



Chemical Transformations: Merging the Science of Food and Culture for Independent Living

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Introduction

"There are people who make things happen, people who watch things happen, people who wonder what happened."[1]

The quote, *"There are people who make things happen, people who watch things happen, people who wonder what happened,"* originated with Nicholas Murray Butler, who served as the President of Columbia University. He delivered the speech on Charter Day at the University of California in March, 1931. He used it in his group activity and in the earliest quote, as he coined the phrase: *"those who make things happen, those who watch things happen, and the overwhelming majority who have no notion of what happens."* This is the perfect segue into my curriculum unit, because the chemistry of cooking will teach students to recognize how their actions during the cooking process affect the chemical and physical properties of food.

This 14-week interdisciplinary science curriculum unit for high school students in grades 9–12 receiving Life Skills special education services is much more than a cooking class. I designed this unit to prepare students for independent living through the science of food by transforming the kitchen into a classroom where chemistry, life skills, and transition education come together. Every recipe, experiment, and shared meal becomes an opportunity for students to investigate scientific concepts while developing the confidence and practical skills they need for adulthood.

Using authentic culinary experiences, students explore how chemical and physical transformations change ingredients during food preparation. As they observe, question, predict, and experiment, they discover that chemistry is part of every meal they prepare. Throughout the unit, students investigate concepts from chemistry, biology, Integrated Physics and Chemistry (IPC), and environmental science while connecting science to nutrition, food safety, history, culture, sustainability, and everyday decision-making.

Learning extends beyond the classroom through community-based instruction and work-based learning experiences. Students develop grocery budgets, compare prices, create shopping lists, read Nutrition Facts labels, purchase ingredients, prepare recipes, and explore careers in the culinary and life sciences. These authentic experiences strengthen communication, teamwork, financial literacy, problem-solving, and workplace readiness while helping students recognize that the skills they practice in the kitchen prepare them

for success at home, in the workplace, and in their communities.

The curriculum unit follows a backward design model that begins with the end in mind. Students work toward a culminating capstone experience in which they collaboratively plan, prepare, and serve a traditional Thanksgiving meal for their families and invited guests. Along the way, they maintain science journals, create a student cookbook and workbook, develop multimedia presentations, and reflect on their learning. The Thanksgiving celebration serves as more than a final assessment—it is a celebration of each student's growth in scientific understanding, confidence, teamwork, and independence.

Rationale

As a special education Life Skills teacher, I believe science should prepare students not only to pass assessments, but also to live more independent, healthy, and productive lives. Too often, students with disabilities learn scientific concepts in isolation without understanding how those concepts relate to the decisions they make every day. I designed this curriculum unit because food provides an authentic and meaningful way for students to experience science while developing the practical skills they will use long after they leave high school.

Cooking is one of the most important independent living skills students can learn. Every meal requires students to read directions, measure ingredients, solve problems, make decisions, follow safety procedures, manage time, communicate with others, and evaluate results. At the same time, every cooking experience provides opportunities to observe chemical and physical transformations, investigate scientific questions, collect evidence, and explain why food changes during preparation. The kitchen naturally becomes a science laboratory where learning is active, relevant, and immediately connected to everyday life.

For students receiving special education services, meaningful learning occurs when instruction is connected to authentic experiences. Throughout this curriculum, students participate in community-based instruction by planning meals, developing grocery budgets, comparing prices, reading Nutrition Facts labels, shopping for ingredients, preparing recipes, and reflecting on their learning. These experiences strengthen self-determination, communication, financial literacy, teamwork, and problem-solving while preparing students for greater independence at home, in the workplace, and within their communities.

The curriculum unit also introduces students to career opportunities in the culinary, hospitality, food science, nutrition, agriculture, and life sciences industries. By exploring these career pathways through authentic classroom and community experiences, students begin to recognize how the scientific knowledge they develop today can support future employment and lifelong learning.

The curriculum unit is grounded in evidence-based transition practices that emphasize career awareness, community experiences, family involvement, self-determination, employment preparation, and independent living instruction. These predictors are embedded throughout every phase of instruction rather than taught as separate lessons. Students learn science by applying it to meaningful tasks that mirror the responsibilities they will encounter as adults.

The curriculum unit culminates in a collaborative Thanksgiving celebration where students plan, prepare, and serve a traditional meal for their families and invited guests. This capstone experience represents much more

than a cooking project. It is an authentic demonstration of scientific understanding, teamwork, communication, leadership, and independent living. Watching students confidently explain the science behind the food they prepared while serving a meal to those they love reflects the ultimate purpose of this curriculum: helping students discover that they are capable learners, valued contributors, and increasingly independent adults.

Hearne Independent School District[2]

Hearne High School is part of Hearne Independent School District, a rural district in Robertson County, Texas, serving approximately 764 students in grades pre-K through 12. The district includes Hearne Elementary School and Hearne Junior High/High School and serves a predominantly economically disadvantaged student population, with 92.9% of students identified as economically disadvantaged, 31.9% considered at risk of dropping out, and 25.5% receiving special education services. The student population is 45.5% Hispanic, 41% African American, 11% White, and 1% other ethnicities, reflecting the rich cultural heritage of the Hearne community. Students represent a wide range of academic abilities and learning needs, including those receiving special education, Dyslexia services, and other academic interventions.

Student Demographics

I teach high school Life Skills science for students in grades 9–12 at Hearne High School in Hearne, Texas. My class includes 16 students with diverse learning needs, including Dyslexia, Attention-Deficit/Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), Specific Learning Disabilities (SLD), and Intellectual Disabilities (ID).

