



STEMsational Ag: The Virtual Farm

MIDDLE TENNESSEE STATE UNIVERSITY



Module 3: Save It For Later! UNIT 3: A PICKLE A DAY Grades 9 – 12



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Fermentation Science

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Module 3: Save It For Later!
UNIT 3: A PICKLE A DAY
Grades 9 – 12



9th – 12th Grade:

Introduction to the Unit:

- 1) Pickles are cucumbers that have been preserved from spoilage by the addition of salt (*sodium chloride -NaCl*) and vinegar (*acetic acid*).
- 2) Spoilage is a breakdown of the cucumber by microbes such that it cannot be eaten. Spoilage is visible when the cucumber becomes mushy, slimy, and/or moldy.
- 3) Spoilage occurs because microbes (*i.e. bacteria and fungi*) on the surface of the cucumber gain access to the inside of the cucumber (*under the skin*) to grow on the fleshy portion of the cucumber.
- 4) Bacteria are prokaryotic microbes (*i.e. cells without a nucleus*), while fungi are eukaryotic microbes (*i.e. cells with a nucleus*). Both bacteria and fungi are ever-present in the environment and are found on the outside of the cucumber.
- 5) Bacteria and fungi release enzymes that break down the skin of the cucumber. They do this to enter into the cucumber so that they can break down the internal sugars to provide the energy for their growth (*there are sugars in a cucumber even if it doesn't taste sugary to you*).



- 6) As bacteria and fungi break down food, they are doing this as Exercise of their metabolism. They are breaking down the molecules, such as sugars, of the food to produce adenosine triphosphate (*ATP*) that they can then use as a source of chemical energy to biosynthesize their own molecules, such as deoxyribonucleic acid (*DNA*), ribonucleic acid (*RNA*), and proteins.
- 7) Bacteria and fungi can also enter into the inside of the cucumber if the skin is punctured, perhaps during the picking process.
- 8) In the making of pickles, salt is added by the person making the pickles, whereas vinegar can be produced by bacteria on the skin of the cucumber (*as is done during a traditional fermentation*), or it can be added by the person making the pickles (*as is done during the making of refrigerator pickles*). In this exercise, you will be adding both the salt and the vinegar as you make refrigerator pickles.
- 9) The presence of salt and/or vinegar make it difficult for microbes to grow and hence spoil the cucumber. In general, microbes don't grow well at the level of saltiness and/or acidity present in pickles.
- 10) Microbial growth doesn't refer to starting out as an infant and growing into an adult like it does for animals. Rather microbial growth refers to a single microbial cell dividing to produce two equivalent cells, thus increasing the total number of microbial cells in a population.
- 11) A microbial growth rate refers to how quickly a single microbial cell can divide to produce two equivalent cells; this division is referred to as binary fission. As an example, a cell that can do this in 20 minutes has a faster growth rate than a cell that can do this in one hour.
- 12) The cold temperature of the refrigerator also slows down microbial decompositions of cucumbers (*and other fresh foods*).
- 13) Microbial decomposition of a food makes the food unattractive and undesirable to eat. The growth of microbes like fungi on vegetable products can also produce toxins that lead to foodborne illness such as vomiting and diarrhea.
- 14) Pickles purchased at the store often have a yellow color inside the pickle. This is due to the addition of yellow food coloring by the pickle manufacturer. You will not be adding yellow food coloring as you make refrigerator pickles, thus they will look like fresh cucumbers.

Pre-assessment - On a piece of paper, write your answers to the questions below:

- 1) How does a pickle look, taste and feel different from a fresh cucumber?
- 2) What words would you use to describe how pickles taste?
- 3) Are pickles always a yellowish color like those you buy in the store?



- 4) Are pickles nutritious?
- 5) Prior to the invention of refrigeration, how would people preserve food?
- 6) Is there a danger in eating decomposed food?
- 7) Why is it more difficult for a microbe to decompose a pickle than it is to decompose a fresh cucumber?

Purpose:

- ▶ To introduce a pickle as a preserved cucumber, with the added salt and vinegar serving as preservatives to prevent spoilage.
- ▶ To create a container of refrigerator pickles to demonstrate how easily pickles can be produced.
- ▶ To discuss different ways to preserve food.

Student Learning Outcomes for the Unit:

- ▶ Students will examine the difference between a pickle and a fresh cucumber, in terms of taste, color, and/or texture.
- ▶ Students will work with ingredients to produce a batch of refrigerator pickles to demonstrate how easily pickles can be made.
- ▶ Students will gain an understanding of why food preservation is necessary and how making pickles is one way to preserve food.

