YALE NATIONAL INITIATIVE
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Curriculum Units by Fellows of the National Initiative
2026 Volume V: Chemistry of Cooking

Kid Cuisine: Cooking Begins at the Molecular Level

Curriculum Unit 26.05.08, published September 2026
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Introduction & Demographic

This unit is designed to teach the science and art of cooking with the end goal of students exiting the experience understanding the why, what, and how associated with designing and creating recipes. Students will explore chemical reactions and apply mathematical reasoning to cooking. Lessons will build schema, teach chemistry concepts, develop cooking skills in children, and promote cross-curricular exchange so that students are equipped to show and explain their culinary ideas culturally and scientifically through published writing. Students will explore traditional techniques and create breads, spices, pasta, desserts, and common treats.

Washington, DC has dual identity in that it is a place wherever-changing global politics and local, historic neighborhoods co-exist. Students in the inner-city school system share commonality in their food preferences. Many of the youngest members of the community live in food deserts where they have little to no access to fresh produce. Much of their diet consists of heavily processed snacks and treats. Most children, like most adults are not familiar with the quality or chemistry associated with their favorite foods. Overconsuming of the most dangerous foods in our society puts communities at a disadvantage when it comes to health and overall wellness. At Barnard Elementary School, the goal is to heighten students' awareness of their daily food choices and use their academic privilege to transform how the larger community thinks about and navigates food culture. The student population is diverse with 46% Hispanic/Latinx, 39% Black, 11% White, 1% Asian, and 4% identifying as multi-racial. Barnard's multiculturalism is essential to the school's longevity and success; student relationships and blending of culture enhance their learning experiences and overall development. Teaching children the art and competence associated with cooking will give them a level of independence critical for their transition from kid to teen. Children become powerful contributors to society when they acquire and expand skillsets they can leverage to make a difference. Cooking skills strengthen households, promote critical thinking and problem-solving, and reinforce discipline that have long-lasting effects.

By the end of the curriculum unit, scholars will produce artifacts as evidence of their content mastery: an original cookbook with recipes explained through chemical formulas & reactions as well as expository writing samples that explain as well as compare/contrast food quality and provide cooking demonstrations on how to leverage ingredients to make balanced, efficient dishes. All content for these artifacts will be standards-based,

and the quality of the student work will be evaluated using the same rubrics aligned with district priorities. This curriculum unit will incorporate reading, writing, and listening standards along with measurement/data, algebra/algebraic thinking, and chemistry learning objectives. Students will be able to self-assess and speak to their mastery because they will have developed real-world cooking skills, demonstrated with expertise how and why tools and techniques achieve specific results, and explained through oral presentations and writing about food culturally and scientifically. Scholars will expand their understanding and capacity for one of humanity's most critical skillsets while also channeling academic prowess in a way that uplifts their school and larger community to be more deliberate and thoughtful about nutrition to promote affordable and culturally appropriate food for all.

Rationale

Teaching all subjects at the 5th grade level welcomes opportunities for cross-curricular exchange and planning where students organically observe connections and are more intentional about how they leverage their academic skills to construct knowledge. The Chemistry of Cooking lessons aligned to this curriculum unit will engage them throughout the school year as well as provide all students regardless of performance level or learning abilities with comprehensive project-based experiences where they will be required to complete standards-based tasks incorporating skills from all subjects taught in our classroom. Scholars will be expected to do actual cooking, explain their discoveries and creations using academic language/formulas, and develop systems for sharing their learning experiences making their work and knowledge accessible to a general audience. Through explorations involving food groups, types, tastes, and textures, recipe development, cooking demonstrations, and scientific research, 5th grade students will tackle challenges and gain real world skills and consciousness essential for their matriculation. Because 5th grade is the end of the elementary era, this curriculum unit serves as a rite of passage that signifies a shift in childhood where students learn to practice and develop appreciation for trial and error.

There are 4 cornerstones of education associated with this curriculum design including focusing on intellectual development, emotional intelligence, building practical skills, and utilizing intelligence to positively impact the real world. Scholars will learn literacy, math, and science skills to explore and explain cooking academically. Kitchen tools are dangerous and correct use must be explicitly taught to build capacity in people. Often children are shielded from kitchen work because adults fear the possibilities related to how they could hurt themselves or others. Learning emotional regulation and intelligence through cooking shapes well-rounded individuals. This will be achieved through strategic implementation of skill-building in phases and intentional introduction of techniques and tools in alignment with the curriculum roll out. Students will be expected to be as practical as they are imaginative throughout the unit. Emphasis on practicality will ensure children are grounded and balanced in their pursuit of results. They will be encouraged to explore wild ambitions; however, the goal is to develop ideas and creations that are useful. Using academic contexts and competencies to develop a cookbook with mathematical and scientific content to explain the rationale for recipes will be culturally impactful as student creators will be inventing/curating experiences that extend beyond themselves. Bridging reading, writing, math, and science concepts throughout the roll out of this curriculum will make students more competitive academically. Cooking is science and art; therefore, STEM education takes precedent as it will cultivate essential critical thinking skills in children.

