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It's Alive! Using Microorganisms in Cooking

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by Pedro Mendia-Landa

Introduction

Food is a universal theme that can be used to integrate all areas of the curriculum; from social studies to math, from biology to chemistry. As a means of engaging your students all that you need to do is ask what is one type of food they eat at home that they never eat in public. That is exactly what I did with my students, and to my astonishment; they mentioned meals that I never had heard of before. Of course, my students may not be representative of the majority of the students in the district where I teach. As an English Language Learner (ELL) instructional coach, I serve a population of new immigrants and second-generation students for whom food is yet another indicator, with language and customs, of significant cultural values that singles them out from the rest.

The topic of food allows for many hands on activities related to how the changes in matter affect the chemical composition of a substance and the chemical changes that take place in the conversion of food from raw materials into energy via the process of preparation (as simple as washing and drying an apple), elaboration (creating a menu with apples as the feature ingredient), to processing (making apple juice), to cooking (making an apple pie), to consumption, and discharge.

However, this unit explores the way that certain microorganisms have assisted human kind to progress through the ages, the ways they are currently used in cooking and other science fields, and what they have to offer to today's civilization as model systems. One of these microorganisms Saccharomyces cerevisiae, otherwise know as baker's yeast, has been used as a model system for the exploration in genetics and cell biology. This is the case because it is a unicellular organism with important similarities to the cell cycle in humans, as well as because of it easy genetic manipulation.

This unit is centered on some microorganisms that through the ages have been used to prepare, create, or assist in the processing of foods so that they can be consumed. As this unit explores these organisms and their interactions before, during, or after cooking, some of the basic chemical principals involved in the process are explained. Among these microorganisms that are discussed we have yeasts and helpful bacteria and enzymes used in the creation of cheese, yogurt, or miso.

As we explore the way that common foods such as pancakes, bread, muffins, and common drinks such as ginger-ale, soda, or carbonated water; we will explore the chemical reactions originated by a very special yeast: Saccharomyces cerevisiae and we will compare it to other microorganisms used in making breads and quick breads based on sourdough starters and on leavening substances such as baking soda and baking yeast.

Goals and Objectives

The main purpose of this unit is to explore the chemical, physical and engineering concepts that take place in cooking as a means of assisting students to make and apply concrete connections of these principles to their daily lives. Thus, the goal is for students to understand that physical, chemical, and biological changes are not a bunch of abstract concepts, but essential principles that take place all around us. The following cooking activities included as part of this unit are the perfect medium to introduce and engage all students to the fascinating field of chemistry.

The kitchen, after all, is and has been the quintessential location in the home where food is stored and cooked, but in most cases, it is also the place where food is consumed and the place where family and friends gather to socialize and entertain. Thus, the kitchen is one of the most important places in the home to begin exploring about the wonders of chemistry.

Through inquiry and participation in the activities of this unit, students explore the following essential concepts and skills outlined below.

Essential Concepts

The following are some of the key concepts that this unit explores:

- Chemistry is the study of matter and energy and the interactions between them.
- Chemistry explains what materials are made of and how they combine with one another.
- Micro-organisms in food can be harmful or beneficial.
- A substance that undergoes a physical change is still the same substance after the change (i.e. boiling milk).
- A chemical change produces new substances with properties different than those of the original substances (i.e. adding a culture to milk to produce yogurt).
- Yeast is a living organism belonging to the fungus family.
- Yeast is a live organism that breaths and grows.
- A substrate is the organic material that the microbe uses to get its food from
- Fermentation is a process of growing microorganisms.
- In order for fermentation to take place we must have fungi or bacteria present, no oxygen, and organic matter to act as a substrate.
- Yeasts and molds are fungi. Yeast are unicellular and molds multi cellular.

Essential Skills

Students will be able to:

- Differentiate between a physical and a chemical change.
- Observe, analyze, and record the unique physical and chemical properties of yeast, bacteria, and mold.
- Observe and analyze the fermentation process.
- Create a three-dimensional model of a chemical compound.
- Create a line drawing model of a chemical compound.
- Design and conduct a "valid" experiment.
- Discover chemistry, physics and engineering principles reflected in cooking.
- Identify direct and indirect impacts of chemistry to their lives.
- Describe and illustrate how these chemistry principles work.

Childhood memories

As the aroma from the oven filled the house, a flood of memories overtook my senses, bringing me in time and space to my mother's kitchen in the countryside of the Basque country. The smell of fresh cut vegetables, the cows mooing and lowing accompanied by the sound of the cowbells as the cows are being milked, the cackling of the chickens as they lay their eggs, the greenery of the corn fields surrounded by walnut, hazel nut, and other delicious fruit trees against a backdrop of green mountain tops; these memories speak of a life centered in subsistence; of a way of life centered on the daily work of sowing, caring, and harvesting the fruits of one's labor. This idyllic memory post card speaks of the hard work, and simple way of life centered on the seasons and cycles of earth. These cycles provide both the work and the harvest of earth's richness to be shared around a table.

As part of this childhood memory, I can still sense the weekly kneading and shaping of the dough into loafs as the smell of the yeast dissolved in the lukewarm water and the nutty aroma emanated from the froth that it created as it bubbled and fizzled up to the top. Little did I know that what I was observing was a live organism that breaths and grows. An organism, Saccharomyces cerevisiae, that because of its simple complexity it is now used as a model system. It is thus very appropriate that this unit celebrates and centers on the richness of what life has to offer as a means of exploring chemical principals related to cooking and eating.

From the time that we mix the yeast to the time that the bread comes out of the oven, we can study the multiple physical and chemical changes that take place before, during, and after. This process of explaining the changes that take place to matter belong to the field of chemistry and thus, the process of making bread, pancakes, pizza dough, soda-pop, etc. illustrates these basic principals of chemistry, and serves as a springboard to explore with students what it means to be a chemist.

Given the fact that I want students to be able to observe and analyze these processes, the unit focuses on hands-on activities that can be completed in the classroom. Thus, the unit moves away from baking breads but explores with pancakes and other quick breads (that can be cooked on an electric griddle) the physical and chemical changes that occur as we use microorganisms to assist in the process. This is not to say that we cannot maintain a sourdough starter, which will be fed and regularly observed. As an extension activity, the bread dough can be kneaded and prepared in the classroom and be sent home with a student to be cooked at home.

