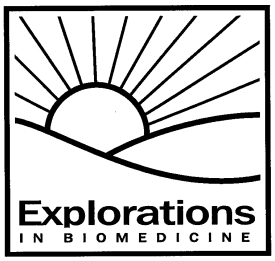

The Physiology of Taste

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The Physiology of Taste

This lab only looks at taste. However, as you know, taste and smell are closely related. Taste and smell belong to our chemical sensing system known as the chemsosenses. This complicated process of taste begins when tiny molecules are released and sensed by gustatory or taste cells. The taste cells are clustered in taste buds primarily on the tongue. Many of the small bumps, known as papillae, can be seen on the tongue. At the base of each of these bumps are areas called taste buds that contain taste receptor cells. Each bud is a separate entity set off from surrounding epithelium by what is known as a CT capsule. There are four basic taste sensations, *sweet, salt, sour,* and *bitter.* Specific regions of the tongue have specific associations with these sensations. However, there are no morphological differences that correlate with functional ones. Therefore, you cannot detect the type of a taste bud simply by looking at it.

Purpose:
The purpose of this experiment is to explore taste and the concept of threshold. Students will also look at the relationship between taste and the choice of the foods they eat. This lab is designed for an entry level Biology/Life Science class.

Objectives:
Students will be able to:

- Determine the areas of the tongue that respond to each of the four taste sensations.
- Develop an understanding of the concept of threshold
- Determine the threshold at which areas of the tongue will respond to taste sensations.

Supplemental Objectives for Extensions:
Students will be able to:

- Correlate the choice of foods they eat to the corresponding thresholds for that taste.
- Explore if there are survival or health benefits for these thresholds.

Materials:

- table salt
- table sugar
- aspirin
- vinegar
- cups with milliliter graduations (The kind hospitals use to dispense medicine work very well. Souffle cups also work. These can be found at food and restaurant supply houses.)
- cotton swabs (Part 1: 8 per group, Part 2: 20 or more per group)
- water (needed for rinsing, celery gives the same results)

NOTE: The amount of solutions needed will depend on the number of experimental groups in the class. Ten milliliters per group of each solution is placed in small cups.

Preparation:
This lab is designed to be used in a school with very limited supplies. It can be easily adapted so that students can determine the thresholds to a much finer degree.

Solutions for the four taste sensations should be made up ahead of time.

Suggested solutions for a class are:

- Sweet: 2 tsp. Sugar + 240 ml water cup)
- Sour: 10ml vinegar + 10ml water
- Salty: 2 tsp. salt + 240 ml water
- Bitter: 2 aspirin + 240 ml water

Teachers who wish to refine this lab should note that the thresholds for detection differ greatly among chemicals that taste the same. An example is the sensation of a sweet taste. The substances of sucrose, 1-propyl-2 amino-4-nitrobenzene and lactose will all taste sweet but are elicited at concentrations of approximately 10 mM, 2 uM and 30 mM (Bowen, 1997).

Examples of Human Thresholds:

Taste	Substance	Threshold for Tasting
Sour	HCl	.0009 M
Sweet	Sucrose	.01 M
Salty	NaCl	.01 M
Bitter	Quinine	.000008 M

(Bowen, Veterinarian Medical School, Colorado State University)

Suggestion: Using this information, the lab can be refined to have students determine a molar concentration when determining the thresholds. I suggest using an acid other than HCl to elicit the sour taste sensation. It has been determined that the threshold concentrations for citric acid, potassium chloride, caffeine, and PTC are, respectively, .023 M, .017 M, .0007 M, and .00002 M (Pfaffman et al., 1971; Schiffman, 1984; Bowen, 1997).

Safety:
Each cotton swab should only be used once and immediately discarded. The swabs should not be shared between students or dipped into the test solutions a second time.

Use the four substances noted above (sugar, vinegar, salt, and aspirin) to prepare the tasting solutions. If this lab is expanded upon, great care must be taken with substitute chemicals be cause many may be toxic or otherwise dangerous.

Procedure: Part I

Engage: Have students keep track of the foods they eat, noting only which of the four taste sensations is elicited. The students should do this for all food and drink for approximately three days.

The accuracy of the responses and length of time your students carry this out will vary greatly. But the results will provide an indication of preferences and the extension of this experiment. The chart should be completed by the time Part II of the experiment is done. Not telling the students why they are doing this chart can generate curiosity. This chart can also be good practice for a diet analysis at a later time.

