The Genetics of Taste

A High School Activity for Teaching Genetics and the Scientific Method

(High School Level)

Developed by:
Megan Brown, Ph.D., University of Washington

Provided by:
Department of Genome Sciences
Education Outreach
University of Washington
http://gsoutreach.gs.washington.edu

Contents:

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Genetics of Taste Activity, Part I. *To taste or not to taste?*

Purpose:
- to examine human variation in the ability to taste different substances
- to introduce students to several tools they may use in their own independent taste investigations: post-it bar graphs and taste papers
- to provide students with practice in generating research hypotheses (through the "rules" part of the activity)
- to demonstrate that preliminary hypotheses can be refined after the collection of more data or a large data set

Materials: Taste papers: Control, PTC, Thiourea, Sodium Benzoate (all available from www.flinnsci.com); drinking water; cups; hard candies; waste containers

Procedure:
1. Place a strip of control paper on your tongue and leave it there for a few moments. Do not chew or swallow the paper. Note any taste or sensation you perceive. Now discard the paper in the waste container provided.

Report on your sensations to the class when asked by the instructor. What did the paper taste like? Did everyone in the class report the same taste?

Drink a small amount of water before continuing.

2. Place a strip of PTC paper on your tongue and leave it there for a few moments. PTC is a chemical substance that is harmless when tasted in small amounts. Note any taste or sensation you perceive. Discard the paper.

Drink some water or have a candy if you like.

Report on your sensations to the class when asked by the instructor. Does the PTC paper taste different from the control paper? How? What does it taste like? Did everyone in the class report the same taste? Why or why not?

3. Contribute your data on PTC tasting to the class bar graph using post-its. (See p. 3 for more information on post-it graphs.) Graph the class data in your lab notebook.

Why might the ability to taste PTC be an advantage or disadvantage?

4. Form groups of four. Following the procedure above, taste other papers and fill in the chart below. (Remove candy from mouth and drink a bit of water first.)

Paper	To me, this paper tastes predominantly:					
	Bitter	Salty	Sour	Sweet	No Taste	Other
Control						
PTC						
Thiourea						
Sodium Benzoate						

Compare your results with others in your group. Note any similarities or differences among your group's taste preferences.

Are there any "rules" of taste you observe in your group? E.g. "Everyone tastes thiourea as bitter." "People who taste PTC as bitter also taste ___________ as bitter." "Only men can taste sodium benzoate." People who can't taste PTC can't taste any of the other papers." Write your rules in the chart below.

Taste Rule	**True for entire class?**

Share some of your rules with the class and see if the data from other groups support or refute them. For as many rules as possible, indicate whether they proved "true" for the entire class or not by writing "Yes" or "No" in the right-hand column of the chart.

Which taste rules would you like to investigate further?

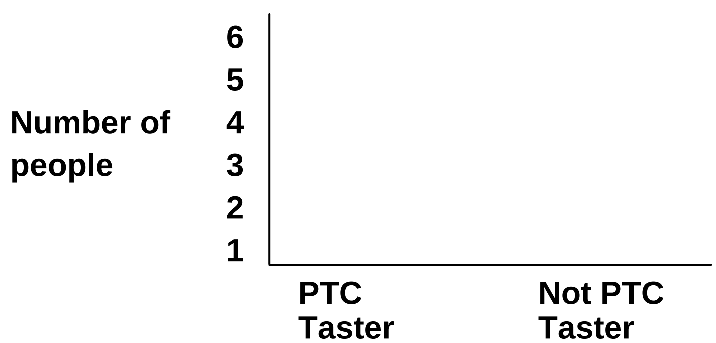
Did whether the rule was true for the entire class make you want to change any of your rules or give you new ideas for more rules? Did whether the rule was true for the entire class help you to decide which rules are worth investigating?

Challenge Question
(for classes that have studied population genetics)
Assume that the ability to taste PTC is controlled by a single, dominant gene. Based on the frequencies of PTC tasters and non-tasters in your class, determine the frequencies of the PTC taster and non-taster alleles. Using this information, calculate how many people in your class should be heterozygotes.