I also serve as the Program Manager of the SOAR-EX Business Service Center, a work-based learning program developed in partnership with the Texas A&M Center on Disability and Development and the Texas Workforce Commission. Through authentic business services—including printing, copying, shredding, laminating, bookbinding, and graphic design—students develop employability, communication, leadership, self-advocacy, and independent living skills while gaining real-world work experience. These experiences provide a strong foundation for this curriculum unit by extending scientific learning beyond the classroom and helping students explore careers in culinary arts, hospitality, food science, and other life science fields.[3]

Special Education[4]

The Individuals with Disabilities Education Act (IDEA) is the law that emphasizes preparing students with disabilities for further education, employment, and independent living skills. This is outlined in their Individual Education Program (IEP), and progress reports are to be submitted to parents every six (6) weeks.

The U.S. Department of Education's transition guidance also supports the need for instruction that helps students move from school to postsecondary life through meaningful, functional, and goal-based learning experiences. For many students with disabilities, success after high school depends not only on academic achievement but also on developing practical life skills, self-determination, financial literacy, communication skills, and community participation.[5]

Five primary practices for independent living focus on students' engagement in self-advocacy and effective transition ecosystems. These concepts are reflected in the curriculum through students' participation in recipe selection, meal planning, grocery shopping, cooking roles, family involvement, and reflection on their progress toward independence.[6]

Content Objectives

Molecules, Food and the Elements[7]

The foods we eat are made up of atoms, the basic building blocks of matter. When atoms chemically bond together, they form molecules that determine the structure, texture, flavor, and nutritional value of food. The food we eat is a mix of these molecular structures, which is important for a healthy body. We need food to supply us with energy, materials for growth, repair tissues, and fight diseases to keep our body healthy.

Our body and most foods are composed primarily of four essential elements: carbon (C), hydrogen (H), oxygen (O), and nitrogen (N). Together, these elements form the major biological molecules (nutrients) that sustain life, including water, carbohydrates, lipids, and proteins. Other elements, such as sodium (Na) and chlorine (Cl), also play important roles in food chemistry.

Digestion breaks down nutrients using mechanical force to crush the food and chemical enzymes to split complex molecules into smaller units that our body can absorb. These chemical breakdowns happen in our mouth (teeth chewing food into smaller pieces), stomach (muscles churning and squeezing), and intestinal sloshing (liquid and gas moving together in the digestive tract).

Taste and Smell: The Chemistry of Flavor

Taste and smell are two chemical senses that work together every time we eat. We use all five senses (taste, touch, smell, sight, and hearing) to comprehend our environment; taste (gustation) and smell (olfaction) play the greatest role in how food is experienced (Figure 1). Flavor is not created by taste alone. As food cooks, heat releases aroma molecules into the air while chemicals dissolved in saliva stimulate taste receptors on the tongue. The brain combines information from both senses, allowing us to recognize sweet, sour, salty, bitter, and umami flavors along with the aromas that make foods unique.

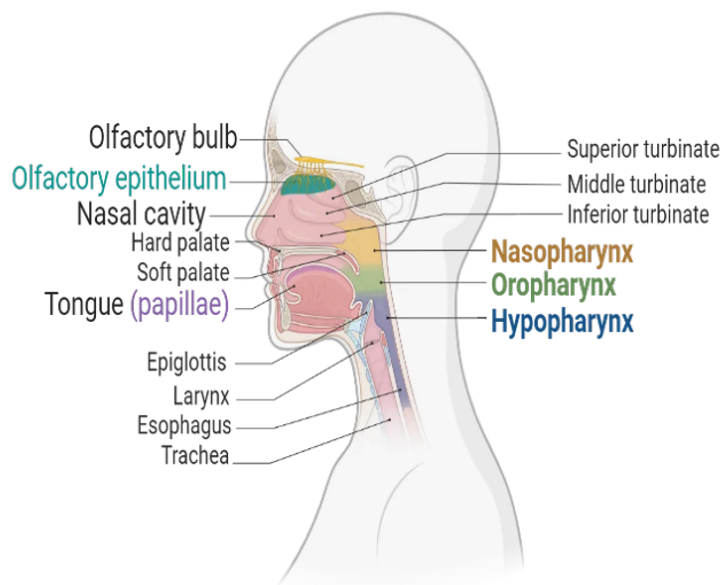


Figure 1. Gross Anatomy of the Gustatory and Olfactory Systems.[8]

Taste begins when food dissolves in saliva and comes into contact with the taste buds located on the tongue (Figure 2). Each taste bud contains specialized receptor cells that detect one of the five basic tastes. When these receptors are activated, they send electrical signals through sensory nerves to the brain. Sweet foods contain sugars, sour foods contain acids, salty foods are detected by sodium ions, bitter compounds often serve as a natural warning against harmful substances, and umami receptors respond to amino acids found in protein-rich foods such as meat, eggs, and cheese.