The success of this unit will be judged not on the content or on the following activities, but by the ability of the teacher to integrate content and context to the background knowledge that the students bring with them to the classroom, and on the ability of the teacher to build upon it. Not only to further engage them in their learning, but also so they are more likely to attach meaning to the new concepts and vocabulary.

Following the analogy of teaching as cooking, the secret in not necessarily in the ingredients, but in how to prepare them; how and when to add the ingredients; how to cook them (medium and time); and how and when to present them at the table. Even then, the job is not complete, because without an appetite, the best meal in the world is not worth the pan where it was cooked.

Microorganisms in the Kitchen

There are many foods and drinks that rely on, and make use of microorganisms to break down complex carbohydrates into more digestible foods. Microorganisms can also act as a preservation agent. The basic principle is that these microorganisms make food resistant to other microbes by overgrowing desirable microorganisms that compete with limited food resources. In the process of fermentation the enzymes produced by the bacteria, mold or yeast change the characteristics of the food increasing the nutritional value of the fruit or cereal mash.

Microorganisms, what are they?

The word Microorganism is made up of "mikro" from the Greek to mean small and organism, an individual animal, plant, or single-celled life form. Thus, a microorganism is a life form not visible to the naked eye.

We are surrounded by millions of types of microorganisms. Microorganisms have adapted to all types of ecosystems and habitats; from the North Pole to the Antarctica. Millions of microorganisms live inside us symbiotically a sin our gut. Some of these microorganisms are benign and are responsible for the breakdown of matter into material that plants are able to use as nutrients. Some examples of these microorganisms are the center of this unit because of the beneficial uses they have in cooking. Others microorganisms are malign, and as such, we need to take the necessary precautions to insure that they do not sicken us or that we slow their effects so that we can consume those foods that they attack. An example of this is the bacteria that make foods and vegetables decay. Storing the produce properly so that the bacteria growth is inhibited can slow the process of decomposition.

There are five distinct types of microorganisms: 1) bacteria, 2) fungi, 3) viruses, 4) algae, and 5) protozoa. This unit manly studies two important members of the fungi family and names a few beneficial bacteria used around the household.

Single-cell organisms are present in all aspects of food preparation from its production, processing, storage, and even digestion. These microorganisms are responsible in some instances for the breaking of food sugars into alcohol molecules as in the case of beer, wine, and spirits, or in the conversion of lactose and other sugars to lactic acid, such as is in the case in yogurt making. In other instances, these microorganisms aid in the preservation of foods, such as is the case of pickled food, through the lactic acid fermentation process.

In simple terms we can refer to fermentation as the process of growing microorganisms in food. In this general definition we do not make a distinction between aerobic (using oxygen) or anaerobic (not using oxygen) chemical reactions that take place. However, these chemical reactions are important depending on the type of microorganism.

There are three different types of beneficial microorganisms that are explored as part of this unit: yeast, molds and some bacterium. These and other benign microorganisms make it possible for us to preserve foods, helps our system to break down, and prepare the nutrients trapped in the food, so that they can be easily digested. One example of the use of microorganisms is in the traditional method of soy sauce production. Here, the combination of roasted soy meal and crushed roasted wheat is fermented for three days with Aspergillus mold and then transferred into containers filled with a brine consisting of Lactobacilli and yeasts. It is in these vats that this mixture is allowed to ferment somewhere between six months to a year, prior to filtering and pasteurization. The final product is soy sauce and the byproduct cake is used as cattle feed.

Yeasts and molds

Both yeasts and molds (moulds) are fungi. One of the main characteristics of fungi is their lack of chlorophyll. Because of this, they grow by feeding on organic matter like mushrooms. Fungi can be unicellular or multi-cellular. This is what differentiates molds from yeasts. While molds are multi-cellular, and as such they grow in the form of filaments, also called hyphae (the vegetative threadlike part of the fungus), yeasts are fungi that grow as single cells.

Often when we think of fungi, the first thing that comes to mind is the harmful types responsible for food decay, causes human disease such as ring worm or athletes' feet, or causes plant disease such as mildew or rust. However, there are other fungi that are most helpful and that are used in the creation of certain drugs (i.e. Penicillin), or used in the breakdown of organic materials in recycling waste and dead organisms, or that are edible, such as mushrooms. It is however the fungi used in the making of cheese, wine, beer, and liquors, bread, and cereals that is of interest to us.

Few are the foods and drinks that have been given credit for influencing and given rise to civilization. Among these we must include bread and beer. Bread has been called the "staff of life" yet there is a continuous debate as to whether beer precedes bread as a source of nourishment. These foods and drinks would have not been possible without two of the most important yeast known to civilization: Saccharomyces cerevisiae for bread and Saccharomyces carlsbergensis for beer.

One fungus Aspergillus oryzae, also known by its most common name of koji, is widely used in Chinese and Japanese cuisine for the fermentation of soybeans in the creation of shoyu (soy sauce) and miso. This mold is also used in the creation of alcoholic beverages such as sake and huangiju. The process consists on converting a simple soluble fermentable sugar by hydrolyzing (decompose by reacting with water) sugar derivatives or complex carbohydrates present in rice, potatoes and other grains such as millet or wheat. Koji is also used in the making of rice vinegar.

The yeast of life: Saccharomyces cerevisiae

Yeast is a live single-cell organism that breaths and grows. As such, it requires an environment that facilitates its growth and subsistence. The optimum environment for Saccharomyces cerevisiae is from 12°ãC to 40°ãC (53.6°ãF to 104°ãF). This yeast tolerates temperatures from freezing to about 55°ãC (131°ãF) and even tolerates almost complete dehydration (this form, dry yeast, is the most common commercial variety).

Yeast is a natural growing organism that is present on fruits, flowers, and other objects that because of the sugar content allows the yeast to thrive. There are over 160 different types of yeast, most of which are of no real value to humans.

One of the most common and useful yeasts in history is Saccharomyces cerevisiae. This yeast is not only responsible for rising the dough in bread, but presently is even more importantly known for its use as a model system. This yeast has been identified as an ideal microorganism for biological studies due to the different biological functions shared with human cells. For example, its non-pathogenic nature, rapid growth and well-identified genetic system make it a useful organism. The cells of S. cerevisiae divide in a similar manner as our cells. Also, as a eukaryotic this yeast has a single nucleus containing chromosomes just like our won cells (Sherman, 198).

