, lets the signal catch up.

PRACTICE

1. Easy What is dopamine tied to, according to current science?

   Show answer

   Wanting, motivation and learning what is rewarding (not pleasure itself).

2. Easy Who discovered the brain's reward area, and when?

   Show answer

   James Olds and Peter Milner, at McGill University, in 1954.

3. Easy About how long does the fullness signal take?

   Show answer

   About 20 minutes.

4. Medium Name three things that help us feel satisfied.

   Show answer

   Fiber, protein and water (and eating slowly).

5. Medium What is the “bliss point”?

Show answer

The level of an ingredient (often sugar or salt) at which a food is most appealing, associated with Howard Moskowitz’s product testing.

6. Medium Why can it be easy to eat past full with some packaged snacks?

Show answer

They combine sweet, salty, rich and crunchy qualities, melt quickly, are low in fiber and protein, and are eaten quickly, so the satiety signal arrives late.

7. Medium How can a habit be changed?

Show answer

Notice the cue, change the routine (for example, a planned snack at the table instead of eating from the bag), and keep repeating the new routine.

8. Hard A cookie is 25 g and 120 kcal; an apple with peanut butter is 200 g and 290 kcal. Compare energy density.

Show answer

Cookie 4.8 kcal/g; apple snack 1.45 kcal/g.

9. Hard Explain why someone who cuts back on salty snacks for several weeks may find them too salty later.

Show answer

Taste perception adapts: with less salt, the threshold resets, so the same salt level tastes stronger.

10. Challenge Write a short plan for enjoying treats in their place using one idea from Scripture and two from this lesson.

Show answer

Answers vary. A strong answer might cite Proverbs 25:16 or Galatians 5:22–23 (self-control as a fruit of the Spirit), plan treats at the table on set occasions, portion them onto a plate, eat slowly, and pair them with fiber or protein.

COMMON MISTAKES

- Saying sugar is “addictive like a drug”; the science is about wanting and learning, and habits can be changed.

- Eating snacks straight from the bag while distracted.
- Thinking any food is forbidden; treats have their place.
- Under-blending hummus.

> **Make it a game · Wanting vs Liking.** Debate your parent for three minutes. Your side: dopamine is about wanting and learning, not pleasure itself. Cite the Olds and Milner experiments of 1954, bliss point and satiety. Your parent argues the common myth, then swaps sides. Judge each other with a point for every accurate fact.

> **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, is listed as fruit that God grows in His people. It is not grim refusal but freedom: enjoying good gifts without being ruled by them.

8.5 Food Allergies: Cooking for Guests Safely

OBJECTIVES

- Name the nine major food allergens in the United States and explain how the 2004 and 2021 laws changed labeling.
- Distinguish cross-contact from cross-contamination and plan a kitchen to prevent allergen cross-contact.
- Read labels for allergen statements and plan a menu free of the top nine allergens.
- Cook a top-nine-free dinner of lemon-herb chicken and potatoes with an oat fruit crisp.

> **Warm-up.** Pick up three packaged foods and find the "Contains:" statement on each. Which of the major allergens appear? Were any in a food where you did not expect them?

WATCH

How to prevent allergen cross-contact in home kitchens | Prevent Allergen Clash

Nourishable · 2:00

https://www.youtube.com/watch?v=q3up769Jhow

> **WHEN TO WATCH**
> Before writing your cross-contact plan. List her steps.

Note: A short video from a registered dietitian's channel; small but clear and accurate.

BACKUP VIDEO

NFSM 2013: Preventing Cross-Contact in the Front of the House

National Restaurant Association · 1:45

https://www.youtube.com/watch?v=e6UwOzgIm6Q

How restaurants prevent cross-contact at the table, from the makers of ServSafe.

KEY TERMS

food allergy

An immune-system reaction to a food protein; reactions can range from hives to anaphylaxis, a severe, life-threatening reaction.

cross-contact

When an allergen is transferred from one food or surface to another, so a "safe" food contains a trace of the allergen. Cooking does not remove it.

precautionary label

A voluntary statement such as "may contain" or "made in a facility that also processes," warning of possible cross-contact.

the nine major allergens

Milk, eggs, fish, crustacean shellfish, tree nuts, peanuts, wheat, soybeans and sesame.

anaphylaxis

A severe allergic reaction affecting breathing, circulation or several body systems; it requires epinephrine and a call to 911.

CORE IDEAS

The story. For years, allergens hid in packaged foods under technical names: whey and casein for milk, albumin for egg. In 2004 Congress passed the Food Allergen Labeling and Consumer Protection Act (FALCPA), which, starting in 2006, required labels to name eight major allergens in plain words. Families pushed for sesame to be added too, and the FASTER Act of 2021 made sesame the ninth major allergen, with labeling required from January 1, 2023.

How they figured it out. The FDA chose the major allergens because, although more than 160 foods can cause allergic reactions, a small group causes most serious reactions in the United States. Doctors, families and food companies learned together that labels only help if they use words that ordinary shoppers recognize, and that kitchens must guard against tiny traces as well as obvious ingredients.

The kitchen science. Allergies are reactions to specific *proteins*. Unlike germs, these proteins are not destroyed by ordinary cooking, so a trace transferred by a spoon, a cutting board, a fryer oil or a crumb can cause a reaction: that is **cross-contact**. Prevent it by planning: read every label (ingredients and "Contains" statements),

wash hands, use freshly washed tools, boards and pans, cook the allergy-safe dish first and keep it covered and separate, and label serving dishes. Ask guests about allergies in advance and believe them. Know the signs of a serious reaction (hives with trouble breathing, swelling of the lips or throat, vomiting, faintness): the person uses his epinephrine auto-injector if he has one, and someone calls 911.

Let's cook. You will cook a dinner free of all nine major allergens for imagined (or real) guests with allergies: lemon-herb sheet-pan chicken with potatoes and green beans, and a fruit crisp with an oat topping made with oil instead of butter. The technique standard: every label read and recorded, a written cross-contact plan followed, chicken to 165 °F, and serving dishes labeled.

PICTURE STUDY



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

Image: Wikimedia Commons, public domain

Albert Anker painted many children of his Swiss village at simple daily tasks. Here a girl eats her soup with full attention. Every child at a table trusts the cook to make food that is safe for her.

Look closely

- Look at the bowl and spoon. What kind of soup might it be?
- Look at the girl's posture and face. What does she seem to feel?
- Look at the plain table. What does it tell you about her home?

Talk about it

1. What would you need to know before serving soup to a guest with a food allergy?
2. How does a careful cook show love to someone with an allergy?
3. What makes a guest feel welcome and safe at your table?

Safety first. Before cooking for any guest, ask about allergies and read every label, including the "Contains" and "may contain" statements; prepare the allergy-safe meal with freshly washed tools and keep it covered and labeled. Cook chicken to 165 °F. Know where the guest keeps his epinephrine and call 911 for any serious reaction.

KITCHEN LAB

Allergy-Safe Lab: Top-Nine-Free Sheet-Pan Dinner and Fruit Crisp

You will plan, shop for and cook a dinner free of the nine major allergens, with a written cross-contact plan and labeled dishes.

You will need

- Two rimmed sheet pans and an 8 × 8-inch baking dish
- Freshly washed boards, knives and utensils
- An instant-read thermometer
- Labels from every packaged ingredient
- Index cards for dish labels

Lemon-Herb Sheet-Pan Chicken with Potatoes and Green Beans, and Oat Fruit Crisp

Serves 6 · Prep 30 min · Roast 40 min · Crisp bakes alongside

Ingredients

- **Dinner:** 3 lb (1.4 kg) bone-in chicken thighs and drumsticks
- 2 lb (900 g) small potatoes, halved
- 1 lb green beans, trimmed
- ¼ cup olive oil, divided
- 2 lemons (zest and juice), 4 cloves garlic minced, 1 tablespoon dried oregano or 2 tablespoons fresh herbs
- 2 teaspoons salt and 1 teaspoon pepper, divided
- **Crisp:** 5 cups fruit (apples, berries or peaches), 2 tablespoons sugar, 1 tablespoon cornstarch, 1 teaspoon lemon juice
- Topping: 1 cup rolled oats labeled gluten-free, ½ cup oat flour or more oats pulsed fine, ⅓ cup brown sugar, 1 teaspoon cinnamon, ¼ teaspoon salt, ⅓ cup neutral oil

Method

1. Heat the oven to 425 °F (220 °C). Toss the potatoes with 2 tablespoons oil and half the salt and pepper; spread on one sheet pan and roast 15

minutes.

2. Mix the remaining oil, lemon zest and juice, garlic, herbs, salt and pepper. Toss the chicken in it and arrange on the second pan. Roast 35–40 minutes, until 165 °F (175–185 °F is best for thighs).
3. After the potatoes have roasted 15 minutes, add the green beans to their pan, toss and roast 15–20 minutes more.
4. **Crisp:** Toss the fruit with sugar, cornstarch and lemon in the baking dish. Mix the topping ingredients with a fork until crumbly; scatter over the fruit. Bake on a lower rack 30–35 minutes at 425 °F (or 40 minutes at 375 °F after the chicken comes out) until bubbling and golden.
5. Label each dish "Free of the nine major allergens" and serve.

Allergy check: Free of the nine major allergens when every packaged ingredient (oats, spices, oil) is checked. Oats must be labeled gluten-free for guests who avoid wheat.

Steps

1. **Guest card.** Write the allergies you are cooking around (real guests or the full top nine).
2. **Label audit.** Collect and read the label of every packaged ingredient; record its "Contains" and "may contain" statements.
3. **Cross-contact plan.** Write the order of work, the tools and pans you will use, how you will wash them, and how dishes will be covered and labeled.
4. Cook the meal. Record the chicken temperature.
5. **Serving check.** Use separate serving spoons and label every dish.
6. **Technique check.** Score 1–3: complete label audit, plan followed, no cross-contact risks, chicken at a safe temperature, dishes labeled, food delicious.
7. **Repeat round.** Adapt a family favorite recipe to be free of one specific allergen and test it.

Tips

- Plan a menu that is naturally free of allergens rather than substituting many ingredients.
- Keep allergy-safe brands of staples on a list; formulas change, so reread labels each time.

- When in doubt, leave it out.

Check your work

- ☐ I can name the nine major allergens and the laws that require labeling them.
- ☐ I can prevent cross-contact with a written plan.
- ☐ I cooked a delicious top-nine-free dinner.

LAB NOTEBOOK

1. Make an allergen reference card: the nine allergens, common hidden names, and steps to prevent cross-contact.
2. Record your label audit and cross-contact plan.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{servings needed} = \text{guests} \times \text{servings per guest}$$

$$\text{cost per serving} = \frac{\text{total cost}}{\text{servings}}$$

From history. Restaurants in many states now must post allergen notices or train staff on food allergies. The same habits that protect restaurant guests (reading labels, separate tools, clear labels) protect guests at home.

WORKED EXAMPLES

Example 1. You will feed 8 guests; 2 need a top-nine-free meal and the rest can eat anything. Is it simpler to make the whole meal top-nine-free, and what does it cost if the safe crisp topping costs $1.20 more than a butter topping?

Show solution

1. Making one safe meal for everyone avoids a second set of pans and the risk of mixing up plates.
2. Extra cost: $\$1.20$ for the whole crisp, or $\$1.20/8 = \$0.15$ per person.

Answer: Yes: one safe meal for all is simpler and safer, at about 15¢ more per person for the crisp.

Example 2. Sheet-pan chicken: 3 lb chicken thighs $5.97, 2 lb potatoes $1.99, 1 lb green beans $2.49, lemon, herbs and oil $1.80. Crisp: fruit $4.00, oats and oil $1.50, sugar and spices $0.50. Serves 6. Cost per serving?

Show solution

1. Total $= 5.97 + 1.99 + 2.49 + 1.80 + 4.00 + 1.50 + 0.50 = \$18.25$.
2. Per serving $= \$18.25 / 6 = \$3.04$.

Answer: About $3.04 per serving.

Example 3. A guest is allergic to wheat. Which of these is safe without checking a label: plain rolled oats, soy sauce, corn tortillas, fresh green beans?

Show solution

1. Fresh green beans: a single whole food, safe.
2. Oats: often processed with wheat; buy oats labeled gluten-free or check.
3. Soy sauce: usually contains wheat.
4. Corn tortillas: usually wheat-free but check, since some contain wheat flour.

Answer: Only the fresh green beans are safe without a label check; read every other label.

PRACTICE

1. Easy List the nine major food allergens.

   Show answer

   Milk, eggs, fish, crustacean shellfish, tree nuts, peanuts, wheat, soybeans, sesame.

2. Easy Which law made sesame the ninth major allergen, and when did labeling begin?

   Show answer

   The FASTER Act of 2021; labeling from January 1, 2023.

3. Easy What is the difference between cross-contact and cross-contamination?

Show answer

Cross-contact transfers an allergen protein (not killed by cooking); cross-contamination transfers germs (which cooking can kill).

4. Medium Why does cooking not make an allergen safe?

Show answer

Allergens are proteins, many of which survive heat; even a trace can trigger a reaction.

5. Medium Name three hidden names or places where milk can appear.

Show answer

Any three: whey, casein, butter, ghee, lactose, cheese powder, bread, chocolate, “natural flavors” on some labels (check the Contains statement).

6. Medium List five steps to prevent cross-contact when cooking for a guest with a peanut allergy.

Show answer

Read every label; wash hands; use freshly washed boards, pans and utensils; cook the safe dish first and cover it; no shared serving spoons; label the dish; keep peanut foods off the counter.

7. Medium What should you do if a guest shows signs of a severe reaction?

Show answer

Help them use their epinephrine auto-injector if they have one, call 911, and stay with them.

8. Hard A meal for 10 needs 1.5 servings of potatoes per person. A 5-lb bag makes about 15 servings. How many bags?

Show answer

15 servings needed; 1 bag.

9. Hard Rewrite a recipe for chicken stir-fry with soy sauce, sesame oil and peanuts to be top-nine-free, naming each swap.

Show answer

Use coconut aminos (or a soy-free, wheat-free sauce) for soy sauce; olive or canola oil for sesame oil; toasted sunflower seeds or crispy chickpeas for peanuts; check the broth and spice labels.

10. Challenge Explain why "may contain" labels are voluntary and what a family managing a severe allergy might do about them.

Show answer

U.S. law does not require precautionary labels, so wording and use vary between companies. Families often avoid such products for severe allergies, call manufacturers, and follow their doctor's advice.

COMMON MISTAKES

- Assuming a food is safe because it was safe last time; formulas change.
- Using the same spoon in several dishes.
- Treating a guest's allergy as a preference.
- Thinking cooking or frying destroys allergens.

Make it a game · Top Nine Test. Write the nine major allergens on paper from memory in sixty seconds. Your parent then reads a recipe and you flag every allergen in it, noting cross-contact risks and which label words matter. Run three recipes. Explain how cross-contact differs from cross-contamination. Check against the nine and record your count.

Scripture. "Let every one of us please his neighbour for his good to edification." (Romans 15:2, KJV)

Cooking with care for a guest's allergy is a practical way to seek your neighbor's good. A safe table says, "You are welcome here."

UNIT 8

Nutrition and the Balanced Diet

Good cooks feed people well. In this unit you will learn the science and history behind MyPlate and the Dietary Guidelines, the macronutrients and food energy, how to read a Nutrition Facts label, how the brain's reward system shapes cravings and habits, and how to cook safely for guests with food allergies. Calories appear only as a unit of energy; this course never discusses weight or appearance. Foods are nutrient-dense foods and treats, and both have their place.

The stories include the 1943 Basic Seven, Wilbur Atwater's respiration calorimeter, the 1990 label law and its 2016 Added Sugars line, Olds and Milner's 1954 discovery and the food-industry "bliss point," and the 2004 and 2021 allergen laws. The labs feed the family: stuffed peppers, grain bowls, oat bars, hummus, and a dinner safe for guests with allergies.

PREREQUISITES

- Units 1–7
- Comfort with percentages, unit rates and reading tables
- Willingness to keep honest food logs (never about body size)

MASTERY CHECKLIST

- ☐ I can describe MyPlate and the Dietary Guidelines and measure foods in cup- and ounce-equivalents.
- ☐ I can use the 4-4-9 factors to describe food energy and plan meals for growth and sport.
- ☐ I can read a Nutrition Facts label and convert grams of added sugar to teaspoons.
- ☐ I can explain the reward system, satiety and habits accurately.
- ☐ I can cook for guests with food allergies without cross-contact.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **MyPlate.gov**: Free at MyPlate.gov: the USDA's MyPlate site with food-group amounts by age and printable tip sheets.
- **FDA: How to Understand and Use the Nutrition Facts Label**: Free. The FDA's guide to every line of the label, for Lesson 8.3.
- **FDA: Food Allergies**: Free. The FDA's page on the nine major allergens and labeling, for Lesson 8.5.

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	**MyPlate and the Dietary Guidelines: From the Basic Seven to Today**	3 sessions of 50 minutes
8.2	**Macronutrients, Food Energy and Eating for Sport**	3 sessions of 50 minutes
8.3	**The Nutrition Facts Label and Added Sugar**	3 sessions of 50 minutes
8.4	**Cravings, Reward and Habits That Last**	3 sessions of 50 minutes
8.5	**Food Allergies: Cooking for Guests Safely**	3 sessions of 50–90 minutes

Unit 8 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Put in order and date: Food Guide Pyramid, MyPlate, Basic Seven, MyPyramid.

2. **6 pts**
   Describe MyPlate's proportions and name one nutrient each food group provides.

3. **6 pts**

   A dinner has 1 cup cooked pasta, 3 oz chicken, 2 cups raw spinach salad and 1½ oz cheese. Give the food-group amounts.

4. **8 pts**

   A meal has 85 g carbohydrate, 30 g protein and 22 g fat. Find its energy in kcal and kJ, and the percentage from fat.

5. **6 pts**

   Who was Wilbur Atwater, and what did he measure?

6. **6 pts**

   Give three guidelines for eating around a game or practice.

7. **6 pts**

   Why does this course's sport nutrition rely on ordinary meals and water rather than pills, powders or stimulant drinks?

8. **8 pts**

   A drink has 2 servings per bottle and 21 g added sugars per serving. How many grams and teaspoons in the bottle, and what %DV?

9. **6 pts**

   Explain total sugars versus added sugars, with an example of a food with sugars but no added sugars.

10. **6 pts**

    Describe accurately what dopamine does in the reward system.

11. **6 pts**

    What is satiety, how long does the fullness signal take, and what three things help it?

12. **6 pts**

    Compare the energy density of a 30-g snack with 150 kcal and a 180-g snack with 200 kcal.

13. **6 pts**

    List the nine major allergens and name the law that added sesame.

14. **6 pts**

    Explain cross-contact and four ways to prevent it.

15. **4 pts**

    Predict: a cook fries breaded shrimp, then fries potatoes in the same oil for a guest with a shellfish allergy. What could happen?

16. **8 pts**

    Essay (one paragraph): Describe a balanced way of eating that fits this unit's teaching about food and bodies, using at least three ideas from the unit and one from Scripture.

ANSWER KEY

1. Basic Seven 1943; Food Guide Pyramid 1992; MyPyramid 2005; MyPlate 2011.
2. About half fruits and vegetables, a quarter grains, a quarter protein, dairy on the side. Examples: vegetables/fruits vitamin C and fiber; grains B vitamins and fiber; protein iron and protein; dairy calcium.
3. Grains 2 oz-eq; protein 3 oz-eq; vegetables 1 cup-eq; dairy 1 cup-eq.
4. $340 + 120 + 198 = 658$ kcal; 2,753 kJ; fat $198/658 = 30\%$.
5. A Wesleyan chemist who, with Edward Rosa, built a respiration calorimeter in the 1890s and measured the energy people get from food (4, 4 and 9 kcal per gram).
6. Balanced meal 2–4 hours before; small carbohydrate snack and water if needed 30–60 minutes before; water during; carbohydrate and protein within an hour or two after.
7. Food provides the protein and energy teens need; pills and powders are unnecessary and loosely regulated, and stimulant drinks are unsuitable for teens.
8. 42 g; about 10½ tsp; 84% DV.
9. Total sugars include natural sugars in fruit and milk; added sugars are added in processing or cooking. Plain milk or an apple.
10. It is a messenger tied to wanting, motivation and learning what is rewarding; it rises when we expect or get something good. It is not pleasure itself.
11. The feeling of satisfaction that tells us to stop eating; about 20 minutes; fiber, protein and water (and eating slowly).
12. 5.0 kcal/g and 1.1 kcal/g.
13. Milk, eggs, fish, crustacean shellfish, tree nuts, peanuts, wheat, soybeans, sesame; the FASTER Act of 2021.
14. Transfer of an allergen protein to a safe food or surface. Read labels; wash hands; use freshly washed tools and pans; cook the safe dish first and cover it; separate serving spoons; label dishes.
15. Shellfish protein in the oil can transfer to the potatoes and cause an allergic reaction; frying does not destroy it.
16. Answers vary. A strong answer speaks of a pattern of mostly nutrient-dense foods covering the five groups, food as energy for growth and work, reading labels, eating slowly and attending to fullness, treats enjoyed in their place, care

for guests, thankfulness and self-control (e.g., 1 Corinthians 10:31; Galatians 5:22–23), and never judges bodies or calls foods good or bad.

UNIT PROJECT: A WEEK OF BALANCED FAMILY MEALS

Plan a week of family dinners (and one breakfast and one packed lunch) that follow MyPlate, use at least three recipes from this course, and include one meal safe for a guest with a food allergy of your choice. Check each meal against the five food groups and write it on a planning chart.

Cook at least three of the meals. For one, calculate the energy and macronutrients per serving and the added sugar. Write a one-page reflection on what you learned about balanced eating, keeping to the course's rule of talking about nourishment, skill and thankfulness, never about weight or appearance.

LOOK FOR	WHAT IT MEANS
Planning chart	Seven dinners, a breakfast and a lunch, each checked against the five food groups.
Cooking	Three meals cooked to standard with safe temperatures and family ratings.
Calculations	Accurate energy, macronutrient and added-sugar calculations for one meal.
Allergy-safe meal	A meal safe for a named allergy, with label audit and cross-contact plan.
Reflection	Thoughtful, kind and accurate, with no talk of weight or appearance.

UNIT 9

Meal Planning and Budgeting

A cook who can plan, shop and budget can feed a family well week after week. In this unit you will plan a week of family meals with planned leftovers and shared ingredients, learn the grocery strategies that began with Clarence Saunders's Piggly Wiggly in 1916, calculate cost per serving and build a weekly food budget, batch-cook and freeze meals the way Clarence Birdseye made possible, and cut food waste.