Next Generation Science Standards:

These outcomes are in line with the National Agricultural Literacy Outcomes for 9-12 students, which address providing examples of food-borne contaminants and points of contamination.

Vocabulary Words:

- ▶ **Acidity:** the amount of acid on or in a food, as can be measured by taste. Acid in food often imparts a sharp, bitter-to-sour taste like vinegar. Acidity is also measured by assessing pH, where $\text{pH} = -\log$ of the concentration of protons in a substance such as a food. In other words, $\text{pH} = -\log [\text{H}^+]$
- ▶ **Bacteria:** single-celled microbes that do not have their DNA stored within a nucleus. Bacteria are found in soil, water, on the surfaces of inanimate objects, and are even floating in the air
- ▶ **Binary Fission:** the division of a microbial cell into two equivalent progeny cells. This is an exponential process where one cell divides to become two cells, two cells divide to become four cells, and so on
- ▶ **Cucumber:** the fleshy fruit of the cucumber vine (*although we often call it a vegetable, it is a fruit because the seeds are inside the fleshy material*).



- ▶ **Fermentation:** a type of metabolism where bacteria produce an organic acid, such as acetic acid or lactic acid, as a product. The bacteria then release this organic acid outside of their cells. In the case of traditional pickle fermentation, this causes the cucumbers to become more acidic. In the refrigerator pickle technique used in this exercise, we are adding vinegar rather than relying on bacteria to produce it
- ▶ **Fungi:** a type of microbe that does not have its DNA stored within a nucleus. Like bacteria, fungi are found in soil, water, on the surfaces of inanimate objects, and are even floating in the air. Unlike bacteria, fungi are often multicellular, with the cells connected into filaments known as hyphae
- ▶ **Growth rate:** a term that describes the rapidity that a microbial cell can undergo binary fission. For example, a microbe with a fast growth rate may take 30 minutes to divide while one with a slow growth rate may take 2 days to divide. **Metabolism:** the biochemical reactions taking place within a cell. These can be catabolic in that they serve to break down nutrients such as glucose to ultimately produce ATP, or they can be anabolic (*biosynthetic*) in that they use ATP as a source of chemical energy to fuel production of DNA, RNA, and protein
- ▶ **Pickle:** a cucumber that has been preserved by the addition of salt and/or vinegar. Salt: crystalline sodium chloride (*NaCl*)
- ▶ **Saltiness:** the amount of salt on or in a food, as can be measured by taste. Saltiness can also be called salinity and can be measured as the % of NaCl in a food, which is the amount of NaCl in grams per 100 ml of food. Thus, a food with 3 g of NaCl per 100 ml food volume has a salinity of 3%
- ▶ **Seed:** a small piece of a plant that can be used to grow a new plant
- ▶ **Vinegar:** a solution of acetic acid, which is a chemical with a sharp, bitter taste

Materials Needed:

- ▶ 3-4 different brands of dill pickles
- ▶ Plastic forks, paper or plastic plates, and a knife
- ▶ Several 1-pound bags of pickling (*mini*) cucumbers (*1 bag needed per group of 3-4 students*)
- ▶ 2 cups of distilled white vinegar
- ▶ 1 cup sugar
- ▶ 1/4 cup kosher or pickling salt
- ▶ 2 tablespoons dill seed
- ▶ 1 tablespoon pickling spices
- ▶ Plastic or glass container capable of holding 1 quart of pickles and brine



solution (the container should be sealable)

- ▶ Mixing bowl
- ▶ Whisk
- ▶ Measuring cups
- ▶ Cutting boards
- ▶ Knives
- ▶ Brushes and sink to clean cucumbers
- ▶ Two small bowls





Activity 1: Review and Complete Exercise A

This exercise is focused on letting students taste and try different brands of pickles from the store. Ask the students which is their favorite brand and why.

Pickles: Exercise A

Also available online at: www.youtube.com/watch?v=Pi38RpckVgQ



Hi, my name is Jeff Leblond. I'm a professor in Middle Tennessee State University's Department of Biology. This is the first of four short videos on pickles and how to make them, and this first one is to get younger students interested in the topic of pickles,



which I really love, as you can see by my pickle-themed baseball hat.



This first video is just a taste test. So what I'd like you to do with younger students is to purchase a few different brands of pickles,



lay them out and



give them a try - delicious.



As you buy these pickles, pay attention to the ingredients. You'll see, of course, that there are cucumbers, but also vinegar and salt.



