K. McCarthy, L. Miller, ASHG
GENA 2008 Cohort

Learning Cycle Stage(s):	Engage/Explore/Explain
Adapted from:	The Genetics of Taste Kathy McCarthy, Amherst Regional High School, MA Lynn Miller, Hampshire College, MA
ASHG Concept(s) Addressed:	Gene expression and regulation #8, #10
Time Required:	115-125 minutes

Lesson 1: Do you have good taste?

[Adapted from "The Physiology of Taste" by Anthony Kilyanek and Gregory Florant; http://www.hartnell.cc.ca.us/faculty/aedens/Bio6L/Taste%20and%20Smell/The%20Physiology%20of%20Taste.htm]

Engage

1) Display a variety of packaged foods or project a collage of images at the front of the classroom and ask students to describe the taste associated with each food in their lab notebooks. Be sure to include sweet, sour, salty, and bitter, and umami (Japanese for savory; an example would be beef jerky) foods. — 5 min
2) Ask students: — 10 min
   a. What different sensations can you taste?
   b. Our sense of sight is the result of using our eyes to collect light pattern data and our brains to make sense of those data. Likewise our sense of hearing results from collecting air vibrations with our ears and interpreting them with our brains. Given these examples, how do you think our sense of taste works? What "data" are being collected and by what part of our bodies?
   c. Does everyone taste things in the same way and to the same degree? Why or why not?
   d. Guide students to make the connection that, like all sensory perception, sense of taste is a trait (phenotype) that is genetically influenced. To maintain the analogy to vision, colorblindness is an extreme difference in sensory perception that is genetically based.

Explore

1) In this lab, students will explore their sense of taste in pairs by testing how well they can taste four different solutions in different areas of their tongues. Parental permission slips may be necessary for students to taste materials in the lab, particularly if you use aspirin as the bitter solution. Each pair of students will need:
   a. 4 plastic medicine cups for solutions
   b. Marker
   c. 32 cotton swabs
   d. 2 cups of water
   e. Paper towels
   f. Latex-free gloves
   g. 5 mL each of sweet solution, bitter solution, salty solution, and sour solution (see recipes below, solution stocks should be numbered 1-4 so they are not identifiable by students)
      i. Sweet: 2 tsp. sugar + 250 mL water
      ii. Sour: 30mL vinegar + 30 mL water
      iii. Salty: 2 tsp. salt + 250 mL water
      iv. Bitter: 2 crushed aspirin + 250mL water (alternatives include strong black coffee, flat tonic

water, solution of unsweetened cocoa powder, cabbage juice)

2) Ask students to pair up and pick up their materials. Distribute copies of the student instructions (Appendix I) to the pairs. One student in each pair should act as the experimenter and the other as the subject. Students should then switch roles and repeat the experiment. Remind students to take small sips of water between tests to cleanse their palates. 30 min
3) Have students complete the analysis questions individually before discussing results as a class. 10 min
4) As a class discuss the following questions: 10 min
    a. How many people got different results from their partner? Why might that be? How does it relate to our earlier discussion?
    b. Did anyone notice different sensitivity to a taste sensation on different parts of their tongue? Was there any pattern across tastes?
        - New research on the location of taste receptor cells has shown that the old tongue charts (bitter in the back, sweet on the tip, salty and sour on the sides) are incorrect. In fact, all identified tastes can be detected anywhere on the tongue that taste buds reside (taste buds are most concentrated on the tip, sides, and at the back). While each taste receptor cell is thought to be tuned to a particular taste profile (i.e., expresses a particular subset of taste receptors/ion channels), no particular part of the tongue is enriched for any subset of taste receptor cells.

Explain

1) As a primer, have students watch 3D animations of transcription (http://www.dnalc.org/resources/3d/12-transcription-basic.html) and translation (http://www.dnalc.org/resources/3d/15-translation-basic.html) and answer the following questions: HW
    a. Where in the eukaryotic cell does transcription occur? Translation?
    b. What molecule serves as the template for transcription? Translation?
    c. What molecule results from transcription? Translation?
    d. What is the purpose of these processes? Why do you think an RNA intermediate is necessary between DNA and protein? (Hint: Cells can make more than one mRNA copy of a gene and more than one protein molecule from an mRNA.)
        - There are actually many valid answers to this question; however the accompanying hint tries to steer student thinking toward one that doesn't require extensive background knowledge.
2) Show the NOVA clip "The Science of Picky Eaters" (http://www.pbs.org/wgbh/nova/body/science-picky-eaters.html) to introduce students to the concept that the taste receptors on the surface of cells on our tongue that interact with molecules in food are proteins encoded by genes. To save time, this clip can be shortened by showing 4:13-9:37. 6-13 min
3) Use the question "How do you get from genotype to phenotype?" to drive presentation of the processes of transcription and translation. Magnetic white board manipulatives from Science Kit/Boreal Labs – Protein synthesis chalkboard model - are a great (optional) resource. To maintain the connection to taste, gene, mRNA, and protein sequences of actual taste receptors can be used for student practice (Appendix II). 30 min
4) End by revisiting the class discussion questions from the taste lab in light of this new information. 15 min
    a. Discuss how alleles of taste receptor genes can lead to differences in taste receptor proteins that make them more or less sensitive to certain taste molecules. So, if you got different taste lab results from your partner, one possibility is that you have different alleles for some of your taste receptors.