Scripture runs through the unit: Joseph storing grain in the good years, the ant gathering in summer, counting the cost before building, and Jesus telling His disciples to gather the fragments. The labs are real family meals: shepherd's pie, sheet-pan pizza, freezer burritos, batch meatballs and a use-it-up frittata, each with its cost calculated.

PREREQUISITES

- Units 1–8, especially food safety, cooling and freezing (Units 1 and 4) and MyPlate (Unit 8)
- Comfort with unit rates, percentages and simple budgets
- Access to grocery receipts or store prices

MASTERY CHECKLIST

- ☐ I can plan a week of balanced family dinners and write a grocery list from it.
- ☐ I can compare unit prices and use store strategies to save money.
- ☐ I can calculate cost per serving and build a weekly food budget.
- ☐ I can batch-cook, freeze, label and reheat meals safely.
- ☐ I can reduce food waste while keeping food safe.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA Food and Nutrition Service: USDA Food Plans: Monthly Cost of Food Reports**: Free. Monthly sample food budgets at several levels for families of different sizes, useful as a reference point in Lesson 9.3.
- **FoodKeeper App (USDA FSIS)**: Free from FoodSafety.gov and app stores. How long foods keep in the pantry, refrigerator and freezer, for Lessons 9.4 and 9.5.
- **A freezer thermometer and freezer labels**: Inexpensive. Keep the freezer at 0 °F and label every package with contents and date.

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

9.1 Planning a Week of Family Meals: Joseph and the Seven Good Years
3 sessions of 50–90 minutes

9.2 Clarence Saunders, Piggly Wiggly and the Unit Price 3 sessions of 50–90 minutes

9.3 Cost per Serving and a Weekly Budget: The Rumford Kitchen
3 sessions of 50–90 minutes

9.4 Batch Cooking and the Freezer: Clarence Birdseye's Fast Freeze
3 sessions of 50–90 minutes

9.5 Gather Up the Fragments: Reducing Food Waste 3 sessions of 50 minutes

Unit 9 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Name four parts of a good weekly meal plan.

2. **6 pts**

   A family of 6 eats 5 home-cooked dinners with 5 oz of cooked protein each. How many pounds of cooked protein?

3. **6 pts**

   Connect Joseph's plan in Genesis 41 to household meal planning.

4. **6 pts**

   Tell the Piggly Wiggly story and explain how it lowered prices.

5. **8 pts**

   Oats: 18 oz for $3.29 or 42 oz for $6.49. Find the unit prices and the percent savings of the better buy.

6. **6 pts**

   Give two reasons the larger package may not be the better buy.

7. **8 pts**

   A recipe uses ¾ of a 2-lb bag of carrots ($1.79), 1.5 lb of a 3-lb bag of onions ($2.99) and a $1.25 can of tomatoes. What do these cost?

8. **6 pts**

   Who was Ellen Swallow Richards, and what did the Rumford Kitchen show?

9. **6 pts**

   Chili for 8 costs $13.60; a restaurant charges $9.50 a bowl. Find the cost per serving and its food-cost percentage at the restaurant price.

10. **6 pts**

    Explain fast freezing and why it gives better quality.

11. **6 pts**

    Give the freezer temperature, three safe thawing methods, and the reheating temperature for leftovers.

12. **6 pts**

    A batch makes 48 meatballs; each meal uses 16. How many meals? If the batch costs $15.36, what is the meatball cost per meal?

13. **6 pts**

What share of U.S. food does the USDA estimate is wasted, and give three ways to waste less at home.

14. **6 pts**

Is “Best if used by” a safety date? When must food be thrown away regardless?

15. **4 pts**

A family wastes $35 of food a week and cuts it to $15. What is the yearly saving?

16. **8 pts**

Essay (one paragraph): Using two Scripture passages from this unit, explain how planning, budgeting and avoiding waste are part of stewardship.

ANSWER KEY

1. Any four: check the calendar; theme nights; planned leftovers; cross-used ingredients; MyPlate balance across the week; pantry check before the grocery list; a flexible night.
2. $6 \times 5 \times 5 = 150$ oz $= 9.4$ lb.
3. He looked ahead, measured how much to store, stored it well, and appointed someone responsible; a cook plans the week, measures needs, stores food safely and divides the work.
4. Clarence Saunders opened the first self-service grocery in Memphis in 1916; shoppers took goods from open, priced shelves, so fewer clerks were needed and costs fell.
5. 18 oz: 18.3¢/oz; 42 oz: 15.5¢/oz; savings $(18.3 - 15.5)/18.3 = 15\%$.
6. It may spoil or go stale before use; the smaller package may be on sale; you may not have room to store it.
7. $1.34 + $1.50 + $1.25 = $4.09.
8. MIT's first woman student and founder of home economics; in 1893 it showed nourishing lunches with their nutrients and cost (about 30 cents) posted.
9. $1.70; $1.70/9.50 = 17.9\%$.
10. Freezing quickly forms many small ice crystals that damage cells less, so thawed food keeps its texture and juices.
11. 0 °F; refrigerator, cold water changed every 30 minutes, microwave if cooking immediately; 165 °F.
12. 3 meals; $5.12.
13. 30–40%; plan and list, FIFO, use-it-up shelf, leftover night, freeze before spoiling, understand date labels.
14. No, it is a quality date (except infant formula). Throw away moldy, slimy or foul food, food left in the danger zone too long, or leftovers older than 3–4 days.
15. $1,040.
16. Answers vary. A strong answer uses Genesis 41, Proverbs 6:6–8, Luke 14:28 or John 6:12 to explain that food and money are gifts entrusted to us; planning ahead, counting the cost and gathering up leftovers honor the Giver, care for the family, and free resources to share with others.

UNIT PROJECT: A FAMILY MEAL PLAN AND BUDGET SPREADSHEET

Plan two weeks of family dinners with planned leftovers, theme nights and one batch-cooking session. Build a spreadsheet (on paper or a computer) listing each meal, its ingredients, quantities, unit prices and cost per serving, with a weekly total compared with your family's usual spending.

Shop for and cook at least four of the meals, including the batch session. Keep a waste log for both weeks. Finish with a one-page report showing what you planned, what you spent, what you saved and wasted, and what you would change, with receipts attached.

LOOK FOR	WHAT IT MEANS
Plan	Two complete weeks with planned leftovers, theme nights, MyPlate balance and a batch session.
Spreadsheet	Accurate unit prices, ingredient costs, cost per serving and weekly totals.
Cooking and safety	Four meals cooked well; batch meals cooled, frozen, labeled and reheated safely.
Waste log	Complete for two weeks, with causes and value.
Report	Clear comparison of plan, spending and waste, with honest improvements.

9.1 Planning a Week of Family Meals: Joseph and the Seven Good Years

OBJECTIVES

- Plan a week of balanced family dinners using a simple structure: themes, planned leftovers and shared ingredients.
- Count servings and ingredients for a week and turn a plan into a grocery list.
- Connect Joseph's planning in Genesis 41 to the habits of a wise household cook.
- Cook a shepherd's pie planned to use ingredients across two meals.

> **Warm-up.** List everything your family ate for dinner last week. How many nights were planned ahead? How many times did someone ask, "What's for dinner?" at 5:30?

WATCH

A system for successful meal planning in under 30 minutes!

That Awkward Mom · 7:32

https://www.youtube.com/watch?v=RY9PylaHPEA

> **WHEN TO WATCH**
> Before you write your weekly plan. Copy her three lists (simple, time-consuming, using leftovers) into your notebook.

Note: A home cook and mother shares a practical planning system with a light sense of humor.

KEY TERMS

meal plan

A written list of the meals for a set period, usually a week, made before shopping.

planned leftovers

Cooking extra of something on purpose so it becomes part of another meal later in the week.

cross-utilization

Using one ingredient in several dishes (for example, a bag of carrots in soup, salad and a roast) so nothing is wasted.

pantry staples

Shelf-stable foods kept on hand, such as rice, pasta, beans, canned tomatoes, flour, oil and spices.

theme night

A weekly pattern (soup night, pasta night, breakfast-for-dinner) that makes planning faster.

CORE IDEAS

The story. In Genesis 41, Pharaoh dreamed of seven fat cows eaten by seven thin ones. Joseph, brought from prison, explained that seven years of plenty would be followed by seven years of famine, and he counseled Pharaoh to store a fifth of the harvest in the good years. Pharaoh put Joseph in charge. When the famine came, Egypt had grain, and people from surrounding lands, including Joseph's own brothers, came to buy food. A plan made in the good years fed nations in the hard ones.

How they figured it out. Joseph's plan had the parts every good meal plan has: he looked ahead, he measured (a fifth of the harvest), he chose storage that would keep, and he put someone in charge of carrying it out. Generations of household cooks have done the same on a smaller scale: thinking through the week on Sunday, buying what is needed in one trip, cooking extra when it is easy and using it when the week is busy.

The kitchen science. A practical weekly plan is built in layers. First check the calendar: busy nights get quick meals or leftovers. Then pick a protein and a vegetable for each night, using theme nights to speed decisions. Plan **cross-utilization** (one bunch of celery for soup, stuffing and salad) and **planned leftovers** (extra mashed potatoes from Monday top Thursday's shepherd's pie). Check MyPlate balance across the week, not only within each meal. Finally, check the pantry and refrigerator before writing the grocery list, so you buy only what you need. Leftovers keep 3–4 days refrigerated, so plan to use them by midweek or freeze them.

Let's cook. You will plan a week of dinners, then cook a shepherd's pie (made with ground beef, it is often called cottage pie) whose mashed-potato topping and vegetables are planned to share ingredients with other meals. The technique standard: a written weekly plan and list, beef cooked to 160 °F, a rich, thickened filling, an even potato topping browned in the oven, and leftovers cooled and stored properly.

PICTURE STUDY



The Harvesters, Pieter Bruegel the Elder, 1565 · Oil on wood · The Metropolitan Museum of Art, New York

Image: Wikimedia Commons, public domain

Bruegel painted the wheat harvest in late summer, when the year's grain was gathered in. Some workers cut and stack the wheat; others take their noon meal under a tree. The bread they eat all winter depends on this harvest, gathered and stored with care.

Look closely

- Find the workers eating. What food do you see?
- Find the sheaves of wheat. How is the harvest being gathered?
- Look into the distance. What other work and life can you see?

Talk about it

1. How would this village have stored the harvest to last until next year?
2. What does this harvest have in common with Joseph's plan in Egypt?
3. What is the "harvest" you plan for in your family's week?

Safety first. Cook ground beef to 160 °F and bake the assembled pie until the center reaches 165 °F. Cool leftovers quickly in shallow containers and refrigerate within 2 hours; label them with the date and use within 3–4 days.

KITCHEN LAB

Planning Lab: A Week of Dinners and Shepherd's Pie

You will write a week-long dinner plan and grocery list, then cook a shepherd's pie that uses planned, shared ingredients.

You will need

- A weekly planning sheet and the family calendar
- A large skillet, a large pot and a potato masher
- A 9 × 13-inch or 3-quart baking dish
- An instant-read thermometer
- Containers and labels for leftovers

Shepherd's Pie (Cottage Pie)

Serves 6–8 · Prep 30 min · Bake 25 min

Ingredients

- **Topping:** 2½ lb (1.1 kg) russet or Yukon Gold potatoes, peeled and cut in chunks (or 5 cups planned leftover mashed potatoes)
- 4 tablespoons butter and ¾ cup warm milk, salt and pepper
- **Filling:** 1 tablespoon oil
- 1½ lb (680 g) ground beef or lamb
- 1 onion, 2 carrots and 2 celery ribs, small dice
- 2 cloves garlic, minced
- 2 tablespoons tomato paste and 2 tablespoons flour
- 1½ cups (360 mL) beef or chicken broth
- 1 tablespoon Worcestershire sauce (optional; contains fish)
- 1 teaspoon dried thyme, 1 teaspoon salt, ½ teaspoon pepper
- 1½ cups frozen peas (or peas and corn)

Method

1. Boil the potatoes in salted water until tender, 15–20 minutes. Drain, mash with butter and milk, and season. (Skip if using leftover mashed

potatoes.) Heat the oven to 400 °F (205 °C).

2. Heat the oil in the skillet over medium-high heat. Brown the meat, breaking it up, until no pink remains and it reads 160 °F. Spoon off excess fat.
3. Add the onion, carrot and celery and cook 6–8 minutes until softened. Add the garlic, tomato paste and flour and stir 1 minute.
4. Stir in the broth, Worcestershire, thyme, salt and pepper. Simmer 5 minutes until thick, then stir in the peas.
5. Spread the filling in the baking dish, top with the potatoes, and rough up the surface with a fork.
6. Bake 20–25 minutes, until bubbling and the peaks are golden (center 165 °F). Rest 5 minutes before serving.

Allergy check: Contains milk (butter, milk) and wheat (flour). Worcestershire sauce usually contains fish. Use oil, plant milk and a cornstarch slurry for milk- and wheat-free.

Steps

1. **Plan the week.** With your family's calendar, write seven dinners, marking busy nights, theme nights, planned leftovers and cross-used ingredients.
2. **Inventory.** Check the pantry, refrigerator and freezer and note what you already have.
3. **Grocery list.** Write the list grouped by store section, with quantities.
4. Cook the shepherd's pie on the planned night; record temperatures.
5. **Follow-through log.** Each night, record whether you followed the plan and why or why not.
6. **Technique check.** Score 1–3: complete plan and list, safe temperatures, thick and well-seasoned filling, golden topping, leftovers stored and labeled.
7. **Repeat round.** Revise the plan for next week based on what worked.

Tips

- Plan for one flexible night; plans need room for life.
- Keep a running grocery list on the refrigerator all week.
- Write the plan where the whole family can see it.

Check your work

- ☐ I can plan a week of dinners with planned leftovers and shared ingredients.
- ☐ I can turn a meal plan into an accurate grocery list.
- ☐ I cooked a shepherd's pie on plan and stored the leftovers safely.

LAB NOTEBOOK

1. Copy your weekly plan and mark cross-used ingredients in one color and planned leftovers in another.
2. Record your follow-through log and what you would change.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{servings needed} = \text{people} \times \text{meals}$$
$$\text{amount to buy} = \text{servings} \times \text{amount per serving} - \text{amount on hand}$$

From history. Shepherd's pie, with lamb, and cottage pie, with beef, grew up in Britain in the late 1700s and 1800s as ways to use the leftover meat from a Sunday roast under a crust of mashed potatoes, once potatoes had become a cheap staple.

WORKED EXAMPLES

Example 1. A family of 5 eats dinner at home 6 nights this week and plans one night of leftovers. Each dinner serving of protein is 4 oz cooked. How many pounds of cooked protein are needed for the 5 cooked dinners?

Show solution

1. Servings: $5 \times 5 = 25$.
2. Ounces: $25 \times 4 = 100$ oz $= 6.25$ lb.

Answer: About 6¼ lb of cooked protein (more raw weight, since meat loses some in cooking; beans or eggs can supply part of it).

Example 2. Your plan needs 3 cups of diced onion for the week. One medium onion gives about 1 cup diced. You have 1 onion. How many to buy?

Show solution

1. $3 - 1 = 2$ onions.

Answer: Buy 2 more (or a 3-lb bag if onions appear in more meals).

Example 3. Joseph stored a fifth of the harvest for 7 years. If the harvest was the same each year, how many years of a normal harvest's worth of grain were stored?

Show solution

1. $7 \times \frac{1}{5} = 1.4$ years' worth.

Answer: 1.4 normal harvests' worth, enough, with rationing, to help through seven lean years when combined with the smaller harvests of those years.

PRACTICE

1. Easy Name three benefits of planning a week of meals.

   Show answer

   Any three: less waste, lower cost, fewer trips to the store, balanced meals, less stress, using leftovers well.

2. Easy What are planned leftovers?

   Show answer

   Extra food cooked on purpose to become part of another meal later.

3. Easy How long do cooked leftovers keep in the refrigerator?

   Show answer

   3–4 days.

4. Medium A family of 4 eats 2 cups of vegetables each at dinner, 6 nights. How many cups of vegetables for the week?

   Show answer

   48 cups.

5. Medium Give an example of cross-utilization with one bag of carrots.

   Show answer

   Carrot sticks for lunch, carrots in Monday's soup, roasted carrots Wednesday, grated carrots in Friday's salad.

6. Medium What should you check before writing a grocery list?

   Show answer

   The calendar, the pantry, the refrigerator and the freezer.

7. Medium What did Joseph advise Pharaoh to store, and why?

Show answer

A fifth of the harvest in the seven good years, to feed the land during seven years of famine.

8. Hard Plan a theme-night structure for a week and give one dinner for each night.

Show answer

Example: Monday soup (chicken noodle), Tuesday tacos (black bean), Wednesday pasta (marinara with meatballs), Thursday leftovers, Friday pizza, Saturday grill (chicken), Sunday roast (roast chicken).

9. Hard Mashed potatoes for Monday serve 6 at ¾ cup each; you want 3 extra cups for Thursday's shepherd's pie. How many cups in all, and about how many pounds of potatoes (1 lb ≈ 2 cups mashed)?

Show answer

$4.5 + 3 = 7.5$ cups; about 3¾ lb, so buy 4 lb.

10. Challenge Explain how Joseph's plan illustrates four parts of good planning, and apply each to a family's week.

Show answer

Forecast (check the calendar); measure (servings and amounts); store well (refrigerate and freeze safely, label); appoint responsibility (someone cooks, someone shops, someone cleans). Answers should apply each to a specific week.

COMMON MISTAKES

- Planning seven elaborate dinners for a busy week.
- Writing the grocery list without checking the pantry.
- Forgetting leftovers until they are too old to eat.
- Not involving the family in the plan.

Make it a game · Seven Good Years. Plan a week of dinners on paper in five minutes, using theme nights and planned leftovers. Your parent then plays the famine: take away an ingredient or a night, and you rebuild the week on the spot using pantry staples. Tell how Joseph planned in Genesis. Three rebuilds, and you may use shared ingredients.

Scripture. “And let them gather all the food of those good years that come, and lay up corn under the hand of Pharaoh, and let them keep food in the cities. And that food shall be for store to the land against the seven years of famine, which shall be in the land of Egypt; that the land perish not through the famine.” (Genesis 41:35-36, KJV)

Joseph’s wisdom was practical: gather in plenty, store with care, and plan ahead for need. A planned week of meals is the same wisdom in a family kitchen.

9.2 Clarence Saunders, Piggly Wiggly and the Unit Price

OBJECTIVES

- Tell how Clarence Saunders opened Piggly Wiggly, the first self-service grocery store, in Memphis in 1916.
- Calculate and compare unit prices, and recognize when the bigger package is not the better buy.
- Use store strategies: a list, the perimeter and the aisles, store brands, sales and seasonal produce.
- Make homemade sheet-pan pizza and compare its cost with delivery.

> **Warm-up.** Look at two sizes of the same product in your pantry (or online): for example, a small and a large jar of peanut butter. Guess which is the better buy. Then look for the unit price on the shelf tag or calculate it.

WATCH

Piggly Wiggly, the first true grocery store - Life in America

Recollection Road · 8:02

https://www.youtube.com/watch?v=lVvgAd_5vpo

> **WHEN TO WATCH**
> After the story. Note the features of Saunders's store that are still in supermarkets today.

BACKUP VIDEO

Understanding Unit Price

Texas EFNEP · 6:28

https://www.youtube.com/watch?v=X_3ka4quxGQ

Before the pricing lab: reading unit prices on shelf tags, from Texas A&M University's nutrition-education program.

KEY TERMS

self-service store

A store where shoppers take goods from the shelves themselves instead of asking a clerk to fetch them.

store brand

A product sold under the store's own label, often made by the same manufacturers as national brands and usually cheaper.

in season

Fruits and vegetables at their natural harvest time, when they are usually cheapest and best.

unit price

The price per standard unit (per ounce, per pound, per count), used to compare packages of different sizes.

loss leader

An item sold at a very low price to bring shoppers into the store.

CORE IDEAS

The story. Before 1916 most American grocery shoppers handed a list to a clerk behind a counter, who gathered each item from the shelves, weighed and wrapped it. On September 11, 1916, Clarence Saunders opened a new kind of store in Memphis, Tennessee: Piggly Wiggly. Shoppers entered through a turnstile, took a basket, walked a set path through the aisles, chose their own goods from open shelves with clearly marked prices, and paid at a checkout at the end. Saunders patented his "self-serving store" in 1917. The idea spread quickly and shaped every supermarket since.

How he figured it out. Saunders saw that clerks fetching every item made shopping slow and costly, and that the cost was added to every price. By letting shoppers serve themselves, he needed fewer clerks and could charge less. He put a price tag on every item so shoppers could compare for themselves. The same idea, clear prices that shoppers can compare, is behind the **unit price** on today's shelf tags.

The kitchen science. The **unit price** divides price by quantity, so a 32-oz jar and a 16-oz jar can be compared fairly. Bigger is often cheaper per unit, but not always, especially on sale, and a bargain that spoils before you use it is no bargain. Good strategies: shop with a list built from your meal plan; compare unit prices; try store brands; buy produce in season; buy staples (rice, beans, oats, flour) in larger

amounts if you will use them; and avoid shopping hungry. Cooking from basic ingredients usually costs far less per serving than prepared or delivered food.

Let's cook. You will make a sheet-pan pizza from a simple yeast dough, with sauce from Lesson 5.2 or a quick one, and calculate its cost per slice against a delivered pizza. The technique standard: dough mixed and risen, stretched evenly to the pan's corners, sauce and toppings spread in thin layers, baked in a very hot oven until the bottom is crisp and the cheese bubbles.

PICTURE STUDY



Interior of a Piggly Wiggly Self-Service Grocery Store, Unknown photographer, c. 1918 · Photograph · Library of Congress, Washington, D.C.

Image: Wikimedia Commons, public domain

This early photograph shows a Piggly Wiggly store soon after Saunders opened his first one in 1916. The shelves are open, the goods are within reach, and every item has a price. Shoppers walked a set path through the aisles to the checkout.

Look closely

- Find the open shelves. How is this different from a counter store where a clerk fetched everything?
- Look for price tags. Why were they so important to self-service?
- Look at the aisles. How would a shopper move through the store?

Talk about it

1. How did self-service change the way people shopped and the prices they paid?
2. What modern store features can you trace back to this store?
3. How can a shopper today use clear prices to save money?

> **Safety first.** Bake pizza at 475 °F: use dry oven mitts, pull the oven rack out rather than reaching in, and slide the pizza onto a board to cut. Cook any raw meat toppings (such as sausage) to 160 °F before putting them on the pizza.

KITCHEN LAB

Budget Lab: Sheet-Pan Pizza Versus Delivery

You will price your pizza ingredients from a real receipt or store website, compare unit prices, and bake a sheet-pan pizza.