Some that are organic lack yellow food coloring, so they might be colored like these with turmeric, as are these pickles.



Some do have yellow food coloring, and the yellow food coloring gives the pickle a yellowish tint that's not very much like a natural cucumber.



So, again, what I'd like you to do with younger kids with this first part of the exercise is to get them introduced to pickles and just give them a taste and ask them what do they like about the pickles, the saltiness, the bitter vinegar taste. Have fun with this!

Activity 2: Review and Complete Exercise B

Divide students into groups of 3-4, and wash and cut into slices a fresh cucumber. Ask the question: How is the taste, texture, and color different from any of the pickles purchased for Exercise A?

Pickles: Exercise B

Also available online at: www.youtube.com/watch?v=nPPZFzVIOig



So the next part of this exercise involves comparing a fresh cucumber, which you'll use to make refrigerator pickles,



to a store-bought pickle.



And what I'd like you to do is to slice the cucumber open.



At first show it to the student, the younger student, that it looks much the same in terms of what's inside. So, of course, you have all the seeds surrounded by the fleshy material.



But the cucumber, of course, is much less yellow again, because certain store pickles have either yellow food coloring or turmeric added to impart a yellow color.



You'll also notice as you compare the two, that the fresh cucumber is a little bit crisper and stiffer



and you can demonstrate that to the student.



And then I know you've already tasted pickles with the first part of this as a taste test comparison,



but have the student taste the fresh cucumber, that will become a pickle,



and the store-bought pickle, and again emphasize the freshness and the crispness of the cucumber versus the store-bought pickle.



Activity 3: Review Exercise C

This activity will introduce you to the process used to make pickles that can be bought at the store.

Pickles: Exercise C

Also available online at: www.youtube.com/watch?v=aj6lbECZGNO



So in this video, I want to talk for a moment about what pickles are and why they've been produced historically.



So historically, pickles are fermented cucumbers where people would add some salt and some water and that would stimulate the bacteria on the skin of the cucumber to use the sugars inside the fleshy material.



And as the bacteria use the sugars, they produce tart acids like lactic acid and acetic acid.



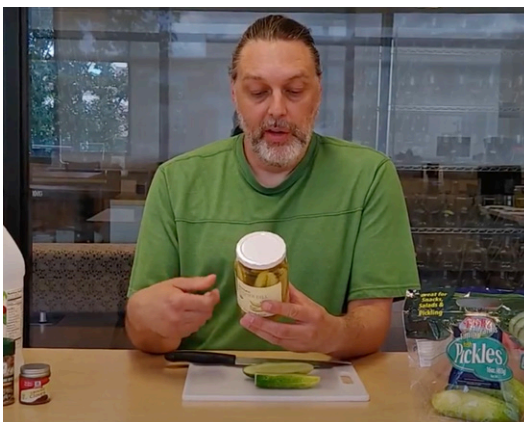
Now, the production of those acids makes the pH of the pickles go down. And in combination with the salt, that makes it very much more difficult for spoilage microbes like fungi and other bacteria to actually decompose the cucumber.



So prior to refrigeration, people would make pickles as a way of preserving cucumbers for the long haul, so perhaps they could have vegetables during the winter.



Now, store-bought pickles like these, the way they're made is a much shorter process.



So as you look at the ingredients, you'll see that there's salt, there's vinegar. It is a direct acidification to short circuit the natural fermentation that takes several weeks to produce the pickles quickly.



Now, you could make pickles the traditional way at home by adding salt and maybe a little bit of vinegar to jumpstart the process, but what I'm going to have you do is to follow a recipe for making refrigerator pickles.



And I have provided several recipes that you can choose from with this unit. What they usually entail is slicing the cucumber to the shape that you like, and you can make either spears' or



or smaller slices,



putting those slices into some kind of container like this plastic container



and then following the recipe to add some vinegar, some salt and perhaps some spices for flavoring. And the recipes might ask you to add some water as well.



