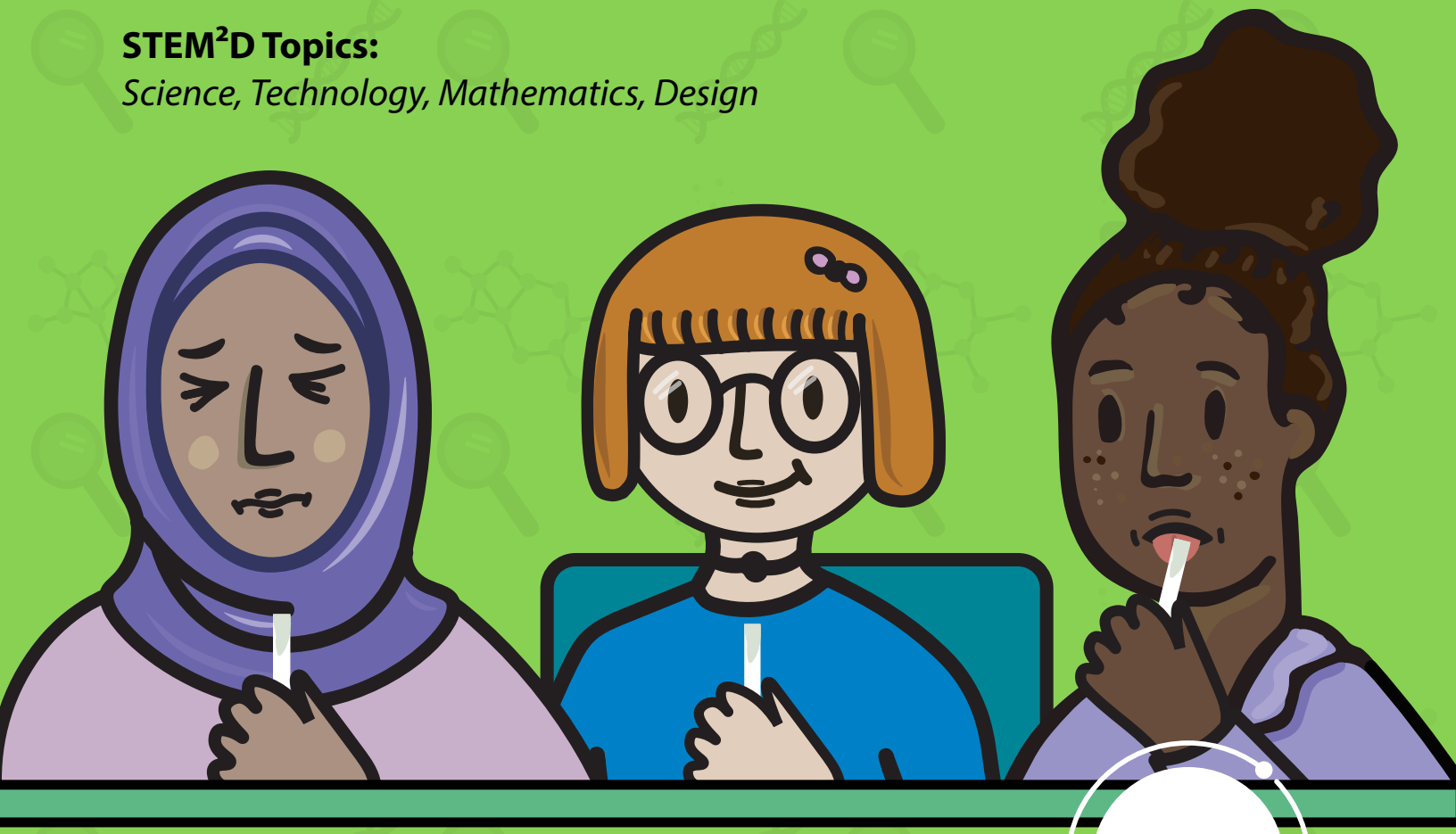
YUCK! THAT TASTES TERRIBLE:

DISCOVERING A UNIQUE GENETIC TRAIT

Target Audience:
Students, ages 11–14

STEM²D Topics:
Science, Technology, Mathematics, Design



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Yuck! That Tastes Terrible: Discovering a Unique Genetic Trait is part of the STEM²D Student Activity Series. The content and layout were both developed by the Smithsonian Science Education Center as part of Johnson & Johnson's WiSTEM²D initiative (Women in Science, Technology, Engineering, Mathematics, Manufacturing, and Design), using a template provided by FHI 360 and JA Worldwide. This series includes a suite of interactive and fun, hands-on activities for girls (and boys), ages 5-18, globally.