You will need

- A rimmed half-sheet pan (13 × 18 inches)
- A large bowl and a kitchen scale
- A pizza cutter or chef's knife
- A grocery receipt or store prices
- A calculator

Sheet-Pan Pizza

Serves 12 slices · Dough 10 min + rise 1–1½ hr · Assemble 10 min · Bake 15–18 min

Ingredients

- **Dough:** 480 g (4 cups) all-purpose or bread flour
- 340 g (1½ cups) warm water
- 10 g (1¾ teaspoons) salt
- 7 g (2¼ teaspoons) instant yeast
- 3 tablespoons olive oil, divided
- **Topping:** 1½ cups marinara (Lesson 5.2) or 1 can (15 oz) crushed tomatoes with ½ teaspoon salt, 1 teaspoon oregano and 1 clove garlic
- 12 oz (340 g) low-moisture mozzarella, grated
- ¼ cup grated Parmesan
- Toppings: pepperoni, cooked sausage, peppers, onions, mushrooms, olives

Method

1. Mix the flour, salt and yeast; add the water and 1 tablespoon oil and stir to a shaggy dough. Knead 5 minutes. Cover and rise until doubled, 1–1½ hours.

2. Heat the oven to 475 °F (245 °C). Oil the sheet pan with the remaining oil. Press and stretch the dough to the corners; if it springs back, rest it 10 minutes and stretch again.
3. Spread the sauce thinly to the edges. Top with the mozzarella, Parmesan and toppings.
4. Bake on the lowest rack 15–18 minutes, until the bottom is browned and crisp and the cheese bubbles and spots golden.
5. Slide onto a board, cut into 12 pieces and serve.

Allergy check: Contains wheat and milk. Pepperoni and sausage may contain soy or milk; check labels.

Steps

1. **Price it.** Record the package price and size of every ingredient, calculate each unit price, and find the cost of the amount used.
2. **Compare sizes.** For the cheese and the flour, compare at least two package sizes or brands by unit price.
3. Bake the pizza; record the bake time.
4. **Cost per slice.** Calculate the cost per slice and compare with a local delivery price including fees and tip.
5. **Technique check.** Score 1–3: dough risen and evenly stretched, thin even sauce, crisp bottom, golden cheese, accurate cost.
6. **Repeat round.** Make a second pizza night with a store-brand-only list and compare cost and taste.

Tips

- Low-moisture mozzarella melts without making the crust soggy.
- Dough can rise slowly in the refrigerator for up to 2 days.
- Too many toppings make a soggy center; less is more.

Check your work

- ☐ I can tell the Piggly Wiggly story.
- ☐ I can calculate and compare unit prices.
- ☐ I baked a sheet-pan pizza and calculated its cost per slice.

LAB NOTEBOOK

1. Draw a map of your grocery store and plan the quickest path for your list.
2. Record your price and unit-price table.
3. Write the lab record with cost per slice, a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{unit price} = \frac{\text{price}}{\text{quantity}}$$

$$\text{savings } \% = \frac{\text{higher price} - \text{lower price}}{\text{higher price}} \times 100$$

From history. Saunders later lost control of Piggly Wiggly in a stock-market battle in 1923 and tried again with new store ideas, including an automated store called the Keedoozle. The Piggly Wiggly chain still operates in the southern United States.

WORKED EXAMPLES

Example 1. Mozzarella costs \$2.49 for 8 oz or \$8.99 for 32 oz. Which is the better buy, and by what percentage?

Show solution

1. Small: $\$2.49/8 = \$0.311$ per oz.
2. Large: $\$8.99/32 = \$0.281$ per oz.
3. Savings $= (0.311 - 0.281)/0.311 \times 100 = 9.6\%$.

Answer: The 32-oz bag is about 10% cheaper per ounce, a good buy only if you will use (or freeze) it before it spoils.

Example 2. Homemade sheet-pan pizza: flour \$0.60, yeast \$0.25, oil \$0.20, sauce \$0.90, cheese (12 oz) \$3.37, toppings \$2.00. It makes 12 slices. A large delivered pizza (8 slices) costs \$17.99 plus a \$3.50 fee and a \$3.00 tip. Compare cost per slice.

Show solution

1. Homemade: $\$7.32/12 = \$0.61$ per slice.
2. Delivery: $(17.99 + 3.50 + 3.00)/8 = \$24.49/8 = \$3.06$ per slice.

Answer: About 61¢ versus \$3.06 per slice: homemade costs about one-fifth as much.

Example 3. Store-brand canned tomatoes cost \$1.19 for 28 oz; the national brand costs \$2.29 for 28 oz. If your family uses 2 cans a week, how much does the store brand save in a year?

Show solution

1. Weekly savings: $2 \times (2.29 - 1.19) = \$2.20$.
2. Yearly: $52 \times \$2.20 = \$114.40$.

Answer: About \$114 a year on one item.

PRACTICE

1. Easy Who opened the first self-service grocery store, where and when?

   Show answer

   Clarence Saunders, Piggly Wiggly, Memphis, Tennessee, September 11, 1916.

2. Easy What is a unit price?

   Show answer

   Price divided by quantity, such as cents per ounce.

3. Easy Name three ways to save money at the grocery store.

   Show answer

   Any three: shop with a list; compare unit prices; buy store brands; buy produce in season; buy staples in bulk if used; avoid shopping hungry; use sales wisely.

4. Medium Rice: 2 lb for $2.79 or 10 lb for $10.99. Unit prices?

Show answer

$1.40/lb and $1.10/lb.

5. Medium Cereal: 12 oz for $3.49 or 18 oz for $5.79. Which is the better buy?

Show answer

12 oz: 29.1¢/oz; 18 oz: 32.2¢/oz. The smaller box is cheaper per ounce.

6. Medium Why might a larger package be a bad buy even when its unit price is lower?

Show answer

If the food spoils or goes stale before it is used, the waste costs more than the savings.

7. Medium How did self-service lower prices?

Show answer

Fewer clerks were needed to fetch goods, lowering the store's costs.

8. Hard Bananas cost $0.59/lb. A bunch weighs 2.6 lb and has 7 bananas. What is the cost per banana?

Show answer

$2.6 \times 0.59 = \$1.53$; $\$1.53 / 7 = \$0.22$ each.

9. Hard A sale offers 3 boxes of pasta (16 oz each) for $4.00; the regular price is $1.79 each. What is the savings percentage?

Show answer

Sale $1.33 each; $(1.79 - 1.33)/1.79 = 25.7\%$.

10. Challenge Design a store-strategy checklist for a family on a tight budget, explaining the reason for each item.

Show answer

Answers vary. Strong answers include planning meals around sales, a list, unit prices, store brands, seasonal produce, buying staples in bulk, using what is on hand, avoiding pre-cut and prepared foods, and shopping alone and not hungry, each with a reason.

COMMON MISTAKES

- Assuming the biggest package is always cheapest.
- Buying sale items you will not use.
- Comparing prices without the same units.
- Shopping without a list.

> **Make it a game · Unit Price Race.** Your parent invents prices for four pantry items. Race to compute each unit price and name the best buy in sixty seconds. Add a twist: the bigger package costs more per ounce. Explain where that can happen. Tell how Clarence Saunders opened Piggly Wiggly in Memphis in 1916.

9.3 Cost per Serving and a Weekly Budget: The Rumford Kitchen

OBJECTIVES

- Tell how Ellen Swallow Richards's Rumford Kitchen at the 1893 World's Fair showed nourishing meals at a low, posted cost.
- Calculate cost per serving and cost per meal for a recipe from a receipt.
- Build a weekly family food budget and compare it with what the family actually spends.
- Cook freezer-friendly beef and bean burritos and calculate their cost per burrito.

> **Warm-up.** Guess what one serving of tonight's dinner costs. Then guess the cost of a similar meal at a restaurant. Write both down before the lesson; you will check them later.

WATCH

How Can I Save Money on Groceries?

Two Cents · 6:31

https://www.youtube.com/watch?v=1VAZmcJ6_50

> **WHEN TO WATCH**
> After the kitchen-science paragraph. List each money-saving idea and mark the ones your family already uses.

Note: From Two Cents, a personal-finance series from PBS Digital Studios.

KEY TERMS

cost per serving

The total cost of a recipe divided by the number of servings it makes.

food budget

A planned limit on how much a household will spend on food in a week or month.

food-cost percentage

In restaurants, food cost divided by menu price, times 100; often around 25–35%.

domestic science

The nineteenth-century name for the study of nutrition, sanitation and household management, later called home economics.

fixed and variable costs

Costs that stay the same (staples always on hand) and costs that change with the menu (fresh meat, produce).

CORE IDEAS

The story. Ellen Swallow Richards (1842–1911) was the first woman admitted to the Massachusetts Institute of Technology and became a chemist and teacher there. She believed that science could help families eat better for less. In 1890 she helped open the New England Kitchen in Boston, which sold nourishing, inexpensive cooked foods to working families. At the 1893 World's Columbian Exposition in Chicago, she ran the Rumford Kitchen, named for Count Rumford, where visitors could buy a lunch and read a card showing its nutrients and its cost, about 30 cents.

How she figured it out. Richards analyzed foods in the laboratory, tested recipes, and calculated the nutrients and cost of each meal. She showed that beans, grains, milk and vegetables, cooked well, could feed a family nourishingly at low cost. She helped found the American Home Economics Association in 1908-09 and is often called the founder of home economics.

The kitchen science. To find **cost per serving**, find the cost of the amount of each ingredient you actually used (package price × fraction used), add them, and divide by servings. Staples like rice, beans, flour and spices cost only cents per serving. A **weekly budget** starts with what the family spends now; then planning, unit pricing (Lesson 9.2), cooking from scratch, batch cooking (9.4) and wasting less (9.5) bring the cost down. The USDA publishes monthly "Cost of Food at Home" reports giving sample food budgets at several levels, which families can use as a reference point.

Let's cook. You will make beef and bean burritos, eat some for dinner and wrap and freeze the rest for busy nights, and calculate the cost per burrito from your receipt. The technique standard: beef cooked to 160 °F, filling well seasoned and thick

enough not to leak, burritos rolled tightly, frozen burritos labeled, and an accurate cost calculation.

PICTURE STUDY



The Poultry Market at Gisors, Camille Pissarro, 1885 · Gouache and pastel on paper · Museum of Fine Arts, Boston

Image: Wikimedia Commons, public domain

Camille Pissarro painted the weekly market in Gisors, a small town in Normandy, France. Shoppers and sellers bargain face to face, comparing quality and price. Every household cook in the crowd is working within a budget.

Look closely

- Find the sellers and the buyers. How can you tell them apart?
- Look at the baskets. What is being sold?
- Look at the faces and gestures. What conversations might be happening?

Talk about it

1. How did shoppers at this market compare prices without shelf tags?
2. What would a careful shopper look for in choosing a chicken or vegetables?
3. How is planning a budget like the choices made in this market?

> **Safety first.** Cook ground beef to 160 °F. Cool the filling before wrapping burritos for the freezer, freeze within 2 hours of cooking, and reheat frozen burritos to 165 °F in the center. Label each package with the contents and date.

KITCHEN LAB

Budget Lab: Freezer Beef and Bean Burritos

You will cook a batch of burritos, calculate cost per burrito from your receipt, freeze half for later, and build a weekly food budget.

You will need

- A large skillet and a medium saucepan
- An instant-read thermometer
- Foil or freezer wrap, freezer bags and labels
- Your grocery receipt and a calculator
- A budget worksheet

Beef and Bean Burritos (Freezer-Friendly)

Serves 10 burritos · Prep 20 min · Cook 25 min

Ingredients

- 1 lb (450 g) lean ground beef
- 1 onion, diced; 2 cloves garlic, minced
- 1 tablespoon chili powder, 2 teaspoons cumin, 1 teaspoon salt, 1 teaspoon oregano
- 1 can (15 oz) black or pinto beans, drained and lightly mashed
- 1 can (15 oz) refried beans
- ½ cup salsa
- 2 cups cooked rice
- 10 large (10-inch) flour tortillas
- 2 cups (8 oz) grated cheddar or Monterey Jack

Method

1. Brown the beef with the onion in the skillet over medium-high heat until no pink remains and it reads 160 °F. Drain excess fat.
2. Add the garlic and spices for 1 minute. Stir in both kinds of beans and the salsa and simmer 5 minutes until thick. Stir in the rice. Taste for

salt.

3. Warm the tortillas briefly so they bend without cracking.
4. Spoon about ¾ cup filling in a line on each tortilla, top with cheese, fold in the sides and roll up tightly.
5. For dinner, toast burritos seam-side down in a dry skillet 2–3 minutes per side. For the freezer, cool the rest, wrap each tightly in foil, bag, label and freeze up to 3 months.
6. To reheat from frozen: unwrap, wrap in a damp paper towel and microwave 2–3 minutes, turning once, or bake in foil at 375 °F about 35–40 minutes, until 165 °F in the center.

Allergy check: Contains wheat (tortillas) and milk (cheese). Use corn tortillas (smaller) or gluten-free wraps and omit the cheese as needed; check refried beans for lard or dairy if relevant.

Steps

1. **Cost it.** From your receipt, calculate the cost of the amount of each ingredient used, the total, and the cost per burrito.
2. Cook, roll, serve and freeze the burritos. Record temperatures.
3. **Weekly budget.** With a parent, total last week's grocery receipts. Set a target for next week and list three strategies to meet it.
4. **Rumford card.** Make a card for your burrito showing cost, food groups and approximate energy.
5. **Technique check.** Score 1–3: safe temperatures, tight rolls that do not leak, labeled freezer packs, accurate cost calculations.
6. **Repeat round.** Reheat a frozen burrito one week later and record its quality and the time saved.

Tips

- A thick filling keeps burritos from going soggy in the freezer.
- Wrap tightly to prevent freezer burn.
- Keep a freezer inventory list on the door.

Check your work

- ☐ I can tell the story of Ellen Swallow Richards and the Rumford Kitchen.
- ☐ I can calculate cost per serving and build a weekly budget.

- [ ] I made, priced and froze a batch of burritos safely.

LAB NOTEBOOK

1. Copy your cost table and your Rumford card.
2. Record your budget worksheet and strategies.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{cost of ingredient used} = \text{package price} \times \frac{\text{amount used}}{\text{package amount}}$$

$$\text{cost per serving} = \frac{\text{total cost}}{\text{servings}}$$

$$\text{food-cost \%} = \frac{\text{food cost}}{\text{menu price}} \times 100$$

From history. Richards also tested Massachusetts water supplies for the state in the 1880s, analyzing tens of thousands of samples, work that led to the first state water-quality standards in the United States.

WORKED EXAMPLES

Example 1. You use 1 cup (about 200 g) of rice from a 2-lb (907 g) bag that cost $2.79. What did the rice cost?

Show solution

1. $\$2.79 \times \frac{200}{907} = \$0.62$.

Answer: About 62 cents.

Example 2. The burritos cost: beef $5.99, beans $1.98, rice $0.62, tortillas (10) $3.49, cheese $2.25, onion, spices and salsa $1.60. They make 10 burritos. Find the cost per burrito. A restaurant burrito costs $10.50. What is its food-cost percentage if its ingredients cost the same as yours?

Show solution

1. Total $= 5.99 + 1.98 + 0.62 + 3.49 + 2.25 + 1.60 = \$15.93$.
2. Per burrito $= \$1.59$.
3. Restaurant food-cost % $= 1.59/10.50 \times 100 = 15\%$.

Answer: About $1.59 per burrito, about 15% of the restaurant price (restaurants must also pay for labor, rent and more).

Example 3. A family of 4 spends $260 a week on groceries. By planning, using unit prices and cooking two batch meals, they cut 12%. What is the new weekly cost and the yearly savings?

Show solution

1. New weekly cost $= 260 \times 0.88 = \$228.80$.
2. Yearly savings $= 52 \times (260 - 228.80) = 52 \times 31.20 = \$1622.40$.

Answer: $228.80 a week, saving about $1,622 a year.

PRACTICE

1. Easy Who was Ellen Swallow Richards?

   Show answer

   The first woman admitted to MIT, a chemist who applied science to household food and sanitation and is called the founder of home economics.

2. Easy What was the Rumford Kitchen?

   Show answer

   Richards's exhibit at the 1893 Chicago World's Fair, serving low-cost, nourishing lunches with cards showing nutrients and cost.

3. **Easy** How do you find cost per serving?

   Show answer

   Add the cost of each ingredient used and divide by the number of servings.

4. **Medium** A 16-oz bag of grated cheese costs $4.49 and you use 6 oz. What did the cheese cost?

   Show answer

   $1.68.

5. **Medium** Chili costing $11.40 serves 8. Cost per serving?

   Show answer

   $1.43.

6. **Medium** Give three foods that cost very little per serving and are nutritious.

   Show answer

   Any three: dried beans and lentils, rice, oats, eggs, potatoes, cabbage, carrots, bananas, frozen vegetables, peanut butter.

7. **Medium** What is food-cost percentage for a $12 plate with $3.60 of food?

   Show answer

   30%.

8. **Hard** A family budget is $1,000 a month for food for 5 people. What is that per person per day (30-day month)?

   Show answer

   $1000 / (5 \times 30) = \$6.67$

9. **Hard** A recipe uses ⅓ of a $3.29 bottle of salsa, ¼ of a $2.49 bunch of cilantro, and 2 of 6 bell peppers costing $4.50. What do these three cost?

   Show answer

   $1.10 + $0.62 + $1.50 = $3.22.

10. **Challenge** Richards posted nutrients and cost on each lunch card. Design a "Rumford card" for your burritos showing cost, food groups and approximate energy, and explain why such cards help families.

Show answer

Answers vary. A strong card lists cost per burrito, MyPlate groups (grain, protein, vegetables, dairy), and approximate kcal from label data, and explains that seeing cost and nourishment together helps families choose wisely and plan.

COMMON MISTAKES

- Counting the whole package price instead of the part used.
- Forgetting small items (spices, oil) in cost calculations.
- Freezing hot food or food left out too long.
- Setting a budget without looking at real receipts first.

Make it a game · Cost per Serving. Your parent invents prices for the ingredients of a recipe, such as burritos. Compute total cost, cost per serving and food-cost percentage if each serving sells for a price they name. Set a weekly budget and see if the plan fits. Tell how Ellen Richards posted costs at the 1893 Rumford Kitchen.

Scripture. "For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it?" (Luke 14:28, KJV)

Jesus used the picture of counting the cost to teach about following Him wholeheartedly. Counting the cost is also simple wisdom for a household budget.

9.4 Batch Cooking and the Freezer: Clarence Birdseye's Fast Freeze

OBJECTIVES

- Tell how Clarence Birdseye developed fast freezing after watching food freeze in Labrador.
- Explain why fast freezing makes small ice crystals and better quality, and how to freeze food well at home.
- Plan and cost a batch-cooking session that makes several meals.
- Bake a big batch of meatballs, serve some and freeze the rest for later meals.

> **Warm-up.** Freeze two small cups of the same juice or fruit purée: one spread thin on a plate, one in a deep cup. Next day, thaw both and compare their texture and how much liquid separates.

WATCH

Top Tips For Freezing And Defrosting Food

The Batch Lady · 6:04

https://www.youtube.com/watch?v=W8YMN1supYY

> **WHEN TO WATCH**
> Before the batch lab. Write down her packing and thawing tips; compare her thawing advice with the USDA's safe methods in the core ideas.

Note: A British batch-cooking teacher. Follow the USDA thawing rules in this lesson where they differ.

KEY TERMS

batch cooking

Cooking a large quantity at once to serve now and store for later meals.

fast freezing

Freezing food quickly so water forms many small ice crystals that damage cells less.

freezer burn

Dry, discolored patches on frozen food where moisture has evaporated from exposed surfaces; safe but poorer in quality.

flash freezing

Freezing pieces spread out on a tray before bagging them, so they do not stick together.

safe thawing

Thawing in the refrigerator, in cold water changed every 30 minutes, or in the microwave if cooking immediately, never on the counter.

CORE IDEAS

The story. Clarence Birdseye was a naturalist and fur trader who lived in Labrador, in northeastern Canada, between about 1912 and 1915. Ice fishing with the Inuit at temperatures far below zero, he noticed that fish pulled from the water froze almost instantly in the bitter wind, and that when they were thawed months later they tasted nearly fresh. Food frozen slowly in ordinary cold storage, by contrast, came out mushy. Back in the United States he developed machines that froze food quickly between cold metal plates, founded a frozen-food company in the 1920s, and in 1930 frozen foods under the Birds Eye name went on sale in stores in Springfield, Massachusetts.

How he figured it out. Birdseye compared fish frozen fast in the Arctic wind with fish frozen slowly and asked why they differed. He reasoned that speed was the key, and he designed equipment to freeze packages of food quickly and evenly. He experimented with many foods, from fish to vegetables to fruit, and with packaging that kept out air.

The kitchen science. When food freezes slowly, water forms large, jagged ice crystals that pierce cell walls; when it thaws, the juice runs out and the food is mushy. Fast freezing forms many tiny crystals that do much less damage. At home: freeze food in small, flat portions; spread pieces on a tray to flash-freeze before bagging; cool cooked food quickly before freezing; press out air to prevent freezer burn; label with the contents and date; and keep the freezer at 0 °F (−18 °C). Freezing stops bacteria from growing but does not kill them, so thaw safely and cook or

reheat to the right temperature. Batch cooking turns one cooking session into several ready meals.

Let's cook. You will bake a large batch of meatballs on sheet pans, serve some with marinara and pasta, and flash-freeze the rest in labeled bags for at least two more meals. The technique standard: meatballs shaped evenly, baked to 160 °F (165 °F if made with poultry), cooled quickly, flash-frozen on a tray, bagged with air pressed out, labeled, and reheated later to 165 °F.

PICTURE STUDY



Clarence Birdseye, Unknown photographer, 1930 · Photograph · Wikimedia Commons

Image: Wikimedia Commons, public domain

This photograph shows Clarence Birdseye around 1930, the year his quick-frozen foods first went on sale in Springfield, Massachusetts. A curious naturalist who paid attention to what he saw in the Arctic changed how the world stores food.

Look closely

- Look at his expression. What kind of person does he seem to be?
- How is he dressed? What does that suggest about his work at this time?
- Compare this photo with Escoffier's in Lesson 1.1. What do both men have in common?

Talk about it

1. What questions do you think Birdseye asked when he first saw fish freeze in the Arctic wind?
2. How has frozen food changed family cooking since 1930?
3. What foods does your family keep frozen, and how could you use the freezer better?