Content Objectives

Cooking Begins at the Molecular Level

Developing nutrition begins with understanding the building blocks of the human body. Protein, carbohydrates, and fats function as macronutrients that provide energy to people by completing chemical processes to fuel and sustain a healthy body. Macrominerals such as sodium, chloride, potassium, calcium, magnesium, phosphorus, and sulphur also play key roles in building and strengthening the anatomy.

Energy is the ability to do work. For the human body, the unit of measurement for such an essential concept in a calorie. A calorie is the amount of energy required to increase the temperature of one gram of water by a single Celsius degree. The life-sustaining chemical reactions that occur within the cells of the human body are known as metabolism, which is measured in kilocalories. Energy must be continuously supplied to power the body. Chemical energy from macronutrients is achieved through oxidation and the production of adenosine triphosphate (ATP) and other by-products including carbon dioxide and water. Cells rely heavily on ATP for functionality and balance.[1]

To complement the work of carbs, protein, and fats in sustaining the human body, micronutrients, trace minerals and vitamins, found in small quantities play critical roles in maintaining adequate health as well. Metabolism is reliant on the presence of micronutrients to sustain normal function. Trace minerals and vitamins work collaboratively to keep the body running smoothly through growth and healing operations.

Carbohydrates are organic molecule structured with carbon, hydrogen, and oxygen atoms. These molecules are classified into three major groups: monosaccharides, disaccharides, and polysaccharides. These natural chemicals that are essential for plants and animals because both organisms manufacture, store, and consume starches and sugars for energy.

Monosaccharides are simple sugars that cannot be broken down into simpler saccharide units. Examples of these simple sugars include glucose, galactose, and fructose. When bonded together monosaccharides form disaccharides. Sucrose, lactose, and maltose are disaccharides. Sucrose, basically table sugar or fruit nectar, is created when glucose and fructose are linked together. Maltose is malt sugar created when two glucose molecules are bonded together. Lactose, or milk sugar, is found in mammals; plants would not produce or carry this sugar. The complex carbohydrates are scientifically named polysaccharides comprised of many to hundreds of simple sugars. Cellulose and starches are common polysaccharides. Cellulose is an organic polymer and structural component of plant cell walls; humans cannot digest cellulose because this compound is an insoluble dietary fiber. The human body does not possess the enzyme, the protein or biological catalyst, that promotes the chemical reactions to breakdown cellulose in the body. However, cellulose is a source of fiber that regulates blood sugar, weight managements, and bowel movements; fiber also supports a healthy gut, and lowers risk of chronic diseases like heart disease, type 2 diabetes, and colorectal cancer. Starches are polysaccharides created when many glucose molecules are linked together. These complex carbohydrates are the primary source of energy for the human body because they break down gradually into hundreds of molecules of glucose.[2]

Despite their differences in molecular structure, monosaccharides, disaccharides, and polysaccharides provide equal energy per gram in human metabolism. It is scientifically proven that carbohydrates breakdown into glucose, also known as blood sugar. Glucose is abundant and circulates in the blood to provide energy to

every cell in the body. When glucose is metabolized, pyruvate, the three-carbon acid created to support the body's ability to break down sugar and convert it into fuel, is a produced and eventually oxidized into acetyl coenzyme A (also known as acetyl CoA). The acetyl coenzyme A is a key signaling molecule during metabolic processes. Red blood cells, which lack mitochondria (powerhouse of the cell), especially depend on glycolysis (sugar metabolism) to gain the energy needed to function properly in the body. Glucose is a considered the primary source of energy for the central nervous system. This is why top organizations including the Food and Agriculture Organization (FAO) and World Health Organization (WHO) strongly promote a dietary carbohydrate intake of 50-75% of total energy intake that should be obtained mostly from whole-grain cereals, fruits, and vegetables.[3] In addition to this load of carbs, it is recommended that thirty grams of fiber be consumed a day.[4]

Fats, scientifically named lipids, do not dissolve in water because of their oily or waxy nature; however, these organic compounds are soluble in non-polar organic compounds. Fat molecules are stored in the body providing long term energy. A fat molecule is a triglyceride comprised of fatty acids and glycerol. These acids are categorized as either saturated or unsaturated. Saturated fats are rich in animal fat, while unsaturated fats are rich in plant oil. These compounds are distinguished by the number of carbon atoms and carbon bonds in their molecular structure. Understanding and distinguishing the structure of these molecules informs how the human body will respond to and chemically process these compounds.