Note: This part of the inquiry is not essential. However, it makes a good tie-in for the "Diet Analysis" lab by Daniel McGee. I suggest using the "Physiology of Taste" lab as an introduction to that activity.

Students will divide into groups of two. The students or have one student act as the experimenter and the other as a subject. The former is recommended to give more data for threshold comparisons. Using cotton swabs, the students test the area of the tongue. In between tests students should clean the palate by either rinsing out their mouths or by chewing a piece of celery if sink space is limited. Have the students record the results on the diagram of the tongue. An overhead or a drawing of a tongue on the board can be used to compile class data as a whole. With entry-level students it helps to keep the class working in the same direction.

Once all the data is compiled, be sure each student has a correct diagram that shows the areas of the tongue which responded to the four taste sensations before going on to Part II.

Procedure: Part II

Engage: An excellent way to introduce the concept of threshold is with a Galton's Whistle (Sargent Welch Science Catalogue, 1997). By varying the frequency and having students raise their hands when they can hear the whistle it is easy to show that the lowest audible sound differs between people. A discussion can be directed as to what other senses have thresholds that will lead into Part II of this inquiry.

Have each student pick up four small medicine cups one of each of the four different solutions.

Suggestion: To keep students on task, it is wise to give only one cup at a time, as this will prevent them from mixing the solutions together to perform an experiment of their own design.

Also give the students several clean empty medicine cups. The students then perform a serial dilution. After the students test the first solution they will then put 10 cc of the solution into an empty medicine cup and add 10 cc of water. The result is a solution with half the concentration of the first. The students continue to follow this procedure until a sensation is no longer elicited. This will allow the students to determine the threshold.

Again, it is important that the students either rinse their mouth or chew a piece of celery in between trials to prevent a carry-over of the taste.

Students do these trials, recording the result for all four tastes. The most primitive of methodology will still give results showing a range of thresholds for *bitter* and *sour*. *Sweet* and *salty* will have thresholds that are different from those of bitter and sour, but not from each other. Changes can be made in the solutions so these thresholds can also be detected. (*These results can be used as a jumping-off point to have students design ways in which the lab can be refined and more exact thresholds determined.*)

Assessment:

- A rubric can be constructed to determine the students' understanding of taste sensations for the level at which they are functioning.
- A diagram of a tongue can be colored using different shades to represent thresholds.
- Students can explain how the concentration changes as solutions are reduced by one-half.

Where To Go From Here:

- Students can research Marcello Malpihi, the seventeenth century anatomist who discovered taste buds on the human tongue.
- Since our basic tastes are influenced complementary and contrasting sensations, labs can be designed to show how one taste can neutralize another.
- Students can research why humans crave various foods in relation to dietary needs.

- A chemical known as PTC (phenylthiocarbamide) will produce a bitter taste in 70 % of the population but not the other 30 %. This can lead to work in genetics.
- Taste and smell go hand in nose and it could be an interesting extension to compare taste sensations with the sense of smell for various substances.

Extensions:
As was noted in teacher preparations, students were to keep track of the foods they eat in terms of the taste that was elicited. This inquiry was designed to be used on the Northern Cheyenne Indian reservation where diets and food choices are unique. The hope is to compare the choice of food to the diet in finding a correlation between preferred taste and dietary needs (See Diet Analysis)

Additional studies can be conducted by combining the substances to determine whether or not there are changes in the thresholds. Can combinations of any two substances cancel out each other? Does the threshold for taste sensation change with age? Have students test their parents.

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Investigating the Sense of Taste

Student Activity Sheet: Part I

Instructions

You will need to work in groups of two.

One student will come up to the desk and pick up:

- One plastic medicine cup of each of the following
  1. sweet solution
  2. bitter solution
  3. salty solution
  4. sour solution
- Eight cotton swabs (four for each member of the team)
- Two cups for water, or a paper plate with celery pieces.
- Paper towels

Procedure

1. One member of the team acts as the *experimenter* and the other as the **subject**.
2. The experimenter will dip the cotton swab into the first solution and press out the excess against the medicine cup or on a paper towel.
3. The subject will stick out his/her tongue and allow the experimenter to place the swab against the five areas of the tongue. See diagram 1.1
4. The subject will record if a taste is noticed and what taste it is.
5. After the first solution is tested, the subject either rinses out his/her mouth or chews a piece of celery to clean the palate.
6. **Discard the swab that was used.**
7. Repeat steps 2-6 for solution two.
8. Repeat steps 2-6 for solution three.
9. Repeat steps 2-6 for solution four.
10. The experimenter and subject change places and repeat steps 2-9.