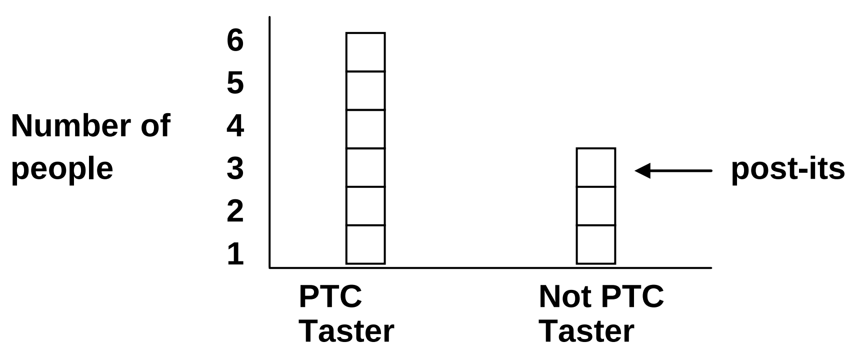
Post-it Graphs

Look at the empty graph on the wall. The completed graph will look similar to the one below. Add your personal PTC tasting data to the graph by taking a post-it note and placing it on the graph in either the “PTC Taster” or "Not PTC Taster” column. Place your post-its one on top of the other, so that a vertical bar is formed in each column.

EMPTY GRAPH
PTC Tasting vs. No PTC Tasting



COMPLETED GRAPH
PTC Tasting vs. No PTC Tasting



The post-it bar graph you have helped create is a type of graph known as a bar graph or histogram.

Genetics of Taste Activity, Part II. *Measuring taste perception using the 9 point category scale and the hedonic scale*

Category scales are a tool commonly used in nutritional research to measure taste sensations and preferences. Other types of scales also exist.

Purpose: to familiarize students with a way to measure taste sensations and preferences that is used in nutritional research (category and hedonic scales) and that they may wish to use in their independent taste investigations.

Materials: PTC paper; drinking water, cups, waste containers

Procedure:

1. Taste PTC paper again. (If you are still have a candy in your mouth, remove it and drink some water before tasting the paper.)

On a scale of 1 to 9, how bitter does PTC taste to you? This type of scale is called a *category scale.*

1=not at all bitter 9=extremely bitter (most bitter imaginable)

Fill in your bitterness score: ____________

Add your data to the class graph using post-its. Use a yellow post-it if your bitterness score was 2 or less. Use a pink post-it if your bitterness score was 5 or greater. Use a blue post-it if your bitterness score was 3 or 4.

What observations can you make about the class data?

2. On a scale of 1 to 9, how do you like the taste of PTC? A scale measuring likes and dislikes is called a *hedonic* scale. This scale is both a category scale and a hedonic scale. Hedonic scales are frequently used to measure likes and dislikes of food rather than chemicals.

1=dislike taste extremely 5=neutral (no taste) 9=like taste extremely

Fill in your hedonic score: ____________

Add your data to the class graph using post-its. Use a yellow post-it if your bitterness score was 2 or less. Use a pink post-it if your bitterness score was 5 or greater. Use a blue post-it if your bitterness score was 3 or 4.

Is there a correlation between bitterness score and hedonic score?

Read the article, *The Bitter Truth.*

Genetics of Taste Activity, Part III. *Measuring Taste Papillae Density*

Our tongue contains structures that allow us to taste. We have all heard of taste buds. Taste buds are contained within larger structures on the tongue called papillae. The density of papillae on the tongue varies from person to person. People with higher papillae densities may be more sensitive to certain tastes

Purpose:

- to determine the density of taste papillae on your tongue and see if higher density correlates with greater sensitivity to the chemical PTC
- to provide students with another tool that they may wish to use in their independent taste investigations

Materials: Cotton swabs, blue or green food coloring, dish for food coloring, handheld mirror, reinforcements, paper towels

Procedure: (Work in groups of 2–3.)

1. Dip a cotton swab in blue or green food coloring and squeeze out some of the excess coloring onto a paper towel.

2. Place a paper reinforcement on your tongue near its tip. “Paint” the exposed circle of tongue within the hole of the reinforcement with the food coloring. Use the mirror to help.

3. Remove the reinforcement and swallow. Swallowing washes off the coloring from the largest papillae (called fungiform papillae) so that they appear pink. The background remains blue or green, making the papillae easier to count.

4. Place the reinforcement back over the colored dot on your tongue. Count the large papillae inside the circle by using a mirror or having a partner count. Record your density below.

My taste papillae density is _______________

What is the highest density in the class? The lowest? What is the most common density?

We will classify the density of taste papillae as follows

Number of papillae in area counted	Classification
20 or more	High density
10-19	Mid-density
0-9	Low density

5. Graph your papillae density on a graph containing a category scale for PTC tasting (bitterness). To do this, place a yellow post-it on the graph if you have a density of 20 or higher, a blue post-it if you have 10–19, and a pink post-it if you have 0–9.

Questions
Do you observe any trends or correlations?

Do “high density” individuals (density=20+) find PTC more bitter than “mid-density” individuals (density=10–19)?

Are most “low density” people (density=0–9) unable to taste PTC?