Safety first. Cook meatballs to 160 °F (165 °F if made with ground poultry), cool them quickly on the pans, and freeze within 2 hours. Reheat frozen meatballs to 165 °F. Wash hands after shaping raw meat, and keep raw meat away from other foods.

KITCHEN LAB

Batch Lab: Freezer Meatballs, Three Meals

You will make a big batch of meatballs, serve one meal and freeze two, labeling and logging them so they are used safely.

You will need

- Two rimmed sheet pans lined with foil or parchment
- A large bowl and a 1½-tablespoon scoop
- An instant-read thermometer
- Freezer bags, labels and a marker
- A freezer thermometer

Batch Baked Meatballs

Serves About 60 meatballs (3 family meals) · Prep 30 min · Bake 18–22 min

Ingredients

- 2 lb (900 g) ground beef (or 1 lb beef and 1 lb pork)
- 1 cup (60 g) fresh bread crumbs or ¾ cup dry crumbs
- ½ cup (120 mL) milk
- 2 large eggs
- ½ cup grated Parmesan
- 1 small onion, finely grated
- 3 cloves garlic, minced
- ¼ cup chopped parsley
- 2 teaspoons salt, 1 teaspoon pepper, 1 teaspoon dried oregano
- For dinner: marinara (Lesson 5.2) and spaghetti

Method

1. Heat the oven to 400 °F (205 °C). Soak the bread crumbs in the milk 5 minutes in a large bowl.
2. Add the eggs, cheese, onion, garlic, parsley and seasonings and mix. Add the meat and mix gently with your hands just until combined. Wash

your hands.

3. Scoop and roll 1½-inch balls (about 1½ tablespoons each) onto the pans in rows.
4. Bake 18–22 minutes, until browned and 160 °F in the center (165 °F if made with poultry).
5. Simmer tonight's meatballs in marinara 10 minutes and serve with spaghetti.
6. Cool the rest on the pans 15–20 minutes, then freeze on the pans 1 hour (flash freeze). Bag in meal-size portions, press out air, label with contents and date, and freeze up to 3 months. Reheat in sauce to 165 °F.

Allergy check: Contains wheat (bread crumbs), milk (milk, Parmesan) and eggs. Use gluten-free crumbs or oats, omit the cheese, and use a plant milk as needed; eggs can be replaced with 2 tablespoons of tomato paste for binding.

Steps

1. **Plan the batch.** Calculate how many meatballs your family eats per meal and how many meals the batch will make.
2. Check the freezer temperature with a thermometer and record it.
3. Make and bake the meatballs; record the temperature of three.
4. **Freezer log.** Make a freezer inventory sheet with item, date, portions and use-by date.
5. **Cost per meal.** Calculate from your receipt.
6. **Technique check.** Score 1–3: even size, safe temperatures, quick cooling, flash frozen, airtight and labeled.
7. **Repeat round.** Use one frozen bag within a month in a different dish (meatball subs or soup) and record the quality after freezing.

Tips

- A scoop makes meatballs the same size, so they cook evenly.
- Grated onion keeps meatballs moist without chunks.
- Flat bags freeze and thaw faster and stack neatly.

Check your work

☐ I can tell Birdseye's story and explain fast freezing.

- ☐ I can plan and cost a batch-cooking session.
- ☐ I made, froze and labeled a batch of meatballs safely.

LAB NOTEBOOK

1. Draw slow-frozen and fast-frozen cells with their ice crystals.
2. Copy your freezer inventory sheet and cost per meal.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{meals from a batch} = \frac{\text{total servings}}{\text{servings per meal}}$$

$$\text{cost per meal} = \frac{\text{batch cost}}{\text{number of meals}}$$

From history. In 1929 Birdseye sold his company and patents to the Postum Company and Goldman Sachs for $22 million; the new owners became General Foods. He went on to invent many other things, holding about 300 patents.

WORKED EXAMPLES

Example 1. A batch makes 60 meatballs. Your family of 5 eats 4 meatballs each per meal. How many meals does the batch make?

Show solution

1. Per meal: $5 \times 4 = 20$ meatballs.
2. $60/20 = 3$ meals.

Answer: Three meals: one tonight and two from the freezer.

Example 2. The meatball batch costs $16.80, and each meal also needs $2.50 of pasta and sauce. What is the cost per meal and per person?

Show solution

1. Meatballs per meal: $\$16.80/3 = \$5.60$.
2. Meal: $\$5.60 + \$2.50 = \$8.10$; per person $\$8.10/5 = \$1.62$.

Answer: About $8.10 per meal, $1.62 per person.

Example 3. A freezer thermometer reads 10 °F. Convert to °C and decide whether it is cold enough.

Show solution

1. $\frac{5}{9}(10 - 32) = -12.2\ ^\circ\text{C}$.

Answer: −12 °C is warmer than the recommended 0 °F (−18 °C); turn the freezer colder.

PRACTICE

1. Easy Where did Clarence Birdseye observe fast freezing, and what did he notice?

   Show answer

   In Labrador (about 1912–1915), ice fishing with the Inuit; fish frozen fast in the bitter cold tasted nearly fresh when thawed.

2. Easy At what temperature should a home freezer be kept?

   Show answer

   0 °F (−18 °C) or colder.

3. Easy Name three safe ways to thaw food.

   Show answer

   In the refrigerator; in cold water changed every 30 minutes; in the microwave if cooking right away.

4. Medium Why does slowly frozen food become mushy when thawed?

   Show answer

   Large ice crystals pierce cell walls; juice runs out on thawing.

5. Medium What is flash freezing, and why is it useful?

   Show answer

   Freezing pieces spread out on a tray before bagging, so they freeze fast and do not stick together.

6. Medium Does freezing kill bacteria?

Show answer

No; it stops their growth. They can grow again after thawing, so handle and cook food safely.

7. Medium What causes freezer burn, and how do you prevent it?

Show answer

Moisture evaporating from exposed food surfaces; wrap tightly and press out air.

8. Hard A batch of soup makes 18 cups. A family meal uses 6 cups. How many freezer containers of 3 cups each will you need for the two extra meals?

Show answer

12 cups extra; 4 containers.

9. Hard A batch session costs $42 and makes 5 dinners for 4 people. Compare its per-person cost with takeout at $11 per person.

Show answer

$\$42/20 = \$2.10$ per person versus $11.

10. Challenge Plan a 2-hour batch-cooking session that produces three different freezer meals, listing the order of tasks so the oven and stove are used efficiently.

Show answer

Answers vary. A strong plan starts the longest item first (for example, meatballs in the oven), uses the stove meanwhile for a soup or chili, assembles a third dish (burritos or a casserole) while things cook, cools everything quickly in shallow pans, then packages and labels.

COMMON MISTAKES

- Freezing food without labels and dates.
- Thawing meat on the counter.
- Packing warm food tightly in the freezer, which slows cooling.
- Keeping frozen food indefinitely; quality fades after a few months.

Make it a game · Freezer Triage. Your parent names ten freezer situations: hot soup, a meatball batch, partly thawed fish, ice crystals on a pie. You say safe thaw or not, how to pack it, and why fast freezing gives small ice crystals. Run all ten with no mistakes. Then explain how Birdseye learned fast freezing in Labrador.

Scripture. “Go to the ant, thou sluggard; consider her ways, and be wise: Which having no guide, overseer, or ruler, Provideth her meat in the summer, and gathereth her food in the harvest.” (Proverbs 6:6-8, KJV)

The ant stores food in the season of plenty for the season of need. A well-stocked freezer of home-cooked meals is the same kind of diligent wisdom.

9.5 Gather Up the Fragments: Reducing Food Waste

OBJECTIVES

- Explain how much food is wasted in the United States and where household waste comes from.
- Use “first in, first out,” date labels, smart storage and leftovers to waste less food.
- Calculate the value of food wasted in a week and the savings from reducing it.
- Cook a leftover-vegetable frittata to 160 °F, a dish built to use what is on hand.

> **Warm-up.** Open your refrigerator and find three foods that need to be used in the next two days. What could you cook with them tonight?

WATCH

USDA Tips to Reduce Food Waste at Home

USDA · 1:00

https://www.youtube.com/watch?v=pPtj-ukCcYE

> **WHEN TO WATCH**
> After the story. Note the four tips and add one of your own.

BACKUP VIDEO

The Life of Your Leftovers

USDA · 3:27

https://www.youtube.com/watch?v=4WI3BibVyuY

Optional: what happens to food scraps from a large USDA cafeteria.

KEY TERMS

food waste

Food that is fit to eat but thrown away, at home, in stores or in restaurants.

FIFO

“First in, first out”: put new groceries behind older ones so the older food is used first.

“Best if used by”

A quality date, not a safety date: the food is at its best before then and often safe after, if stored properly (except infant formula).

frittata

An Italian open-faced omelet with vegetables, meat or cheese mixed into the eggs, finished in the oven.

use-it-up shelf

A spot in the refrigerator for foods that need to be eaten soon.

CORE IDEAS

The story. After Jesus fed five thousand men, besides women and children, with five barley loaves and two small fishes, He told His disciples, “Gather up the fragments that remain, that nothing be lost” (John 6:12). They filled twelve baskets. The Lord who had just multiplied the food did not waste what was left. Today, the U.S. Department of Agriculture estimates that 30–40% of the American food supply is wasted, and a large share of it is thrown away in homes.

How they figured it out. Researchers measured waste by sorting trash, by surveys and by comparing how much food is sold with how much is eaten. Household waste comes mostly from buying more than needed, forgetting food in the back of the refrigerator, misunderstanding date labels, cooking too much and not using leftovers. Each has a simple fix.

The kitchen science. Most date labels (“Best if used by”) are about quality, not safety; the USDA advises using your senses and safe storage instead of throwing food out by the date alone (except infant formula). Store foods well: leafy greens in a bag with a paper towel, herbs in water, bread in the freezer if it will not be used in a few days, bananas apart from other fruit (they give off ethylene, which ripens nearby fruit). Use **FIFO** and a use-it-up shelf. Repurpose: stale bread becomes crumbs, croutons or bread pudding; vegetable trimmings become stock (Lesson 4.4); soft fruit becomes smoothies or crisps; leftover vegetables go into a frittata, soup or fried rice. But food safety still rules: leftovers are used within 3–4 days, and anything moldy, slimy or left in the danger zone too long is discarded.

Let’s cook. You will make a frittata from eggs and the vegetables, cheese and cooked meat already in your refrigerator. The technique standard: an inventory first,

leftovers checked for safety, vegetables cooked before adding the eggs, eggs set gently on the stove and finished in the oven to 160 °F, and a log of food saved from waste.

PICTURE STUDY



The Gleaners, Jean-François Millet, 1857 · Oil on canvas · Musée d'Orsay, Paris

Image: Wikimedia Commons, public domain

Millet painted three poor women gleaning: gathering the stalks of wheat left in the field after the harvest. Gleaning was an ancient right of the poor, commanded in the law of Moses (Leviticus 19:9–10) and practiced by Ruth in the field of Boaz. Nothing of the harvest was wasted.

Look closely

- Find the three women. What are they doing with their hands?
- Look into the distance. What is happening there?
- Compare the size of the great stacks with what the women are gathering.

Talk about it

1. Why did the law of Moses tell farmers to leave some grain for the poor?
2. How is gathering the gleanings like using leftovers at home?
3. What "fragments" in your kitchen could be gathered up this week?

> **Safety first.** Before using leftovers, check that they are within 3–4 days and have been refrigerated; discard anything moldy, slimy or off-smelling. Cook the frittata until the center reaches 160 °F and is no longer liquid. Move the hot skillet with dry mitts, and leave a mitt on its handle.

KITCHEN LAB

Waste Lab: Use-It-Up Frittata and a Waste Audit

You will audit your family's food waste for a week, then cook a frittata from what needs to be used.

You will need

- A 10-inch oven-safe skillet (nonstick or cast iron)
- A bowl and whisk
- An instant-read thermometer
- A waste-log sheet
- A marker for a use-it-up shelf label

Use-It-Up Vegetable Frittata

Serves 6 · Prep 15 min · Cook 20 min

Ingredients

- 10 large eggs
- ⅓ cup (80 mL) milk
- ¾ teaspoon salt and ¼ teaspoon pepper
- 1 tablespoon olive oil or butter
- 2–3 cups leftover or fresh vegetables, cut small (peppers, onions, spinach, broccoli, zucchini, potatoes, mushrooms)
- 1 cup leftover cooked meat (ham, chicken, sausage), optional
- ¾ cup grated or crumbled cheese (any kind)
- Fresh herbs if you have them

Method

1. Heat the oven to 375 °F (190 °C). Whisk the eggs, milk, salt and pepper.
2. Heat the oil in the skillet over medium heat. Cook raw vegetables until tender (5–8 minutes); add cooked vegetables and meat just to heat through.

3. Pour in the eggs and stir gently a few times to distribute. Cook without stirring 3–4 minutes, until the edges set.
4. Sprinkle with cheese and move to the oven. Bake 10–14 minutes, until the center is set and reads 160 °F.
5. Rest 5 minutes, loosen the edges, and cut into wedges. Refrigerate leftovers and eat within 3–4 days.

Allergy check: Contains eggs and milk. Use a plant milk and omit the cheese for milk-free.

Steps

1. **Waste audit.** For one week, log every food thrown away at home: item, amount, reason and estimated cost.
2. **Inventory.** List the foods in your refrigerator that need to be used soon; set up a use-it-up shelf.
3. Cook the frittata from that list; record which foods it used and their value.
4. Record the frittata's final temperature.
5. **Analyze.** Total the week's waste value and its main causes, and project it over a year.
6. **Technique check.** Score 1–3: safe leftovers chosen, vegetables cooked first, eggs set gently, 160 °F, complete audit.
7. **Repeat round.** Run the audit again the next week after making changes and compare.

Tips

- Almost any leftover vegetable works in a frittata; drain watery ones well.
- Low heat on the stove and a moderate oven keep eggs tender.
- Make a weekly "leftover night" a family habit.

Check your work

- ☐ I can explain the scale and causes of food waste and connect John 6:12 to stewardship.
- ☐ I can audit waste and calculate its cost.
- ☐ I cooked a frittata from foods that needed to be used, safely to 160 °F.

LAB NOTEBOOK

1. Copy your waste log and graph the value by cause.
2. Draw a refrigerator map showing your use-it-up shelf and FIFO order.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{weekly waste value} = \sum(\text{cost of each food thrown away})$$
$$\text{yearly savings} = 52 \times \text{weekly reduction}$$

From history. During the First World War the U.S. Food Administration urged families to “use all leftovers” and not waste food so that more could be shipped to soldiers and allies; families signed pledge cards and hung them in their windows.

WORKED EXAMPLES

Example 1. In one week a family throws away half a bag of salad ($3.49 bag), 3 bananas ($0.25 each), 1 cup of leftover rice ($0.40), and a quarter of a loaf of bread ($3.29 loaf). What is the waste worth?

Show solution

1. $0.5(3.49) + 3(0.25) + 0.40 + 0.25(3.29) = 1.75 + 0.75 + 0.40 + 0.82 = \$3.72.$

Answer: About $3.72 this week; over a year, about $193 if it happened every week.

Example 2. If 30% of a family’s $240 weekly grocery spending were wasted, how much would that be per year? If they cut waste by two-thirds, what would they save?

Show solution

1. Weekly waste: $0.30 \times 240 = \$72$; yearly $52 \times 72 = \$3744$.
2. Savings: $\frac{2}{3} \times 3744 = \$2496$.

Answer: $3,744 a year wasted; cutting it by two-thirds saves about $2,496.

Example 3. Twelve baskets of fragments were gathered from five loaves and two fishes. If one basket held about the leftovers of 400 people's portions, how many portions did the fragments represent?

Show solution

1. $12 \times 400 = 4800$ portions (an illustration only; Scripture gives the twelve baskets, not their size).

Answer: The point is plain without the arithmetic: there was abundance, and none of it was wasted.

PRACTICE

1. Easy What did Jesus tell His disciples after feeding the five thousand?

   Show answer

   "Gather up the fragments that remain, that nothing be lost" (John 6:12).

2. Easy About what share of the U.S. food supply does the USDA estimate is wasted?

   Show answer

   30–40%.

3. Easy What does FIFO mean?

   Show answer

   First in, first out: use older food before newer food.

4. Medium Is a "Best if used by" date a safety date? Explain.

   Show answer

   No; it indicates quality. Properly stored food is often safe after it, though infant formula is an exception; use senses and safe storage.

5. Medium Give three uses for stale bread.

   Show answer

   Bread crumbs, croutons, bread pudding, French toast, panzanella, stuffing.

6. Medium Name three foods that should never be saved from waste.

Show answer

Moldy soft foods, slimy or foul-smelling food, food left in the danger zone more than 2 hours, leftovers older than 3–4 days.

7. Medium Why should bananas be stored apart from other fruit?

Show answer

They release ethylene gas, which speeds ripening of nearby fruit.

8. Hard A family wastes $28 of food a week. They cut it to $10. What do they save in a year?

Show answer

$936.

9. Hard Write a five-step plan to reduce waste in your kitchen this week.

Show answer

Example: plan meals and shop with a list; FIFO when putting away groceries; set a use-it-up shelf; plan a leftover night; freeze bread, bananas and extra portions before they spoil.

10. Challenge Explain how avoiding waste is both stewardship and food safety, and where the two must be balanced.

Show answer

Stewardship uses God's gifts and money wisely; safety protects health. Use food fully (leftovers, trimmings, stale bread) but discard anything spoiled, moldy, too old or left in the danger zone; wasting a little is better than making someone sick.

COMMON MISTAKES

- Throwing out food by the "best if used by" date alone.
- Saving food that is no longer safe.
- Buying in bulk without a plan to use it.
- Cooking far more than the family will eat without planning for leftovers.

Make it a game · Waste Audit Sprint. Open the fridge and set a five-minute timer. List everything near its date and plan three meals that use them, with a frittata among them. Sort the items first in, first out. Your parent counts how many you saved from the trash. Then explain what Best if used by really means. Beat your count weekly.

Scripture. “When they were filled, he said unto his disciples, Gather up the fragments that remain, that nothing be lost.” (John 6:12, KJV)

The Lord who provided more than enough still cared that nothing be wasted. Using leftovers well is a daily act of thankfulness.

UNIT 9

Meal Planning and Budgeting

A cook who can plan, shop and budget can feed a family well week after week. In this unit you will plan a week of family meals with planned leftovers and shared ingredients, learn the grocery strategies that began with Clarence Saunders's Piggly Wiggly in 1916, calculate cost per serving and build a weekly food budget, batch-cook and freeze meals the way Clarence Birdseye made possible, and cut food waste.

Scripture runs through the unit: Joseph storing grain in the good years, the ant gathering in summer, counting the cost before building, and Jesus telling His disciples to gather the fragments. The labs are real family meals: shepherd's pie, sheet-pan pizza, freezer burritos, batch meatballs and a use-it-up frittata, each with its cost calculated.

PREREQUISITES

- Units 1–8, especially food safety, cooling and freezing (Units 1 and 4) and MyPlate (Unit 8)
- Comfort with unit rates, percentages and simple budgets
- Access to grocery receipts or store prices

MASTERY CHECKLIST

- ☐ I can plan a week of balanced family dinners and write a grocery list from it.
- ☐ I can compare unit prices and use store strategies to save money.
- ☐ I can calculate cost per serving and build a weekly food budget.
- ☐ I can batch-cook, freeze, label and reheat meals safely.
- ☐ I can reduce food waste while keeping food safe.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **USDA Food and Nutrition Service: USDA Food Plans: Monthly Cost of Food Reports**: Free. Monthly sample food budgets at several levels for families of different sizes, useful as a reference point in Lesson 9.3.
- **FoodKeeper App (USDA FSIS)**: Free from FoodSafety.gov and app stores. How long foods keep in the pantry, refrigerator and freezer, for Lessons 9.4 and 9.5.
- **A freezer thermometer and freezer labels**: Inexpensive. Keep the freezer at 0 °F and label every package with contents and date.

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

9.1 Planning a Week of Family Meals: Joseph and the Seven Good Years
3 sessions of 50–90 minutes

9.2 Clarence Saunders, Piggly Wiggly and the Unit Price 3 sessions of 50–90 minutes

9.3 Cost per Serving and a Weekly Budget: The Rumford Kitchen
3 sessions of 50–90 minutes

9.4 Batch Cooking and the Freezer: Clarence Birdseye's Fast Freeze
3 sessions of 50–90 minutes

9.5 Gather Up the Fragments: Reducing Food Waste 3 sessions of 50 minutes

Unit 9 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   Name four parts of a good weekly meal plan.

2. **6 pts**

   A family of 6 eats 5 home-cooked dinners with 5 oz of cooked protein each. How many pounds of cooked protein?

3. **6 pts**

   Connect Joseph's plan in Genesis 41 to household meal planning.

4. **6 pts**

   Tell the Piggly Wiggly story and explain how it lowered prices.

5. **8 pts**

   Oats: 18 oz for $3.29 or 42 oz for $6.49. Find the unit prices and the percent savings of the better buy.

6. **6 pts**

   Give two reasons the larger package may not be the better buy.

7. **8 pts**

   A recipe uses ¾ of a 2-lb bag of carrots ($1.79), 1.5 lb of a 3-lb bag of onions ($2.99) and a $1.25 can of tomatoes. What do these cost?

8. **6 pts**

   Who was Ellen Swallow Richards, and what did the Rumford Kitchen show?

9. **6 pts**

   Chili for 8 costs $13.60; a restaurant charges $9.50 a bowl. Find the cost per serving and its food-cost percentage at the restaurant price.

10. **6 pts**

    Explain fast freezing and why it gives better quality.

11. **6 pts**

    Give the freezer temperature, three safe thawing methods, and the reheating temperature for leftovers.

12. **6 pts**

    A batch makes 48 meatballs; each meal uses 16. How many meals? If the batch costs $15.36, what is the meatball cost per meal?

13. **6 pts**

What share of U.S. food does the USDA estimate is wasted, and give three ways to waste less at home.

14. **6 pts**

Is “Best if used by” a safety date? When must food be thrown away regardless?

15. **4 pts**

A family wastes $35 of food a week and cuts it to $15. What is the yearly saving?

16. **8 pts**

Essay (one paragraph): Using two Scripture passages from this unit, explain how planning, budgeting and avoiding waste are part of stewardship.