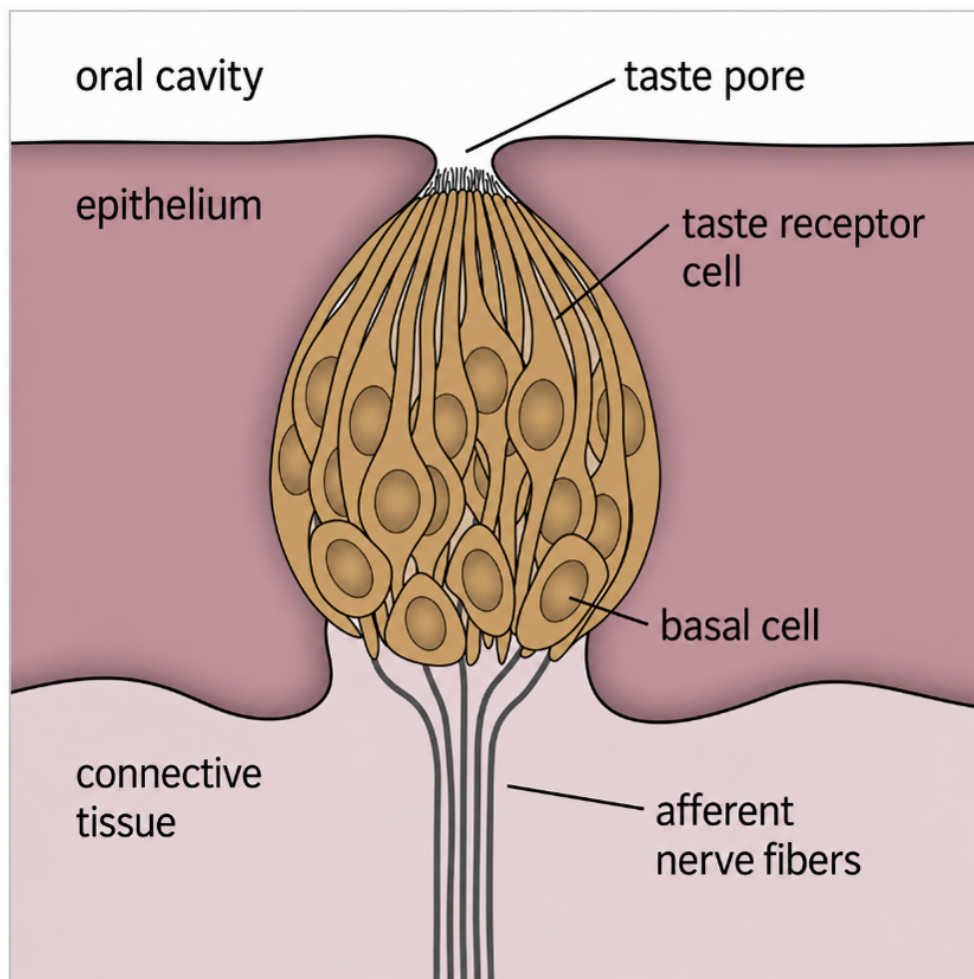


Figure 2. Anatomy of a Taste Bud Structure [9]

Smell also plays an essential role in flavor perception. As food is heated, tiny odor molecules are released and enter the nasal cavity, where they bind to olfactory receptor cells in the olfactory epithelium shown in Figure 1. These receptors send signals through the olfactory nerve to the olfactory bulb and then to the brain. This is why foods often seem to have very little flavor when a person has a cold or a stuffy nose. Together, taste and smell allow people to distinguish the rich flavors and aromas of foods and better understand the chemical changes that occur during cooking. Together, taste and smell enable students to understand that flavor results from chemical interactions between food molecules and sensory receptors.

Water: The Universal Solvent in Cooking

Water is often described as the universal solvent because its polar molecular structure enables it to dissolve more substances than any other liquid. In food preparation, water serves as the primary medium through which many physical and chemical changes occur. Its unique properties influence the movement of nutrients, the dissolution of ingredients, and the reactions that transform raw foods during cooking.

Water plays a critical role in numerous chemical processes, including hydration, hydrolysis, diffusion, osmosis, starch gelatinization, protein denaturation, enzyme activity, and fermentation. It also regulates temperature during cooking because of its high specific heat capacity and heat of vaporization, making boiling, steaming, blanching, and simmering effective methods of heat transfer. Changes in water content affect food texture,

tenderness, moisture retention, microbial growth, shelf life, and nutrient availability. Water helps our bodies digest the nutrients in the food we eat. It is important to drink plenty of water daily.

Proteins: Building, Repairing, and Transforming Foods Through Heat

Proteins are essential nutrients that support growth, tissue repair, and many of the body's vital functions. They are composed of amino acids linked together in specific sequences that fold into complex three-dimensional structures. As illustrated in Figure 3, proteins are organized into four structural levels—primary, secondary, tertiary, and quaternary. The unique shape of each protein determines how it functions within living organisms and how it behaves during food preparation.