It is important to note here that both yeast and sourdough starters act as catalysts for the fermentation process to occur. The difference is that in using yeast, Saccharomyces cerevisiae is the only catalyst, while sourdough starters are composed of other yeasts and lactobacillus (a type of anaerobic bacteria responsible of turning lactose and other sugars to lactic acid).

Starters

Through the ages we see different cultures around the world creating many recipes to harvest and maintain yeasts' cultures alive. One way of maintaining these yeasts alive is through the creation of a starter. A starter is a medium of water, flour and yeast (or yogurt) that is kept alive by feeding it every so often and replacing it as time goes on. These starters mature with time. As the yeast cell dies it releases its contents into the medium and enhances the original flavor. Theses starters, although they contain some of the original yeast, are also populated with other bacteria, giving it a sour taste. Bread starters are also referred as "sponges", and in the most basic sense starters are yeast substitutes.

One of my favorite sources for making starters appeared in an article in the New York Times, on June 27, 1880 by someone under the initials L.H. This article lists at least six different ways of creating your own starter. They range from those made with grape leaves to starters made with potatoes. Who knew that there is such a variety of yeast "mediums"? I look forward to exploring some of these in my own cooking and with students. The following hop yeast recipe is but an example of the few worth exploring. In reading this recipe I deduce that the first time you create this starter, as it is the case with most starters, you make use of regular dry or other types of yeasts to expedite the process (even though you can do without it):

> Three large potatoes, one handful of hops; put in a small bag; put the

> potatoes and hops into two quarts of water and boil down to one quart; take out the bag of hops and potatoes; mash the potatoes fine and throw back into the boiling water; stir flour into this while hot until it is quite stiff; let it stand until it is nearly cold, then add a half cupful of yeast, half a cupful of sugar, one tablespoon of salt, and half a tablespoon of ginger; set in a small place to rise; when light put in a covered jar and place in a cool place. (June 27, 1880)

The more recipes for sourdough starters that you read, the more variations on one theme that you uncover. That is, in some recipes all they call for is water, flour, and time for the airborne microorganisms and those organisms in the flour to begin the fermentation process. However, in others, as the one mentioned above, we can observe the use of other ingredients that expedite or give a different flavor to the starter. The final end is the same.

The rationale for the sourdough starter is that it is created only with the natural ingredients included in the whole grain. As a matter of fact, under a less than favorable environment, adding sugar to the starter, other less beneficial bacteria might grow, making it useless. It is clear that the way to create and maintain a good sourdough starter is to encourage the growth of yeast and lactobacillus that are part of whole grains.

Something important to remember about sourdough starters is that you want to feed the starter twice a day discarding (or using for cooking) half of the amount and replacing it with more flour and water. The purpose of continuing to feed the starter is to encourage more growth and keep it alive. The starter will last longer if refrigerated. In this case you only need to feed it every couple of weeks. As stated earlier, although there are many microorganisms as part of the flour, you want to encourage only the growth of yeast and lactobacillus. At least one of the performance tasks of this unit will look at the differences between sourdough starters and yeasts.

In modern times there are other means of leavening grains that make use of substances such as baking soda and baking yeast. These products do not only expedite the cooking process, but additionally they are more consistent in the way they leaven the batters resulting in more consistent and reliable recipes.

Bacteria

Bacteria are another important unicellular microorganisms used in the preserving and processing of foods. A bacterium is a prokaryotic (does not have a nucleus), unlike yeast that has a nucleus (also called eukaryotic). We can find different types of bacteria that are important in the breakdown and processing of foods. Among the most important is the bacteria responsible for turning milk into yogurt (Lactobacillus bulgaricus, Lactococcus thermophilus, and/or Streptococcus thermophilus), kefir (different microbes, yeasts, and lactobacilli, Lactococci, and leuconostocs), and in cheese (Streptococcus and Lactobacillus).

In addition to the fermentation of milk, beneficial bacterial encompasses functions such as food digestion (by fermenting complex carbohydrates), acting as a barrier against pathogens and the making of vitamins (they synthesize folic acid, vitamin K, and biotin).

Among other less well known bacteria we have Aspergillus niger, which is responsible for the production (for commercial purposes) of large quantities of citric acid. In making sauerkraut, Leuconoctoc mesenteroides and Lactobacillus brevis are responsible for fermenting the sugars from raw cabbage and turning them into lactic acid, acetic acid, ethanol, and mannitol. Additionally, we have Lactobacillus plantarum and Lactobacillus mesenteroids as the bacteria responsible for starting the process of fermentation of green olives and making them edible.

As we can see from these examples, the use of bacteria extends farther than the bacteria found on the surfaces of the human body, which can be benign (i.e. Staphylococus epidermidis) or malign (i.e. Streptococcus pneumoniae). However, this bacterium is of no interest to us in that they are not a useful microorganism in the processing, preparation or cooking of food.

Chemistry: Why does it matter?

Matter occupies space and has mass. Thus it matters; it is in your face if big enough, or even when so small that cannot be seen with the human eye. It is the properties it has and the way that it behaves that matters in matter. And so matter matters in this unit for the simple reason that it is the focus of the study of chemistry and of this unit as we explore it through cooking.

Chemistry does not only offer a closer understanding of everything in the world that surrounds us and how it works. In doing so, it looks at the properties of matter in terms of atoms, the building blocks of matter. These properties of matter relate not only to its composition (the kind of atoms it contains) but also its structure (how these atoms are arranged).

Atoms are combined into molecules. A molecule is made up of at least two atoms bound by a chemical bond with a specific arrangement or shape. There are at least three ways of depicting molecules: through three-dimensional computer models, tangible plastic models, or line drawings. One important aspect of chemistry is visualizing molecular structures. For this reason, students in this unit will be able to depict molecules through line drawings and tangible plastic models to visualize chemical and physical changes. In a chemical change, the atoms are rearranged and there is no gain or loss in the number of atoms, however, the molecules present before the change are not the same after the reaction. In a physical change, all the molecules present at the end of the reaction are the same as those present at the beginning. The only difference is that the arrangement of those molecules relative to one another has changed.

There are about one hundred basic substances, called elements, which make up matter. In studying changes to matter, we look at the way that the properties of these elementary substances, or elements, affect their composition.

Among some of these basic elements, we have carbon, oxygen, hydrogen, or iron. Additionally, these elements are the building blocks that when combined can create an unlimited number of chemical compounds.