ANSWER KEY

1. Any four: check the calendar; theme nights; planned leftovers; cross-used ingredients; MyPlate balance across the week; pantry check before the grocery list; a flexible night.
2. $6 \times 5 \times 5 = 150$ oz $= 9.4$ lb.
3. He looked ahead, measured how much to store, stored it well, and appointed someone responsible; a cook plans the week, measures needs, stores food safely and divides the work.
4. Clarence Saunders opened the first self-service grocery in Memphis in 1916; shoppers took goods from open, priced shelves, so fewer clerks were needed and costs fell.
5. 18 oz: 18.3¢/oz; 42 oz: 15.5¢/oz; savings $(18.3 - 15.5)/18.3 = 15\%$.
6. It may spoil or go stale before use; the smaller package may be on sale; you may not have room to store it.
7. $1.34 + $1.50 + $1.25 = $4.09.
8. MIT's first woman student and founder of home economics; in 1893 it showed nourishing lunches with their nutrients and cost (about 30 cents) posted.
9. $1.70; $1.70/9.50 = 17.9\%$.
10. Freezing quickly forms many small ice crystals that damage cells less, so thawed food keeps its texture and juices.
11. 0 °F; refrigerator, cold water changed every 30 minutes, microwave if cooking immediately; 165 °F.
12. 3 meals; $5.12.
13. 30–40%; plan and list, FIFO, use-it-up shelf, leftover night, freeze before spoiling, understand date labels.
14. No, it is a quality date (except infant formula). Throw away moldy, slimy or foul food, food left in the danger zone too long, or leftovers older than 3–4 days.
15. $1,040.
16. Answers vary. A strong answer uses Genesis 41, Proverbs 6:6–8, Luke 14:28 or John 6:12 to explain that food and money are gifts entrusted to us; planning ahead, counting the cost and gathering up leftovers honor the Giver, care for the family, and free resources to share with others.

UNIT PROJECT: A FAMILY MEAL PLAN AND BUDGET SPREADSHEET

Plan two weeks of family dinners with planned leftovers, theme nights and one batch-cooking session. Build a spreadsheet (on paper or a computer) listing each meal, its ingredients, quantities, unit prices and cost per serving, with a weekly total compared with your family's usual spending.

Shop for and cook at least four of the meals, including the batch session. Keep a waste log for both weeks. Finish with a one-page report showing what you planned, what you spent, what you saved and wasted, and what you would change, with receipts attached.

LOOK FOR	WHAT IT MEANS
Plan	Two complete weeks with planned leftovers, theme nights, MyPlate balance and a batch session.
Spreadsheet	Accurate unit prices, ingredient costs, cost per serving and weekly totals.
Cooking and safety	Four meals cooked well; batch meals cooled, frozen, labeled and reheated safely.
Waste log	Complete for two weeks, with causes and value.
Report	Clear comparison of plan, spending and waste, with honest improvements.

UNIT 10

Hospitality and the Capstone Meal

The end of cooking is not a plate of food but people fed and welcomed. In this final unit you will learn the history of the family table and saying grace, set a table and serve a meal in courses, cook for a crowd, plan a timeline that brings every dish to the table at once, and finally plan, budget, shop for, cook and serve a three-course meal for guests.

The stories run from Luther's table prayers and Chardin's *Saying Grace* to Emily Post's *Etiquette*, Fred Harvey's railroad restaurants, Sarah Josepha Hale's campaign for Thanksgiving, and Abraham's welcome of three strangers under the tree at Mamre. The motto of the course fits the capstone best of all: *Fabricando fit faber*, by making, one becomes a maker. By cooking for others, you become a cook and a host.

PREREQUISITES

- Units 1–9: every technique, safety rule, planning and budgeting skill of the course
- A parent at home and willing to help host
- Guests to invite (family, friends, neighbors)

MASTERY CHECKLIST

- ☐ I can describe the tradition of giving thanks at meals and keep a regular family table.
- ☐ I can set informal and formal places and serve courses in order.
- ☐ I can scale recipes for a crowd and adjust seasoning, pans and time.
- ☐ I can build and follow a backward timeline so several dishes are served hot together.
- ☐ I can plan, budget, cook and serve a three-course meal for guests with hospitality.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **The Emily Post Institute: Table Setting Guides**: Free. Diagrams of basic, informal and formal place settings for Lesson 10.2.
- **USDA FSIS: Let's Talk Turkey—A Consumer Guide to Safely Roasting a Turkey**: Free on the USDA Food Safety and Inspection Service website (fsis.usda.gov). Thawing and roasting times and safe temperatures for Lesson 10.4.
- **Place cards and a printed menu**: Optional and homemade. A simple card at each place and a handwritten menu make guests feel especially welcome at the capstone.

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

10.1 The Family Table and Saying Grace — 3 sessions of 50–90 minutes

10.2 Table Setting and Service: Emily Post and Martha's Kitchen
3 sessions of 50 minutes

10.3 Cooking for a Crowd: Fred Harvey and the Harvey Houses
3 sessions of 50–90 minutes

10.4 Timelines: Sarah Josepha Hale and the Thanksgiving Dinner
3 sessions of 50–90 minutes

10.5 The Capstone Meal: Abraham's Welcome — 3 sessions of 60–90 minutes

Unit 10 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   What did Luther's Small Catechism (1529) provide for family meals, and with which psalm do its table prayers begin?

2. **6 pts**

   Rolls need 20 min mixing, 80 min rising, 15 min shaping, 40 min proofing and 18 min baking. Dinner is at 6:15 p.m. When do you start?

3. **6 pts**

   Describe an informal place setting and the reason for two of its customs.

4. **6 pts**

   Who was Emily Post, and what did she say manners were for?

5. **6 pts**

   How much soup is needed for 12 guests at ¾ cup with 2 cups extra, in quarts?

6. **6 pts**

   What did Jesus say to Martha, and how does it apply to a host?

7. **8 pts**

   Scale a recipe for 6 to 40: give the yield factor, the amount of pasta if the original uses 1 lb, and how you would handle the salt.

8. **6 pts**

   Explain how Fred Harvey’s restaurants served passengers well in 30 minutes.

9. **6 pts**

   Why does one deep pan take longer to bake than two shallow pans holding the same food?

10. **6 pts**

    Tell how Sarah Josepha Hale helped establish Thanksgiving.

11. **8 pts**

    A 4-lb turkey breast roasts 22 min/lb and rests 20 min; prep is 15 min. Dinner is at 6:00 p.m. When do you start, and what can you do during the rest?

12. **6 pts**

    What is the critical path in a meal timeline? Give an example.

13. **8 pts**

    A capstone menu costs $48.80 for 8 diners. Find the cost per diner and the savings compared with a $30-per-person restaurant meal.

14. **6 pts**

    List six items in a capstone planning packet.

15. **6 pts**

    Give four food-safety rules for serving a meal to guests.

16. **4 pts**

    Essay (one paragraph): Using Genesis 18 and at least three skills from this course, describe what makes a meal truly hospitable.

ANSWER KEY

1. Simple prayers before and after meals; Psalm 145:15–16.
2. Total 2 h 53 min; start by 3:22 p.m.
3. Fork left; knife (blade in) and spoon right; glass above the knife; napkin left or on the plate. Reasons: outside-in order of use; blade facing in for safety; glass near the right hand.
4. Author of *Etiquette* (1922); manners exist for consideration of others, to put people at ease.
5. 11 cups ≈ 2¾ quarts.
6. That she was careful and troubled about many things, but one thing is needful; a host should serve well but not so busily that she misses the guests and the Lord.
7. Factor 6.67; about 6⅔ lb pasta; add about 75% of the scaled salt and adjust by taste.
8. Trains telegraphed the passenger count ahead; kitchens prepared the right amounts with planned menus and consistent standards, and the first course was ready on arrival.
9. Heat must travel farther to reach the center; time grows roughly with the square of the depth.
10. As editor of *Godey's Lady's Book*, she campaigned for 17 years; in 1863 she wrote to Lincoln, who proclaimed a national Thanksgiving.
11. $88 + 20 + 15 = 123$ min; start by 3:57 p.m. During the rest: make gravy, finish vegetables, bake rolls, carve.
12. The longest chain of tasks that must happen in order, which sets the earliest serving time; usually the roast (prep, roast, rest).
13. \$6.10 per diner; $240 - 48.80 =$ \$191.20 saved.
14. Menu, guest and allergy list, costed shopping list, prep list, backward timeline, oven-and-stove map, food-safety plan, table plan (any six).
15. Separate raw and ready-to-eat foods; cook to safe temperatures with a thermometer; hold hot food at 140 °F or above and cold at 40 °F or below; refrigerate leftovers within 2 hours; follow the cross-contact plan for allergies.
16. Answers vary. A strong answer connects Abraham's eagerness, generosity and attentiveness with specific skills (planning and timelines, safe cooking,

balanced menus, table setting and service, care for allergies) and with giving thanks.

UNIT PROJECT: THE CAPSTONE MEAL PORTFOLIO

Present your capstone meal (Lesson 10.5) as a portfolio: the complete planning packet (menu, guest and allergy list, costed shopping list, prep list, backward timeline, oven-and-stove map and food-safety plan), the receipts, the logs of actual times and temperatures, and photographs of the table and each course.

Add guest ratings and comments, a comparison of planned and actual cost and timing, and a two-page reflection on the whole year: the three skills you most improved, one failure you learned from, and how cooking has become a way to serve others. Include one recipe you created or adapted this year, written so someone else could cook it.

LOOK FOR	WHAT IT MEANS
Planning packet	Complete, realistic and reviewed in advance; balanced menu; allergies addressed.
Execution	Every dish meets its technique standard and safe temperature; courses served hot and on time.
Hospitality	Table set, guests welcomed, thanks given, host present with the guests; kitchen cleaned.
Records	Receipts, cost per diner, actual times, temperatures and photos complete and accurate.
Reflection and original recipe	Honest, specific reflection on the year; a clear, tested original or adapted recipe.

10.1 The Family Table and Saying Grace

OBJECTIVES

- Describe the long Christian practice of giving thanks at meals, including the table prayers in Luther's Small Catechism (1529).
- Explain why regular family meals matter, and plan a simple shared-table routine.
- Scale and time a yeast-roll recipe so warm bread reaches the table with the meal.
- Bake soft herbed dinner rolls for a family supper and lead or join in grace.

> **Warm-up.** Ask an older relative how meals were eaten in his or her childhood home: who cooked, who sat where, what was said before eating, what was talked about. Write down one thing you would like to bring back to your own table.

WATCH

How to Set a Table - Life Skills with Griffin Churchill

GriffinsLifeSkills · 1:51

https://www.youtube.com/watch?v=hpKYnvcx1Ao

> **WHEN TO WATCH**
> Before the lab: a quick guide to setting a simple family table before supper.

Note: A short life-skills video made by a young teen; simple and clear.

KEY TERMS

grace

A short prayer of thanks before (and sometimes after) a meal, from the Latin *gratias*, "thanks."

family table

The regular shared meal of a household, where food, conversation and prayer are shared.

proof (rolls)

The final rise of shaped dough, until puffy and nearly doubled.

egg wash

Beaten egg brushed on dough to give a shiny, golden crust (baked, so it is fully cooked).

timeline

A schedule worked backward from the time food must be served.

CORE IDEAS

The story. Christians have given thanks at meals since the beginning: Jesus gave thanks before feeding the five thousand and at the Last Supper, and Paul wrote that food is "sanctified by the word of God and prayer" (1 Timothy 4:5). In 1529 Martin Luther wrote his Small Catechism to help fathers teach the faith at home. Near the end he included simple table prayers for before and after meals, beginning with Psalm 145:15–16, "The eyes of all wait upon thee; and thou givest them their meat in due season." For centuries Christian families learned their table prayers by heart, and painters such as Jean-Siméon Chardin pictured children saying grace before supper.

How they figured it out. The habit of thanks grew from Scripture and was kept alive by repetition at the most ordinary daily event: the meal. Families found that a regular shared table did more than feed the body: it was where children learned manners, conversation, Scripture and the stories of the family. Many modern surveys have also found that teenagers who often eat with their families tend to do better in school and in many other ways, though researchers note that the meal is one part of a caring home rather than a cure-all.

The kitchen science. The family table also depends on simple logistics: a meal served at a set time, warm and together. Yeast rolls are a good test of timing. Dough must be mixed, risen (about 1–1½ hours at warm room temperature), shaped, proofed (30–45 minutes) and baked (15–20 minutes), so a cook must start about 3 hours before supper, or mix the dough the night before and let it rise slowly in the refrigerator. Rolls are done when golden and about 190 °F inside; brushing them with melted butter keeps them soft.

Let's cook. You will bake herbed dinner rolls on a timeline so they come out of the oven as the family sits down, set the table, and lead or join in grace. The technique standard: dough kneaded smooth, risen until doubled, rolls shaped evenly by weight, proofed until puffy, baked to 190 °F, and served warm at the planned time.

PICTURE STUDY



Saying Grace (Le Bénédicité), Jean-Siméon Chardin, 1740 · Oil on canvas · Musée du Louvre, Paris

Image: Wikimedia Commons, public domain

Chardin painted a quiet moment in a Paris household: the mother has set down the soup, and the youngest child folds her hands to say grace while her mother and sister wait. The painting was shown at the Paris Salon of 1740 and presented to King Louis XV.

Look closely

- Find the youngest child. What is she doing with her hands?
- Look at the mother's face. How is she waiting?
- Find the dishes on the table. What is being served?

Talk about it

1. Why do you think the mother waits for the child to finish?
2. What does this painting suggest about who teaches children to give thanks?
3. How does your family give thanks before a meal?

Safety first. Do not taste unbaked dough, which contains raw flour and egg. Bake the egg-washed rolls to 190 °F, and handle the hot pan with dry mitts. If anyone at the table has allergies, check the roll ingredients (wheat, milk, eggs) and offer an alternative.

KITCHEN LAB

Table Lab: Herbed Dinner Rolls on Time

You will bake dinner rolls on a written timeline so they are warm when the family sits down, set the table, and give thanks together.

You will need

- A digital scale, a large bowl and a bench scraper
- A 9 × 13-inch pan, greased
- A pastry brush and an instant-read thermometer
- A clock and your timeline
- Table settings for the family

Soft Herbed Dinner Rolls

Serves 16 rolls · Mix 20 min · Rise 1–1½ hr · Proof 40 min · Bake 15–20 min

Ingredients

- 480 g (4 cups) all-purpose flour
- 50 g (¼ cup) sugar
- 8 g (1½ teaspoons) salt
- 7 g (2¼ teaspoons) instant yeast
- 240 g (1 cup) warm milk, about 100 °F
- 57 g (4 tablespoons) butter, melted, plus 2 tablespoons for brushing
- 1 large egg, plus 1 egg beaten for egg wash
- 2 tablespoons chopped fresh herbs (parsley, chives, rosemary) or 2 teaspoons dried

Method

1. Mix the flour, sugar, salt, yeast and herbs. Add the milk, melted butter and 1 egg and mix to a soft dough.
2. Knead 8–10 minutes until smooth and elastic. Cover and rise in a warm place until doubled, 1–1½ hours.

3. Weigh the dough, divide into 16 equal pieces, and roll each into a tight ball by cupping it on the counter. Arrange in the pan in rows.
4. Cover and proof until puffy and touching, 30–45 minutes. Heat the oven to 375 °F (190 °C).
5. Brush with beaten egg. Bake 15–20 minutes, until golden and 190 °F in the center.
6. Brush with melted butter and serve warm.

Allergy check: Contains wheat, milk and eggs. Use plant milk and oil for milk-free; skip the egg wash and brush with milk for egg-free (use a little extra milk in the dough).

Steps

1. **Timeline.** Write the timeline backward from the time supper will be served, and post it.
2. Mix, rise, shape (by weight), proof and bake the rolls. Record the actual time of each step.
3. **Set the table** while the rolls bake.
4. **Give thanks.** Lead or join in a table prayer (one you have learned, or one you wrote).
5. **Table conversation.** Ask each person one good question (for example, “What was the best part of your day?”).
6. **Technique check.** Score 1–3: timeline followed, even rolls, proper proof, 190 °F, served warm on time.
7. **Repeat round.** Make the dough the night before and refrigerate it; compare flavor and convenience.

Tips

- Shape rolls by dragging them on an unfloured counter under a cupped hand to tighten them.
- Rolls baked touching in a pan stay soft on the sides.
- Leftover rolls freeze well; reheat wrapped in foil.

Check your work

- ☐ I can describe the practice of grace at meals and Luther’s table prayers.
- ☐ I can plan a baking timeline backward from serving time.

- [ ] I baked warm, even dinner rolls and served them at a family table with thanks.

LAB NOTEBOOK

1. Copy your timeline with planned and actual times.
2. Write out a table prayer you learned or wrote.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{start time} = \text{serving time} - (\text{mix} + \text{rise} + \text{shape} + \text{proof} + \text{bake})$$

$$\text{weight per roll} = \frac{\text{total dough weight}}{\text{number of rolls}}$$

> **From history.** Luther's table prayers ended with thanks after the meal from Psalm 136:1, "O give thanks unto the LORD; for he is good: for his mercy endureth for ever." Many families still close meals with a short prayer of thanks.

WORKED EXAMPLES

Example 1. Supper is at 6:00 p.m. Mixing takes 20 minutes, rising 75 minutes, shaping 15 minutes, proofing 40 minutes and baking 18 minutes. When must you start?

Show solution

1. Total: $20 + 75 + 15 + 40 + 18 = 168$ min $= 2$ h 48 min.
2. 6:00 p.m. − 2 h 48 min = 3:12 p.m.

Answer: Start by about 3:10 p.m. (or mix the dough the night before and refrigerate it).

Example 2. Your dough weighs 1,020 g. You want 16 equal rolls. How much should each weigh?

Show solution

1. $1020/16 = 63.75$ g.

Answer: About 64 g each. Weighing makes every roll the same size, so they bake evenly.

Example 3. The recipe makes 16 rolls; Sunday guests bring the count to 11 people at 2 rolls each. Scale the 480 g of flour.

Show solution

1. Rolls needed: 22. Factor $22/16 = 1.375$.
2. Flour $= 480 \times 1.375 = 660$ g.

Answer: 660 g of flour (and 1.375 times every other ingredient).

PRACTICE

1. Easy What does the word “grace” at meals come from?

   Show answer

   The Latin *gratias*, “thanks.”

2. Easy When did Luther publish his Small Catechism, and what did it include for meals?

   Show answer

   1529; simple table prayers for before and after meals, beginning with Psalm 145:15–16.

3. Easy What internal temperature shows yeast rolls are done?

   Show answer

   About 190 °F.

4. Medium Supper is at 5:30 p.m.; rolls need 2 h 40 min from start to finish. When do you start?

   Show answer

   2:50 p.m.

5. Medium How can you make rolls for a 6:00 p.m. supper if you are away all afternoon?

   Show answer

   Mix the dough the night before or in the morning and let it rise slowly in the refrigerator; shape when you get home, proof and bake.

6. Medium A dough weighs 900 g. How many 60-g rolls can you make?

Show answer

15.

7. Medium Give two reasons families have valued a regular shared table.

Show answer

Any two: giving thanks together, conversation and teaching, passing on manners and family stories, nourishing meals, a set time to gather.

8. Hard A roll recipe for 12 uses 360 g flour. You need 30 rolls. Scale the flour and write the yield factor.

Show answer

Factor 2.5; 900 g flour.

9. Hard Why does a cold refrigerator rise improve flavor?

Show answer

Yeast works slowly in the cold, giving time for flavorful compounds to form through slow fermentation.

10. Challenge Write a short table prayer in your own words that gives thanks for the food, the hands that prepared it and the people at the table, and explain how 1 Timothy 4:4–5 shapes it.

Show answer

Answers vary. A strong answer thanks God as the giver, mentions the cooks and farmers, asks blessing on the meal and the company, and explains that receiving food with thanksgiving and prayer “sanctifies” it.

COMMON MISTAKES

- Starting yeast bread too late for supper.
- Uneven rolls that bake at different rates.
- Underproofing, which gives dense rolls.
- Rushing grace or skipping it when busy.

Make it a game · Grace and Timing. Your parent names a dinner roll recipe and a dinner time. Work backward on paper to a timeline: proof, bake, egg wash, rest. Check each time for realism. Then recite a simple table prayer from memory, such as one from Luther's Small Catechism, and explain why family meals matter. Two timelines, no cheating.

Scripture. “For every creature of God is good, and nothing to be refused, if it be received with thanksgiving: For it is sanctified by the word of God and prayer.” (1 Timothy 4:4-5, KJV)

Food received with thanks becomes an occasion of worship. Grace at the table is not a formality but a confession that every good thing comes from God.

10.2 Table Setting and Service: Emily Post and Martha's Kitchen

OBJECTIVES

- Tell how Emily Post's *Etiquette* (1922) taught Americans practical manners grounded in consideration for others.
- Set an informal and a formal place setting correctly and explain the reasons behind the arrangement.
- Serve a meal in courses, serving and clearing in order, and calculate portions for a first course.
- Make and serve a first course of roasted butternut squash soup.

> **Warm-up.** Set one place at the table from memory. Then compare it with a diagram. Which things did you put in the right place? Why do you think forks go on the left?

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 your table. Notice the reasons he gives for where each piece goes.

Note: He sets a simple place with a water glass and explains each choice.

KEY TERMS

place setting

The dishes, flatware, glass and napkin set for one person.

informal setting

A dinner plate, fork on the left, knife (blade facing the plate) and spoon on the right, a water glass above the knife, and a napkin.

outside-in rule

Flatware is set in the order it will be used, from the outside toward the plate.

course

One part of a meal served in order, such as soup, main course and dessert.

etiquette

Customs of courtesy that help people treat one another with consideration.

CORE IDEAS

The story. Emily Post (1872–1960) was a writer from a well-to-do family who, after her divorce, supported herself by writing. In 1922 she published *Etiquette*. It became a best-seller and was revised many times. Post insisted that manners were not snobbery: their whole purpose was consideration for others, to make people comfortable. Her book explained the reasons behind table customs so that anyone could learn them.

How she figured it out. Post gathered the customs of her day and asked of each one: does it help people feel at ease? She kept the rules that did and explained them plainly. The place setting is a good example: flatware is set in the order of use, from the outside in, so no guest has to guess; the knife blade faces the plate for safety; the water glass sits above the knife so a right-handed guest can reach it without crossing the plate.

The kitchen science. Service has an order. In home service, the host or helpers serve guests from the left and clear from the right, serve the eldest or the guest of honor first, and wait until everyone is served before eating (unless the host says to begin). Hot food goes on warm plates, cold food on chilled plates. A first course should be small (about ¾–1 cup of soup) so guests are ready for the main course. In the Gospel, Martha served Jesus and was "cumbered about much serving," while Mary sat at His feet; Jesus did not condemn serving, but He reminded Martha that "one thing is needful." A good host serves well without being so busy that she misses her guests.