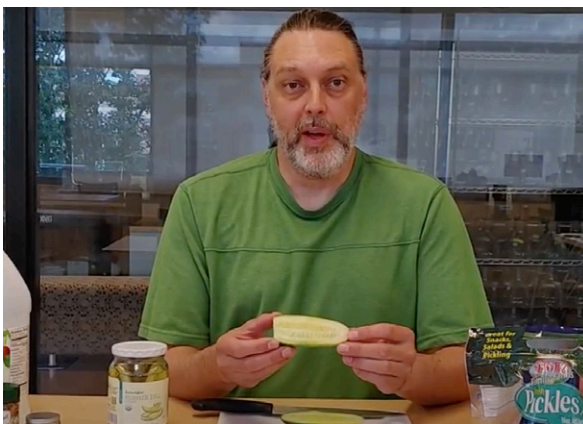
This is more similar to production of pickles like a company might make them to sell because you're not going to let them sit for weeks on end



to actually allow the bacteria associated with the skin of the cucumber to ferment the sugars and produce acids again, like lactic acid and acetic acid. So you are adding the salt and adding the vinegar.



And in the span of a few days, you'll have pickles in the refrigerator that are quite tasty.



Now, as you look at these, when they're finished after a few days, because you haven't added any yellow food coloring or if you haven't added to the turmeric, they're not going to be a yellow color.



The finished pickle that you make will look much like the original cucumber, but it will be a little bit softer and, of course, saltier and more vinegary.



So these are meant to be kept in the refrigerator. They are perishable. You'll need to eat them within a reasonable amount of time, like a week or two.



But have fun making these and enjoy that the good flavor that they offer.

Activity 4: Follow the recipe and enjoy!

The following recipe is adapted from "Refrigerator Pickles" in The Gardeners' Community Cookbook by Victoria Wise (*Workman Publishing, New York, 1999, pg. 317*). It has been adapted for simplicity to accommodate groups of 3-4 students.

1. Scrub cucumbers with a brush under running water. Cut out any bad spots.
2. Cut cucumbers into spears or disks, depending on the students' choice.
3. Make the brine solution by whisking into a mixing bowl 2 cups distilled white vinegar, 1 cup sugar, and $\frac{1}{4}$ cup kosher or pickling salt.
4. Place cut cucumbers into the container.
5. Pour the brine solution in. Some cucumber slices may float to the top – this is OK as long as they are mostly submerged in the brine. Hold on to extra brine as you may be able to combine it with extra brine from other groups to make even more pickles.



6. Add 2 tablespoons dill seed and 1 tablespoon pickling spices to the cucumber slices and brine mixture.
7. Seal container and place in the refrigerator for 1 week.
8. Taste.

Activity 5: Additional Recipe Resources

Here are several additional excellent recipes for making fresh refrigerator pickles; you may find reading these recipes useful for additional background information on pickle-making strategies. The recipes are all similar in their approach and are all easy to do.



Image Credit: Coco Morante

Recipe 1: How to Make Easy Refrigerator Pickles

www.simplyrecipes.com/recipes/how_to_make_easy_refrigerator_pickles/

Ingredients

- ▶ 1 pound Kirby or other small cucumbers
- ▶ 1 small sweet yellow onion
- ▶ 1 cup apple cider vinegar
- ▶ 1 cup water
- ▶ 1/4 cup granulated sugar
- ▶ 1 tablespoon kosher salt
- ▶ 1 1/2 teaspoons pickling spice, homemade or store-bought

Directions

1. Wash and dry the jars and cucumbers:

Wash 2 wide-mouth pint jars and their lids in hot, soapy water. Set them aside to dry. Rinse the cucumbers well under cold water, pat them dry, and then set them on a towel to dry completely.

2. Slice the cucumbers and onion, then pack them in the jars:

With a sharp knife or a mandoline slicer, slice the cucumbers and onion into slices 1/8 to 1/4 inch thick. Firmly pack the cucumbers and onions into the jars, fitting in as many as you can without smashing the vegetables. Leave 1/2 inch or so of headspace at the top of the jars.

3. Make the brine:

In a small saucepan over medium-high heat, bring the vinegar, water, sugar, salt, and pickling spice up to a simmer. Stir occasionally and continue simmering until the sugar and salt are dissolved.



4. Pour the brine over the vegetables:

If you have a canning funnel, use it here to make it easier to fill the jars. Carefully pour or ladle the hot brine into each jar, filling the jars until the cucumbers and onions are covered. It's ok if a few small pieces poke out the top.

5. Cool and refrigerate for 24 hours:

Screw on the lids, then let the jars cool to room temperature (*about an hour*). The cucumbers will start off bright green, but will become darker and more "pickle-colored" as they cool. Place them in the refrigerator. Wait at least 24 hours before eating the pickles in order to let the flavors develop. Use them within one month.