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YUCK! THAT TASTES TERRIBLE: DISCOVERING A UNIQUE GENETIC TRAIT

Topics: Science, Technology, Mathematics, Design
Target Audience: Students, ages 11–14

ACTIVITY DESCRIPTION

In this genetic trait research activity, students will have fun discovering who makes a face when they taste PTC-treated strips. PTC (phenylthiocarbamide) is a chemical that has been widely used to detect genetic variation in tasting ability. Students will conduct the taste test experiment, gather data, use the Punnett square, graph the class findings, and design a simple research project to find correlations between tasters and non-tasters, and taste preferences or other genetic traits. In addition to experimental design, data collection, decision-making, and creativity, students will use interpersonal skills needed in STEM²D careers, such as presenting ideas, negotiating, organizing, and working as a collaborative team. This activity connects to *Genes and Molecular Machines*, SSEC curriculum.

ESTIMATED TIME:
This session typically takes one hour to complete.

STUDENT DISCOVERIES

Students will:

- Participate in a team-based learning experience
- Learn how STEM²D—science, technology, engineering, mathematics, manufacturing, and design—subjects are used in the study of genetics
- Build important STEM²D skills such as data collection, estimation, decision-making, problem-solving, and research design
- Consider STEM²D concepts, including genotypes and phenotypes, dominant and recessive traits, graphing and percentages, and correlations
- Become aware of their own unique genetic traits and those of their parents

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- Recognize that STEM²D offers diverse and exciting career opportunities, including those connected with genetic research
- Have fun experiencing STEM²D

GETTING READY

Materials: Suggested materials preparation prior to the activity with students.

- Activity Leader Checklist
- Tell My Story form
- For each student:
  - Let the Tasting Begin: Bingo sheet
  - 1 PTC-treated strip
  - 1 non-treated strip (control)
  - 1 sticky note
  - 1 peppermint candy (optional)
  - 1 Certificate
- For each team of four students:
  - 2 small plastic bags
  - 1 copy of "Two Scientists' Discoveries"
  - 10-ounce plastic cup
  - 1 PTC Research Data Collection Sheet
- Camera (optional)

Estimated Materials Cost:
Activity leaders can expect to spend less than $15 (assuming handouts are printed and crayons or colored markers are available) on materials when completing this activity with 24 students organized into six teams of four. The peppermint candy pieces are to help dissipate the bitter PTC taste.

ACTIVITY LEADER PREPARATION

1. Read **Spark WiSTEM²D.** This is essential reading for all volunteers interested

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in working with youth, as it provides important background knowledge about STEM²D, strategies for engaging students, and tips for working with groups of students. Download at STEM2D.org.

2. Review the **Activity Leader Checklist** for details and specific steps for planning and preparing to implement this activity.

3. See the **STEM²D Student Activities Overview** for additional information.

4. Prepare the **Pre-Survey for Taste Test Activity** as a Google doc for students to complete before the day of the taste test. Students should have access to the survey data when working on their research projects.

5. Read "Two Scientists' Discoveries."

6. Prepare materials for each student team:
    - With sterile gloves on, put four control strips in a small plastic bag marked CS
    - With sterile gloves on, put four PTC strips in a small plastic bag marked PTC
    - Put one small plastic bag of each, the CS and PTC strips, in a plastic cup
    - Put four sticky notes in each plastic cup
    - Put four peppermint candies in each cup
    - There should be one plastic cup ready for each team

STEP-BY-STEP ACTIVITY:

YUCK! THAT TASTES TERRIBLE: DISCOVERING A UNIQUE GENETIC TRAIT

Welcome and Introductions (15 minutes)

- Greet the students
- Tell the students your name and your organization/company. Talk about your educational and career path. Use the Tell My Story form as a basis for your remarks. Be prepared to describe your job or a typical day, and provide information about your background including:
    - Your education – focus on secondary and post-secondary classes and courses

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- Current work projects
- Interests and hobbies
- Why you love STEM²D, and how your work is connected
- Write your introduction ideas here

