Genetics Engagement and Education (GENE) Network

PTC Taste Testing

Recommended Prior Knowledge:

1. Genes are discrete units of inheritance
2. The inheritance of dominant and recessive traits (Mendelian inheritance)

Item Needed	Cost
PTC Taste Testing Strips	$4.97/100 strips
Bulk Beads/Coffee Beans	$5.48/12 oz.
Glass Vases (need at least 2)	$12.50/ea
OPTIONAL: Full Taste Test Kit with Multiple Strips	$15.49/100 ea. strip

Instructions for Teachers:

1. Share handout (Pre-Lesson Reading, see below) on the background of PTC and bitter taste perception with students before the activity.
2. Refresh the concepts of Mendelian inheritance and alleles.
    a. Genes are discrete units of DNA that are inherited from parents.
    b. Each person has two copies of each gene. You can have different versions of genes, called alleles, on each copy. Sometimes people have two different alleles (heterozygotes, coming from the root "hetero-" meaning different) or two copies of the same allele (homozygotes, coming from the root "homo-" meaning same).
    c. Review how to calculate allele frequencies in a population using the Hardy-Weinberg equation ($p^2 + 2pq + q^2 = 1$ and $p+q=1$), if desired.
3. Discuss with students that about 60-70% of individuals are bitter "tasters" due to a dominant allele of *TAS2R38.*
    a. 18% of individuals (1/4 of tasters) will be "supertasters" having two dominant strong-sensing alleles. Pause. Since you know that "supertasters" have two dominant alleles, can you calculate the frequency of "tasters" and "non-tasters"?
    b. Review frequency estimates. ½ individuals are either heterozygous for 1 tasting and 1 non-tasting allele, or have a rarer combination of intermediate-sensing alleles. 28% of individuals are "non-tasters" due to two recessive non-sensing alleles.
    c. Ask students what food or drinks they think people with each genotype will prefer. Do you think someone with increased sensitivity to very bitter flavors will like bitter foods, such as black coffee or broccoli?
4. Ask if students would like to test their tasting ability.
    a. If students are eating or drinking, direct them to put food/drink aside or rinse their mouth with a drink of water.
    b. If they have volunteered to participate, direct students to place a test strip on their tongue. If they are a taster, they will experience a taste immediately. It may taste slightly bitter (taster) or vile (supertaster).
    c. If they do not taste anything after 10-15 seconds, they are not a taster. If asked, you may supply them with control paper for comparison.
    d. OPTIONAL: Repeat as appropriate with other test strips. All strips test tasting ability of *TAS2R38* and related taste receptor genes. Students may report slightly different bitter, umami, or salty flavors.
    e. If they do not wish to taste, let them observe other students. Assure students that testing strips are safe and have an extremely small amount of each chemical.
5. Ask participants to record their tasting ability in the jars provided. Direct them to place a coffee bean/bead in that jar that matches their ability.

a. There are two jars – one for tasters and one for non-tasters. Since the degree of flavor is more subjective, we will not provide a jar for supertasters. Direct supertasters to place a ball in the "taster" jar.
b. At the end, assess if students match the approximate % expected: about 70% taster and 30% non-taster.
c. If student % of tasters and non-tasters is very different, discuss some possible reasons:
    i. Population stratification – Tasting alleles can be as prevalent as 90% in certain populations, like in people of African descent.
    ii. Random chance/sampling bias – You are only sampling a small number of students. The given allele frequencies were calculated using 1000s of samples.
    iii. Faulty test – If no one in the class can taste PTC, make sure that the test strips are working! Compare to a piece of control paper.

Resources:

1. Genetics of Taste Lab from the Denver Museum of Nature & Science: https://science.dmns.org/museum-scientists/nicole-garneau/the-genetics-lab/
2. PTC – The Genetics of Bitter Taste from the Genetic Science Learning Center at University of Utah: https://learn.genetics.utah.edu/content/basics/ptc/
3. The Bitter Truth about PTC Tasting from The Scientist: https://www.the-scientist.com/research/the-bitter-truth-about-ptc-tasting-51548
4. Guo and Reed, 2001. "The genetics of phenylthiocarbamide perception." Ann Hum Biol, 28(2):111-142. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3349222/
5. PTC tasting: the myth from John H. McDonald at the University of Delaware: https://udel.edu/~mcdonald/mythptc.html

Pre-Lesson Reading:

Are you a Supertaster?

You might not know it, but you might be super! A supertaster, that is. To find out, you'll want to test your ability to taste the chemical PTC, or phenylthiocarbamide. The bitter taste of PTC was discovered in 1931 by DuPont chemist A.L. Fox who synthesized the chemical while researching artificial sweeteners.

After years of study, scientists determined that the ability to taste PTC largely relied on common variation in the *TAS2R38* gene. This gene encodes a protein for a taste receptor. Taste receptors are found in the tongue's taste buds and act as chemical sensors for different flavors. Did you know that taste and smell both rely on chemical sensors to pick up flavor or scent molecules?

> *"Dr A. L. Fox had occasion to prepare a quantity of phenyl-thio-carbamide… As he was placing this compound in a bottle some of it was dispersed into the air as dust. Thereupon another occupant of the laboratory complained of the bitter taste of the dust. This surprised Fox, who being much closer to the scene of operations had of course inhaled more of the dust, but had perceived no taste. He was so positive that the stuff was tasteless that he went so far as to taste some of the crystals directly, finding them as tasteless as chalk. Nevertheless, the other chemist was convinced the substance was bitter and was confirmed in this impression when he in turn tasted the crystals and found them to be intensely bitter. Naturally a lively argument arose. In an attempt to settle it, the two chemists called in various other laboratory workers, friends and other people with whom they could establish contact. Some people declared the substance was tasteless and some again found it bitter."* [1]

There are two major forms of the *TAS2R38* gene, a dominant form and a recessive form. If you have at least one copy of the dominant form of the gene, you often have at least some ability to taste PTC and other bitter flavors. Two copies of the dominant form make you a supertaster! Often, this means that bitter foods taste particularly bad to you. You might have an aversion to strong black coffee, broccoli, and brussel sprouts. Adult supertasters are also less likely to smoke but more likely to drink alcohol [2,3].

Testing your ability to taste PTC is easy. All you need is a small test strip with a very small amount of the chemical on it. Your teacher will provide this. Rest assured – the test strip is completely safe for both tasters and non-tasters.

References:

1. Boyd WC. Genetics and the Races of Man. An Introduction to Modern Physical Anthropology. Boston: Little, Brown and Company; 1950.
2. Risso DS, et al. 2016. Genetic Variation in the TAS2R38 Bitter Taste Receptor and Smoking Behaviors. PLoS One, 11(1):e1064157. doi://10.1371/journal.pone.064157.
3. Ramos-Lopez, et al. 2015. Association of a novel TAS2R38 haplotype with alcohol intake among Mexican-Mestizo population.