It is critical to note that fat and fatty acids are not the same concept. A fat molecule includes three molecules of fatty acids and one glycerol molecule. Some common fatty acids are stearic acid, oleic acid, linoleic and linoleic acids. Stearic acid is an eighteen-carbon saturated fatty acid that can be utilized for binding, thickening, and emulsifying agent in foods. Oleic acid is a monounsaturated omega-9 fatty acid that is found abundantly in nature. This fatty acid is widely used in the making of olive, canola, and sunflower cooking oils. As a monounsaturated fatty acid, oleic acid is widely recognized as highly beneficial to maintaining a healthy body. Linoleic acid is a polyunsaturated omega-6 fatty acid that is essential for a balanced diet; however, the human body cannot synthesize or manufacture this fatty acid on its own and must be obtained by consuming plant oils, nuts, and seeds.[5]

Because dietary fats include triglyceride, cholesterol, and phospholipid, the FAO and WHO recommend a minimum fat intake for adults of 15% of total energy intake. Fats are macronutrients because these molecules support in building cell membranes, producing hormones, insulating vital organs, promoting satiation, and weight management. Balancing the intake of saturated and unsaturated fats is critical to ensuring the body can chemically process foods without depositing excess cholesterol into areas that could increase risk on chronic disease.[6]

While the human body is made mostly of water, the second most abundant chemical compound is protein. Proteins build muscle, bones, skin, hair, and nails; protein ensures the human body is functional by regulating immune systems, hormonal balance, and transporting oxygen throughout the body making them crucial to the metabolic processes and serving as a backup source for energy in times of crises or intense exercise. Unlike carbohydrates and fats, proteins are chains of amino acids (organic compounds required for sustaining life) connected by peptide bonds defined as chemical links of amino acids that are the building blocks of proteins. The shape and conformation of the protein determine its function. These molecules are made in the body by the ribosome in cells. Consuming protein keeps the body in a continuous cycle of breaking these molecules into amino acids for the purpose of producing more protein. Since *Homo sapiens* are omnivorous with teeth and digestive systems designed and capable of processing plant and animal food, the options for finding and fueling up on protein are plentiful.[7]

Daily protein requirement in the healthy adult is estimated to be 0.9 g/kg of body weight. Optimum protein recommendations can and will vary when critical illnesses are factored in. Depending on the severity of the body's needs, the requirement for intake of certain amino acids may take precedence of others.[8] Considering that the human body is incapable of producing nine essential amino and must be ingested through dietary means, food choices are essential for maintaining or achieving optimal health in either case.

How the Human Body Uses Carbs, Fats, and Proteins

The human body leverages carbohydrates, fats, and proteins as fuel to carry its daily functions and synthesize new tissues continuously and systemically. Carbohydrates are the main and quickest fuel source; they provide immediate energy. These molecules power the brain and muscles with excess stored in the liver and muscles as glycogen (stored sugar). Fats are complex but efficient compounds that serve as energy reserves. These molecules protect our organs and support the body by absorbing and using vitamins to improve functionality. Proteins are the building blocks of the body used mainly for growth and maintenance. The breaking down and arrangement of amino acids ensure the body can build and repair muscles, organs, skin, and enzymes (specialized proteins important for starting and stopping chemical reactions).

Understanding Food Through Taste and Smell

A personal relationship between the body and food occurs as a product of the contact between the senses and body structures, with the stimuli provided by the environment. Food stimuli greatly influence decision-making processes and eating behaviors.[9] The relationship between how people experience food through taste and smell informs the biological and cultural ties developed over time. Taste is more complicated than smell because taste molecules need to be free. Solubility is the central property for taste because molecules must be in a solution to reach taste receptors. By increasing the solubility of flavor compounds in water, the result is increased flavor. Activation of smell and taste receptors is dependent on molecules matching and binding together. Taste and smell are "chemical senses." It can be argued that the difference between the two chemosensory modalities must entail the structures of molecules interacting with specific chemosensory proteins. The universality of such a distinction based on chemical features is, however, falsified by the existence in nature of chemosensory compounds that simultaneously trigger olfactory, gustatory, and chemesthetic sensations. This implies that the terms "smell" and "taste," being applicable to the same concrete chemical objects is unsubstantiated.[10]

All smell and taste reception and registration happen in the brain. The human body processes taste and smell through receptors that register in the brain and create memories associated with food preparation and consumption. Molecules activate taste and smell receptors. Gustation, which is taste, and olfaction, which is smell, are chemical senses dependent upon the binding of specialized receptors through ligands (binding molecules) and proteins (receptors). While there are only 5 taste receptors (sweet, bitter, savory, salty, and sour), the quantity of smell receptors can range from hundreds to millions. This explains the diversity in how different bodies and cultures link smell and taste as well as why there are an abundance of flavors that be achieved in the kitchen.