_____
_____
_____
_____

- Ask the students or any volunteers helping today to introduce themselves.
- Use Conversation Starters to learn more about the students and their interests.
- Discuss the opportunities that exist in the local community to support students as they develop their interests and personal experiences.
- Tell the students that your career is only one of the many careers available in STEM²D – science, technology, engineering, mathematics, manufacturing, and design.
- Explain that STEM²D careers are **high-demand**, **high-growth careers** and are predicted to remain in demand over the next 10 years.
- Some STEM²D careers do not require a college degree and offer young people exciting, high-paying opportunities. Stress the importance of gaining mathematics skills and engineering practices to succeed in any STEM²D career.

CONVERSATION STARTERS: *CAREER PLANNING*

- When you consider your future, what are you most excited about?
- Do you see yourself working with others, for a large company, with your friends, for yourself? Why or why not?
- What does the perfect work day look like to you? Are you outdoors? Are you working alone, or with others? Do you solve problems? Do you fix or build things?

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CONVERSATION STARTERS:
LEARNING ACTIVITY

Taste Test Student Pre-Survey (optional activity)

Use the pre-survey for taste test activity to collect student data before the taste test, which the students can use to discover correlations when completing their research projects. So that names are not used, each student should use their student ID number.

Let the Tasting Begin, Bingo (optional activity)

Hand out one Bingo activity sheet to each student

Have the students enter the foods they like above the diagonal of each square. Give the signal for six minutes of matching to begin. Students are to find classmates who have the same likes they do and initial below the diagonal of each square. It is easiest to exchange cards with a person and look for a match, then initial and return the card.

Each person with a match can initial only one square. After six minutes, see who has the most Bingo lines, across, down, or diagonally.

Have the students write the number of Bingo lines on the top right of their sheet. If there is time, discuss:

- What was hard to match?
- Which category was hardest to fill in before the game started?
- What were some bitter foods you listed?

NOTE: Small food prizes can be awarded, where appropriate and authorized by the school.

Review:

Ask a few probing questions to gather prior knowledge of genetics.

- What are some genetic traits that we have?
- Where are these genetic traits carried? Do families have similar genetic traits?
- Are there certain traits that seem to be dominant? Recessive?
- Can two parents with brown eyes have a blue-eyed child? Why?
- Do you think there is a genetic trait for tasting bitter things?

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Show YouTube Videos:

NOTE: YouTube may not accessible in all schools, given the potential for inappropriate content.

- *Are You a Super Taster? SciShow, August 25, 2015 (2½ minutes)*
- *Why People Taste Things Differently, Seeker, July 23, 2013 (3 minutes)*

Instructions

- Divide the class into teams of four students each.
- Read "Two Scientists' Discoveries"(optional)

  Students should know the history behind the PTC test and how it was discovered. Have the student teams read the short history "Two Scientists' Discoveries," which is provided as an attachment. This may also be done as a "popcorn" reading where the facilitator randomly calls on students to read, and then for deeper understanding, calls on other students to summarize the main points of what was read.
- Have one student from each team gather the plastic cup of materials for their team. Discuss the difference between texture and taste. This is important, because this activity is about a taste that is presented on a paper strip. The control paper has been described as having a taste by some students, but that isn't a taste; rather, it is the texture of the paper.

SAFETY NOTE: Students should be made aware that tasting is not something that is normally done in a science lab. Scientists are careful to keep their food outside of laboratory settings so that their food is not contaminated with potentially harmful chemicals and so that their experiments aren't contaminated by food!

- Each student should take a control strip, place it on their tongue, move it around so it mixes with their saliva, and determine if there is a taste.
- Each student should take a PTC-enhanced strip, place it on their tongue, move it around so it mixes with their saliva, and determine the type of PTC taster they are: AA—strong bitter taste; AB—mild bitter taste; BB—no bitter taste.
- Both the control strip and the PTC strip should be discarded in the plastic cup.
- Peppermint candies are provided to help dissipate the bitter taste of

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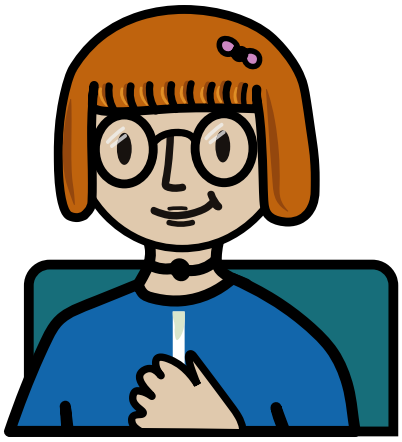
the PTC for the AA and AB tasters.