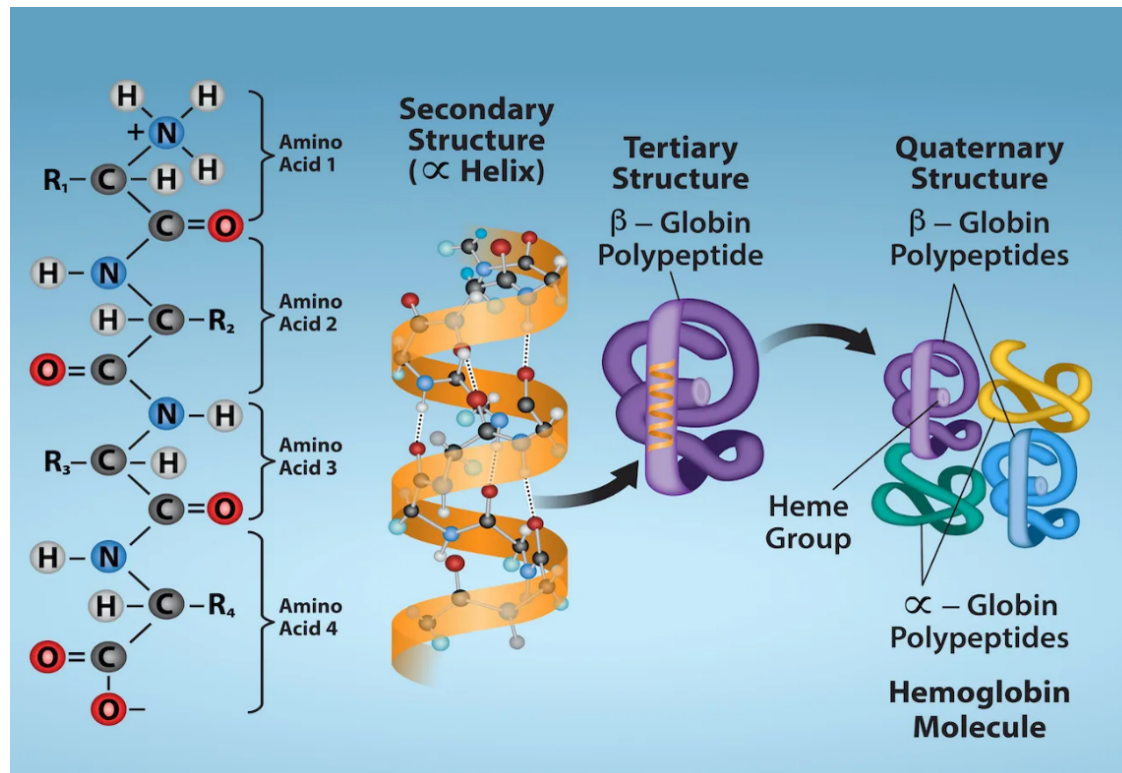


Figure 3. The Four Levels of Protein Structure[10]

In the kitchen, proteins provide an excellent opportunity to observe chemistry in action. As foods such as eggs, poultry, meat, dairy products, and legumes are heated, their protein molecules unfold through a process called denaturation. As heating continues, the unfolded proteins form new bonds with one another in a process known as coagulation, creating permanent changes in texture, color, firmness, and moisture. These structural changes explain why egg whites change from clear to opaque, why meat becomes firmer as it cooks, and why cheese melts differently depending on its composition.

Carbohydrates: Energy, Starches, Sugars, and Fermentation

Carbohydrates are organic compounds composed primarily of carbon, hydrogen, and oxygen and serve as the body's primary source of energy. Produced naturally by plants through photosynthesis, carbohydrates are found in foods such as grains, fruits, vegetables, legumes, and dairy products. They are classified into three groups based on their molecular structure: monosaccharides (simple sugars), disaccharides (double sugars), and polysaccharides (complex carbohydrates). These molecules provide energy for the body while also

contributing to the structure and function of many foods.

Carbohydrates play an important role in food chemistry because they undergo significant physical and chemical changes during cooking. When starches are heated in the presence of water, they absorb moisture and swell through a process known as gelatinization, producing the soft textures associated with foods such as rice, pasta, potatoes, and baked products. As cooked foods cool, starch molecules gradually reorganize in a process called retrogradation, influencing texture, moisture retention, and shelf life.

Sugars also contribute to important chemical reactions during cooking. When exposed to high temperatures, they undergo caramelization, producing the characteristic brown color, distinctive aromas, and complex flavors found in many baked and roasted foods.

Lipids (Fats): Energy Storage, Flavor, Texture, and Heat Transfer

Lipids, commonly referred to as fats and oils, are organic compounds composed primarily of carbon, hydrogen, and oxygen. Unlike carbohydrates, lipids contain relatively little oxygen, making them an energy-dense nutrient that provides approximately nine kilocalories of energy per gram. In addition to serving as the body's long-term energy reserve, lipids contribute to cell structure, protect organs, and aid in the absorption of fat-soluble vitamins. Dietary fats are commonly classified as saturated, monounsaturated, or polyunsaturated, with each type possessing unique physical and chemical properties that influence its behavior during cooking.

The chemical properties of lipids play an essential role in food preparation. Because oils can be heated to temperatures higher than water, they are effective for cooking methods such as sautéing, frying, and roasting. As fats are heated, they melt, transfer heat efficiently, and contribute to the flavor, texture, and appearance of food. Excessive heat can cause oils to break down beyond their smoke point, resulting in undesirable flavors, reduced nutritional quality, and the formation of compounds associated with overheated fats. Understanding lipid behavior helps explain why selecting the appropriate cooking fat and controlling temperature are important for producing high-quality, flavorful, and safe foods.

Nutrient	Primary Biological Function	Common Food Sources	Chemical Changes During Cooking	Examples in the Kitchen
Proteins	Build and repair body tissues; support enzymes, hormones, and muscles.	Eggs, poultry, beef, fish, dairy products, beans, and nuts.	Denaturation (proteins unfold); Coagulation (new bonds form).	Egg whites turn white; meat becomes firmer; cheese melts.
Carbohydrates	Provide the body's primary source of energy.	Bread, rice, pasta, potatoes, fruits, vegetables, and grains.	Gelatinization; Retrogradation; Caramelization; Fermentation.	Rice softens; bread rises; sugar browns; mashed potatoes thicken.
Lipids (Fats)	Store energy, protect organs, and aid vitamin absorption.	Butter, vegetable oils, olive oil, nuts, seeds, and avocados.	Melting; Heat Transfer; Oxidation; Smoke Point Breakdown.	Butter melts; foods fry in oil; oils smoke when overheated.

Table 1. Comparison of Major Food Molecules and Their Chemical Transformations During Cooking

Note. Proteins, carbohydrates, and lipids are the three major macronutrients. Each undergoes characteristic chemical changes during cooking that influence food texture, flavor, appearance, and nutritional quality.

Oil and Water: Polarity and Emulsions

Oil and water do not mix because they differ in their molecular structure. Water is a polar molecule, meaning it has slight positive and negative charges that allow water molecules to attract one another. Oils and fats, however, are nonpolar and do not share these electrical properties. As a result, water and oil naturally separate into distinct layers. This behavior follows the basic chemical principle of "like dissolves like," meaning that polar substances dissolve in other polar substances, while nonpolar substances dissolve in nonpolar substances.

Although oil and water naturally separate, they can be combined into stable mixtures through a process known as emulsification. Emulsifiers are molecules that contain both a water-attracting (hydrophilic) end and an oil-attracting (hydrophobic) end, allowing them to hold the two substances together. Lecithin, found naturally in egg yolks, is a common emulsifier used to stabilize foods such as mayonnaise, hollandaise sauce, and many salad dressings.