Let's cook. You will make roasted butternut squash soup and serve it as a first course at a table you have set correctly, then clear and bring the main course. The technique standard: squash roasted until caramelized, soup puréed smooth and

seasoned, table set correctly, soup served hot in warmed bowls in about 1-cup portions, and the courses served and cleared in order.

PICTURE STUDY



Kitchen Scene with Christ in the House of Martha and Mary, Diego Velázquez, 1618 · Oil on canvas · The National Gallery, London

Image: Wikimedia Commons, public domain

Velázquez painted this when he was about nineteen. In the front, a young woman works hard in the kitchen with fish, eggs, garlic and a mortar, looking unhappy as an older woman speaks to her. Through an opening in the wall we see the Gospel scene: Mary sitting at Jesus' feet while Martha stands.

Look closely

- Find the fish, eggs and garlic. What is being prepared?
- Look at the young woman's face. How does she seem to feel about her work?
- Find the scene in the background. Who is sitting and who is standing?

Talk about it

1. What do you think the older woman is saying to the young cook?
2. How can a cook serve well and still enjoy the guests?
3. What does Jesus' word to Martha mean for a busy host today?

> **Safety first.** Roast the squash with mitts and turn it with a spatula. Purée hot soup in a blender no more than half full with the lid vented under a towel, or use an immersion blender. Carry hot bowls on a tray and set them down from the guest's left, warning "hot bowl."

KITCHEN LAB

Service Lab: Roasted Butternut Squash Soup as a First Course

You will set a table for a three-course family dinner, serve the soup course in order, and clear for the main course.

You will need

- A rimmed sheet pan, a large pot and a blender or immersion blender
- Soup bowls warmed in a low oven, a ladle and a tray
- Place settings for each person (informal or formal)
- A table-setting diagram
- A measuring cup to portion

Roasted Butternut Squash Soup

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

Ingredients

- 1 large butternut squash (about 3 lb), peeled, seeded and cut in 1-inch cubes
- 1 onion, cut in wedges, and 2 carrots, cut in chunks
- 3 tablespoons olive oil and 1 teaspoon salt
- ½ teaspoon cinnamon and ¼ teaspoon nutmeg (optional)
- 4 cups (960 mL) chicken or vegetable broth
- ½ cup milk or cream (optional)
- 1 tablespoon maple syrup or brown sugar (optional) and 1 teaspoon lemon juice
- Garnish: toasted pumpkin seeds, a swirl of cream or yogurt, chopped chives

Method

1. Heat the oven to 425 °F (220 °C). Toss the squash, onion and carrots with the oil, salt and spices and roast on the sheet pan 35–40 minutes, turning once, until tender and browned at the edges.
2. Put the vegetables in the pot with the broth; simmer 10 minutes.

3. Purée until smooth (blender half full and vented, or immersion blender). Stir in the milk or cream and heat without boiling.
4. Balance with maple syrup, lemon juice and salt to taste.
5. Ladle about 1 cup into warmed bowls, garnish, and serve from the guest's left.

Allergy check: Contains milk if cream, milk or yogurt is used. Check the broth label. Pumpkin seeds are not among the nine major allergens.

Steps

1. **Set the table** for soup, main course and dessert, following a diagram; photograph one place setting.
2. Make the soup; warm the bowls.
3. **Serve in order.** Serve the soup to the eldest or guest of honor first, from the left; sit and begin when the host begins.
4. **Clear and serve the next course.** Clear soup bowls from the right, then bring the main course (from another lesson or the family's plan).
5. **Portion check.** Record how much soup you made, served and had left.
6. **Technique check.** Score 1–3: smooth, balanced soup, correct setting, hot service in warm bowls, courses served and cleared in order, calm hosting.
7. **Repeat round.** Host a second dinner with a cold first course (a salad on chilled plates).

Tips

- Warm bowls in a 200 °F oven for 10 minutes or fill them with hot water and dry them.
- Roasting brings out the squash's sweetness better than boiling.
- Practice carrying a tray of bowls with water first.

Check your work

- ☐ I can tell Emily Post's story and explain the reasons behind table customs.
- ☐ I can set informal and formal places correctly.
- ☐ I served a hot first course and cleared and served in order.

LAB NOTEBOOK

1. Draw an informal and a formal place setting, labeled.
2. Record your portion check and service notes.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{total soup} = \text{guests} \times \text{portion}$$

$$1 \text{ quart} = 4 \text{ cups}$$

From history. After Emily Post's death, the Emily Post Institute, run by her descendants, continued to revise her book. The 1922 first edition included advice on everything from introductions to how to write a thank-you note, which Post considered one of the most important courtesies of all.

WORKED EXAMPLES

Example 1. You will serve ¾ cup of soup to each of 10 people, with 2 extra cups for seconds. How many quarts do you need?

Show solution

1. $10 \times 0.75 + 2 = 9.5$ cups.
2. $9.5 / 4 = 2.4$ qt.

Answer: About 2½ quarts (10 cups).

Example 2. Your soup recipe makes 8 cups. How many times should you make it for the dinner above?

Show solution

1. $9.5 / 8 = 1.19$.

Answer: Make it 1¼ times (a yield factor of 1.25), or simply double it and freeze the extra.

Example 3. A butternut squash weighs 3 lb as purchased and yields about 70% usable flesh. How many pounds of flesh do two squash give?

Show solution

1. $2 \times 3 \times 0.70 = 4.2$ lb.

Answer: About 4.2 lb of usable squash.

PRACTICE

1. Easy In an informal setting, where do the fork, knife, spoon and water glass go?

   Show answer

   Fork left of the plate; knife (blade toward the plate) and spoon to the right; water glass above the knife.

2. Easy What is the "outside-in" rule?

   Show answer

   Use flatware starting from the outside, in the order it was set for each course.

3. Easy What did Emily Post say was the purpose of manners?

   Show answer

   Consideration for others: making people comfortable.

4. Medium From which side are guests served and cleared in home service?

   Show answer

   Served from the left and cleared from the right (a common custom).

5. Medium Why serve soup in warmed bowls?

   Show answer

   A cold bowl draws heat from the soup; warm bowls keep it hot.

6. Medium How many cups of soup for 14 guests at 1 cup each with 2 cups extra? How many quarts?

   Show answer

   16 cups; 4 quarts.

7. Medium What did Jesus tell Martha, and what does it teach a host?

Show answer

That she was troubled about many things but one thing is needful; serve well, but do not be so busy that you miss the people and the Lord.

8. Hard Describe a formal place setting for a meal of soup, main course, salad and dessert.

Show answer

From the outside: soup spoon farthest right, then the dinner knife; on the left the salad fork (outside if salad comes first) and dinner fork; dessert spoon and fork above the plate; bread plate and butter knife upper left; water glass above the knives; napkin on the plate or left.

9. Hard A squash yields 70%. How many pounds as purchased give 5 lb of flesh?

Show answer

$5 / 0.70 = 7.1$ lb.

10. Challenge Explain how three table customs show consideration for others.

Show answer

Answers vary: waiting until all are served so no one eats alone; passing food to the right in one direction so dishes do not collide; the knife blade facing in for safety; serving the eldest first as respect; not reaching across others.

COMMON MISTAKES

- Setting forks on the right or the knife blade outward.
- Serving soup in cold bowls.
- Huge first-course portions that spoil the appetite for the main course.
- A host so busy in the kitchen that she never sits with the guests.

> **Make it a game · Set the Table.** Set an informal and a formal place on the table in two minutes, using the outside-in rule. Your parent then removes one piece, and you name what is missing. Run it three times. Then tell why Emily Post tied manners to consideration for others. Try the setting blindfolded for a bonus round.

> **Scripture.** “And Jesus answered and said unto her, Martha, Martha, thou art careful and troubled about many things: But one thing is needful: and Mary hath chosen that good part, which shall not be taken away from her.” (Luke 10:41-42, KJV)
>
> Serving is good, and Jesus received Martha’s hospitality. But He reminded her that the most needful thing is to be with Him. A well-planned meal frees the host to sit down and enjoy the people at the table.

10.3 Cooking for a Crowd: Fred Harvey and the Harvey Houses

OBJECTIVES

- Tell how Fred Harvey's restaurants along the Santa Fe Railway served good meals to train passengers in about 30 minutes.
- Scale a recipe for a crowd with a yield factor, adjusting pans, seasoning and cooking time.
- Plan equipment and oven space for a large meal.
- Bake a baked ziti for 12, scaled from a family recipe.

> **Warm-up.** Look at your largest pot and your largest baking dish. Estimate how many servings each could hold. Then think: what would you need to feed 24 people at a church supper?

WATCH

Scaling up/down recipes | Increasing/decreasing recipes all explained

Hanbit Cho · 7:11

https://www.youtube.com/watch?v=1EYMHAmtAHM

> **WHEN TO WATCH**
> After the kitchen-science paragraph. Note how he scales by multiplier and by pan size.

Note: A professional pastry chef and teacher explains scaling factors and pan-area scaling.

BACKUP VIDEO

Scaling a Recipe

Association of Nutrition & Foodservice Professionals · 1:38

https://www.youtube.com/watch?v=nTZLHfpvOF0

A short review of the conversion factor from a foodservice professionals' association.

KEY TERMS

yield factor (conversion factor)

New yield divided by old yield; multiply every ingredient by it.

hotel pan

A rectangular steel pan used in restaurants; a full pan is about 12 × 20 inches, about two 9 × 13 pans.

holding

Keeping cooked food hot (at 140 °F or above) or cold (at 40 °F or below) until it is served.

portion control

Serving consistent amounts with scoops, ladles or a planned cut so everyone gets a fair share and the food lasts.

potluck

A shared meal to which each family brings a dish.

CORE IDEAS

The story. In the 1870s, rail travelers in the American West often ate terrible food at station stops: stale bread, rancid meat and bitter coffee, gulped down before the train left. Fred Harvey, an English-born businessman, opened his first restaurant with the Atchison, Topeka and Santa Fe Railway in Topeka, Kansas, in 1876, and soon a chain of "Harvey Houses" lined the route. Trains telegraphed ahead the number of passengers; staff had the first course on the table when they arrived; and a full, well-cooked meal on linen tablecloths was served in about 30 minutes. His waitresses, the Harvey Girls, were young women hired from the East and Midwest under strict rules of conduct.

How he figured it out. Harvey solved a problem of numbers and time. Knowing the count in advance, the kitchen could prepare exactly enough. Menus were planned and rotated so that passengers on a long trip did not see the same meal twice. Every Harvey House kept the same standards and portions, so travelers knew what to expect. It was a system of planning, scaling and consistency, much like Escoffier's brigade.

The kitchen science. To cook for a crowd, multiply each ingredient by the **yield factor**. But not everything scales simply: seasonings and strong spices should be added at about 75% of the scaled amount and adjusted by taste; liquids may need

slight reduction because larger pots evaporate less per serving; and cooking time depends on the depth of the food, not just the amount. Two 9 × 13 pans bake in about the same time as one, but one very deep pan takes much longer. Hot food for a crowd must be held at 140 °F or above and served within the safe time, and leftovers cooled by the two-stage rule.

Let's cook. You will scale a family baked-ziti recipe for 6 up to 12, divide it between two 9 × 13 pans, bake it, and serve it with portion control. The technique standard: correct scaled amounts, sauce seasoned by taste, pasta slightly underdone before baking, two pans baked evenly to 165 °F in the center, cut into equal portions, and leftovers cooled safely.

PICTURE STUDY



Helping the Plates at Dinner on the Grounds, All-Day Community Sing, Pie Town, New Mexico, Russell Lee, Farm Security Administration, 1940 · Photograph · Library of Congress, Washington, D.C.
Image: Wikimedia Commons, public domain

In 1940 Russell Lee photographed the homesteaders of Pie Town, New Mexico, at an all-day community singing, with "dinner on the grounds" at noon. Each family brought food to share, and many hands served a crowd.

Look closely

- Find the dishes on the table. How many families might have brought food?
- Look at who is serving. How are plates being filled?
- Look at the setting. What equipment did they have, and what did they lack?

Talk about it

1. How did these families feed a crowd without a restaurant kitchen?
2. What food-safety concerns would you think about at an outdoor community meal?
3. What dish would you bring to a dinner like this, and how much?

Safety first. Cook the meat to 160 °F and bake the ziti until the center reaches 165 °F. Keep hot food at 140 °F or above while serving, and refrigerate leftovers in shallow containers within 2 hours. Lift heavy, hot pans with two dry mitts.

KITCHEN LAB

Crowd Lab: Baked Ziti for Twelve

You will scale a family recipe for twelve, plan equipment, bake two pans and serve controlled portions.

You will need

- A large pot (8 quarts or more) and a colander
- A large skillet
- Two 9 × 13-inch baking dishes
- An instant-read thermometer and a large spoon or spatula for portions
- Foil

Baked Ziti for a Crowd

Serves 12 (two 9 × 13 pans) · Prep 40 min · Bake 30–35 min

Ingredients

- 2 lb (900 g) ziti or penne
- 2 lb (900 g) Italian sausage (casings removed) or ground beef
- 2 onions, diced; 6 cloves garlic, minced
- 8 cups marinara (Lesson 5.2) or four 24-oz jars
- 30 oz (850 g) ricotta cheese
- 2 large eggs
- 1 cup (80 g) grated Parmesan, divided
- ¼ cup chopped parsley; 1 teaspoon dried basil
- 4 cups (16 oz) grated mozzarella
- Salt to taste (start with 2¼ teaspoons in the sauce and meat, then taste)

Method

1. Heat the oven to 375 °F (190 °C). Boil the pasta in two batches or a very large pot 2–3 minutes less than the package time. Drain.
2. Brown the sausage with the onions until no pink remains and it reads 160 °F; add the garlic for 1 minute. Stir in the marinara and simmer 10

minutes. Taste and adjust the salt.

3. Mix the ricotta, eggs, ½ cup Parmesan, parsley and basil.
4. Toss the pasta with about two-thirds of the sauce. In each dish layer: half that dish's pasta, dollops of ricotta mixture, a cup of mozzarella, the rest of the pasta, the remaining sauce, and the remaining mozzarella and Parmesan.
5. Cover with foil and bake 20 minutes; uncover and bake 10–15 minutes more, until bubbling, browned and 165 °F in the center.
6. Rest 10 minutes. Cut each pan 3 × 4 and serve with a salad and bread.

Allergy check: Contains wheat, milk and eggs. Sausage may contain soy or milk; check the label. Use gluten-free pasta for wheat-free.

Steps

1. **Scale.** Start from a recipe for 6 and write the scaled amounts for 12 and for 50 in a table.
2. **Equipment plan.** List every pot, pan and utensil you need and check that your oven holds both pans.
3. Cook and assemble; record the temperature of each pan's center.
4. **Portion control.** Cut and serve 12 equal portions; weigh one and record it.
5. **Leftovers.** Cool and refrigerate leftovers properly; record the time.
6. **Technique check.** Score 1–3: accurate scaling, seasoning adjusted by taste, even baking, safe temperatures, equal portions.
7. **Repeat round.** Bring a scaled dish to a church, school or neighborhood gathering and record how many it fed.

Tips

- Underdone pasta finishes in the oven and does not turn mushy.
- Rotate the pans halfway through baking if your oven heats unevenly.
- A casserole assembled ahead can be refrigerated; add 15–20 minutes to the covered baking time.

Check your work

☐ I can tell the Harvey House story.

☐ I can scale recipes for a crowd and adjust seasoning, pans and time.

- [ ] I baked and served baked ziti for twelve safely and fairly.

LAB NOTEBOOK

1. Copy your scaling table for 6, 12 and 50.
2. Draw your oven with the pans placed and your equipment list.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{yield factor} = \frac{\text{new yield}}{\text{old yield}}$$

Seasoning for big batches: start with about $0.75\times$ the scaled amount, then taste

$$\text{pans} = \frac{\text{total volume}}{\text{volume per pan}}$$

From history. A 1946 movie, *The Harvey Girls*, made the waitresses famous. Many of the women married in the West and settled there; the Harvey company's strict standards of courtesy and cleanliness influenced restaurant service across America.

WORKED EXAMPLES

Example 1. A baked ziti for 6 uses 1 lb pasta, 1 lb ground beef or sausage, 4 cups marinara, 15 oz ricotta, 2 cups mozzarella and 1½ tsp salt (in the sauce). Scale it for 12.

Show solution

1. Yield factor $= 12/6 = 2$.
2. Pasta 2 lb; meat 2 lb; marinara 8 cups; ricotta 30 oz; mozzarella 4 cups.
3. Salt: scaled $1.5 \times 2 = 3$ tsp; start with $0.75 \times 3 \approx 2.25$ tsp and taste.

Answer: Double everything except the salt: begin with about 2¼ teaspoons and adjust by taste.

Example 2. Now scale the same recipe for 50 at a church supper. What is the yield factor, how many pounds of pasta, and how many 9 × 13 pans if each holds 6 servings?

Show solution

1. Factor $= 50/6 = 8.33$.
2. Pasta $= 8.33$ lb; buy 9 lb.
3. Pans $= 50/6 = 8.3$, so 9 pans (or 5 full hotel pans).

Answer: Factor 8⅓: about 8⅓ lb pasta (buy 9 lb), baked in 9 pans of 9 × 13 inches.

Example 3. Each 9 × 13 pan is cut 3 × 4. If the pan's food weighs 3.6 kg, how much is one portion?

Show solution

1. 12 portions; $3600/12 = 300$ g.

Answer: About 300 g (10½ oz) per portion.

PRACTICE

1. Easy When and where did Fred Harvey open his first railway restaurant?

   Show answer

   1876, in Topeka, Kansas, with the Santa Fe Railway.

2. Easy What is the yield factor to scale a recipe for 8 up to 20?

   Show answer

   2.5.

3. Easy At what temperature must hot food be held for a crowd?

   Show answer

   140 °F or above.

4. Medium Why add only about 75% of the scaled salt and spices at first?

   Show answer

   Seasoning does not always scale linearly; large batches can become too salty or spicy, so add most and adjust by taste.

5. Medium Why does a deep pan of casserole take longer to bake than two shallow pans with the same food?

Show answer

Heat must travel farther to the center of a deep pan; time grows with depth (about with the square of thickness).

6. Medium A chili recipe for 6 uses 2 lb beans. How much for 45?

Show answer

15 lb.

7. Medium How did trains help Harvey Houses serve meals in 30 minutes?

Show answer

They telegraphed ahead the number of passengers so the kitchen could have food ready.

8. Hard Scale ¾ cup of milk for a recipe going from 4 to 18 servings. Give cups.

Show answer

Factor 4.5; $0.75 \times 4.5 = 3.375$ cups (3⅜ cups).

9. Hard A potluck expects 40 people; each dish should provide about 10 servings. You bring a main dish. How many 9 × 13 pans of ziti (12 portions each) cover a quarter of the guests?

Show answer

10 portions needed; 1 pan.

10. Challenge Plan oven space and timing for baking 4 pans of ziti for 6:00 p.m. in a home oven that fits 2 pans at once, with each batch baking 45 minutes and resting 10.

Show answer

Bake batch 1 from about 4:20 to 5:05 and hold it covered in a warm place at 140 °F or above (or a 200 °F warming oven); bake batch 2 from 5:05 to 5:50; rest and serve at 6:00. Keep batch 1 hot and check temperatures.

COMMON MISTAKES

- Multiplying salt and spices fully for a big batch.
- Using one very deep pan so the center stays cold.

- Running out of oven space because the plan was not checked.
- Leaving food for a crowd out too long.

> **Make it a game · Scale It Up.** Your parent names a recipe for 4, such as baked ziti. Compute the yield factor to feed 12 and scale five ingredients in sixty seconds. Name a hotel pan fit and a holding temperature. Run three recipes. Then tell how Fred Harvey fed train passengers in about thirty minutes.

> **Scripture.** “Use hospitality one to another without grudging.” (1 Peter 4:9, KJV)
>
> Cooking for a crowd is hard work. Peter asks believers to offer hospitality gladly, without complaint, as a gift to one another.

10.4 Timelines: Sarah Josepha Hale and the Thanksgiving Dinner

OBJECTIVES

- Tell how Sarah Josepha Hale's seventeen-year campaign led President Lincoln to proclaim a national Thanksgiving in 1863.
- Build a backward timeline that brings several dishes to the table hot at the same time.
- Schedule oven and stovetop use so dishes do not compete for space.
- Cook a roast turkey breast with pan gravy, green beans and mashed potatoes on a timeline.

> **Warm-up.** Think of a holiday meal at your house. What was the hardest part of getting everything to the table at once? What was cold, late, or burned?

WATCH

History of Thanksgiving - Sarah Josepha Hale

Fun School Media · 2:28

https://www.youtube.com/watch?v=Dy7HiC4nnJ0

> **WHEN TO WATCH**
> After the story. Note the dates and the people Hale wrote to.

Note: A short history of Hale's campaign with period pictures.

KEY TERMS

backward scheduling

Planning a meal by starting at serving time and working back through each dish's cooking, resting and prep times.

critical path

The longest chain of tasks that must happen in order; it sets the earliest possible serving time.

make-ahead dish

A dish prepared hours or a day before and reheated or served cold.

holding

Keeping finished dishes hot (140 °F or above) without overcooking them.

resting

Letting roast meat sit after cooking so carryover finishes and juices settle; a good time to finish the sides.

CORE IDEAS

The story. Sarah Josepha Hale (1788–1879) was a widowed mother of five who became one of the most influential editors in America at *Godey's Lady's Book*, a popular magazine; she also wrote the poem "Mary Had a Little Lamb." For seventeen years she wrote editorials and letters to governors and presidents urging a national day of Thanksgiving. In 1863, in the middle of the Civil War, she wrote to President Abraham Lincoln, and he proclaimed a national day of Thanksgiving for the last Thursday of November. Hale's magazine also printed menus and recipes that helped make roast turkey, stuffing and pumpkin pie the traditional dinner.

How she figured it out. Hale was persistent and patient, and she planned: year after year she published the case for the holiday and described how families could celebrate it. Every Thanksgiving cook since has faced the same challenge of planning: one oven, many dishes, and a family that wants everything hot at once.

The kitchen science. A meal timeline is built backward from serving time. List each dish with its prep, cooking and resting time. Find the **critical path**, usually the roast, which needs the most time and the oven. Use the roast's **rest** (15–30 minutes) to finish stovetop dishes and gravy, or to bake a side in the now-empty oven. Choose some **make-ahead** dishes (pies, cranberry sauce, rolls) and some that hold well (mashed potatoes in a covered pot over low heat). Write the schedule with clock times, and set the table early.

Let's cook. You will cook a smaller Thanksgiving-style dinner: roast turkey breast to 165 °F, pan gravy, mashed potatoes and green beans, all served hot at a planned time. The technique standard: a written backward timeline, turkey breast at 165 °F and rested, gravy smooth, potatoes held hot, green beans bright, and every dish on the table within 5 minutes of the planned time.