Image Credit: Alexandra Grablewski

Recipe 2: Quick & Easy Refrigerator Pickles

www.ouceuponachef.com/recipes/quick-and-easy-dill-pickles.html

Ingredients

- ▶ 1-1/4 cups distilled white vinegar (*5% acidity*)
- ▶ 3 tablespoons kosher salt
- ▶ 2 tablespoons sugar
- ▶ 2 cups cold water
- ▶ 1-3/4 to 2 pounds Kirby cucumbers (*about 6*), cut into halves or spears
- ▶ 2 tablespoons coriander seeds
- ▶ 6 large garlic cloves, peeled and halved
- ▶ 1 teaspoon mustard seeds
- ▶ 1/4 teaspoon red pepper flakes
- ▶ 16 dill sprigs

Instructions

Combine the vinegar, salt and sugar in a small non-reactive saucepan (*such as stainless steel, glass, ceramic or teflon*) over high heat. Whisk until the salt and sugar are dissolved. Transfer the liquid into a bowl and whisk in the cold water. Refrigerate brine until ready to use.

Stuff the cucumbers into two clean 1-quart jars. Add the coriander seeds, garlic cloves, mustard seeds, red pepper flakes, dill sprigs, and chilled brine into jars, dividing evenly. If necessary, add a bit of cold water to the jars until the brine covers the cucumbers. Cover and refrigerate about 24 hours, then serve. The pickles will keep in the refrigerator for up to one month.



Image Credit: Taste of Home

Recipe 3: Easy Refrigerator Pickles

www.tasteofhome.com/recipes/easy-refrigerator-pickles/

Ingredients

- ▶ 6 cups thinly sliced cucumbers
- ▶ 2 cups thinly sliced onions
- ▶ 1-1/2 cups sugar
- ▶ 1-1/2 cups cider vinegar
- ▶ 1/2 teaspoon salt
- ▶ 1/2 teaspoon mustard seed
- ▶ 1/2 teaspoon celery seed
- ▶ 1/2 teaspoon ground turmeric
- ▶ 1/2 teaspoon ground cloves

Directions

Place cucumbers and onions in a large bowl; set aside. Combine remaining ingredients in a saucepan; bring to a boil. Cook and stir just until the sugar is dissolved. Pour over cucumber mixture; cool. Cover tightly and refrigerate for at least 24 hours before serving.



Image Credit: Joe Lingeman

Recipe 4: How To Make Refrigerator Pickles

www.thekitchn.com/how-to-make-refrigerator-pickles-83971

Ingredients

- ▶ 1 pound small cucumbers
- ▶ 1 small sweet onion
- ▶ 1 cup apple cider vinegar
- ▶ 1 cup water
- ▶ 1/4 cup granulated sugar
- ▶ 1 tablespoon kosher salt

Equipment

- ▶ Measuring cups and spoons
- ▶ Knife
- ▶ Cutting board
- ▶ 2 wide-mouth pint canning jars (16-ounces each) Canning funnel (optional)



Directions

1. Wash and dry the jars. Wash 2 wide-mouth pint jars, lids, and rings in warm soapy water and rinse well. Set aside to dry or dry completely by hand. *(Alternatively, run everything through the dishwasher.)*
2. Prepare the cucumbers and onion. Wash and dry the cucumbers. Thinly slice into 1/4 inch thick rounds. Halve and thinly slice the onion. Toss the cucumbers and onion together in a large bowl to evenly distribute the onion among the pickles.
3. Pack the cucumbers and onion into the prepared jars. Pack the vegetables into the 2 jars, leaving a 1/2 inch of space at the top. Pack them in as tightly as you can without smashing.
4. Make the brine. Place the vinegar, water, sugar, salt, and mustard seeds in a small saucepan over high heat. Bring to a boil, stirring to dissolve the salt and sugar.
5. Add the brine to the jars. Pour the brine over the vegetables, filling each jar to within 1/2 inch of the top. You might not use all the brine. Gently tap the jars against the counter a few times to remove all the air bubbles. Top off with more brine if needed.
6. Tightly seal the jars. Place the lids over the jars and screw on the rings until tight.
7. Cool the jars, then refrigerate for 24 hours. Let the jars cool to room temperature. Store the pickles in the refrigerator. The pickles will improve with flavor as they age — try to wait at least 24 hours before using.