- Have the teams discuss the results of their PTC tasting. Each student should put their student ID and their PTC code on a sticky note.

Example:

#78643 BB



In front of the classroom (on a wall, whiteboard, or chalk board) make a bar graph of the class results. Place all AA sticky notes in the first column, all ABs in the second column, and all BBs in the third column.

Discuss the results as a class. What is the sample number? What percent of the class were AA, AB, and BB?

Guide students through a Punnett square. Have students work in their teams or as a whole team. Ask them to suggest a genotype for each phenotype. How many phenotypes are there? Ask the students to complete the squares for possible parents' genotypes.

Discuss the lack of diversity and the small number of the classroom sample group. Ask if they think the classroom sample group findings can be attributed to the population at large? Is the classroom sampling close to the demographic makeup of the general population? Why or why not? *(The answer is "No.")* In general, larger samples are better, but they also require more time and effort to manage. The results of 1,000 surveys will be stronger than the results of 20.

Hand out the PTC Research Data Collection Sheet to each team. Have students come up with a research question about PTC tasters. See the research example below.

- Students can gather the PTC codes of their classmates from the sticky notes in the front of the room and use their student ID number to find the survey data for that person.
- Students should be given results electronically, by student ID number, from all their classmates to gather the data they need and determine any correlations.

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- Students are now ready to collect the PTC taster code type and the desired research data.

  Strong taster: AA
  Mild taster: AB
  Non-taster: BB

Research Example: Do mild PTC tasters (AB) have a preference for milk chocolate or dark chocolate?

AB Taster Code ID	Milk Chocolate	Dark Chocolate
#6743	x	
#9065		x
#2651		x

- Give the teams time to work on their research projects.
- An important question is, who might be interested in their findings? They should think about this and be able to offer suggestions. For the research project above, for example, the answer might be: Hershey's or other chocolate-making companies, bakeries, cafeterias, vending machines, or other places where chocolate toppings are served, etc.

Reporting Results:

- Have each team pick one person to report on the work of their team, the research they were asked to do, and their findings, if any.
- As a class, discuss any patterns they see within the classroom sample group. Did they find any interesting correlations? Were they what they expected?
- Ask who might be interested in their research?
- Give positive feedback after each team presentation and encourage the other teams to applaud their work.
- This is a good time to take pictures of each team.
- Collect the **Research Data Sheets** for a possible bulletin board display.

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Student Reflection (10 minutes)

Have the students reflect on this activity by answering the following questions:

- What did you learn from taking the PTC taste test?
- Was it fun? What made it fun?
- Who are you going to tell about today's activity? Why?
- What did you learn about designing a research project?
- What was your biggest challenge in completing the activity?
- Was there another correlation you would have liked to research?
- Would you consider a career in scientific research? Explain.

After a few minutes ask the students to share their thoughts.

Thank the students for participating.

This is a great time to present each student with a certificate that has been prepared ahead of time with each student's name and signed by the Johnson & Johnson volunteer. Also, pass out the WiSTEM^{2}D posters to each student.

EXTENDED LEARNING

1. Broaden the PTC tasting sample to the whole grade in the school and possibly the whole district. Share the results.
2. Design a study to find out specific correlations with a broadened sample.
3. Find students who have both parents and grandparents and possibly great-grandparents willing to take the PTC test tracking the genetic trait.
4. Set up a PTC taste test booth at a PTA meeting to share the experience with parents.