Enzymes and Fermentation: Nature's Chemical Catalysts

Enzymes are specialized proteins that function as biological catalysts, speeding up chemical reactions without being consumed in the process. By lowering the activation energy required for a reaction, enzymes allow many biological and food-related processes to occur more efficiently.

Their activity is influenced by factors such as temperature, pH, and the availability of specific substances, making enzymes essential to both living organisms and food preparation.

Fermentation is a natural biochemical process in which microorganisms, including yeast and beneficial bacteria, use enzymes to convert carbohydrates into simpler compounds. During alcoholic fermentation, yeast produces carbon dioxide and ethanol, allowing bread to rise and contributing to the production of fermented beverages.

Lactic acid fermentation, carried out by beneficial bacteria, produces the distinctive flavors and textures found in foods such as yogurt, cheese, kimchi, sauerkraut, and pickled vegetables while helping preserve food and inhibit the growth of harmful microorganisms.

The Maillard Reaction: The Chemistry of Browning and Flavor Development[11]

The Maillard reaction is a chemical reaction between sugars and proteins that occurs when foods are heated to high temperatures, typically above 140°C (285°F). First described by French chemist Louis-Camille Maillard in 1912, this reaction is responsible for the browning that occurs during cooking and for many of the rich flavors and aromas associated with roasted, baked, toasted, and grilled foods. As heat causes sugars and amino acids to react, a series of chemical changes produces hundreds of new compounds that enhance both the appearance and flavor of food.

Unlike caramelization, which involves only the heating of sugars, the Maillard reaction requires both sugars and proteins. The extent of browning depends on factors such as temperature, moisture, pH, and cooking time. These conditions influence the formation of melanoidins, the brown pigments that give cooked foods their characteristic color, along with aromatic compounds that create the distinctive flavors of roasted meats,

toasted bread, baked cookies, coffee, chocolate, and grilled vegetables.

History and Culture of Food

The history of food provides an important foundation for understanding the chemistry of cooking by demonstrating how scientific knowledge developed through centuries of observation, experimentation, and cultural traditions. Long before chemistry became a formal science, people discovered that heat changed the texture and flavor of food, salt and smoke preserved meat, fermentation transformed grains and dairy products, and seasonal harvests influenced the foods available throughout the year. These discoveries became the basis of many modern cooking techniques and continue to shape food preparation today.

Food traditions also reflect the close relationship among culture, agriculture, geography, and science. Communities adapted to their local environments by using available crops, natural resources, and seasonal ingredients to prepare nutritious meals. Techniques such as smoking, drying, fermenting, salting, pickling, and slow cooking were developed through practical experience and are now understood through the principles of chemistry, biology, microbiology, and environmental science. [12]

Food Identification and Ingredient Function

Food identification involves recognizing and classifying foods according to their biological origin and chemical composition. Every ingredient contains a unique combination of water, carbohydrates, proteins, lipids, vitamins, minerals, and other naturally occurring compounds that influence its nutritional value, flavor, texture, and behavior during cooking. Understanding these characteristics helps explain why ingredients respond differently to heat, moisture, and other cooking methods.[13]

Beyond identification, each ingredient serves a specific function within a recipe. Flour provides structure, eggs contribute proteins that coagulate and emulsify, sugars add sweetness while promoting browning, and fats improve tenderness, flavor, and heat transfer. Herbs and spices contain natural compounds that enhance flavor and aroma, while ingredient labels identify preservatives, emulsifiers, stabilizers, and other additives that influence shelf life and food quality.

Agriculture and Food Production

Agriculture is the cultivation of plants and animals that provide the food and resources essential for sustaining life. Modern agriculture combines biology, chemistry, environmental science, and technology to produce safe, nutritious foods while maintaining healthy soil and sustainable farming practices. Plant growth depends on sunlight, water, carbon dioxide, and essential nutrients absorbed from the soil, all of which influence the nutritional quality of foods before they are harvested.

Food production continues after harvest through processes that preserve freshness, maintain nutritional value, and ensure food safety. Refrigeration, freezing, dehydration, canning, fermentation, and packaging slow spoilage and extend shelf life by controlling physical, chemical, and biological changes.

Seasonal Foods and Local Agriculture¹⁴

Seasonal foods are harvested during their natural growing seasons, allowing fruits and vegetables to develop their best flavor, texture, color, and nutritional value. Environmental factors such as temperature, rainfall, sunlight, and soil quality influence plant growth, sugar production, vitamin content, and the development of natural pigments and flavors. Produce harvested at peak maturity generally offers greater freshness and higher nutritional quality.

Local agriculture reduces the time between harvest and consumption, helping preserve nutrients and reduce chemical changes that occur during transportation and storage. Supporting local farms also strengthens regional economies, reduces transportation-related energy use, and encourages sustainable farming practices.

Farm-to-Table

The farm-to-table concept emphasizes the connection between agriculture, food distribution, preparation, and nutrition. From harvest to the dinner table, foods continue to undergo chemical and biological changes that affect their freshness, flavor, texture, and nutritional value. Proper handling, storage, and temperature control slow these changes, reduce spoilage, and maintain food quality. Scientific principles guide how food is grown, transported, stored, and prepared, helping ensure both quality and safety throughout the food system. Chefs and restaurants buy produce, meat, and dairy products directly from local growers and producers.

Grocery Store Science

Modern grocery stores organize foods according to their storage requirements, nutritional value, and methods of preservation. Fresh produce, refrigerated dairy products, frozen foods, canned goods, and dry pantry items each require specific conditions to maintain quality and food safety. Refrigeration, freezing, dehydration, and airtight packaging help slow chemical reactions and microbial growth that contribute to spoilage. Food labels provide valuable information about nutrition, serving size, ingredients, allergens, preservatives, and storage recommendations.