Could “mid-density” people be heterozygotes for the PTC tasting gene and “high density” individuals have two copies of the gene? (Your instructor will tell you what research has shown to be the answer to this question.)

Taste is indeed complex. Interactions between genes controlling the ability to taste with anatomical factors such as taste bud density as well as a person’s lifetime taste experiences all play roles in both taste ability and taste preferences.

Genetics of Taste Activity, Part IV. *Food preferences and PTC Tasting*

Purpose:

- to examine taste preferences for licorice and look for correlations in licorice taste preference with tasting genes
- to introduce another tool used in nutrition research, the pairwise combination test.

Note: although the relationship between PTC tasting and preferences for some foods such as broccoli and coffee have been examined, the preference for licorice has never been studied.

Materials: PTC paper, red and black licorice, drinking water, small dishes of sugar, cups, waste containers

Procedure:

1. Taste a piece of red licorice. Hold the licorice in your mouth for a few seconds, chew slowly, and swallow. How bitter did the licorice taste? How well did you like the taste? Assign a bitterness and hedonic score to red licorice.

   1=not at all bitter   9=extremely bitter (most bitter imaginable)

Bitterness score: ____________

   1=dislike taste extremely   9=like taste extremely

Hedonic score: ____________

2. Now taste a piece of black licorice. Hold the licorice in your mouth for a few seconds, chew slowly, and swallow. Assign a bitterness and hedonic score to black licorice.

   1=not at all bitter   9=extremely bitter (most bitter imaginable)

Bitterness score: ____________

   1=dislike taste extremely   9=like taste extremely

Hedonic score: ____________

Does the class find red or black licorice more bitter?

3. Circle the statement that is most true for you:

   A. I prefer red licorice to black licorice.

   B. I prefer black licorice to red licorice.

   C. I like red and black licorice equally.

Asking people to indicate which of two different foods they prefer is another way that nutritionists determine individual food preferences. This test is called “pairwise combinations.”

Graph your licorice preference on the class post-it graph. Use a yellow post-it if you are a PTC taster and a pink post-it if you cannot taste PTC. Study the graph.

Do the data provide evidence for a relation between PTC tasting and licorice preference?

4. Dip another piece of black licorice in water and then roll it in the dish of sugar provided. Now taste it. Assign a bitterness and hedonic score to the black licorice dipped in sugar.

   1=not at all bitter 9=extremely bitter (most bitter imaginable)

Bitterness score: ____________

   1=dislike taste extremely 9=like taste extremely

Hedonic score: ____________

5. Circle the statement that is most true for you:

   A. I prefer black licorice to black licorice dipped in sugar.

   B. I prefer black licorice dipped in sugar to black licorice.

   C. I like black licorice and black licorice dipped in sugar equally.

Graph your licorice preference on the class post-it graph. Use a yellow post-it if you are a PTC taster and a pink post-it if you cannot taste PTC. Study the graph.

Do the data provide evidence for a relation between the PTC tasting gene and whether a person prefers black licorice with or without sugar?

If the results are inconclusive, what changes could be made to the experiment, if any, to improve its significance?

Can you think of other bitter foods that could be tested in an experiment similar to the licorice experiment?

Taste Investigation

Defining Research Questions

What questions about taste preferences and/or genes for tasting would you like to investigate? Brainstorm with the class about interesting questions. List questions below.

Procedure

Break into research groups of about 4 people. Each group will investigate a question of its choice (from the list above or novel) about one of the following: tasting ability and genes, inheritance of tasting ability, taste preferences, the effect of taste genes on taste preferences, taste bud density and food preferences, etc.

Your group will design an experiment to answer your research question. You may use materials and tools like those we have used in the Genetics of Taste activities: taste papers, category scales, hedonic scales, questionnaires or surveys, measuring taste bud density, various foods and beverages or food mixtures (e.g. licorice + sugar).

Answer the questions on the next page and have them checked by your instructor before continuing.

Materials for your experiment

When we meet next, your group will carry out its experiment. You are responsible for bringing all the equipment and materials for your experiment. This includes food, beverages, and any utensils needed for tasting. We will provide: drinking water, sugar, small cups, small plates, taste papers, food coloring, reinforcements, cotton swabs.

If you are using a survey or form to gather data from research subjects, you can leave a copy of your survey with the instructor, who will photocopy it for you before the next class meeting. Be sure to specify how many copies you will need.

Research subjects (people) for your experiment

You may use the other students in your class as subjects in your experiment (with their permission). During the experiment session, some members of your group should stay to man your station and collect data. Other group members should rove from station to station and participate in other groups' experiments by tasting foods, filling out surveys, etc. After awhile, the "rovers" should switch places with the "data collectors." You may also gather data outside of class using family members or friends to make your data set larger. You may obtain extra taste papers to take outside of class for additional data gathering.