Lessons and Activities

As earlier stated, this integrated language arts and science unit will create the needed foundation for the students to explore other types of microorganisms and for students to be able to use the scientific method as they present and follow through with an experiment related to this unit.

Appendix B lists the most important standards that this unit covers in the areas of science, social studies, and language arts. It will be observed from the list that not all the standards are specific to the seventh grade (in which this unit will be implemented). Suffice to say that most curriculums should be recursive and spiraling in complexity and breadth. It is for this reason, that some of the science standards that the unit targets will be new to students (i.e. science standard 7.4.a-Various microbes compete with humans for the same sources of food) and detailed instruction required; others, will have been introduced in prior years and can be used as springboards (i.e. science standard 6.1.b-Materials can be classified as pure substances or mixtures, depending on their chemical and physical properties); others yet are here included because they closely align to the content of this unit and with modifications the activities could be implemented in those grade levels (i.e. science standard 2.4.b-People eat different foods in order to satisfy nutritional needs for carbohydrates, proteins and fats).

Given that this is an integrated unit, I include social studies and language arts standards that are aligned with the content at hand.

A critical thinking pedagogy: Moving past the lecture

It is not the first time that when talking to a middle or high school teacher we hear their complaints that by the time our students get to them, they have lost all sense of inquiry and self-discovery. That all students want is for someone to tell them what to do, how to do it, and what to say.

This curricular unit looks at ways that we can create activities that will engage all learners and provide teachers and students with activities that reflect both effective teaching strategies and meaningful student tasks around the ways that microorganisms assist us in preparing, processing, and digesting food.

One way of introducing and engaging students is via some overarching open-ended questions. At times, these questions will drive the small anticipatory group discussions to the unit (the hook of the lesson) or to the sample activities here proposed. As such, these questions become the essential questions that we will continue to revisit throughout the unit. In other instances, these questions are posed as a means to activate prior knowledge and set an environment where enquiry and collaboration are highly encouraged and expected. The following is the guiding question to this unit:

°¤ How do we use microorganisms to make food? (i.e. what do cheese, yogurt , ginger ale. and bread have in common?)

Due to the fact that my work requires that I take into account the needs of English language learners (ELLs) at all times, and that I look for ways of engaging classroom teachers in meaningful discussions with and among students around content area topics, these lessons are to be representative of both effective strategies as well as meaningful to the lives of the students.

Science misconceptions

- °¤ All microorganisms are harmful to humans.
- °¤ When something is fermented it has gone bad.

Essential vocabulary

Fungi, yeast, mold, culture, fermentation, release, carbon dioxide, substrate

Outline of suggested sequence of instructional activities

The organization and layout of this unit attempts to be to a student what a cookbook is to the chef. The unit will progress, as a good meal does, through different courses from appetizers, to dessert. The appetizers become the building blocks, or the chemistry principles that will assist the learner to understand the importance that chemistry has. In the case of this unit, we start by looking at elements and compounds in terms of the ingredients in a recipe. That is, at the macro level, and as a way of contextualizing the chemistry building blocks of atoms into molecules, into elements, into chemical compounds, this will be illustrated with the ingredients needed in making pancakes. The basic elements we use are water, yeast, and flour. After these elements are combined they create a compound. At the micro level look at the makeup of each separate element: flour, water, and yeast. Here we study the composition of each ingredient separately.

However, before we can start with a menu, we must ensure that we know who is coming to the meal, or in other words, who are guests are.

Activity #1 - A meal - Introducing the unit

As a means of generating interest in the unit, I will send a note home with the students (please see appendix A) that will serve two separate purposes. First, it will provide the parents with a general description of the unit and second, the letter will serve as a parental permission slip asking for their collaboration in making their child's favorite dish. Most importantly, this letter requests information about any food allergy that will impede their child's full participation in all the activities in the unit.

Given that we are going to be working with live microorganisms, especially fungi, I recommend using an indoor mushroom patch (http://www.fungi.com/kits/indoor.html) to illustrate how mushrooms and yeast are members of the same fungi family. They are relatively inexpensive, easy to maintain, and if purchased well in advance, a great way to begin talking about microorganisms.

Activity #2 - Let's have a potluck party!- Students Sharing

This activity is great to implement early in the year for multiple reasons. It is a way of involving students and their families. Just make sure that you have responses in writing from all the parents so that you are aware of any food allergies or other food concerns. By doing this well in advance, from the beginning of the activity you will be able to ensure everyone's participation.

To begin, the teacher introduces the main goals of the unit and lets students know that throughout the unit they will learn about microorganisms, how to make soda pop, cook the most incredible pancakes, waffles, and other delicious foods using beneficial microorganisms, and that they are going to design and implement the winning science project.

As in a lab experiment, each recipe has a procedure that was followed from start to end that anyone could follow and get similar results. These steps are necessary if anyone wants to replicate the dish. The main point to get across by the completion of the activity is that the ingredients and instructions are to a recipe what materials and procedure are to an experiment.

The teacher models for the students the procedure that students will follow in presenting to their classmates the dish they brought, and copies of the recipe. The teacher orally will describe the name of the dish and the process that they followed. Given that one of the follow up lessons has to do with physical and chemical changes, the teacher will in context integrate such comments throughout the presentation. i.e. making the salad, although all the ingredients were cut into smaller pieces, and the salad dressing was homemade, the changes are physical.

As the teacher is re-telling the steps or procedure involved, he creates a list highlighting the task elements of what the presenter needs to do. i.e. First, name the dish. Second, pass a copy of the recipes to all the students (or direct them to the page where it can be found). Then, give two reasons as to why it is their favorite dish. After, list the steps needed to make the recipe (instructions). Finally, make a suggestion on how to improve the recipe.

Once the teacher has modeled the procedure to follow, in small groups the students present orally, which is their favorite dish. Even though they might not have cooked it themselves, each student will read or describe the steps in the making of the dish by following the outline of the steps created by the teacher.

Once the meal is over, the teacher will create a KWL+ chart. This graphic organizer will build on the students' prior knowledge on what they know (K) about foods, and their questions of what they want to know (W). The following questions might drive the discussion:

What do the dishes that we shared have in common? How are they different? Did any of the dishes contain any live microorganisms? What are some of the changes that took place? How did those changes take place? How is the leftover food changing? What about the food that we ate? Are these chemical or physical changes?

The teacher charts students' responses under what they (L)earned, (K)now, or (W)ant to know. Additionally (+), the teacher draws lines or creates other graphic organizers to show connections between each of the parts of what students (K)now, (W)ant to know, and (L)earned.