History of Cooking

The origins of cooking are not definitive; however, cooking concepts and techniques can be traced back hundreds of thousands of years and linked to human discovery of fire. Prior to the modernization of cooking strategies and trends using ceramics, early civilizations roasted, grilled, smoked, or desiccated foods using open/outdoor fire. Meats and tubers could be boiled in clay-lined hollows dug into the ground and filled with

water into which heated stones could be dropped. Organs and other parts of dead animals could be converted using technology that made boiling or roasting of foods more efficient for humans. Earlier forms of cooking pots were designed by wrapping meat and vegetables in layers of clay and heating them in the embers of a campfire.[11]

As people and places evolved, invention and mass production of vessels that could withstand the demands of food preparation, especially in large quantities, revolutionized cooking beginning in Mesopotamia. True cooking requires controlling temperature and time using containers that are permanent and fireproof. Mass production of early cooking pots started in Mesopotamia along with the oldest recorded recipes and cuisine which are written on clay tablets in cuneiform Akkadian script and housed at Yale University. These artifacts are also the oldest manifestation of culinary art.[12]

The development of ceramic cooking technology and processing food by cooking are uniquely human traits ever since *H. erectus* discovered fire to make tough, chewy meat and hard tubers and vegetables more pleasurable and easier to eat.[13] Considering the conditions of the past, present, and what will inevitably be the future, human progress is dependent on building strong, athletic anatomies and experiencing cognitive evolution.[14] Cooked food at the start of civilization was required to achieve such ambitions because the building the body begins with feeding it.

Cooking Tools and Technology

The processes associated with making food edible and safe begin with using tools that allow for application of high temperatures, separating/ protecting food from harmful contaminates, and practicing appropriate hygiene and techniques for preparing meals involving meats especially. While humans have progressed from relying primarily (if not all) on woodfires, hot stones, and clay pottery for preparing meals, it must be acknowledged that inventing cooking pots was important for human evolution by serving as a paradigmatic shift and game changer in food processing.[15] Inventing ceramic cooking vessels allowed for softening foodstuff in water, thereby improving drastically food energy economy by avoiding loss of high energy lipids. As a result of such innovation, cooked food could be nearly completely metabolized by the body thereby providing more nutritional value and benefit. In contrast, raw food provides only a fraction of the potentially available energy content.[16]

In modern times, civilizations have access to stainless steel, ceramic, nonstick, glass, porcelain, aluminum, copper, carbon steel, and cast-iron options for their cookware. These options yield varying results and experiences when cooking with proteins, carbohydrates, and fats.

Cooking with Different Temperatures

There are essential procedures one should follow when cooking with different tools and cookware. For stainless steel pots and pans, preheat the pan before adding oils. This technique prevents food from sticking to the pan. Because ceramic cookware heats up quickly and retains heat rather intensely using low to medium is ideal when preparing food. These pans do not require preheating (do not preheat an empty pan); it is good practice to add a fat (an oil or butter) to a ceramic pan before applying heat to it to protect the coating. Similarly, nonstick cookware and porcelain require low to medium heat and should never be preheated; use a thin layer of fat, and cook only with silicone, wood, or nylon utensils. Never use metal utensils on nonstick or porcelain pots and pans because the surface could be easily scratched or permanently damaged.

Glass is more of an insulator rather than a conductor; therefore, this type of cookware is not great for stovetop

cooking or broiling. Because glass retains heat, using such cookware for baking is often a superior option to metal pans. Aluminum is a soft metal and highly reactive when exposed to acidic and salty foods. Be intentional about using aluminum that features a protective non-reactive coating that is safe for all recipes. Aluminum is not magnetic and will not work on an induction cooktop (an electric stovetop that uses electromagnetic fields to heat pots and pans). However, clad aluminum has a magnetic steel base that could work with an induction stove. Never store food in aluminum cookware because prolonged contact can cause the metal to interact with the food.

Copper is potentially one of the greatest conductors of heat compared to other metals. Just like aluminum, copper reacts with highly acidic foods. When cooking with this metal, use cookware lined with tin or stainless steel as bare copper is toxic. The drastic change in temperature when removed from heat makes cooking with copper easy to manage and control. Avoid preheating, always add a fat or liquid before exposing this cookware to heat, cook on medium to low heat, and use soft silicone, rubber, or wooden utensils. Carbon steel and cast-iron cookware require similar care; however, these pots and pans yield different results and are used for different purposes. While carbon steel is perfect for preparing delicate items like eggs because of its ability to heat and cool quickly, cast iron is more suitable for searing and braising items. Both pans build a natural layer that is non-stick when used and cared for consistently. Using oils before and after each use is critical to maintaining the health of this cookware.