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VOCABULARY:

DOMINANT TRAIT: In genetics, a trait that will appear in the offspring if one of the parents contributes it

RECESSIVE TRAIT: In genetics, a trait that can be carried in a person's genes without appearing in that person

HOMOZYGOTE: A person who has two identical forms of a particular gene, one inherited from each parent

GENOTYPE: The genetic make-up of an individual organism

PHENOTYPE: The set of observable characteristics of an individual, resulting from the interaction of its genotype with the environment

FUNGIFORM PAPILLAE: The part of the tongue that is the taste buds

PUNNETT SQUARE: The diagram used to determine the probability of an offspring having a particular genotype

CORRELATION: A statistical measure that indicates whether two variables fluctuate together

ACTIVITY LEADER REFLECTIONS

After the activity, take a few minutes to reflect on the following:

- What went well and what could be improved?
- What would you do differently next time?
- How comfortable did you feel leading the learning experience?
- Do you have a better understanding of the STEM^{2}D concepts?
- How useful was the information presented in the **Spark WiSTEM^{2}D**?
- Will you volunteer for this type of experience again?

RESOURCES AND REFERENCES

1. Kim, U., Jorgenson, E., Coon, H., Leppert, M., Risch, N., and Drayna, D. Positional cloning of human quantitative trait locus underlying taste sensitivity to phenylthiocarbamide, Science, 299: 1221-1225, 2003
2. ***That's Tasty*** from Neuroscience for Kids
3. ***Our Chemical Senses (Taste)*** from Neuroscience for Kids
4. ***Does Color Affect Taste?*** from Neuroscience for Kids

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5. ***Are You a Super Taster?*** YouTube, SciShow, August 25, 2015
6. ***Why People Taste Things Differently***, YouTube, Seeker, July 23, 2013
7. https://www.genome.gov/pages/education/modules/ptctastetestactivity.pdf
8. scienceprimer.com/Punnett-square-calculator
9. What is Sampling in Research? Natalie Boyd, study.com
10. Margaret Emmons, S.T.E.M. Coach, Branchburg Township School District

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ACTIVITY LEADER CHECKLIST:

DID YOU . . .

- ☐ Read Spark WiSTEM²D? This is essential reading for all volunteers interested inworking with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with female students. Download at www.STEM2D.org.
- ☐ Visit the implementation site and observe the young people? (optional) If visiting, take note of the following:
  - ☐ How does the site encourage orderly participation? For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems with managing the class of young people?
  - ☐ What does the site do to make each student feel important and at ease?
  - ☐ How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
  - ☐ How can you engage the site representative in your presentation?
- ☐ Meet with and finalize the logistics with the Site Representative?
  - ☐ Confirm the date, time, and location of the activity?
  - ☐ Confirm the number of students attending? Knowing this will help you decide how to group the students into teams, as well as the appropriate materials to purchase.
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity:
  - ☐ Read the entire activity text prior to implementation?
  - ☐ Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - ☐ Complete the Tell My Story Form, which will prepare you to talk about your educational and career path with the students?
  - ☐ If teams are needed for this activity, please ask the teacher in advance to organize the students into teams.
- ☐ Practice your presentation, including the hands-on, minds-on activity? Be sure to:
  - ☐ Do the activity; make sure you can explain the concepts to students, if needed, and that you know the correct answers.
- ☐ Obtain the required materials (see the Materials and Estimated Materials Costs sections) and, if asked for in the Getting Ready section, photocopy the Student Handouts and Materials Testing Sheets. In addition:
  - ☐ Organize the materials to ensure each team has everything listed in the Materials section—keep in mind some materials are shared among the teams.
- ☐ Prepare the space? Specifically:
  - ☐ Make sure tables and chairs are arranged to accommodate teams of students.
  - ☐ Bring a camera, if desired, to take photographs.
- ☐ Obtain and collect permission slips and photo release forms for conducting the activity if applicable?
- ☐ Have fun!

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ACTIVITY LEADER MATERIALS

"Tell My Story" Form

This form will help volunteers serving as activity leaders prepare to talk about their STEM2D interests, education, and career path.

ABOUT YOU

Name: _____

Job Title: _____

Company: _____

When/Why did you become interested in STEM2D? _____

_____

_____

What do you hope young people, especially females, will get out of this activity? _____

_____

FUN FACT:

Share a little about your background. Ideas:

- Share a memory from childhood where you first had your spark or interest in STEM.
- Detail your journey; highlight what you have tried, what you learned, steps to success, etc.
- Failures or set backs are also great to talk about—difficulties, and/or challenges and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most? _____

_____

How did you know you wanted to pursue a STEM²D career?

_____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why to the students.*

_____

What your current position entails. *Be sure to include how you use STEM²D on a typical work day.*

_____

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TASTE BINGO

Vegetable	Salty	Fruit	Sweet

Find a person with one of your entries on their card.
Have them initial in that box.
Each person that matches can sign only one match on your card.