We will make use of this KWL+ chart as a review board listing all of the activities students have participated in; as a reflecting tool to answer the questions, did the activities help us to answer a question that we had? What did we learn from the activity? How did it help us understand? In reviewing and making connections, the teacher draws lines or creates another graphic organizer to show connections between each of the parts of what students (K)now, (W)ant to know, and (L)earned. This is the + of the KWL+.

Thus, this KWL+ is our departing point, a roadmap of where we are going, a journal of where we have been, and the end point of our lessons.

Starters or Appetizers

In a fancy meal, the appetizer places the role of getting the juices flowing in order to begin the digestion process. At the same time, it serves as a way to appeal to the person's taste to what is yet to come.

In the classroom this can be seen as the warm up before the lesson is to begin. It represents the activation of ideas and of prior knowledge that begins to generate thinking. Although, this part of the lesson is important for all our students, it is essential for second language learners. Often times this part of the lesson comes in many forms, in activating prior knowledge we can use a graphic organizer or do a brainstorm; we can create an anticipatory guide of the material that is going to be covered, or we can do a three minute individual write up about what students think of when they talk about food. This can then be shared in pairs and later presented to the whole class.

The idea here is to not only activate prior knowledge, and assess how much students know about the topic, but to wet their appetite in order to engage them in the content and in the activities that are to come. This is the first step in the learning cycle. I propose to start reviewing the previous day's KWL+ chart. This is an effective means of generating some discussion as prior knowledge is activated through small group conversation, at the same time that will serve as a "classroom memoir" of where we are, where we are going, and where we have been.

Activity # 3 - Chemical versus physical changes

In order for students to be able to understand the difference between a chemical and a physical change, students create a 3 by 5 inch card with the words chemical change on one side, and physical change on the other. The teacher proceeds to tell the following story to which students will respond when prompted as to whether it is a physical or chemical change, by raising their card with their answer. If possible, this activity is done in real time so that students can observe the changes taking place.

> First I measure and combine in a bowl 1.5 cup of flour, 2 tablespoons of granulated sugar, 2 teaspoons of baking power, and 1/2 teaspoon of baking soda. Is this a physical or chemical change?
> In a separate bowl, I blend an egg, and 1 1/3 cups of plain nonfat yogurt? Is this a physical or chemical change?
> I add the blended liquid ingredients into the dry mixture and mix them well. Is this a physical or chemical change?
> After the griddle is hot, I add 1/2 cup of the mixture to it. I let if cook until I see the bubbles and the batter is dry on the edges. I flip it with a spatula and let it cook on the other side. Is this a physical or chemical change?
> I put it in a plate and eat the pancake. Is this a physical or chemical change?

At each of the pauses, when students are prompted to respond by showing the card, the students turn and talk with the person next to them and give their reason as to why they think it is a physical or chemical change that it took place. When the story is completed the students, in pairs, create a definition of what a chemical and a physical change is providing samples from this or other recipe.

Finally, each group shares with the rest of the class their definition and the rationale with examples from the cooking exercise.

Activity # 4 - Main Course

The main goal of this activity is to informally present to students, through active participation, the elements of the scientific method. In order to do so, students are encouraged to do some hands-on exploration.

In the exploration phase students actively explore with the concepts of the unit without direct instruction from the teacher. Here students modify the ingredients of the basic pancake recipe used for the chemical versus physical changes activity with the objective of coming up with the "best" pancake recipe. Students must give their recipe a unique name. The role of the teacher in this phase is to expand the students' thinking process by posing open ended questions and directing students to come up with their own hypothesis, answers, and questions. Some key questions include: What do you observe happening when...? What is your thinking about why...? How could you investigate...? How could you communicate that....? What are some of the changes that you would make...? What questions do you still have...? Why did you....?

As a class we will create a rubric of what we mean by "best" pancake recipe and rate each of the pancakes batches. This rubric should be created prior to the cooking and tasting and it is best done in small groups, before coming up with a class rubric. The following is an example of a data table and rubric created as part of this activity.

		Pancake Formula							
Recipe	Recipe name	Flour	Sugar	Baking Power	Baking Soda	Eggs	Milk	Salt	Butter
1									
2									
3									
4									

		Characteristics									
Recipe	Recipe name	Fluffy	Thick	Moist	Salty	Sweet	Spongy	Flavorful	Sour	Tangy	Total
1											
2											
3											
4											

Each recipe characteristic is rated from 0 "not at all" to 5 "very much".

In the next phase of the task, once students have had opportunities to explore with the concepts and content, the teacher explains and goes over formal concepts and clarifies misunderstandings or questions. In the case of this activity, we come up with the elements of the scientific method (what are we investigating or which is the problem?; making observations based on real data and coming up with hypothesis or explanations of how one property affects another; create a "fair and valid" experiment that allows us to test one variable at a time; conduct the experiment as designed; collect and analyze data, draw conclusions and present results).

Lab 1. What's for breakfast? Brewer's sugar fungus is for breakfast.

Saccharomyces cerevisae, Brewers yeast, is a living microorganism and as such, careful attention needs to be placed when working with it. When mixing yeast, special attention to temperature is a must. If the water is too hot, the reaction will be to become overactive, but soon it will soon wear out and die. If the temperature of the water is too cool, the reaction is insufficiently active, and rising will be considerably slow. At the right temperature (95 F - 105 F), lukewarm, this living microorganism releases carbon dioxide as it reacts with the sugar or gluten from the flour. It is the liberation of the carbon dioxide as the fermentation takes place that produces mini bubbles that stretch the dough and make it rise. In a sense, the texture of bread is millions of these gas bubbles, each in its own house of dough.

There are different types of flours; each characterized by the different amount of proteins that they have. Some of these proteins create gluten, which with the liquid and kneading develops and becomes the substrate for the yeast. A substrate is the organic material that the microbe uses to get its food from. In the case of yeast, the substrate is either the glucose from the sugar, or from the flour. As soon as the yeast comes into contact with the glucose, the fermentation process begins.

The gluten is what gives the texture, elasticity and volume to the bread or other flour/grain-based recipe. The gluten is the framework or scaffold that will trap the carbon dioxide bubbles created in the process of leavening. The higher the gluten content is, the greater the volume that the bread will have.