Cooking with different temperatures is required and beneficial when developing cuisine that is both scientifically and culturally appealing. The vessels selected in the kitchen are essential for achieving the best quality and tasty combinations while also ensuring the appropriate physical and chemical changes occur throughout the cooking process. The purpose of cookware is to safely conduct and transfer heat and transform raw ingredients into edible, palatable, and digestible foods. Human engineering has led to the creation of many variations of cookware that allow for all types of culinary techniques to be manufactured and improved. For safe cooking and consumption, proteins such as meats, seafood, poultry, and other items should achieve internal temperatures between 145–165-degrees Fahrenheit. Fruits, grains, and vegetables should be cooked to a minimum internal temperature of 135-degrees Fahrenheit. Below these minimums, bacteria can grow making food less safe to eat. For refrigerated foods, aim to keep ingredients 40-degrees Fahrenheit or lower for safe storage.

Physical Changes in the Kitchen

Most cooking is the culmination of physical changes. From mixing and emulsifying to mechanical and state of matter changes, much of what takes place in the kitchen results in transforming the ingredients without compromising their molecular structure. So many of the most popular foods/cuisines in the world are made by altering the state, size, and shape of substances without changing their chemical identify.

An example of one of the simplest preparations is pasta or noodle making which requires few ingredients but great technique. Pasta is the Italian word for dough; noodle is the German term. Both pasta and noodle share the same preparation.[17] The goal when making pasta or noodle is to transform dry flour particles into a cohesive mass that is malleable (easily molded or shaped) enough to stay intact when boiled.[18] The process of mixing and incorporating flour, egg, and gradual amounts of water produce a dough that is structured by gliadin and glutenin proteins through the development of a gluten network. The mixing, kneading, resting, and mechanical manipulation of the dough in preparation for cooking are all physical changes. The molecular structure of the flour, egg, and water remain unchanged.

Uncooked pasta/noodle dough consists of raw starch granules embedded in the matrix of gluten protein. When

preparing to cook the egg pasta/noodle, the protein network and starch molecules at and near the rear of the noodle surface absorb the water, swell, expand, and soften. The outer protein layer is ruptured, and the dissolving starch escapes into the cooking water.[19] Even in the process of boiling the pasta, the molecular structure of the ingredients, protein network, and final products are not completely altered. It should be noted that the starch molecules on the outer layers of the pasta/noodle breakdown into smaller fragments that dissolve in the water which is a chemical change. Cooking pasta requires the application of heat, and the process is irreversible; however, most of the changes to the substances are physical.

The ingredients selected when preparing food work together strategically; therefore, this requires understanding how to leverage carbohydrates, fats, and proteins through matching and mixing the appropriate levels/amounts of substances while also understanding molecular bonds and why certain agents need to be applied throughout the cooking process. Everyday cooking is done by creating/applying recipes that call for the use of basic molecules such as water, sugars, salts, proteins and oils in varying mixtures. Knowing that oil and water do not mix because their molecular structures do not allow for a stable mixture, cooking requires using emulsifiers, different forms of heat transfer, and techniques to obtain the stable mixtures desired.

Chemical Changes in the Kitchen

Cooking is applied chemistry. The foods human consume are largely composed of proteins (myofibrils, collagen, gelatine, cartilage, connecting tissue), polysaccharides or carbohydrates (sugars, starch, cellulose), and fats (lard, tallow, oils) along with vitamins, minerals, fragrant compounds, and coloring β-glycosides (anthocyanins and flavones).[20] Chemical bonds give molecular shape. The chemistry of cooking is found in the transforming of the molecular structure of foods by changing their texture, flavors, and colors. The complexity of recipes is rooted in how different cooking strategies break apart, rearrange, and form new molecular bonds. Chemical changes in cooking are classified as Maillard reactions, caramelization, protein denaturation, protein coagulation, leavening, and starch gelatinization.

The browning of foods has incredible impacts on how different flavors, aromas, and colors are discovered and created in the kitchen. Caramelization and Maillard reactions are forms of browning where brown pigments and rich flavors are produced in cooked foods. Where they differ is how the browning is achieved. Caramelization is the thermal breakdown of sugar that can result in hundreds of different reaction products including varying syrup types, organic acids, sweet and bitter derivatives, many fragrant volatile molecules, and brown-colored syrups.[21] Some flavors produced during caramelization, which is achieved when sugar is heated to 330 degrees Fahrenheit or higher, are sweet (sucrose or other sugars), sour (acetic acid), bitter (complex molecules), fruity (esters), sherry-like (acetaldehyde), butterscotch (diacetyl), caramel (maltol), and nutty (furans).[22] This process is how and why candy and other sweets exist.