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Two Scientists' Discoveries

In 1931, a chemist named Arthur Fox sat at his DuPont Company lab bench, mixing a powdered chemical. He accidentally let a bit of the powder blow into the air around him. Fox and another scientist got some of the chemical into their mouths. Dr. Fox's colleague exclaimed how bitter the powder tasted. Fox was surprised—he had been much closer to the chemical, but he tasted nothing at all. Both men tasted the chemical again. Again, Fox said the chemical was tasteless, but his co-worker insisted it was very bitter. Fox handed out crystals of the chemical, which were not poisonous, to his friends, family members, and fellow scientists and asked them if they tasted anything. Some people, like Fox, tasted nothing; others found the chemical somewhat bitter or intensely bitter.

Consuming chemicals in a lab is not a recommended practice!

Dr. Fox's chemical, called phenylthiocarbamide (PTC), has been used widely since its discovery to detect genetic variation in tasting abilities. Studies soon after the incident in Fox's lab showed that there is a genetic component that influences how PTC tastes. Scientists found that people were much more likely to find PTC bitter if other members of their family also found it bitter. The evidence was so strong for a genetic link that PTC tasting ability was used as evidence in paternity tests before DNA tests were available.

More than 70 years later, a single gene underlying this variation was discovered and reported by Un-Kyung Kim and colleagues from the National Institute on Deafness and Other Communication Disorders. This was something of a surprise, because for many years scientists suspected that more than one—possibly many—genes were responsible for PTC taste sensitivity.

Geneticists argued for years about how many genes might be responsible for this variation and where these genes might be located on our chromosomes. Using molecular genetics techniques with a variety of families, Kim isolated an area on chromosome 7 that was likely to contain a gene affecting PTC tasting ability. This region, however, also contained more than 150 other genes. Of these, nine were known to produce proteins for bitter taste receptors on the tongue. To narrow down their search, the researchers figured out the DNA sequences of all nine of these genes. They looked to see if different people had different versions of the same gene for any of these, and if so, if any gene variations correlated with PTC sensitivity.

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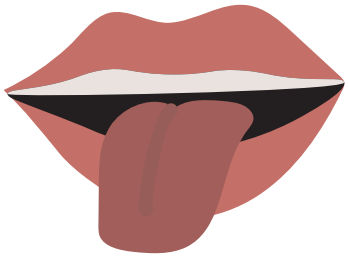
The researchers found a single gene for a bitter taste receptor that explains different PTC tasting abilities. There are actually three versions of this gene that differ from one another only slightly. This small difference in the gene, and in the protein it makes, eventually forms a taste receptor that has a different shape from a "normal" bitter taste receptor. This altered shape means that person's receptors will not respond to PTC and the person will not think the PTC tastes bitter. Since people have two copies of most genes, different combinations of the bitter taste gene (two copies of form 1; one copy of form 1 and one of form 2; two copies of form 3) determine whether someone finds PTC intensely bitter, somewhat bitter, or without any taste at all.



Other interesting facts about PTC:

- Being able to taste PTC is a dominant trait. About 2/3 to 3/4 of a sample group should be able to taste it.
- Super tasters are homozygous for the dominant allele.
- Only half of Aboriginal peoples from Australia and New Guinea are tasters.
- Nearly 100 percent of indigenous Americans (American Indians and Inuits) are tasters.
- PTC tasters are more likely to be non-smokers.
- PTC tasters are less likely to drink coffee or tea.
- Super tasters are more likely to find green vegetables bitter.
- Women, Asians, and African-Americans are all more likely to be super tasters.

References

1. Kim, U., Jorgenson, E., Coon, H., Leppert, M., Risch, N., and Drayna, D. Positional cloning of human quantitative trait locus underlying taste sensitivity to phenylthiocarbamide, Science, 299: 1221-1225, 2003

1. ***That's Tasty*** from Neuroscience for Kids
2. ***Our Chemical Senses (Taste)*** from Neuroscience for Kids
3. ***Does Color Affect Taste?*** from Neuroscience for Kids
4. https://www.genome.gov/pages/education/modules/ptctastetestactivity.pdf

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PRE-SURVEY FOR TASTE TEST ACTIVITY

Student ID Number: _____

Check the answers that best apply.