Students should be able to come up with these conclusions on their own through experimentation or through making use of the student resources at the end of this unit. The following are some of the multiple research questions or problems that can lead to experimenting with live microorganisms.

°¤ Does the type of flour increase or decrease yeast activity? (Whole flour, all purpose, enriched, buckwheat, spelt, etc)

°¤ How much sugar should we add to the batter to reach the maximum yeast activity?

°¤ How does the type of flour affect yeast activity?

°¤ What is the effect of temperature on yeast activity?

°¤ What is the effect of sugar on yeast activity?

°¤ What is the effect of yeast on pancakes?

°¤ What effect do chemical leavening agents have on pancakes?

As an extension, we will be making our own sourdough starter using some of the yeast batter and without yeast so that we can at a later time compare and contrast to other leavening agents. Our guiding question will be what is the best medium for the sourdough bacteria to grow?

Cause and Effect Connecting Words organizer

The purpose of this activity is internalize and use the knowledge that the students have acquired throughout the unit and use it as a means of rehearsing and using connecting words in writing and orally in conversation. Note the parallelism between hypothesis testing and the cause and effect exercise. For example, the cause is to the independent variable what the effect is to the dependent variable. i.e. the more food the more that the yeast grows. The independent variable, or cause (food), has a direct effect on the variable of interest, in this case growth of the yeast.

This activity can also be used as a demonstration class. The teacher can combine the ingredients and then discuss which is the cause and which is the effect with the rest of the class. Additionally, this lesson will engage the students into thinking about carbonated water and will serve as a launch pad to the next activity where students will explore and create their own ginger ales using yeast. Thus, students will be able to explore the similarities and differences between carbonated water, carbonated soda, and ginger ale.

As I stated earlier it is important that these activities integrate all the modalities of language at the same time that both the linguistic and academic needs are taken into account at all times. Additionally, it makes use of ESL strategies that will enhance use and comprehension of the language. This follow-up activity demonstrates how to integrate all modalities.

After the demonstration lesson, the teacher creates as many groups of four students as possible. Each student (in every group) is numbered from 1 through 4. Then, the teacher creates groups of "experts" by calling all the number one students to one group, all the number two students to another group, all the number threes to another group, and all the number four students to the last group. In each group they will become "experts" on the essay that they read. All the number one students read the essay What is the difference between soda and carbonated water (http://tutorials.carbonatedseltzerwater.com/category/carbonated-and-distilled/carbonated-water/). Number two students read Carbonated Drinks (http://tutorials.carbonatedseltzerwater.com/category/carbonated-and-distilled/carbonated-beverage/). Number three students read Making carbonated water (http://tutorials.carbonatedseltzerwater.com/category/carbonated-and-distilled/carbonated-soda/). The last group reads Where can you buy seltzer water? (http://tutorials.carbonatedseltzerwater.com/category/flavored-seltzer-soda-sparkling/)

After each student has finished reading their assigned section, as a group, students discuss their findings on what they read and take notes of the main idea, a couple of supporting facts, and some samples. Finally, each student (now an expert in the topic to be presented) goes back to their original group and shares what he or she learned about carbonation. In the follow up activities, students will be able to make connections between the principles involved in water carbonation and making pancakes using chemical leavening agents or microorganisms.

With the use of the KWL+ chart (see previous lesson), the teacher models how to use/create a Cause and Effect T-Chart. Model how students will use a T-Chart to keep track of the events in following a recipe or in one of the model lessons focusing on cause (why did it happen) and effect (what happened). On the left column, students write the cause and in the right column the effect. i.e. You add baking power to the lemonade. The lemonade fizzles and turns into pop lemonade.

Students then make use of the T-chart to create sentences using different connecting words. After students write sentences using cause and effect connecting words, they read them to a partner and sequence them chronologically according to the steps on the recipe. Students can make use of the following connecting words:

because, so, consequently, therefore, due to the fact, since, as a result, the reason for, thus, nevertheless

Cause (Why did it happen?)	Effect (What happened?)
Add baking soda to lemonade	Lemonade turns into pop

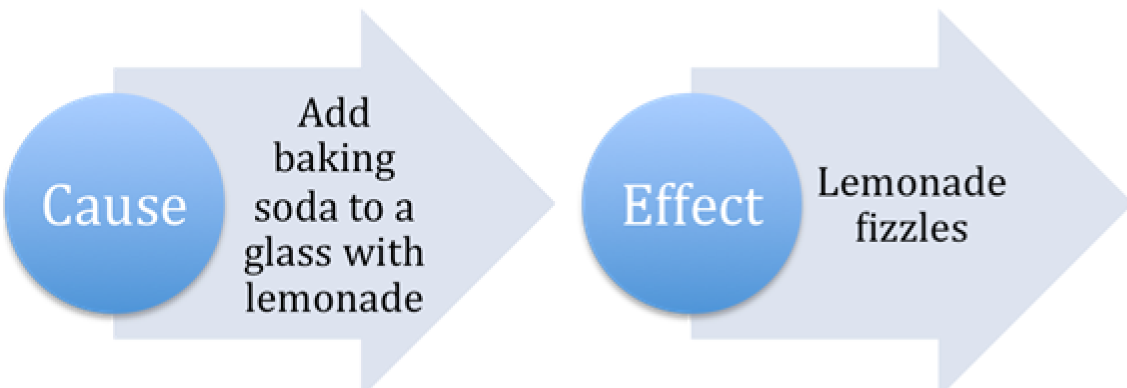
Example:

I added baking soda to lemonade. Consequently, the lemonade turns into pop.

Due to the fact that I added baking soda to lemonade, it turned into pop.

I added baking soda to the lemonade. As a result, the lemonade turned into pop.

Students will use the content from the reading about carbonation, as well as the findings from the pancake experiment, to create a cause and effect T-chart. Students will also be able to experiment with baking soda, syrup, lemons and water to experiment hands on creating their own carbonated drink.



Lab 2. What's to drink? Which is the best ginger ale we can make?

Once students have had an opportunity to create a carbonated drink using lemonade, in this activity they explore making their own ginger ale using yeast. This lesson follows the same guidelines and sequence as the previous activity.

Prior to students receiving a basic recipe for ginger ale, they are provided with portions of Chapter 1, Root Beers in American History (Cresswell, 1998). Here students read about carbonated drinks and its history. Students read about health-giving waters, the birth of the soda fountain, from corks to caps, the legacy of prohibition, root beer, and a section on self-sufficiency. The reading can be done as a jig-saw, like in the previous activity, or assigned to the group as a whole and then discussed. Each group has to come up with a main idea and supporting details for each of the sub headings of the text.