Observations

Answer on separate sheet of paper.

1. Did your tongue respond the four taste sensations in more than one area? Explain.
2. Were your lab partner's results the same as yours? Explain.
3. Where do you think there may be experimental errors in this lab?
4. How do you think this lab could be improved?
5. What other kinds of taste sensations do you think there might be? How would you test them?
6. How would you test them? Design an experiment.

Investigating Thresholds for Taste Sensations

Student Activity Sheet: Part II

Instructions

- Work in groups of two.
- You will do four containers, one for each of the following taste solutions:
  - Sweet
  - Salty
  - Bitter
  - Sour

One student will come up to the desk and pick up:

- taste Container
- twenty cotton swabs (ten for each member of the team).
- two cups for water or a paper plate containing celery pieces)
- a liter bottle of water
- paper towels or tissues
- two sheets of graph paper.
- eight empty medicine cups.

Procedure:

1. Using your diagram of the tongue that you constructed from Part I of this lab you will now test these areas to determine the threshold a taste is elicited. It is only necessary to test the area that corresponds to the solution you are testing. (Test the salty area when using the salty solution, etc.)
2. As in Part I, one member of the team will start as the experimenter and the other as the subject.
3. The experimenter dips the cotton swab into the solution and presses out the excess against the medicine cup or on the paper towel.
4. The subject sticks out his/her tongue and the experimenter places the swab on the tongue area that has been identified as responding to this taste sensation.
5. If a response is elicited color a box above the sensation on Data Sheet.
6. Place 10 milliliters of this solution in a clean medicine cup and add exactly 10 milliliters of water.
7. The subject cleans his/her palate with either water or celery.
8. The experimenter repeats step 3 using this new solution.
9. Repeat step 5. Color a box on top of the existing ones every time there is a response.
10. Repeat step 6. Note that you are using the solution you have diluted already. You will continue in this manner.
11. The experimenter will again proceed as in step 3. The subject must clean his/her palate between each trial as described in step 7.

12. Repeat the procedure with the solution being diluted by half each time. (10 milliliters of solution to 10 milliliters of water) Continue doing this until a taste response in no longer elicited.
13. The experimenter repeats steps 1 to 12 with each of the remaining solutions.
14. After you have tested the four solutions, the experimenter and the subject trade places and repeat steps 1 through 12.

Observations

Answer on separate sheet of paper.

1. Were you able to dilute all the solutions the same number of times and still taste them? Explain.
2. How did your lab partner's results compare to yours? Explain.
3. Where do you think there may be errors in the way this lab was conducted?
4. How could you refine the manner by which you determined the thresholds?
5. Design an experiment to learn whether combinations of flavors (ex. sweet and bitter) change each other's taste threshold.

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Student Activity Sheet: Food Intake

Please list all of the foods and beverages that you have consumed since you woke up this morning. Be as specific as possible.
List specific foods, brand names, amounts eaten, and the amounts of spices and condiments added. Use a separate sheet for each day.

	Solid Foods			**Beverages**
Day #_____	Foods Eaten:	How much:	Spices/Condiments:	What and How Much:
Morning				
Mid-day				
Evening				

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Student Activity Sheet: Thresholds for Taste Sensations

Data Sheet:

Dilution 10					
Dilution 9					
Dilution 8					
Dilution 7					
Dilution 6					
Dilution 5					
Dilution 4					
Dilution 3					
Dilution 2					
Dilution 1					
Full Strength	*100%*				
	% Dilution	*Sweet*	*Salty*	*Sour*	*Bitter*

Instructions: Each time a dilution results in eliciting a taste, shade in the box. Calculate the percent dilution for each trial. Full strength has the value of 100%. Write your calculation in the appropriate box in the column marked “100% Dilution.” Remember that each dilution is 50% of the previous dilution. Therefore, Dilution 1 is 50%. Dilution 2 is then 25%. You calculate the rest.