Image Credit: Kids Activities Blog

Recipe 5: Make Your Own Pickles {In the Refrigerator!}

kidsactivitiesblog.com/76419/make-your-own-pickles/

Ingredients

- ▶ Mini cucumbers *(or use regular ones and slice them!)*
- ▶ Mason jars
- ▶ Fresh dill
- ▶ Chopped garlic
- ▶ 3 cups Water
- ▶ 6 tablespoons white vinegar
- ▶ 3 tablespoons kosher salt



Directions

1. Combine water, vinegar, and kosher salt to make a brine solution. Make sure that the salt is completely dissolved.
2. Add a few sprigs of fresh dill into the bottom of a jar and add in the cucumbers.
3. Fill up the jar with cucumbers and add some more dill on top along with some minced garlic.
4. Pour the brine over the top of the spices and cucumbers, filling the jar.
5. Put in the refrigerator for at least two days to chill. Serve anytime you want!



Activity 6: Review Exercise D

Review before explaining Exercise D to your students:

Pickles: Exercise D

Also available online at: www.youtube.com/watch?v=_nGx0yHqGfw



So I mentioned in the previous video that one of the historical purposes for making pickles is to make the cucumber more resistant to microbial decomposition, to preserve that cucumber so people can eat it at a later time.



I want you this time to examine microbial decomposition by comparing how quickly a slice of cucumber decomposes compared to an already made store-bought pickle.



This is easy to do. You'll just take your slice of cucumber, put it in a bowl or on a plate, set it somewhere maybe like on top of the refrigerator where a pet can't get at it, and



do the same thing with your store-bought pickle. Let them sit out in the open for maybe five to seven, maybe ten days and



examine how they look as time goes by. You should notice with the fresh cucumber that it starts to shrivel up. Maybe it'll get slimy, maybe you'll get mold growing on it.



That should happen more quickly than what you find with the store-bought pickle.



Remember, the store-bought pickle is salty. It's vinegary. It may also have other preservatives. If you look at the label, you might see some.



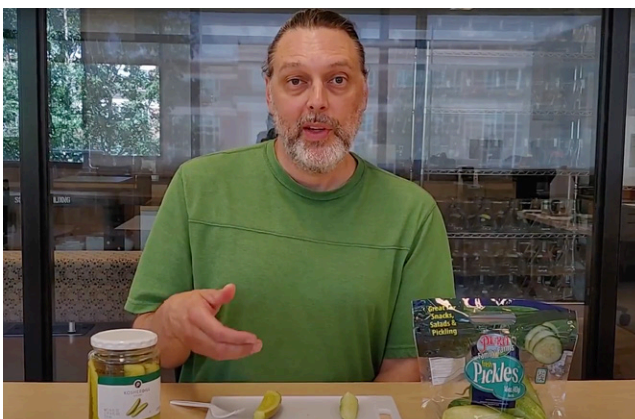
So this should last longer and be less susceptible to decomposition than the cucumber itself.



Now, when this is finished, of course, just throw these away. Don't be tempted to eat the decomposed cucumber or the decomposed pickle.



The intent is to just illustrate that the pickle with the salt and vinegar and maybe other preservatives should be more resistant to decomposition than the fresh cucumber.



And that, again, is why people started making pickles centuries ago.



Activity 7: Start Exercise D

- ▶ Divide students into groups of 3-4.
- ▶ Have each group take a cucumber (*or a cucumber slice*) and an equivalently sized pickle (*try to match cucumber and pickle size and shape as closely as possible*), place each one in a small bowl, and let them sit out at room temperature for 7-10 days.
- ▶ As time goes by, examine which one appears to decompose more or faster (*this can be evidenced by the presence of mold or sliminess on the surface*).
- ▶ Throw each away in the trash when finished (**do not eat decomposed food**).

Activity 8: Post-Assessment

Post-Assessment - Look back at your Pre-assessment. Do you agree with what you wrote?

Write a one-page paper answering the questions below:

- 1) Historically, why have people made pickles?
- 2) Prior to the invention of refrigeration, how would people preserve food?
- 3) Why is it more difficult for a microbe to decompose a pickle than it is to decompose a fresh cucumber?
- 4) Is there a danger in eating decomposed food? Why or why not?
- 5) Why are pickles able to withstand spoiling longer than fresh cucumbers?
- 6) If the pickles you made were left out in the open, would they spoil faster than pickles stored in the refrigerator? Why or why not?
- 7) Why is it more difficult for a microbe to decompose a pickle than it is to decompose a fresh cucumber?
- 8) Why is food susceptible to microbial decomposition?
- 9) Is microbial decomposition of food a form of microbial metabolism? Explain.

We are wondering:

- 1) Do your refrigerator pickles look and taste like store-bought pickles?
- 2) Which do you prefer? The salty and vinegary taste of pickles or the fresh taste of cucumbers?