Stephen Cresswell (1998) includes many recipes for root beer (p.32), ginger ale (p.33) and pop. Any of those recipes are simple enough to be used as a basic recipe that students can experiment with as they learn about the chemical reactions taking place in the conversion of sugar into carbon dioxide. However, I like the soda pop recipe provided by LearningHerbs.com (http://www.familyherbalremedies.com/how_to_make_soda.html).

This basic recipe calls for 2 to 3 ounces of fresh ginger, 3 tablespoons of lemon juice and 3 tablespoons of orange juice, ¾ cups of sugar, 4 ½ quarts of water, bread or ale yeast and some soda bottles. This recipe will make 8, 16 ounce bottles. Given that students will be experimenting in creating the perfect ginger ale, I recommend that the quantities be cut in half until a "winning" recipe is found. Close attention needs to be placed to the amount of yeast that is added. A very small amount goes a long way!

The following research questions or problems can lead to experimenting with yeast.

- °¤ Does water sugar increase or decrease yeast activity?
- °¤ How much sugar should we add to the water to reach maximum "pop"?
- °¤ How does the type of sugar affect yeast activity?
- °¤ What is the effect of temperature on yeast activity?
- °¤ What is the effect of sugar/juice on yeast activity?
- °¤ How is the effect of chemical leavening agents different to microorganisms?

The following tables can serve as a means of tracking different recipes in each group, or as a class.

		Pop Formula							
Recipe	Recipe name	Water	Sugar	Lemon juice	Orange Juice	Yeast	Ginger	__________	
1									
2									
3									
4									

Last word and extension activities - dessert

The need of all students to engage with hands-on experiences cannot be overemphasized enough. This is specially so in the case of English Language Learners, who through these types of concrete activities are able to integrate both language and content as they rehearse new and already known language structures.

The KWL+ chart is the logical point to give closure to this unit. As a guiding map, the KWL+ is a working chart of where we were at the beginning of this unit, and a look as to where we are in our exploration of the most important microorganisms used in cooking.

The following is a list of additional extension activities for each of the curriculum areas:

Language arts: Compare and contrast Matrix: Similarities and differences between yeast, molds, and bacteria (this can also be used as a post-assessment). Students write a persuasive essay and make and oral presentation about the benefits of microorganisms to our society.

Social Studies: Locate the names of the countries where the following specialty foods based on lactic acid fermentation are consumed: Korea (kimchi), Russia (kefir), Egypt (laban rayab and laban zeer - fermented milks) and kishk (fermented milk and cereal mixture), Nigeria (gari-fermented cassava), South Africa (magou - fermented maize porridge), Thailand (nham - fermented fresh pork), Philipphines (balao balao - fermented rice and shrimp mixture).

Mathematics: Graph consumption of cheese, bread, kefir, miso, and other foods made with the use of yeast, molds, or other bacteria.

Resources

Teacher Resources

(2009). "The Free Dictionary." Retrieved July 20, 2009, from http://encyclopedia.thefreedictionary.com/.

Although with the explosion in technology there are numerous electronic reference sites, this dictionary is an instrument that needs to be part of every teachers' and students' toolbox. Great photographs, hyperlinks and diagrams make this a must have resource.

Barham, P. (2001). The Science Of Cooking. Berlin ; New York, Springer.

So you thought that it could not be done. You are wrong and this book proves it. Yes, you can teach all the science that you need to cover as part of your science curriculum when you include many of the activities and content included in this must have resource.

Brown, T. L., H. E. LeMay, et al. (2000). Chemistry: The Central Science. Upper Saddle River, N.J., Prentice Hall.

As a chemistry text book, I like the clear samples that the first couple of chapters have to offer to the reader. A great resource for new teachers to the field of chemistry.

Carr, J., U. Sexton, et al. (2007). Making Science Accessible To English Learners: A Guidebook For Teachers. San Francisco, CA, WestEd.

This book is a must read for anyone having English Language Learners in their classrooms, regardless of the content area. Although initially designed with middle school and high school science teachers in mind, the framework, theory and strategies presented throuout the book make it a necessary resource for any teacher, regardless of the content area they teach.

Cresswell, S. E. (1998). Homemade Root Beer, Soda, & Pop. Pownal, Vt., Storey Books.

Anything and everything that you wanted to know about home brewing! This book contains an extensive collection of recipes taken from old cooking books and journals. Great resource for the teacher but not necessarely for students given the inclusion of beer making.

Education, C. S. D. o. (2008). "Introduction to Connecicut's Social Studies Framework." from http://www.sde.ct.gov/sde/lib/sde/pdf/curriculum/socialstudies/ssfrmwkchrt_11_25_08.pdf.

This is the document to check if you need to know which are the latest changes to the social studies framewoks and standards at the CT State Department of Education level. They are broken down by strand and grade level.

Education, C. S. D. o. (March 2009). "Connecticut Prekindergarten-Grade 8 Science Curriculum Standards Including Grade-Level Expectations." from http://www.sde.ct.gov/sde/lib/sde/pdf/curriculum/science/PK8_sciencecurriculumstandards2009.pdf.

These are the most up-to-date science standards for grades K-8 for the state of Connecticut. There has been some significant changes made both to grade and content standards.

Gardner, R. and B. G. Conklin (2004). Chemistry Science Fair Projects Using French Fries, Gumdrops, Soap, And Other Organic Stuff. Berkeley Heights, NJ, Enslow Publishers.

This is a great collection of science fair experiments related to food that anyone can replicate! The experiments are based on organic chemistry and range from chromatography to polymers and plastics. There is a complete chapter on organic chemistry in the kitchen that explores different leavening agents such as baking power and yeast.

McGee, H. (2004). On Food And Cooking : The Science And Lore Of The Kitchen. New York, Scribner.

This has to be the most concise yet extensive reference of food and cooking. If you do not get to see any other resource in this reference list, make this the one to read. Not only because of the clarity in which is written but because of the range of topics it covers. Great illustrations and tables.

Sherman, F. (1998). An Introduction to the Genetics and Molecular Biology of the Yeast Saccharomyces cerevisiae.

Stamets, P. (2009). "Indoor Mushroom Patch." Retrieved July 15, 2009, from http://www.fungi.com/kits/indoor.html.