PICTURE STUDY



The First Thanksgiving at Plymouth, Jennie Augusta Brownscombe, 1914 · Oil on canvas · Pilgrim Hall Museum, Plymouth, Massachusetts

Image: Wikimedia Commons, public domain

Jennie Brownscombe painted this imagined scene of the 1621 harvest feast at Plymouth nearly 300 years later. Historians note details she imagined, but the painting shows how Americans in her day pictured the first Thanksgiving: a shared outdoor meal opened with thanks to God.

Look closely

- Find the man giving thanks. What are others doing while he prays?
- Find the women carrying dishes. What foods can you see?
- Look at the guests. Who has been invited to the table?

Talk about it

1. What would it have taken to cook a feast for many people over open fires in 1621?
2. What did the cooks need to plan, and in what order?
3. Why do you think Sarah Josepha Hale wanted the whole nation to have a day of thanks?

> **Safety first.** Do not rinse the raw turkey; pat it dry and wash hands, board and sink area after handling it. Roast to 165 °F in the thickest part of the breast, not touching bone. Keep hot dishes at 140 °F or above while holding, and refrigerate leftovers within 2 hours.

KITCHEN LAB

Timeline Lab: Turkey Breast Dinner on Time

You will write a backward timeline for a four-dish dinner and cook it so everything is hot on the table at the planned minute.

You will need

- A roasting pan or 12-inch oven-safe skillet
- A large pot for potatoes, a skillet or pot for green beans, a saucepan or the roasting pan for gravy
- An instant-read thermometer and a carving board
- A clock, your timeline and a pencil
- Serving dishes and a set table

Roast Turkey Breast with Pan Gravy, Mashed Potatoes and Green Beans

Serves 6 · About 2 hours from start to table

Ingredients

- 1 bone-in, skin-on turkey breast (3–4 lb)
- 2 tablespoons softened butter or olive oil, 1½ teaspoons salt, ½ teaspoon pepper, 1 teaspoon dried thyme or sage
- **Gravy:** pan drippings, 2 tablespoons butter if needed, 3 tablespoons flour, 2 cups (480 mL) turkey or chicken broth, salt and pepper
- **Potatoes:** 3 lb potatoes, ¾ cup warm milk, 4 tablespoons butter, salt
- **Green beans:** 1½ lb green beans, 1 tablespoon butter or oil, salt, lemon juice

Method

1. Heat the oven to 350 °F (175 °C). Pat the turkey dry; rub with butter and the seasonings, under and over the skin. Wash your hands.
2. Roast skin-side up 70–90 minutes (about 20–25 minutes per pound), until 165 °F in the thickest part. Move to a board and rest 20 minutes.

3. Meanwhile boil, drain and mash the potatoes with milk and butter; hold covered over very low heat.
4. Gravy: pour off all but 3 tablespoons fat from the pan (add butter if needed). Over medium heat whisk in the flour 1 minute; whisk in the broth, scraping up the browned bits, and simmer 3–5 minutes until thick. Season.
5. Green beans: boil 4–5 minutes in salted water until bright and tender-crisp; drain and toss with butter, salt and lemon.
6. Carve the turkey across the grain and serve everything at once.

Allergy check: Contains milk (butter, milk) and wheat (flour in the gravy). Use oil and plant milk for milk-free, and a cornstarch slurry for wheat-free gravy.

Steps

1. **Timeline.** Write a backward timeline with clock times for every task for all four dishes and the table. Mark the critical path.
2. **Oven and stove map.** Note which burner or oven each dish uses at each time, and check for conflicts.
3. Cook by the timeline, writing the actual time beside each planned time.
4. Record the turkey's final temperature and the temperature of each dish when served.
5. **On-time score.** Record how many minutes early or late each dish reached the table.
6. **Technique check.** Score 1–3: complete timeline, no equipment conflicts, turkey at 165 °F and rested, smooth gravy, hot potatoes, bright beans, served together.
7. **Repeat round.** Add one dish (stuffing, rolls or a pie) to the timeline and cook the meal again.

Tips

- Write the timeline in large print and tape it near the stove.
- Set the table and fill water glasses before the last 30 minutes.
- If the turkey is done early, tent it loosely with foil; it will stay warm for 30–40 minutes.

Check your work

- ☐ I can tell Sarah Josepha Hale's story.
- ☐ I can build and follow a backward timeline with a critical path.
- ☐ I served a four-dish dinner hot and on time.

LAB NOTEBOOK

1. Copy your timeline with planned and actual times, highlighting the critical path.
2. Draw your oven-and-stove map.
3. Write the lab record with a family rating and one change for the repeat round.

KEY FORMULAS

$$\text{start time} = \text{serve time} - (\text{prep} + \text{cook} + \text{rest})$$

Turkey breast at 350 °F: roughly 20–25 min per lb (confirm with a thermometer)

From history. Hale also championed the Bunker Hill Monument in Boston and the preservation of George Washington's home at Mount Vernon. She edited *Godey's Lady's Book* for about forty years, retiring in 1877 at the age of eighty-nine.

WORKED EXAMPLES

Example 1. A 3½-lb bone-in turkey breast roasts at about 22 minutes per pound and rests 20 minutes. Dinner is at 5:00 p.m., and prep takes 15 minutes. When do you start?

Show solution

1. Roast: $3.5 \times 22 = 77$ min.
2. Total: $15 + 77 + 20 = 112$ min $= 1$ h 52 min.
3. 5:00 p.m. − 1 h 52 min = 3:08 p.m.

Answer: Start prep at about 3:05 p.m.; turkey in the oven by 3:20; out at about 4:37 (when 165 °F); rest until 4:57.

Example 2. Mashed potatoes take 35 minutes (peel, boil, mash); green beans 12 minutes; gravy 10 minutes after the turkey comes out. Fit them into the turkey's timeline for 5:00 p.m.

Show solution

1. Potatoes: start at 4:20, done 4:55 (hold covered on low).
2. Gravy: 4:40–4:50, while the turkey rests.
3. Green beans: 4:48–5:00.
4. Carve the turkey at 4:57.

Answer: Potatoes 4:20, gravy 4:40, beans 4:48, carve 4:57, serve 5:00.

Example 3. Lincoln proclaimed Thanksgiving in 1863 after Hale had campaigned for 17 years. In what year did her campaign begin?

Show solution

1. $1863 - 17 = 1846$.

Answer: About 1846.

PRACTICE

1. Easy Who was Sarah Josepha Hale, and what did she accomplish in 1863?

   Show answer

   Editor of *Godey's Lady's Book* and author of "Mary Had a Little Lamb"; her campaign led Lincoln to proclaim a national Thanksgiving in 1863.

2. Easy What is backward scheduling?

   Show answer

   Planning from serving time back through each dish's times to find when to start each one.

3. Easy What is the safe temperature for turkey?

   Show answer

   165 °F.

4. Medium A pie bakes 55 minutes and cools 2 hours. Dinner and dessert are at 5:00 p.m. and 6:00 p.m. When must the pie go in, at the latest?

Show answer

By 3:05 p.m. (or bake it the day before).

5. Medium Why is the roast usually on the critical path?

Show answer

It takes the longest and occupies the oven.

6. Medium Name two ways to use the roast's rest time.

Show answer

Make gravy; finish stovetop vegetables; bake rolls or a side in the now-free oven; set the table.

7. Medium How can mashed potatoes be held hot for 20 minutes?

Show answer

Covered in the pot over very low heat or in a 200 °F oven, stirring in a little warm milk if they thicken.

8. Hard Write a timeline for rolls (bake 18 min), turkey breast (out at 4:35, rest 25 min) and stuffing (bake 35 min at the same temperature) for a 5:00 p.m. dinner with one oven.

Show answer

Stuffing in with the turkey from about 3:55 to 4:30; turkey out 4:35; rolls in 4:38–4:56 while the turkey rests; carve and serve at 5:00.

9. Hard A 12-lb whole turkey roasts about 13 min/lb at 325 °F and rests 30 minutes. Dinner is at 2:00 p.m. When should it go in?

Show answer

$12 \times 13 = 156$ min; plus 30 = 3 h 6 min; in by about 10:55 a.m.

10. **Challenge** Explain how Hale's seventeen-year campaign shows the same virtues needed to put on a great family meal.

Show answer

Patience, persistence, planning ahead, attention to detail and a purpose bigger than oneself (gratitude to God); answers should connect each to planning a meal.

COMMON MISTAKES

- Starting with the quickest dishes instead of the roast.
- Two dishes needing the oven at different temperatures at the same time.
- Making gravy before the roast is out (there are no drippings yet).
- Forgetting the rest time in the timeline.

Make it a game · Backward Schedule. Your parent sets the serving time at 6:00 p.m. for a turkey breast, potatoes, vegetables and rolls. Build a backward timeline on paper in five minutes, marking the critical path and resting times. Then your parent breaks it: the oven is late by thirty minutes. Reschedule. Explain Sarah Hale's seventeen-year campaign.

Scripture. "Enter into his gates with thanksgiving, and into his courts with praise: be thankful unto him, and bless his name." (Psalm 100:4, KJV)

Thanksgiving was a habit of God's people long before it was a national holiday. Every carefully cooked meal can be an act of praise when it is received with thanks.

10.5 The Capstone Meal: Abraham's Welcome

OBJECTIVES

- Plan, budget, shop for, cook and serve a three-course meal for guests, using skills from the whole course.
- Write a menu, a costed shopping list, a prep list, a backward timeline and a food-safety plan.
- Serve the meal with hospitality: a set table, grace, courses in order and attention to guests.
- Reflect honestly on the results and plan improvements.

> **Warm-up.** Read Genesis 18:1–8. List every task Abraham and Sarah did to welcome their guests, and the speed at which they did them. What can you learn from them about hospitality?

WATCH

Hospitality: What It Is, and What It's Not

Crossway · 1:52

https://www.youtube.com/watch?v=QU6re-MRaXs

> **WHEN TO WATCH**
> During the warm-up, after reading Genesis 18. Write one sentence on how her idea of hospitality differs from simply entertaining.

Note: From Crossway, a Christian publisher: an author speaks briefly on hospitality as welcome rather than display.

KEY TERMS

hospitality

Welcoming guests, especially strangers, with food, rest and kindness; from the Latin *hospes*, guest or host.

menu

The planned list of dishes and courses for a meal.

three-course meal

A first course (soup or salad), a main course with sides, and dessert.

prep list

Every task needed for the menu, with times, in the order it must be done.

mise en place

Everything ready before cooking begins (Lesson 1.2), now for a whole meal.

CORE IDEAS

The story. In Genesis 18, Abraham sat in the door of his tent in the heat of the day when three strangers appeared. He ran to meet them, bowed, and offered water for their feet, rest under the tree and "a morsel of bread." Then he hurried: Sarah made cakes from three measures of fine meal on the hearth; a young man prepared a tender calf; Abraham brought butter and milk and stood by his guests under the tree while they ate. The guests were the LORD and two angels, bringing the promise of a son. Hospitality in Scripture is eager, generous and attentive.

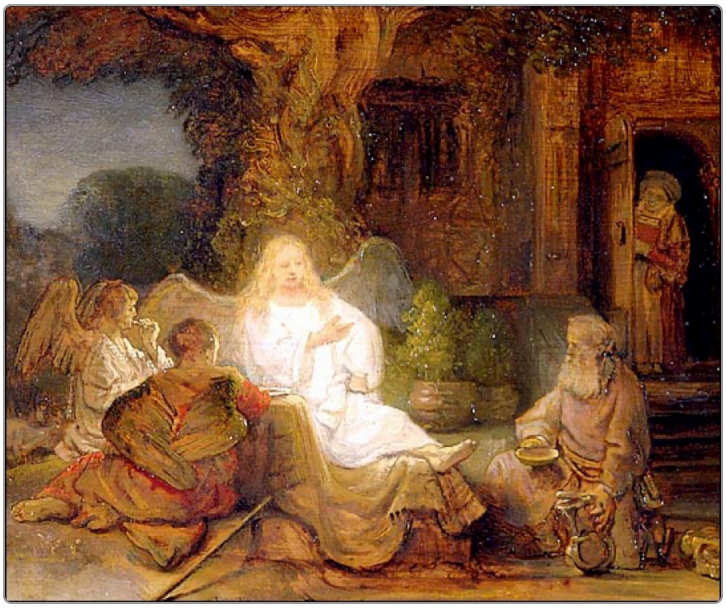
How they figured it out. Abraham's household had what every good host needs: food on hand, many hands willing to help, and a host who put the guests first. Your capstone brings together every unit of this course to do the same: safety and order from Unit 1, knife skills from Unit 2, cooking methods from Units 3 and 4, sauces and baking from Units 5 and 6, flavor and plating from Unit 7, balance from Unit 8, planning and budgeting from Unit 9, and the table and timeline from this unit.

The kitchen science. A successful guest meal depends on planning more than on difficulty. Choose dishes you have made before; balance the menu by color, texture, flavor and MyPlate; include at least one make-ahead course; make sure the oven and stove plan works; account for guests' allergies (Lesson 8.5); budget with unit prices and cost per serving; write a prep list and a backward timeline; and plan safe temperatures, holding and cooling. Then, on the day, set the table early, greet guests, give thanks and enjoy them.

Let's cook. You will plan and serve a three-course meal for at least four guests beyond your family, or for your family with honored guests such as grandparents. A model menu is given below; you may substitute any dishes from this course. The technique standard: the plan is complete and realistic; every dish meets its standard

from the lesson where you learned it; every safe temperature is reached and recorded; the meal is served hot and on time, in courses, at a set table, with grace; and the kitchen is cleaned.

PICTURE STUDY



Abraham Serving the Three Angels, Rembrandt van Rijn, 1646 · Oil on panel · Private collection
Image: Wikimedia Commons, public domain

Rembrandt painted Genesis 18 in warm, glowing light: three heavenly visitors rest beneath the tree at Mamre while old Abraham, humble and attentive, serves them himself, and Sarah listens at the door. Rembrandt shows hospitality as something done with one's own hands.

Look closely

- Find Abraham. What is he doing, and what is his posture?
- Find the dish and the food. What has been served?
- Find Sarah. Where is she, and why?

Talk about it

1. What does Abraham's posture teach about being a host?
2. How did Abraham and Sarah prepare a meal so quickly for unexpected guests?
3. Whom could you welcome to your table this year?

Safety first. Write a food-safety plan before the meal: separate boards for raw meat, the thermometer checks for every protein (chicken 165 °F), holding hot food at 140 °F or above, and refrigerating leftovers within 2 hours. Ask every guest about food allergies in advance and follow your cross-contact plan. A parent is at home for the whole capstone.

KITCHEN LAB

Capstone: A Three-Course Meal for Guests

This is the final kitchen lab. You plan, budget, shop for, cook and serve a three-course meal for guests, bringing together the whole course.

You will need

- All the equipment for your menu (see each lesson)
- An instant-read thermometer
- Your planning packet: menu, guest and allergy list, costed shopping list, prep list, timeline, oven-and-stove map, food-safety plan
- Table settings, serving dishes and place cards (optional)
- A camera

Model Capstone Menu (substitute any dishes from this course)

Serves 8 · Plan 1 week ahead · Shop 1–2 days ahead · Cook about 3 hours

Ingredients

- **First course:** Green salad with cucumbers, carrots and a shaken vinaigrette (⅓ cup olive oil, 2 tablespoons cider vinegar, 1 teaspoon Dijon mustard, 1 teaspoon honey, salt, pepper)
- **Main course:** Two herb-roasted chickens with root vegetables (Lesson 3.2, doubled)
- Soft herbed dinner rolls (Lesson 10.1)
- Pan gravy from the drippings (Lesson 5.3 method)
- **Dessert:** Apple crisp with an oat topping (Lesson 8.5 crisp, scaled by 1.33), served warm, with whipped cream or yogurt if you like

Method

1. **One week ahead:** invite guests and ask about allergies; choose and balance the menu; write the costed shopping list.
2. **The day before:** shop; make the rolls' dough and refrigerate it; make the vinaigrette; wash and dry the salad greens; set the table.

3. **About 3 hours before:** shape the rolls and let them proof; prepare the chickens and vegetables; assemble the crisp.
4. **Following your timeline:** bake the crisp first (it holds well) or during the meal; roast the chickens to 165 °F; bake the rolls while the chickens rest; make the gravy.
5. **Serve:** welcome guests, give thanks, serve the salad, then the main course carved and plated or served family style, then the warm crisp.
6. **Afterward:** refrigerate leftovers within 2 hours; clean the kitchen with your helpers.

Allergy check: The model menu contains milk (butter, cream), wheat (rolls, flour, possibly oats) and eggs (rolls). Adjust with the swaps in each lesson for your guests' allergies.

Steps

1. **Plan.** Complete the planning packet and have a parent review it a week ahead.
2. **Budget.** Calculate the estimated cost per diner; after shopping, record the actual cost.
3. **Mise en place.** Prepare the day-before and morning tasks on schedule.
4. **Cook and log.** Follow the timeline, writing actual times and every safe temperature.
5. **Host.** Greet guests, lead or join in grace, serve courses in order, and sit down to enjoy the meal.
6. **Clean up.** Store leftovers safely and leave the kitchen clean.
7. **Reflect.** Collect guest ratings and comments, compare planned and actual times and costs, and write a two-page reflection.
8. **Repeat round.** Within a month, host another guest meal using what you learned.

Tips

- Choose one impressive dish and keep the rest simple.
- Do as much as possible the day before.
- Ask a sibling to be your commis: assign clear jobs, as Escoffier did.

Check your work

- ☐ I planned, budgeted and shopped for a three-course meal.
- ☐ I cooked every dish to its standard and safe temperature.
- ☐ I served guests hot food on time at a set table, with thanks and hospitality.

LAB NOTEBOOK

1. Keep your complete planning packet in the notebook.
2. Paste photos of the table and plates, and your timeline with actual times.
3. Write your two-page reflection and a list of three skills you most improved this year.

KEY FORMULAS

$$\text{cost per guest} = \frac{\text{total cost}}{\text{number of diners}}$$

$$\text{yield factor} = \frac{\text{diners}}{\text{recipe servings}}$$

$$\text{start time} = \text{serve time} - (\text{prep} + \text{cook} + \text{rest})$$

From history. Hospitality to strangers was a mark of the early church; the Roman emperor Julian, in the 300s, complained that Christians fed not only their own poor but pagans too. Christian households and monasteries were known for centuries as places where travelers could find bread and a bed.

WORKED EXAMPLES

Example 1. Your model menu for 8: salad with vinaigrette $6.20; roast chicken (two birds) $15.80; roasted potatoes and carrots $4.60; dinner rolls $2.40; apple crisp $6.50. Find the total and the cost per diner. A restaurant would charge about $28 per person. How much does home hospitality save?

Show solution

1. Total $= 6.20 + 15.80 + 4.60 + 2.40 + 6.50 = \$35.50$.
2. Per diner $= 35.50/8 = \$4.44$.
3. Restaurant: $8 \times 28 = \$224$; savings $\$224 - 35.50 = \$188.50$.

Answer: $35.50 total, about $4.44 per diner, saving about $188 compared with a restaurant, and offering a welcome no restaurant can.

Example 2. The roast chicken recipe (Lesson 3.2) serves 4–6 from one 4½-lb bird. How many birds for 8 diners with leftovers for lunch the next day (10 servings)?

Show solution

1. Using 5 servings per bird: $10/5 = 2$ birds.

Answer: Two chickens, roasted side by side on one large pan or two pans.

Example 3. Dinner is at 6:30 p.m. The chickens roast 75 minutes at 425 °F and rest 15 minutes; prep takes 20 minutes. The rolls bake 18 minutes at 375 °F and should go in when the chickens come out. When do the chickens go in, and do the rolls finish on time?

Show solution

1. Chickens: out at $6{:}30 - 15 \text{ min} = 6{:}15$, in at 6:15 − 75 min = 5:00 p.m.; prep from 4:40.
2. Rolls: in at 6:15, plus a few minutes for the oven to cool to 375 °F, out at about 6:36, six minutes late.
3. Fix: start the chickens 10 minutes earlier (4:50 p.m.) so they come out at 6:05 and rest 25 minutes; the rolls bake from about 6:08 to 6:26.

Answer: Chickens in at 4:50 p.m. rather than 5:00, so the rolls come out at about 6:26. Test every timeline on paper before the day.

PRACTICE

1. Easy List the three courses of the model menu.

   Show answer

   Salad with vinaigrette; roast chicken with roasted vegetables and rolls; apple crisp.

2. Easy Name five documents in your capstone plan.

   Show answer

   Menu, costed shopping list, prep list, backward timeline, food-safety plan (plus guest and allergy list, table plan).

3. Easy What did Sarah make for Abraham's guests?

Show answer

Cakes of fine meal baked on the hearth.

4. Medium Your menu costs $42.60 for 6 diners. What is the cost per diner?

Show answer

$7.10.

5. Medium Why choose dishes you have cooked before for a guest meal?

Show answer

They are tested; you know the timing and technique, so there is less risk and stress.

6. Medium Give three ways to check a menu for balance.

Show answer

Color, texture and flavor contrast; MyPlate groups covered; a mix of rich and light dishes; one make-ahead course.

7. Medium A guest has a sesame allergy. Which dishes from this course would you avoid or change?

Show answer

Hummus with tahini (7/8 lessons), sesame oil in fried rice or steamed fish sauce; check bread and roll labels; use the swaps given.

8. Hard Scale the apple crisp (serves 6) for 8 diners and list the yield factor and the fruit amount (5 cups).

Show answer

Factor 1.33; about 6⅔ cups fruit.

9. Hard Identify two possible conflicts in a timeline where a roast at 425 °F, a crisp at 375 °F and rolls at 375 °F share one oven, and propose fixes.

Show answer

Two temperatures at once: bake the crisp before the roast (it holds well) or after, during the meal; bake rolls during the roast's rest at 375 °F or rewarm pre-baked rolls.

10. **Challenge** Write a one-paragraph reflection plan: what questions will you ask yourself and your guests afterward, and how will you use the answers?

    Show answer

    Answers vary. Strong plans ask about timing, temperature, flavor, portions, conversation and welcome; record guest ratings; compare plan with actual times and costs; and choose specific improvements for the next meal.

COMMON MISTAKES

- Choosing too many new or difficult dishes.
- Forgetting to ask about allergies.
- A timeline never tested on paper.
- Being so busy in the kitchen that you never sit with your guests.