The Maillard reaction, which was discovered and described by French physician Louis Camille Maillard in the early 1900s, is explained through a sequence of changes that begin with interactions between carbohydrates and amino acids. These reactions occur mostly in cooking and produce a browning effect and desired flavor extractions because aromatic molecules are produced throughout the chemical reactions. For the Maillard reactions to happen, foods must be heated above 285-degrees Fahrenheit with the addition and support of fats substances to allow the browning to occur more efficiently. The use of fats in Maillard reactions allow for food temperatures to overcome energy barriers. Some flavors produced by Maillard reactions are savory (peptides and amino acids), floral (oxazoles), onions/meatiness (sulfur compounds), green vegetables (pyridines, pyrazines), chocolate (pyrazines), and potato/earthy (pyrazines).[23]

The breaking down and creation of protein are among the most significant processes in the human body. The fundamental purpose of cooking is making food more palatable and beneficial to the digestion system. When cooking proteins, the chemical reactions that break bonds in proteins are denaturation and coagulation. Amino acids and peptides influence protein behavior. Amino acids are especially important in generating palatable and pleasurable food experiences by contributing to overall flavor.

Proteins are strategically linked by the amine nitrogen of one amino acid with a carbon atom on another amino acid and then repeating the peptide bond to make a chain dozens or hundreds of amino acids long.[24] Heating and other cooking processes can break peptide bonds and cause long protein chains to denature (lose their natural molecular structure). Protein denaturation involves breaking the bonds that maintain the molecule's folded shape. It is a change in structure not composition; however, structure dictates how proteins behave. Denatured proteins function differently from their originals. Cooking that exposes foods to temperatures of 140–180-degrees Fahrenheit or highly acidic environments are a couple of ways to denature proteins.[25]

Denatured proteins are left vulnerable making it possible for them to bond with each other, also known as coagulating. Protein coagulation irreversibly transforms denatured proteins by developing continuous network of proteins with water held in the pockets between protein strands. Foods develop thickness or density that can be delicate and delightful; the details of protein denaturation and coagulation in any given food are intricate and fascinating.[26] In baking and cooking processes, this manipulation of proteins changes food from soft or liquid states into firm, solid structures.

Teaching Strategies

Interdisciplinary & Transdisciplinary Learning: Students will apply content from their science and ELA classes to synthesize knowledge and build/enhance skills between academic disciplines. By completing research projects, analyzing/solving real world problems as individuals and in teams, as well as through case studies, students will develop problem-solving skills involving complex topics and issues.

Cooperative Learning: Through this student-centered instructional strategy, students will engage in small group activities to achieve shared learning goals. Students will prioritize structured interactions and apply pre-established norms and protocols to ensure all group members are equitably responsible for their individual and team success.

Inquiry-Based Learning: While some teacher-led instruction will take place in no more than 10–15-minute whole group touchpoints, majority of student learning will happen through structured and guided inquiry opportunities. During structured inquiry lessons, students will be provided tasks, materials, and step by step procedures to discover known outcomes**.** Guided inquiry lessons are provided research topics and/or case studies and are responsible for designing the explanations and methods for problems.

Project-Based Learning: As a culmination to their learning journey throughout this unit, students will tackle open-ended, real-world problem-solving requiring the application of critical thinking skills, creativity, and innovation to achieve successful outcomes.

Classroom Activities

Activity 1: Unit launch with reading materials to explore and explain food at the molecular level as well as the function of carbohydrates, fats, and proteins

Suggested reading materials: ***Chemistry Helps Feed the World*** *from American Chemical Society*, Articles from Nemours Children's Health Website including: "What Are Carbohydrates?", "What's Protein?" & **"**Learning About Fats"

Students actively engage with the reading materials by building, drawing, and explaining basic designs of carbohydrates, fats, and amino acids/proteins to enhance their understanding and function of these molecules. The ***Chemistry Helps Feed the World*** text provides hands-on activities to complement the reading material which can broaden student understanding of simple chemistry concepts and food science. Exploring, explaining, and modeling how carbohydrates, fats, and proteins work in the body through reading and writing activities to launch the unit provide language/vocabulary, opportunities for concept development, and background knowledge students will reference and utilize throughout all activities in this sequence.

Activity 2: Understanding the Connection Between Smell and Taste

Suggested reading material: "Sense and Sensibility" by Kirsten Weir

In activity 2, students will use reading materials, investigation, and writing tasks to discover and explain the olfactory and gustatory systems. Understanding that taste and smell are chemical senses that work close together is essential for developing cooking skills. This activity will begin split into two parts.

Investigation Part 1: Randomizing food items to explore how olfactory and gustatory systems work together to create flavor

- Students work in partnership with one student blindfolded and the other student curating a smell/taste experience by mixing 2 uncommon food items: one for the blindfolded student to smell and another for the student to taste.
- Students will switch roles each round. There should at least 2 rounds where each partner can be the curator and the test subject an equal number of times.
- Students record their observations and notes in their science notebooks.
- Students debrief their experiences and explain the flavor combinations they discovered throughout the investigation.