This site provides the user with access to the finest mushrooms and related products and resources. A great site to purchase organic mushroom kits that can be used as a springboard to yeast and mold microorganisms.

Sulllivan, J. (2006). "Cells Alive." Retrieved July 18, 2009, from http://www.cellsalive.com/.

This site includes an extensive video and computer-enhanced collections of images that can be used to explore the cell cycle and its make up. Concepts related to the different phases of mitosis and meiosis are clearly explained and demonstrated through colorful interacting graphics and images.

Therrien, R. (2009). "New Haven Science." Retrieved July 20, 2009, from http://www.newhavenscience.org/.

If you teach science in New Haven this is the ultimate site to visit. It contains the most up-to-date information on frameworks, standards, curriculum, and the citywide science fair. Additionally, it includes multiple professional development resources and links.

Electronic Resources

Fogel, R. and P. Rogers. (2003). "Fun Facts About Fungi." Retrieved July 15, 2009, from http://herbarium.usu.edu/fungi/FunFacts/factindx.htm.

This site has received numerous awards and it is an excellent source of information regarding fungi. It contains experiments, puzzles,

games, fun facts and teacher resources. Recommended for both teachers and students.

http://www.cellsalive.com/.

This site includes an extensive video and computer-enhanced collection of images that can be used to explore the cell cycle and its make up. Concepts related to the different phases of mitosis and meiosis are clearly explained and demonstrated through colorful interacting graphics and images.

Student Resources

(2009). "The Free Dictionary." Retrieved July 20, 2009, from http://encyclopedia.thefreedictionary.com/.

Although with the explosion in technology there are numerous electronic reference sites, this dictionary is an instrument that needs to be part of every teachers' and students' toolbox. Great photographs, hyperlinks and diagrams make this a must have resource.

Cobb, V. and D. Cain (1994). Science experiments you can eat. New York, NY, HarperCollins.

One of the biggest strengths of this book is the manner in which it demonstrates various scientific principles through the use of simple language and fantastic edible experiments.

Cobb, V. and P. J. Lippman (1979). Experimentos Cient¨ªficos Que Se Pueden Comer. Philadelphia, Lippincott.

Experiments with food demonstrate various scientific principles and produce an eatable result. Includes fruit drinks, grape jelly, muffins, yogurt, and junket.

Gardner, R. and B. G. Conklin (2004). Chemistry Science Fair Projects Using French Fries, Gumdrops, Soap, And Other Organic Stuff. Berkeley Heights, NJ, Enslow Publishers.

This is a great collection of science fair experiments related to food that anyone can replicate! The experiments are based on organic chemistry and range from chromatography to polymers and plastics. There is a complete chapter on organic chemistry in the kitchen that explores different leavening agents such as baking power and yeast.

Appendix A

Sample Letter

Dear Parent/Guardian;

We are embarking on a unit on the chemistry of food and I need your assistance. We are going to be studying some basic physical, chemical, and engineering principals as we explore the way that microorganisms (yeast and bacteria) aid us in preparing common foods such as pancakes, bread, yogurt, and ginger ale. In the process we will be designing and tasting new recipes for these popular foods. Some of these activities and related projects will become part of the Science Fair.

It is important as we begin such an exciting unit that I am aware of any food allergies or food reactions to dairy, wheat, nuts, etc. so that your child is able to participate in the preparation, processing, and especially consumption of the foods we prepare.

Our unit will start on ……….. I am requesting that your child brings a sample of a favorite food along with a recipe to accompany it. If your child is unable to bring a favorite dish, please send a copy of the recipe (It's OK if it is handwritten or modified from a different recipe). I will copy and compile all recipes into a Favorite Recipes Mini-Cookbook prior to the activity so everyone will have a copy for this special event.

Please sign the following permission slip and send a copy of your child's favorite recipe no later than…………...
.

Warmest regards,

Mr. Mendia

I____, parent/guardian of ____will be sending ____for the take off celebration of the unit. This is one of his/her favorite foods. I include a copy of the recipe.

I also give permission for my child to participate in the ongoing science activities, including tasting and preparation. However, please be aware that my child is allergic/reacts to

____
____ .

Appendix B - Content Standards

Science Standards

Science and Technology in Society

2.4.b. People eat different foods in order to satisfy nutritional needs for carbohydrates, proteins and fats. (1) Explain that food is a source of carbohydrates, proteins and fats -- nutrients that animals (including humans) convert to energy they use to stay alive and grow. (4) Compare and contrast how different cultures meet needs for basic nutrients by consuming various foods.

Properties of Matter

6.1 -- Materials can be classified as pure substances or mixtures, depending on their chemical and physical properties

6.1.a Mixtures are made of combinations of elements and/or compounds, and they can be separated by using a variety of physical means.

6.1.b Pure substances can be either elements or compounds, and they cannot be broken down by physical means.

Structure and Function

7.2 -- Many organisms, including humans, have specialized organ systems that interact with each other to maintain dynamic internal balance.

7.2.a All organisms are composed of one or more cells; each cell carries on life-sustaining functions.

Science and Technology in Society

7.4 -- Technology allows us to improve food production and preservation, thus improving our ability to meet the nutritional needs of growing populations.

7.4.a Various microbes compete with humans for the same sources of food. (4) Discover and discuss how humans use bacteria to produce food and identify examples. (5) Compare and contrast the role of bacteria in food production and food spoilage. (6)Evaluate and report how each method of food preservation including dehydration, pickling, irradiation and refrigeration works to stop or inhibit bacterial growth and give examples of each.

Social Studies

1.13 Compare similarities and differences of cultural groups in different regions of the world (e.g., beliefs, values, traditions, institutions)

Geography

SOC.5-8.9: Students will use spatial perspective to identify and analyze the significance of physical and cultural characteristics of places and world regions. (1)Students will be able to locate major countries located within the region.

Language Arts

Standard 3: Communicating with Others

Students produce written, oral and visual texts to express, develop and substantiate ideas and experiences. (1) Students use descriptive, narrative, expository, persuasive and poetic modes. (2)Students prepare, publish and/or present work appropriate to audience, purpose and task.

Standard 4: Applying English Language Conventions

Students apply the conventions of Standard English in oral, written and visual communication. (1) Students use knowledge of their language and culture to improve competency in English. (2)Students speak and write using standard language structures and diction appropriate to audience and task. (3)Students use Standard English for composing and revising written text.