b. Discuss why different areas of the tongue may be more or less sensitive to taste molecules. Although all of your tongue cells contain the genes for taste receptors, only certain specialized cells actually transcribe and translate those genes into receptor proteins. These cells, called taste receptor cells, are said to "express" those genes.

5) Have students complete the "Transcribe and Translate a Gene" module at http://learn.genetics.utah.edu/content/begin/dna/transcribe/.

HW

Appendix I

Investigating Your Sense of Taste

Materials:

- 4 plastic medicine cups for solutions
- marker
- 32 cotton swabs
- 2 cups of water
- Paper towels
- 5 mL each of solutions 1-4
- Latex-free gloves

Procedure:

1) Assign one member of the team to act as the experimenter and the other as the subject.

2) Number each of the solution cups 1 – 4, and put 5 mL of each numbered solution in the appropriate cup.

3) The experimenter should put on a pair of gloves and dip the cotton swab into the first solution, pressing out the excess against the medicine cup or paper towel.

4) Have the subject stick out his/her tongue and allow the experimenter to place the swab against the back of the tongue (be careful not to choke the subject!).

5) **Without closing his/her mouth**, the subject should record in the data table if a taste is noticed and what type of taste it is.

6) Have the subject take a small sip of water and rinse his/her mouth. Repeat the experiment using a new swab and the same solution at the center, tip, and one side of the subject's tongue. **Remember to rinse after each test and discard the used swabs.**

7) Repeat steps 2 through 6 for the other three solutions, one solution at a time.

8) Switch roles and repeat steps 2 – 7.

Data Tables:

Subject:____

Solution Number	Area of Tongue	Taste? (Yes or No)	Type of Taste
1	Back		
1	Center		
1	Tip		
1	Side		

2	Back		
2	Center		
2	Tip		
2	Side		
3	Back		
3	Center		
3	Tip		
3	Side		
4	Back		
4	Center		
4	Tip		
4	Side		

Subject:_______________________________________

Solution Number	Area of Tongue	Taste? (Yes or No)	Type of Taste
1	Back		
1	Center		
1	Tip		
1	Side		
2	Back		
2	Center		
2	Tip		
2	Side		
3	Back		
3	Center		
3	Tip		
3	Side		
4	Back		
4	Center		
4	Tip		
4	Side		

Analysis Questions:

1) Did your tongue respond to 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 the experimental design of this lab could be improved?

5) What other types of taste sensations do you think there might be? How would you test them?

Appendix II

TAS1R1 (subunit of TAS1R1+3 heterodimer [umami])

Coding Strand
5'…ATGCTGCTCTGCACGGCTCGCCTGGTCGGCCTGCAGCTTCTCATTTCCTGCTGCTGGGCCTTTGCCTGCCATAGCAC GGAGTCT…3'

Non-coding/Template Strand
3'…TACGACGAGACGTGCCGAGCGGACCAGCCGGACGTCGAAGAGTAAAGGACGACGACCCGGAAACGGACGGTATCGTG CCTCAGA…5'

mRNA
5'…AUGCUGCUCUGCACGGCUCGCCUGGUCGGCCUGCAGCUUCUCAUUUCCUGCUGCUGGGCCUUUGCCUGCCAUAGCAC GGAGUCU…3'

Protein
N-ter MLLCTARLVGLQLLISCCWAFACHSTES…C-ter

TAS1R3 (subunit of TAS1R1+3 heterodimer [umami] and TAS1R2+3 [sweet])

Coding Strand
5'…ATGCTGGGCCCTGCTGTCCTGGGCCTCAGCCTCTGGGCTCTCCTGCACCCTGGGACGGGGGCCCCATTGTGCCTGTC ACAGCAA…3'

Non-Coding/Template Strand
3'…TACGACCCGGGACGACAGGACCCGGAGTCGGAGACCCGAGAGGACGTGGGACCCTGCCCCCGGGGTAACACGGACAG TGTCGTT…5'

mRNA
5'…AUGCUGGGCCCUGCUGUCCUGGGCCUCAGCCUCUGGGCUCUCCUGCACCCUGGGACGGGGGCCCCAUUGUGCCUGUC ACAGCAA…3'

Protein
N-ter MLGPAVLGLSLWALLHPGUGAPLCLSQQ…C-ter