Sustainability and Environmental Stewardship

Sustainability is the responsible use of natural resources to meet today's food needs while protecting the environment for future resources. Sustainable agriculture supports healthy soils, conserves water, reduces pollution, and protects biodiversity through practices such as crop rotation, composting, efficient irrigation, and responsible land management. Environmental stewardship also includes reducing food waste, conserving energy, and making thoughtful choices throughout the food system. By connecting science with responsible decision-making, sustainable practices help ensure a safe and reliable food supply for the future.

Teaching Strategies

The teaching strategies used in this curriculum support the diverse learning needs of high school students receiving special education services while promoting scientific inquiry, independent living, and transition readiness. Instruction integrates evidence-based practices, authentic culinary experiences, and community-

based learning to help students connect chemistry concepts to everyday life through active participation, collaboration, and hands-on investigation.

Collaborative Learning¹⁵

Students work in small groups to prepare recipes and conduct laboratory investigations, developing communication, teamwork, problem-solving, and a sense of shared responsibility while completing authentic culinary tasks.

Community-Based Instruction (CBI)¹⁶

Community-Based Instruction extends learning beyond the classroom through grocery shopping, meal planning, budgeting, and analysis of Nutrition Facts labels, reinforcing scientific concepts while strengthening consumer awareness and independent living skills.

Culinary Demonstrations

Teacher demonstrations model safe food-preparation techniques and scientific concepts, including heat transfer, protein denaturation, emulsification, fermentation, and the Maillard reaction, before students conduct laboratory investigations.

Direct Instruction¹⁷

Scientific vocabulary, laboratory safety, and food chemistry concepts are introduced through explicit instruction and guided practice before students apply their knowledge during hands-on investigations.

Gradual Release of Responsibility¹⁸

Instruction follows the "I Do, We Do, You Do" model, gradually transferring responsibility from teacher modeling to guided practice and independent application.

Inquiry-Based Learning

Students investigate food chemistry by asking questions, making predictions, collecting observations, and developing evidence-based explanations of the physical and chemical changes that occur during cooking.

Learning Environment and Instructional Resources

Instruction takes place in both the classroom and culinary laboratory using kitchen equipment, laboratory tools, recipes, Nutrition Facts labels, grocery advertisements, digital resources, and science journals to support authentic scientific investigations.

Project-Based Learning

Students apply scientific concepts through collaborative projects that culminate in planning, preparing, and serving a traditional Thanksgiving meal as the unit's authentic performance assessment.

Universal Design for Learning (UDL) and Differentiated Instruction

Universal Design for Learning principles provide multiple means of engagement, representation, and

expression through visual supports, scaffolding, flexible grouping, assistive technology, and adaptive equipment to ensure equitable access for all learners.

Assessment Throughout Instruction

Student learning is assessed continuously through teacher observations, science journals, laboratory discussions, performance tasks, reflections, and formative assessments that monitor growth in scientific understanding and practical skills.

Classroom Activities

Fourteen-Week Instructional Framework - Daily Lesson Plan Structure - 1st Semester

Monday - Friday (2) 50-minute classes - Life Skills Science; SOAR-EX Work-Based Learning

5 minutes - warm-up/bell ringer, 15 minutes - mini lesson - I Do, 10 minutes - mini lesson - We Do, 10 minutes - You Do independent work, 5 minutes exit ticket, 5 minutes clean-up

The classroom activities are organized into four instructional phases that gradually increase in complexity throughout the 14-week unit. Each phase builds upon the scientific concepts introduced in the previous phase while preparing students for the culminating Thanksgiving capstone experience. The activities described below represent the instructional sequence of the curriculum and may be modified to meet individual classroom schedules, student needs, and available resources.

Phase I: Building the Scientific Foundation

Weeks: 1–4 “People Who Make Things Happen”

Instructional Focus

This phase establishes the scientific foundation for the entire curriculum unit by introducing the fundamental principles of food chemistry and safe laboratory practices. Students begin exploring the structure of matter, including atoms, elements, molecules, physical and chemical changes, and heat transfer during cooking. Emphasis is placed on scientific observation, accurate measurement, laboratory safety, and proper use of culinary equipment as students develop the habits and vocabulary needed for future investigations. These introductory experiences prepare students to recognize that every cooking activity is an opportunity to observe scientific principles in action. By the end of the phase, students have developed the foundational knowledge necessary to investigate increasingly complex chemical transformations throughout the remainder of the curriculum.

Chemistry Concepts

- Atoms, elements, and molecules
- Physical and chemical changes
- States of matter
- Heat transfer

- Measurement
- Laboratory and kitchen safety

Essential Questions

- What makes cooking a science?
- How do atoms and molecules form the foods we eat?
- How does heat transform food?

Representative Classroom Activities

- Kitchen and laboratory safety orientation – students complete a kitchen scavenger hunt. They will be given pictures to locate in the kitchen
- Students will be given scenarios of safe and unsafe kitchen practices and discuss them to become familiar with kitchen safety best practices
- Physical versus chemical changes laboratory – students will watch chemical reaction videos and discuss their observations
- Heat transfer demonstrations
- Students will build their food with activities using the molecular model kits. Example: **H₂O — Water** - Students use two hydrogen atoms and one oxygen atom. Then introduce simple models representing molecules associated with carbohydrates, proteins, and fats without overwhelming students with advanced molecular structures.
- Taste and Smell activity – students will watch a video demonstrating the Smell-O-Vator investigation and duplicate the video to practice the five basic tastes – sweet, salty, sour, bitter, and umami.
- Science journal reflections

Culminating Learning Experience

Students apply laboratory safety procedures and scientific observation skills while completing their first food chemistry investigation.