Make it a game · Pitch the Capstone. Pitch your three-course guest meal to your parent in two minutes: menu, costed shopping list, prep list and a timeline. Your parent plays a skeptical guest and asks three hard questions about allergies, budget and timing. Answer each in one sentence. Then name Abraham's welcome and the lesson of hospitality.

Scripture. "And Abraham hastened into the tent unto Sarah, and said, Make ready quickly three measures of fine meal, knead it, and make cakes upon the hearth. And Abraham ran unto the herd, and fetcht a calf tender and good, and gave it unto a young man; and he hasted to dress it. And he took butter, and milk, and the calf which he had dressed, and set it before them; and he stood by them under the tree, and they did eat." (Genesis 18:6-8, KJV)

Abraham's household gave their best, quickly and gladly, and Abraham stood by his guests while they ate. That is the heart of hospitality, and the goal of everything you have learned this year.

UNIT 10

Hospitality and the Capstone Meal

The end of cooking is not a plate of food but people fed and welcomed. In this final unit you will learn the history of the family table and saying grace, set a table and serve a meal in courses, cook for a crowd, plan a timeline that brings every dish to the table at once, and finally plan, budget, shop for, cook and serve a three-course meal for guests.

The stories run from Luther's table prayers and Chardin's *Saying Grace* to Emily Post's *Etiquette*, Fred Harvey's railroad restaurants, Sarah Josepha Hale's campaign for Thanksgiving, and Abraham's welcome of three strangers under the tree at Mamre. The motto of the course fits the capstone best of all: *Fabricando fit faber*, by making, one becomes a maker. By cooking for others, you become a cook and a host.

PREREQUISITES

- Units 1–9: every technique, safety rule, planning and budgeting skill of the course
- A parent at home and willing to help host
- Guests to invite (family, friends, neighbors)

MASTERY CHECKLIST

- ☐ I can describe the tradition of giving thanks at meals and keep a regular family table.
- ☐ I can set informal and formal places and serve courses in order.
- ☐ I can scale recipes for a crowd and adjust seasoning, pans and time.
- ☐ I can build and follow a backward timeline so several dishes are served hot together.
- ☐ I can plan, budget, cook and serve a three-course meal for guests with hospitality.

OPTIONAL BOOKS AND TOOLS FOR THIS UNIT

- **The Emily Post Institute: Table Setting Guides**: Free. Diagrams of basic, informal and formal place settings for Lesson 10.2.
- **USDA FSIS: Let's Talk Turkey—A Consumer Guide to Safely Roasting a Turkey**: Free on the USDA Food Safety and Inspection Service website (fsis.usda.gov). Thawing and roasting times and safe temperatures for Lesson 10.4.
- **Place cards and a printed menu**: Optional and homemade. A simple card at each place and a handwritten menu make guests feel especially welcome at the capstone.

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

10.1 The Family Table and Saying Grace — 3 sessions of 50–90 minutes

10.2 Table Setting and Service: Emily Post and Martha's Kitchen
3 sessions of 50 minutes

10.3 Cooking for a Crowd: Fred Harvey and the Harvey Houses
3 sessions of 50–90 minutes

10.4 Timelines: Sarah Josepha Hale and the Thanksgiving Dinner
3 sessions of 50–90 minutes

10.5 The Capstone Meal: Abraham's Welcome — 3 sessions of 60–90 minutes

Unit 10 test

Calculators are allowed. Show your work and units for every calculation, and answer the concept questions in complete sentences. The test is worth 100 points.

1. **6 pts**
   What did Luther's Small Catechism (1529) provide for family meals, and with which psalm do its table prayers begin?

2. **6 pts**

   Rolls need 20 min mixing, 80 min rising, 15 min shaping, 40 min proofing and 18 min baking. Dinner is at 6:15 p.m. When do you start?

3. **6 pts**

   Describe an informal place setting and the reason for two of its customs.

4. **6 pts**

   Who was Emily Post, and what did she say manners were for?

5. **6 pts**

   How much soup is needed for 12 guests at ¾ cup with 2 cups extra, in quarts?

6. **6 pts**

   What did Jesus say to Martha, and how does it apply to a host?

7. **8 pts**

   Scale a recipe for 6 to 40: give the yield factor, the amount of pasta if the original uses 1 lb, and how you would handle the salt.

8. **6 pts**

   Explain how Fred Harvey’s restaurants served passengers well in 30 minutes.

9. **6 pts**

   Why does one deep pan take longer to bake than two shallow pans holding the same food?

10. **6 pts**

    Tell how Sarah Josepha Hale helped establish Thanksgiving.

11. **8 pts**

    A 4-lb turkey breast roasts 22 min/lb and rests 20 min; prep is 15 min. Dinner is at 6:00 p.m. When do you start, and what can you do during the rest?

12. **6 pts**

    What is the critical path in a meal timeline? Give an example.

13. **8 pts**

    A capstone menu costs $48.80 for 8 diners. Find the cost per diner and the savings compared with a $30-per-person restaurant meal.

14. **6 pts**

    List six items in a capstone planning packet.

15. **6 pts**

    Give four food-safety rules for serving a meal to guests.

16. **4 pts**

    Essay (one paragraph): Using Genesis 18 and at least three skills from this course, describe what makes a meal truly hospitable.

ANSWER KEY

1. Simple prayers before and after meals; Psalm 145:15–16.
2. Total 2 h 53 min; start by 3:22 p.m.
3. Fork left; knife (blade in) and spoon right; glass above the knife; napkin left or on the plate. Reasons: outside-in order of use; blade facing in for safety; glass near the right hand.
4. Author of *Etiquette* (1922); manners exist for consideration of others, to put people at ease.
5. 11 cups ≈ 2¾ quarts.
6. That she was careful and troubled about many things, but one thing is needful; a host should serve well but not so busily that she misses the guests and the Lord.
7. Factor 6.67; about 6⅔ lb pasta; add about 75% of the scaled salt and adjust by taste.
8. Trains telegraphed the passenger count ahead; kitchens prepared the right amounts with planned menus and consistent standards, and the first course was ready on arrival.
9. Heat must travel farther to reach the center; time grows roughly with the square of the depth.
10. As editor of *Godey's Lady's Book*, she campaigned for 17 years; in 1863 she wrote to Lincoln, who proclaimed a national Thanksgiving.
11. $88 + 20 + 15 = 123$ min; start by 3:57 p.m. During the rest: make gravy, finish vegetables, bake rolls, carve.
12. The longest chain of tasks that must happen in order, which sets the earliest serving time; usually the roast (prep, roast, rest).
13. \$6.10 per diner; $240 - 48.80 =$ \$191.20 saved.
14. Menu, guest and allergy list, costed shopping list, prep list, backward timeline, oven-and-stove map, food-safety plan, table plan (any six).
15. Separate raw and ready-to-eat foods; cook to safe temperatures with a thermometer; hold hot food at 140 °F or above and cold at 40 °F or below; refrigerate leftovers within 2 hours; follow the cross-contact plan for allergies.
16. Answers vary. A strong answer connects Abraham's eagerness, generosity and attentiveness with specific skills (planning and timelines, safe cooking,

balanced menus, table setting and service, care for allergies) and with giving thanks.

UNIT PROJECT: THE CAPSTONE MEAL PORTFOLIO

Present your capstone meal (Lesson 10.5) as a portfolio: the complete planning packet (menu, guest and allergy list, costed shopping list, prep list, backward timeline, oven-and-stove map and food-safety plan), the receipts, the logs of actual times and temperatures, and photographs of the table and each course.

Add guest ratings and comments, a comparison of planned and actual cost and timing, and a two-page reflection on the whole year: the three skills you most improved, one failure you learned from, and how cooking has become a way to serve others. Include one recipe you created or adapted this year, written so someone else could cook it.

LOOK FOR	WHAT IT MEANS
Planning packet	Complete, realistic and reviewed in advance; balanced menu; allergies addressed.
Execution	Every dish meets its technique standard and safe temperature; courses served hot and on time.
Hospitality	Table set, guests welcomed, thanks given, host present with the guests; kitchen cleaned.
Records	Receipts, cost per diner, actual times, temperatures and photos complete and accurate.
Reflection and original recipe	Honest, specific reflection on the year; a clear, tested original or adapted recipe.

COURSE EXAM

Midterm Exam

Covers Units 1–5. Time: 100 minutes.

You have 100 minutes. A calculator is allowed; no notes. Use $c_{\text{water}} = 4.186\ \text{J/(g·°C)}$, $L_v = 2260\ \text{J/g}$ and $C = \tfrac{5}{9}(F - 32)$. For every calculation write the formula, substitute with units and give the answer with its unit; correct work earns partial credit. Answer concept questions in complete sentences. The exam has 26 problems worth a total of 100 points.

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1. **3 pts** **Lesson 1.1**

   Name the station chefs for sauces, roasts and pastry in Escoffier’s brigade, and explain the critical path in one sentence.

2. **4 pts** **Lesson 1.1**

   Scale a recipe for 8 to 30 servings: give the yield factor and the new amount of an ingredient that was 1¼ lb.

3. **4 pts** **Lesson 1.2**

   You buy 5.0 lb of onions and keep 4.4 lb after peeling. Find the yield percentage and the as-purchased weight needed for 6 lb usable.

4. **4 pts** **Lesson 1.3**

   Bacteria double every 20 minutes. How many will 40 become in 2 hours 40 minutes?

5. **4 pts** **Lesson 1.3**

   What is a healthy carrier? Name the historical example and the bacterium.

6. **4 pts** **Lesson 1.4**

   Give the USDA safe minimum internal temperatures for poultry, ground beef, whole cuts of pork and fish, and convert 160 °F to °C.

7. **4 pts** **Lesson 1.5**

   Soup is 135 °F at 1:00 p.m., 72 °F at 3:00 p.m. and 40 °F at 6:00 p.m. Does it pass the two-stage cooling rule?

8. **3 pts** **Lesson 2.1**

   A blade is 1.8 inches wide. What spine height gives a 17° sharpening angle?

9. **3 pts** **Lesson 2.1**

   Explain honing versus sharpening and why stainless steel resists rust.

10. **4 pts** **Lesson 2.2**

    Compare the surface-to-volume ratios of ⅛-inch brunoise and ½-inch medium dice, and estimate how many times longer medium dice take to cook if time grows with the square of thickness.

11. **3 pts** **Lesson 2.3**

    Convert 2 tablespoons of fresh thyme to dried, and explain why a dull knife darkens basil.

12. **4 pts** **Lesson 2.4**

    How much heat warms a 2.0-kg cast-iron pan (c = 0.45 J/(g·°C)) from 20 °C to 220 °C?

13. **4 pts** **Lesson 2.5**

    A student scoops 145 g for a 120-g cup of flour. Find the percent error, and convert 340 g to ounces.

14. **4 pts** **Lesson 3.1**

    Explain why crowded mushrooms steam instead of browning, and compute the energy to evaporate 180 g of water.

15. **4 pts** **Lesson 3.2**

    A 4-lb chicken roasts at 16 min/lb and rests 15 minutes; dinner is at 6:00 p.m. When must it go in? What is carryover cooking?

16. **4 pts** **Lesson 3.3**

    Using the inverse-square rule, compare broiler intensity at 4 and 6 inches. What did Herschel discover in 1800?

17. **4 pts** **Lesson 3.4**

    How much oil makes a ¼-inch layer in a skillet with a 10-inch flat bottom (1 cup ≈ 14.4 in^3)? What do you do if the oil catches fire?

18. **4 pts** **Lesson 3.5**

Your thermometer reads 31 °F in ice water and 143 °F in a pork roast. What is the true temperature, and is it done?

19. **4 pts** **Lesson 4.1**

How much energy heats 4 kg of water from 15 °C to 100 °C? What did Joseph Black discover?

20. **4 pts** **Lesson 4.2**

Compare the heat given to skin by 3 g of steam at 100 °C condensing and cooling to 40 °C with 3 g of water cooling from 100 °C to 40 °C.

21. **4 pts** **Lesson 4.3**

Explain why a pot roast is braised to about 200 °F, and find the cost per 4-oz cooked serving of a 3-lb, $6.29/lb roast with a 65% yield.

22. **4 pts** **Lesson 4.4**

Give the mirepoix ratio and the amounts in 16 oz; why is stock simmered, not boiled?

23. **4 pts** **Lesson 4.5**

About what temperature does water boil in a pressure cooker at full pressure, and roughly how many times faster does food cook if every 10 °C doubles the rate?

24. **4 pts** **Lesson 5.1**

How much butter and flour make 4 cups of medium béchamel, and why does a roux prevent lumps?

25. **4 pts** **Lesson 5.2–5.3**

How many times more acidic is pH 4.2 than pH 6.2? What is fond, and how is a pan sauce made from it?

26. **4 pts** **Lesson 5.4–5.5**

Explain why overcooked scrambled eggs weep, and write the reaction that makes buttermilk pancakes rise.

ANSWER KEY

1. Saucier, rôtisseur, pâtissier. The critical path is the longest chain of tasks that must happen in order; it sets the earliest finish time.
2. Factor 3.75; $1.25 \times 3.75 = 4.7$ lb.
3. 88%; $6 / 0.88 = 6.8$ lb.
4. 8 doublings: $40 \times 2^8 = 10{,}240$.
5. A person who spreads an illness without feeling sick; Mary Mallon, *Salmonella* Typhi.
6. 165 °F; 160 °F; 145 °F with a 3-minute rest; 145 °F. $\frac{5}{9}(128) = 71.1$ °C.
7. No: Stage 1 requires 70 °F or below by 3:00 p.m.; 72 °F fails (Stage 2 would pass).
8. $1.8 \times \sin 17^\circ = 0.53$ in.
9. Honing realigns the edge; sharpening grinds a new edge. Chromium forms a thin, self-healing oxide layer.
10. 48 in^{-1} and 12 in^{-1}; $(0.5/0.125)^2 = 16$ times (roughly).
11. 2 teaspoons dried; crushed cells release enzymes that brown the leaves (enzymatic browning).
12. $2000 \times 0.45 \times 200 = 180{,}000$ J.
13. 20.8%; 12.0 oz.
14. Water released cannot escape, so the food sits in liquid at 212 °F, too cool for fast browning; $180 \times 2260 = 406{,}800$ J.
15. 64 + 15 = 79 min: in by 4:41 p.m. Carryover: the temperature rise after leaving the oven as stored heat moves inward.
16. $(6/4)^2 = 2.25$ times as intense at 4 inches; infrared radiation, invisible heat beyond red light.
17. $\pi(5)^2(0.25) = 19.6$ $in^3 \approx 1.4$ cups. Turn off the heat and cover with a lid or sheet pan; never water; call 911 if it spreads.
18. It reads 1 °F low: true 144 °F; not yet 145 °F; cook a little longer, then rest 3 minutes.
19. $4000 \times 4.186 \times 85 = 1.42 \times 10^6$ J; latent heat.
20. Steam $3(2260) + 3(4.186)(60) = 7533$ J; water 753 J; about 10 times more.
21. Collagen needs long, moist heat to become gelatin. Cooked 31.2 oz ≈ 7.8 servings; $\$18.87 / 7.8 = \$2.42$.

22. 2:1:1; 8 oz onion, 4 oz carrot, 4 oz celery. Boiling clouds and greases it.
23. About 121 °C (250 °F); $2^{2.1} \approx 4$ times faster.
24. 8 Tbsp each; fat coats the flour so it disperses before the starch swells.
25. 100 times. Fond is browned bits from searing; deglaze with broth, thicken with a roux or slurry, season.
26. The protein network tightens and squeezes out water. $\mathrm{NaHCO_3} + \mathrm{H^+} \rightarrow \mathrm{Na^+} + \mathrm{H_2O} + \mathrm{CO_2}$.

COURSE EXAM

Final Exam

Covers Units 1–10. Time: 120 minutes.

You have 120 minutes. A calculator is allowed; no notes. Use $c_{\text{water}} = 4.186\ \text{J/(g}\cdot\text{°C)}$, $L_v = 2260\ \text{J/g}$, 4/4/9 kcal per gram, 4 g sugar ≈ 1 tsp, and the USDA safe temperatures. Show the formula, the substitution with units and the answer with its unit for every calculation. The exam has 30 problems worth a total of 100 points.

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1. **3 pts** **Lesson 1.2**

   Celery yields 75%. How much should you buy for 3 lb usable?

2. **3 pts** **Lesson 1.4**

   Convert the danger zone 40–140 °F to °C and state the two-hour rule.

3. **3 pts** **Lesson 1.5**

   State the FDA two-stage cooling rule and three ways to meet it.

4. **3 pts** **Lesson 2.2**

   How many ¼-inch dice come from a 3-inch cube?

5. **4 pts** **Lesson 2.4–2.5**

   How much heat warms a 1.2-kg aluminum pan (c = 0.90) from 20 °C to 200 °C? Convert 1¾ cups of flour to grams (120 g/cup).

6. **3 pts** **Lesson 3.1**

   Why pat meat dry before searing?

7. **4 pts** **Lesson 3.5**

   Explain the USDA's 2011 change for pork and why the rest time is part of the standard.

8. **3 pts** **Lesson 4.1**

   Why does salting pasta water not make it cook faster?

9. **3 pts** **Lesson 4.3**

   Why do tough cuts become tender in a braise?

10. **3 pts** **Lesson 4.5**

    Name three pressure-cooker safety rules.

11. **3 pts** **Lesson 5.1**

    How much roux (each of fat and flour) for 3 cups of thin béchamel?

12. **3 pts** **Lesson 5.4**

    To what temperature are egg dishes cooked, and why?

13. **4 pts** **Lesson 6.1**

    Make 1,500 g of dough at flour 100%, water 70%, salt 2%, yeast 1.0%. Give each weight.

14. **3 pts** **Lesson 6.2**

    Explain how kneading and yeast make bread rise.

15. **3 pts** **Lesson 6.3**

    What causes tunnels in muffins?

16. **4 pts** **Lesson 6.4–6.5**

    Give the 3-2-1 pie-dough amounts for 240 g flour and the pound-cake amounts for 300 g flour.

17. **4 pts** **Lesson 7.1**

    Soup weighs 2,000 g. How much salt makes it 1.0%? How many teaspoons of table salt (6 g)?

18. **3 pts** **Lesson 7.2**

    Name the plant parts of cinnamon, cloves and nutmeg, and give the date and place da Gama reached India.

19. **3 pts** **Lesson 7.3**

    How many ingredient pairs are possible among 9 ingredients?

20. **4 pts** **Lesson 7.4**

    Describe the two-zone method for bone-in chicken and four grill safety rules.

21. **3 pts** **Lesson 7.5**

Flank steak loses 25% when cooked. How much raw steak for 6 portions of 4 oz cooked?

22. **4 pts** **Lesson 8.2**

A meal has 90 g carbohydrate, 35 g protein and 20 g fat. Find its energy and the percentage from protein.

23. **3 pts** **Lesson 8.3**

A drink has 30 g added sugars per serving and 2 servings. How many teaspoons in the bottle, and what %DV?

24. **3 pts** **Lesson 8.4**

Describe accurately what dopamine does, and name three things that help satiety.

25. **3 pts** **Lesson 8.5**

List the nine major allergens and define cross-contact.

26. **4 pts** **Lesson 9.2–9.3**

Coffee-free cocoa mix: 8 oz for $3.29 or 24 oz for $8.49. Find unit prices. A chili costing $14.40 serves 9: cost per serving?

27. **3 pts** **Lesson 9.4**

Why does fast freezing give better quality, and how should frozen meat be thawed?

28. **3 pts** **Lesson 9.5**

A family cuts food waste from $30 to $12 a week. What is the yearly saving?

29. **4 pts** **Lesson 10.3–10.4**

Scale a recipe for 6 to 45 (yield factor), and find the start time for a dinner at 5:30 p.m. needing 20 min prep, 90 min roasting and 20 min rest.

30. **4 pts** **Lesson 10.5**

Essay (two paragraphs): Describe how you would plan and serve a three-course meal for eight guests, one of whom has a peanut allergy. Include the menu, budget method, timeline, food-safety and allergy plan, service and the spirit of hospitality, drawing on at least five units.

ANSWER KEY

1. 4 lb.
2. 4.4–60 °C; perishable food may stay in the danger zone no more than 2 hours (1 hour above 90 °F).
3. 135→70 °F in 2 h, then →41 °F in 4 more; shallow pans, ice bath with stirring, smaller containers.
4. $(3/0.25)^3 = 1728$
5. $1200 \times 0.90 \times 180 = 194{,}400$ J; 210 g.
6. Surface water must evaporate (2,260 J/g) before the surface can exceed 212 °F and brown.
7. Whole cuts became safe at 145 °F with a 3-minute rest; killing germs depends on temperature and time, and the rest supplies the time.
8. Salt raises the boiling point only a small fraction of a degree.
9. Long, moist heat converts collagen into gelatin.
10. Parent present; fill ≤ ⅔ (½ for beans); check gasket and valve; lock the lid; release pressure as directed; never force it open.
11. 3 Tbsp each.
12. 160 °F; it kills harmful bacteria such as *Salmonella*, and the egg is fully set.
13. Total 173%: flour 867 g, water 607 g, salt 17 g, yeast 9 g.
14. Kneading builds an elastic gluten network; yeast makes CO_2, which the network traps.
15. Overmixing, which develops too much gluten.
16. Pie: 160 g fat, 80 g water. Pound cake: 300 g each of butter, sugar and eggs.
17. 20 g; about 3⅓ tsp.
18. Bark, flower buds, seed; Calicut, May 1498.
19. 36.
20. Sear over direct heat, finish over indirect heat with the lid closed to at least 165 °F. Any four: adult lights charcoal; no liquid starter; outdoors away from house; long tongs; lid and extinguisher ready; never unattended; coals cool 24–48 h.
21. 32 oz (2 lb).
22. $360 + 140 + 180 = 680$ kcal; protein $140/680 = 21\%$.
23. 15 tsp; 120% DV.

24. It is tied to wanting and learning what is rewarding; fiber, protein and water (and eating slowly).
25. Milk, eggs, fish, crustacean shellfish, tree nuts, peanuts, wheat, soybeans, sesame; transfer of an allergen protein to another food or surface.
26. 41.1¢/oz and 35.4¢/oz; $1.60.
27. Small ice crystals damage cells less; thaw in the refrigerator, in cold water changed every 30 minutes, or in the microwave if cooking right away.
28. $936.
29. Factor 7.5; total 2 h 10 min; start by 3:20 p.m.
30. Answers vary. A strong essay names a balanced menu of tested dishes; costs it with unit prices and cost per diner; writes a backward timeline with a critical path and oven map; lists safe temperatures, holding and cooling rules; reads every label and prevents cross-contact for the peanut allergy; sets the table, gives thanks, serves courses in order and sits with the guests; and connects it to Genesis 18 or another passage on hospitality.