Gender

- ☐ Male
- ☐ Female

Eye color

- ☐ Brown
- ☐ Blue
- ☐ Between brown and blue

Hair color

- ☐ Blond
- ☐ Brown
- ☐ Black
- ☐ Red

Hair texture

- ☐ Straight
- ☐ Wavy
- ☐ Curly

Which chocolate do you like best?

- ☐ I like milk chocolate
- ☐ I like dark chocolate

Do you like coffee?

- ☐ Yes
- ☐ No

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Do you like broccoli?

- [ ] Yes
- [ ] No

Do you like Starbursts?

- [ ] Yes
- [ ] No

Are you a salad lover?

- [ ] Yes
- [ ] No

Do you like cranberry juice?

- [ ] Yes
- [ ] No

Does anyone in your household smoke?

- [ ] Yes
- [ ] No

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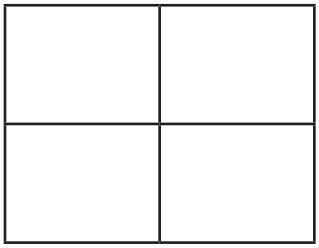
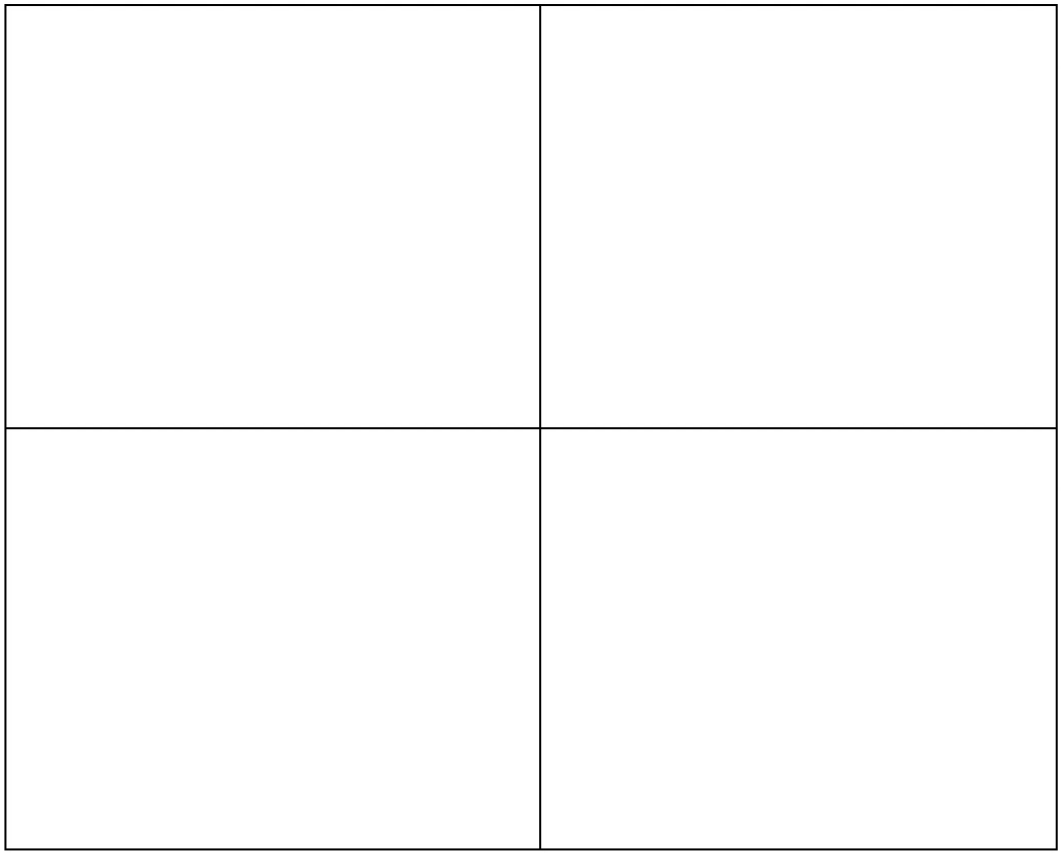
PUNNETT SQUARE

Genetic contribution of one parent →

Genetic contribution of second parent ↓





PTC Research Data Collection Sheet

Research Question:

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