Investigation Part 2: Reading and writing about olfactory and taste systems

- After completing the part 1 of the activity, each student receives a copy of the "Sense and Sensibility" text to complete a first read of the text independently.
- During a second read as a whole group, teachers and students discuss the chemical senses and annotate diagrams of the olfactory and gustatory systems to explain smell and taste reception and how the human body processes information.
- Students will complete vocabulary activities and text dependent questions aligned to the reading material to demonstrate their comprehension of the concepts.

Activity 3: Exploring Cooking through Mixtures (Explaining physical and chemical changes in cooking)

In this activity, students will be split into teams of 3-4 people and assigned a station. Students will be exploring and explaining cooking through mixtures. While there will be no chemical changes during these cooking experiences, students will begin to learn essential cooking skills through mixtures where critical thinking, measurement, modeling phase changes, and proper use of kitchen tools. Activity 3 requires students to create basic recipes, use simple, fresh ingredients, and record the recipes using scientific language. Each station is stocked with a variety of ingredients, and students select what they will use to build their recipes. Throughout the cooking process, teams work collaboratively to capture their steps, ingredient selections, measurements, techniques, and outcomes in their scientific notebooks using chemistry vernacular, chemical nomenclature as well as explaining the physical changes they observed using words, numbers, and pictures to finalize recipes aligned to each station.

Station Investigation: Creating Basic Foods with Fresh Ingredients

- Station 1: Beyond Hidden Valley: Making Salad Dressings (Exploring emulsification)

Ingredients list: 2-4 seed oil options, vinegar, apple cider vinegar, lemon juice, lime juice, salt, pepper, mustard options, garlic, herb options, shallots, honey, and maple syrup

- Station 2: Making Simple Syrups (Exploring hydrogen bonding)

Ingredients list: White granulated sugar, water, freeze dried fruit options

- Station 3: Making Crispy Rice Treats (Exploring sugar crystallization and lipid-protein-carbohydrate interactions)

Ingredients list: Salted and unsalted butter options, marshmallows, vanilla extract, sprinkle options, crispy rice cereal

- Station 4: Making Ice Cream (Exploring freezing and emulsification)

Ingredients list: cream, granulated sugar, vanilla extract, ice, rock salt, 2-4 sealed bags

- Station 5: Making Fresh, Simple Dips (Exploring emulsion, flavor binding, and osmosis)

Ingredients list: black-eyed peas, black beans, corn, diced tomatoes, bell peppers, onion options, jalapeno, cilantro, seed oil options, vinegar, apple cider vinegar, garlic, honey, lime juice, lemon juice, seasoning options, and tortilla chips

Activity 4: Exploring and Explaining Maillard Reactions

In Activity 4, students begin to explore and explain chemical changes in the kitchen. The class is split into 3 teams with each team making noodles from scratch using 3 ingredients: flour, eggs, and water only. Throughout the dough making phase of this activity, the class will discuss/explain protein bonding, gluten formation, gluten relaxation, and moisture redistribution.

Phase 1: Making and Flavoring Noodles (Creating a Pasta Station)

- Step 1: Exploring protein bonding and gluten formation through simple pasta making
- Step 2: Explaining gluten relaxation and moisture redistribution

While the dough rests, students will work on their plans for flavoring their pasta. During this phase each team is assigned the task of creating a red sauce, white sauce, or flavored broth. Students will also be given the option of cooking with meat and/or vegetables for their sauce assignment. Students are provided seed oil options, crushed tomatoes (for red sauce team), cream (for white sauce team), chicken or vegetable broth options (flavored broth team), seasoning blends, aromatic options, fresh/frozen/canned vegetable blends, cheese options, herb options, chicken, turkey, or beef options.

Phase 2: Making and Flavoring Noodles (Creating a Pasta Station)

- Step 3: Forming noodle shapes and preparing ingredients for cooking pasta
- Step 4: Exploring Maillard reaction by browning meats, vegetables, and aromatics
- Step 5: Designing and making pasta dishes with red sauce, white sauce, or flavored broth

Phase 3: Quantifying Mixtures and Techniques

Throughout the cooking process, teams work collaboratively to capture their steps, ingredient selections, measurements, techniques, and outcomes in their scientific notebooks using chemistry vernacular, chemical nomenclature as well as explaining the physical changes they observed using words, numbers, and pictures to finalize recipes aligned to each team's creation.

Activity 5: Designing and Creating Cookbook

Phase 1: After completing activities 1-4, students are afforded the opportunity to design an original cookbook that showcases their recipes, techniques, and scientific discoveries. Scientific notebooks will be critical resources during this stage because students will revise and edit their concepts and creations using the notes they captured during their investigations. Partnerships and teams will update and submit their writing samples including recipes, step by step instructions, and complete ingredient lists in a hard copy using a teacher provided template for review and feedback. When students receive their feedback, they are tasked with organizing, digitizing, and submitting final versions of all recipes to be included in the final project.