Oral research presentations

After conducting your experiment, your group will be given time to analyze the data it has collected. Each group will present its findings to the class in an oral presentation using visual aids such as overhead transparencies. Guidelines for presentations are given on p. 10-11.

Taste Investigation

Date ________________________

Group Members ____

As a group, answer questions 1–4 and have them checked by your instructor during the experiment planning session.

Your group will need to turn in one copy of this page the day of the final presentation.

1. What research question will you investigate?

2. What tools will you use in your experiment (e.g. taste bud density measurement, category scale surveys—bitter and hedonic)?

3. What materials will you use in your experiment (e.g. red and black licorice, sugar)?

4. Outline basic experimental design:

Instructor Signature __________________________________

5. Briefly list results and conclusions from your experiment (to be filled out after experiment)

General Format of Taste Investigation Report:

1. **State research question.**

2. **Explain how you investigated the question (experimental design). Include survey questions, tools and materials used, variables, controls, etc.**

3. **Describe your results.**

4. **State your conclusions.**

5. **Describe any protocol modifications you would make if you repeated this experiment or any follow-up experiments you would like to do.**

overhead master

Taste Investigation Presentation Guidelines (detailed version)

Type: Oral presentation to class, with visual aids

Time: Up to 8 minutes

Presenters: 1–4 people OK

Presentations should include *most* of what is listed below, although not necessarily in the order given.

Question:
- State research question
- State hypothesis/question and prediction

Experiment:
- Explain how you investigated the research question. Describe experimental design, including materials and tools used, including survey instruments. State variable tested, how measured, and how controlled.

Results:
- State whether hypothesis was supported or refuted by data. State whether any data were of use in answering the research question.
- Provide at least one overhead of data. Graphs, charts, diagrams are encouraged. Try to provide at least some quantitative data.
- Explain your findings.

Evaluate:
- State your conclusions.
- What were potential sources of error?
- What are the limitations of the tools used in your experiments? Limitations of materials? Limitations of research subjects? Other limitations?
- What is the usefulness of your findings?
- How would you modify your protocol if you were to repeat this experiment?
- What experiments would you do next?
- What new questions might you ask?

Genetics of Taste

Challenge Question

(for classes that have studied population genetics)
Assume that the ability to taste PTC is controlled by a single, dominant gene. Based on the frequencies of PTC tasters and non-tasters in your class, determine the frequencies of the PTC taster and non-taster alleles. Using this information, calculate how many people in your class should be heterozygotes.

Use Hardy-Weinberg to figure this out.

Tasters in our group (TT and Tt) = 16
Non-tasters in our group (tt) = 8

p = frequency of T allele in group
q = frequency of t allele in group

p^2 = frequency of TT in group
2pq = frequency of Tt in group
q^2 = frequency of tt in group

$p + q = 1$

$p^2 + 2pq + q^2 = 1$

$q^2 = 8/24 = 0.33$

therefore: q = .57 and p = .43

$p^2 = (.43)(.43) = 0.18$ (frequency TT homozygotes)

$2pq = 2(.43)(.57) = 0.49$ (frequency Tt heterozygotes)

$q^2 = (.57)(.57) = 0.33$ (frequency tt homozygotes)

Number of people in our group who should be heterozygotes is (.49)(24) = 12

References: Genetics of Taste

Drewnowski, A. and Gomez-Carneros, C. (2000) *Bitter taste, phytonutrients, and the consumer: a review.* Am J Clin Nutr 72, 1424-1435.

Duffy, V.B. and Bartoshuk, L.M. (2000) *Food acceptance and genetic variation in taste.* J Am Diet Assoc 100, 647-655.

Fackelmann, K. (1997). *The bitter truth: do some people inherit a distaste for broccoli?* Science News 152, 24-25.

UW researchers show that the human genome is helpless in the face of chocolate. (2001) Online press release from University of Washington can be found at http:www.washington.edu/medical/amc_admin/amc_releases/ncr20010201.html

Discovery of taste receptors may make bitter a bygone taste. (2000) Online press release from the NIH can be found at http//www.nih.gov/news/pr/mar2000/nidcr-16.htm

Smith, D.V. and Margolskee, R.F. (2001) *Making sense of taste.* Scientific American, March 2001.

Tepper, B.J. (1998) *6-n-propylthiouracil: a genetic marker for taste, with implications for food preference and dietary habits.* Am J Hum Genet 63, 1271-1276.