Transition Connection

Students begin developing safe workplace habits, following multi-step procedures, and using kitchen equipment responsibly.

Phase II: Investigating Chemical Transformations

Weeks: 5–7 “People Who Watch Things Happen”

Instructional Focus

During this phase, students investigate the chemical and physical transformations that convert raw ingredients into finished foods. The content focuses on proteins, carbohydrates, lipids, water, enzymes, and the effects of heat on food structure and function. As students prepare a variety of recipes, they examine scientific concepts such as protein denaturation, starch gelatinization, emulsification, caramelization, fermentation, and the Maillard reaction. These investigations strengthen students' understanding of how molecular changes influence texture, flavor, color, aroma, and nutritional quality. This phase provides the

scientific framework that explains why foods behave differently during preparation and cooking.

Chemistry Concepts

- Egg Investigation: Protein Denaturation - Crack an egg into a clear bowl so students can observe the transparent egg white and yellow yolk. Students describe the color, texture, smell, and physical state. Cook the egg in a skillet. Students watch the egg white change from clear and liquid to white and firm.
- Bread Investigation: Fermentation - Prepare two small mixtures:

Cup A: warm water + yeast + sugar Cup B: warm water + yeast, no added sugar

Place a balloon over each bottle or container.

Students predict:

Which balloon will inflate more?

- Mashed Potato Investigation: Starch Gelatinization - Why does a hard potato become soft and creamy? Give students a small piece of raw potato before cooking.

Have them safely examine it. Students observe: Hard or soft? Dry or moist? Easy or difficult to mash? Then boil the potato pieces. After cooking, students test them again and mash them. Explain that when starch granules are heated in the presence of water, they absorb water, swell, and contribute to thickening and texture changes. This process is called starch gelatinization.

- Science Journal Reflection

Assessment Opportunities

- Science journal entries
- Laboratory observations
- Small-group discussions
- Cooking performance tasks
- Exit reflections

Transition Connections

Students continue to develop kitchen organization, teamwork, communication, problem-solving, and safe food-preparation practices while strengthening their understanding of the science behind cooking.

Phase III: Connecting Food Science to Independent Living

Weeks: 8-11 "People Who Discover Why It Happens"

Instructional Focus

Community Partnership, Food Access, and Service Learning

To strengthen community-based instruction and reduce the cost of food used for classroom investigations, I established a partnership with the Hearne Food Bank, which receives food through its relationship with the

Brazos Valley Food Bank. Available food items can supplement ingredients used throughout the Chemistry of Cooking curriculum unit, allowing students to plan meals, adapt recipes, compare food costs, interpret Nutrition Facts labels, examine food safety and storage, and make decisions based on available foods. Using donated or low-cost food resources can reduce the district funding required for cooking investigations and practice meals, allowing limited instructional funds to be allocated to ingredients not available through the partnership.

Chemistry Concepts

- Food preservation
- Oxidation
- Food spoilage
- Nutrition chemistry
- Acids and bases in food
- Water activity
- Food safety
- Chemical changes during storage

Essential Questions

- How does chemistry help keep food safe?
- How does food chemistry influence nutrition?
- How do science and consumer choices affect healthy living?

Representative Classroom Activities

- Nutrition Facts Label Investigation - Nutrition Facts Label Investigation — “Food Label Detectives”
Question: *What can a food label tell me before I buy or eat a food?*

Give each student or team 3–4 real food packages of foods they recognize—for example, cereal, canned vegetables, chips, pasta sauce, bread, yogurt, or frozen foods.

Students locate and record the serving size, servings per container, calories, total fat, sodium, carbohydrates, added sugars, protein, and selected vitamins/minerals.

- Meal Planning Challenge
- Budgeting Investigation
- Food Preservation Investigation
- Consumer Product Comparison

Assessment Opportunities

- Science journals
- Budget plans
- Nutrition label analysis
- Reflection writing
- Group presentations

Transition Connections

Students strengthen consumer awareness, budgeting, meal planning, grocery shopping, financial literacy, and decision-making skills that support independent living and successful adulthood.

Phase IV: Demonstrating Chemistry of Food Through the Thanksgiving Capstone

Weeks: 12–14 “People Who Make Things Happen”

Instructional Focus

The final phase provides students with an opportunity to synthesize the scientific concepts explored throughout the curriculum by planning, preparing, and serving a traditional Thanksgiving meal. Students apply their understanding of chemical transformations while coordinating food preparation, monitoring cooking processes, evaluating results, and solving problems that arise during meal production. Throughout the project, students demonstrate scientific reasoning while integrating culinary skills, teamwork, organization, and communication in an authentic setting. The Thanksgiving capstone serves as a culminating performance assessment that celebrates students' growth in scientific understanding and highlights the connections among food chemistry, independent living, and community.

Chemistry Concepts

- Integration of all chemical transformations
- Heat transfer
- Protein chemistry
- Carbohydrate chemistry
- Lipid chemistry
- Food safety
- Timing and reaction control

Essential Questions

- How do scientific principles work together to prepare a complete meal?
- How does chemistry contribute to successful food preparation?
- How does scientific knowledge support independent living?

Representative Classroom Activities

- Thanksgiving Menu Planning
- Kitchen Brigade Assignments
- Thanksgiving Meal Preparation
- Family Thanksgiving Celebration
- Student Cookbook Presentation
- Reflection and Scientific Explanation

Assessment Opportunities

- Performance assessment
- Science journal
- Teacher observations
- Teamwork rubric

- Student self-reflection
- Capstone presentation

Transition Connections

Students demonstrate the scientific knowledge, culinary skills, communication, teamwork, organization, and independent living competencies developed throughout the curriculum as they prepare and serve a Thanksgiving meal for their families and invited guests.