Phase 2: Cookbook Designing and Publishing Party

Students will be split into stations to help design and publish the class project. The work completed at each station will be instrumental in successfully publishing the project and sharing with the public.

- Station 1: Develop front and back cover art
- Station 2: Design cookbook layout and organize materials
- Station 3: Develop visual content for the inside of the project
- Station 4: Create and design title options for the project

To celebrate the completion of the cookbook, students and teachers will host a publishing party where copies of the cookbooks will be shared, student lead presentations about the chemistry of cooking, and food samples distributed to attendees.

Readings & Bibliography

Coxwell Matthewman, Madeline, and Rahul Costa-Pinto. Macronutrients, minerals, vitamins, and energy, 2022.

Excellent resource for background knowledge on macronutrients and energy transformations.

Heimann, Robert B. “Ancient and Historical Cooking Pots and Food: An Eternal Communion. A Topical Review.” Archaeometry 67, no. 1 (May 16, 2024): 219–34. https://doi.org/10.1111/arcm.12986.

Great resource for learning and explaining about ancient cooking tools and techniques.

Leghi, Barbara Esteves, Carina Carlucci Palazzo, Lilian Magalhães, and Rosa Wanda Diez-Garcia. “Does the Body Speak? Body Map of the Relationship with Food Narrated by Women in an Intervention for Food Consciousness.” Interface - Comunicação, Saúde, Educação 28 (2024). https://doi.org/10.1590/interface.240410.

This resource provides insight into how the body selects, processes, and uses food culturally and scientifically.

Mcgee, Harold. On food and cooking: The science and lore of the kitchen. New York: Scribner, 2004.

Excellent and comprehensive resource that explains cooking and food science in great detail.

Wolke, Robert L., and Marlene Parrish. What Einstein told his Cook: Kitchen science explained. New York: W.W. Norton & Co, 2008.

Great resource for background knowledge on carbohydrates and fats.

Appendix on Implementing District Standards

5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen.

5-PS1-3: Make observations and measurements to identify materials based on their physical properties.

5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

5.PS3-1: Use models to describe that energy in animals’ food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

RI.5.1: Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.5.2: Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.

RI.5.3: Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.

RI.5.4: Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 5 topic or subject area*.

RI.5.9: Integrate information from several texts on the same topic to write or speak about the subject knowledgeably. Integrate information from several texts on the same topic to write or speak about the subject knowledgeably.

W.5.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

W.5.4: Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

W.5.5: With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

W.5.6: With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of two pages in a single sitting.

W.5.8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

Endnotes

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[1] Matthewman and Costa-Pinto. “Macronutrients, minerals, vitamins, and energy”

[2] Wolke, What Einstein Told His Cook. 7

[3] Matthewman and Costa-Pinto. “Macronutrients, minerals, vitamins, and energy”

[4] Matthewman and Costa-Pinto. “Macronutrients, minerals, vitamins, and energy”

[5] Wolke, What Einstein Told His Cook. 66-70

[6] Matthewman and Costa-Pinto. “Macronutrients, minerals, vitamins, and energy”

[7] Wolke, What Einstein Told His Cook. 124

[8] Matthewman and Costa-Pinto. “Macronutrients, minerals, vitamins, and energy”

[9] Leghi, Palazzo, Magalhaes, Diez-Garcia. “Does the body speak? Body map of the relationship with food narrated by women in an intervention for food consciousness”

[10] Mollo, Boero, Penuelas, Fontana, Garson, Roussis, Cerrano, Polese, Cattaneo, Mudianta, Genta-Jouve,

Taglialatela-Scafati, Appendino, Amodeo, Ghiselin. “Taste and Smell: A Unifying Chemosensory Theory”

[11] Heimann. “Ancient and historical cooking pots and food: an eternal communion. A topical review”

[12] Heimann. “Ancient and historical cooking pots and food: an eternal communion. A topical review”

[13] Heimann. “Ancient and historical cooking pots and food: an eternal communion. A topical review”

[14] Heimann. “Ancient and historical cooking pots and food: an eternal communion. A topical review”

[15] Heimann. “Ancient and historical cooking pots and food: an eternal communion. A topical review”

[16] Heimann. “Ancient and historical cooking pots and food: an eternal communion. A topical review”

[17] McGee, On Food and Cooking. 571

[18] McGee, On Food and Cooking. 573

[19] McGee, On Food and Cooking. 575

[20] Heimann. “Ancient and historical cooking pots and food: an eternal communion. A topical review”

[21] McGee, On Food and Cooking. 778

[22] McGee, On Food and Cooking. 779

[23] McGee, On Food and Cooking. 779

[24] McGee, On Food and Cooking. 806

[25] McGee, On Food and Cooking. 808

[26] McGee, On Food and Cooking. 808

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