Kitchen Brigade: Leadership Roles and Responsibilities

"Leadership is the catalyst that transforms scientific inquiry, responsibility, collaboration, and service into confident, independent learners."

Focus Overview

The culinary laboratory is organized using the Kitchen Brigade system, an instructional leadership model adapted from Auguste Escoffier's *brigade de cuisine*, the organizational structure developed for professional culinary kitchens.[19] Throughout this curriculum, students rotate through leadership roles that promote collaboration, scientific inquiry, workplace readiness, and independent living skills while supporting safe and efficient laboratory investigations.

Kitchen Brigade Leadership Roles

Students rotate through authentic culinary leadership roles during each laboratory investigation to develop scientific inquiry, workplace readiness, collaboration, and independent living skills.

- Head Chef: Leads the laboratory team and coordinates recipe preparation.
- Sous Chef: Assists the Head Chef and manages daily kitchen operations.
- Food Scientist: Observes and records physical and chemical changes during cooking.
- Food Safety & Sanitation Manager: Ensures food safety and laboratory sanitation.
- Nutrition Specialist: Analyzes Nutrition Facts labels and promotes healthy food choices.
- Purchasing & Inventory Manager: Organizes ingredients, budgeting, and grocery planning.
- Equipment & Materials Manager: Maintains kitchen tools and laboratory equipment.
- Timekeeper: Monitors preparation, cooking, and clean-up schedules.
- Science Journal & Data Recorder: Documents laboratory observations and scientific data.
- Quality Control Manager: Evaluates recipe quality using established criteria.
- Hospitality Coordinator: Assists with serving meals and welcoming guests.
- Clean-Up & Sustainability Team Leader: Oversees sanitation, recycling, and laboratory organization.

Implementation Resources and Estimated Budget

This curriculum unit is designed to be implemented in a culinary arts laboratory or adapted for a traditional classroom using portable cooking equipment and commonly available kitchen supplies. At Hearne High School, instruction takes place in a fully equipped culinary laboratory that provides students with authentic experiences in food preparation, food safety, and scientific investigation. Schools with limited facilities may successfully implement the curriculum using hot plates, countertop appliances, and basic kitchen equipment.

Students use recipes, laboratory investigation guides, science journals, Nutrition Facts labels, grocery advertisements, digital resources, and molecular model kits to explore the chemistry of cooking.

The estimated consumable budget for a fourteen-week implementation is approximately \$3,400, including ingredients for weekly cooking investigations, laboratory demonstrations, grocery shopping and meal-planning activities, and a Thanksgiving capstone meal prepared and served to approximately fifty family members, school personnel, and community guests. Additional costs include molecular modeling materials, sanitation supplies, disposable serving items, and replacement kitchen utensils as needed.

Schools may reduce implementation costs by developing partnerships with local grocery stores, restaurants, school nutrition departments, churches, food banks, agricultural organizations, Cooperative Extension offices, civic groups, parent organizations, and community businesses. These partnerships may provide food donations, reusable kitchen supplies, guest speakers, workplace learning experiences, and financial support for student projects.

Chemistry of Cooking to Independence

Chemical Transformations: A Transition to Independent Living illustrates that learning extends far beyond the classroom. My purpose in implementing this food science journey has been to help students explore how chemistry influences every aspect of food preparation, from the molecular structure of ingredients to the chemical reactions that create flavor, texture, aroma, and appearance. Through laboratory investigations, cultural exploration, grocery shopping, meal planning, nutrition analysis, and hands-on cooking experiences, students have discovered that science is an essential part of everyday life. Each lesson builds on the previous one, allowing students to apply scientific concepts while developing practical skills for independent living.

Preparing a traditional Thanksgiving meal serves as the culminating performance assessment for this curriculum unit. By preparing and serving this meal for their families and school community, students showcase not only their understanding of food chemistry but also their growth in communication, teamwork, problem-solving, budgeting, food safety, and self-confidence.

Figure 4 illustrates how these interconnected experiences culminate in a meaningful learning journey that transforms scientific knowledge into lifelong independence.

SCIENCE OF FOOD Taste & Smell | Proteins | Carbohydrates | Lipids | Chemical Reactions

THANKSGIVING CAPSTONE MEAL Students apply the chemistry of cooking to prepare a culturally meaningful family meal.

MENU ITEM	CHEMISTRY CONNECTION
Turkey & Dressing	Protein denaturation, coagulation, browning, and moisture transfer
Candied Yams	Caramelization, sugar concentration, and starch softening
Cranberry Sauce	Pectin gel formation, acidity, and sugar concentration
Mashed Potatoes	Starch gelatinization and texture development
Cornbread Muffins	Leavening reactions, starch gelatinization, and protein coagulation
Rice Krispie Treats	Melting, emulsification, adhesion, and cooling-induced setting
Pound Cake	Creaming, emulsification, leavening, and protein coagulation
INDEPENDENT LIVING & TRANSITION SKILLS Meal Planning • Budgeting • Grocery Shopping • Nutrition Labels • Measuring • Food Safety • Teamwork • Career Readiness	

Understanding Food Chemistry → Preparing a Thanksgiving Meal → Building Independence

Figure 4. Chemical Transformations: From Molecules to the Thanksgiving Table. Original illustration developed by the author.

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Appendix: Implementing District Standards

Scientific and Engineering Practices Texas Essential Knowledge and Skills

- A. The scientific and engineering practices found in §112.42(c)(1)-(3), §112.43(c)(1)-(3), §112.44(c)(1)-(3), and §112.45(c)(1)-(3)
- B. Chemistry TEKS Alignment

19 TAC §112.43

- A. Biology TEKS Alignment

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A. Integrated Physics and Chemistry TEKS Alignment

19 TAC §112.44

A. Physics TEKS Alignment

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End Notes

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