

# Is there a gene for liking broccoli?

**You may have heard your mom or dad say, "Eat your broccoli. It's good for you!"**

Maybe you are a broccoli fan, or maybe you just can't stand the taste. Scientists are interested in learning more about why we eat specific foods. Taste is one of the sensory factors that is important in determining what we eat, so it is an important topic for scientific research.

The tastes we can sense are divided into the flavors of salty, sour, sweet and bitter. It's easy to imagine salty chips, sour lemons, sweet honey, and bitter coffee. You may be less familiar with a fifth flavor called savory, which some people describe as "meaty and rich." Starting at birth, we are attracted to sweet tastes, and we associate these with being good for us. We usually dislike very bitter tastes, and this may be a protection developed in early humans against eating plants that might be poisonous.

## A "bitter" dispute

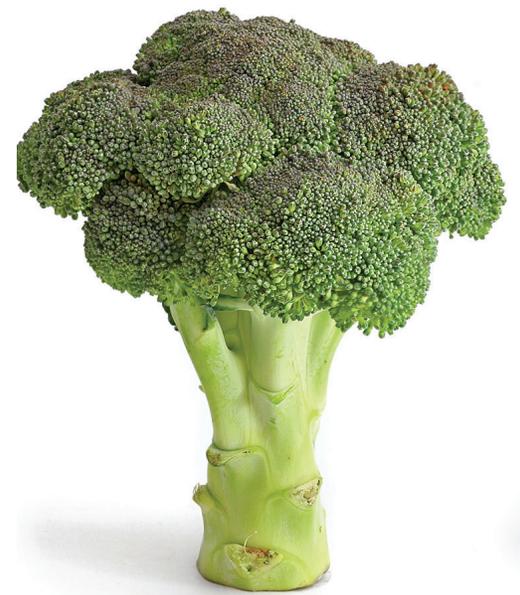
Every person has a variety of easily observed traits such as hair and eye color, ear lobe shape, even the ability to roll your tongue! These traits — and many more — are determined by genes that we inherit from our parents. Back in the early 1930s, two chemists first observed a human trait related to taste by doing something that they really should not have done.

**Here's the story ...**

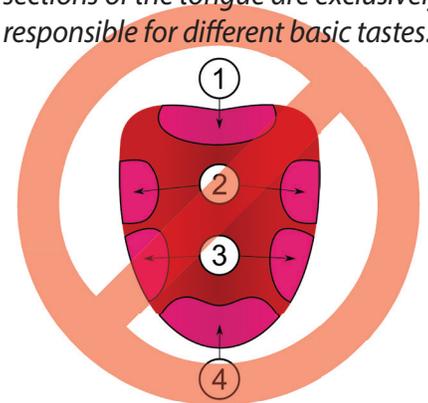
A chemist named Arthur Fox was placing a white powdery chemical into a bottle. While getting the powder into the bottle, some of it swirled around in the air. Fox, who had made the chemical, didn't notice anything unusual as the powder entered the air. But another chemist, named C.R. Noller, who was working close to Fox said that he detected a very bitter taste in the air. He wondered what the stuff was that Fox was putting in the bottle.

Since Fox hadn't tasted anything bitter, the two chemists started to argue. Fox went so far as to actually put some of the powder on his tongue! **(Chemists today do not taste chemicals!)** He declared it to be as tasteless as chalk. Noller, not to be outdone, also purposely tasted the white powder and declared it to taste even more bitter than before.

The two men then asked other coworkers and family members to taste the white powder. **(Chemists today do not have coworkers taste chemicals!)** Some people declared the powder to taste very bitter and some found the white powder to be completely tasteless!



**Did you know?** The tongue taste map below shows a common misconception that different sections of the tongue are exclusively responsible for different basic tastes.



# So, what did Fox make?

The chemical that Fox had made was **phenylthiocarbamide**, which is sometimes called PTC. We now know that the ability to taste or not taste PTC is an inherited trait. The gene for the ability to taste or not taste PTC is found on human chromosome 7.

**What makes PTC taste different to different people?**



You received one copy of the gene for tasting or not tasting PTC from your mom and one from your dad. This gene comes in two forms: dominant and recessive. These different forms of a gene are called alleles. The combination of alleles you carry for a trait is called your genotype. The traits that are expressed (observable) is called your phenotype. If you have either one or two copies of the dominant allele for the ability to taste PTC you are a "taster."

## It's a miracle!

Called "Miracle Fruit," the fruit of the *Synsepalum dulcificum* plant from West Africa, is a berry that when chewed before eating bitter foods will eliminate the bitter sensation and can even cause low pH sour foods such as lemons to taste sweet.

A molecule in the fruit temporarily binds to taste receptors in the tongue to cause the effect.

The fruit is sold under many brand names in the form of tablets or candy.

dominant allele (ability to taste PTC) = "T"  
recessive allele (non-tasting) = "t"

Genotype	Phenotype
TT (homozygous dominant)	PTC taster
Tt (heterozygous)	PTC taster
tt (homozygous recessive)	PTC non-taster

genes you've got

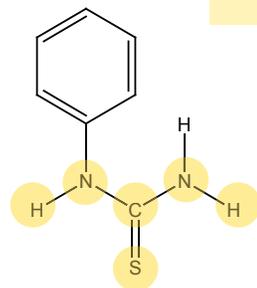
traits you show

## Another bitter "pill" to swallow...

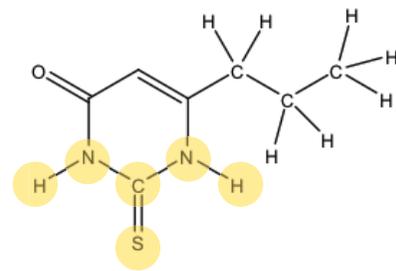
Even back in the 1930s, Fox and Noller knew the structure of the white powder was that shown here. Today PTC is used in very small amounts for genetic studies of taste traits but its use is a little controversial since PTC is also toxic.

Scientists later found another compound with the same genetic taste properties of PTC called propylthiouracil or PROP. PROP tastes bitter to people with the "T" or "Tt" genotype, and is tasteless to people with the "tt" genotype. Using PROP in taste studies instead of PTC is considered safer because very small amounts are used. Also, the side effects of PROP are better understood because PROP is used as a drug for thyroid disorders.

Looking for similarities between PTC and PROP you can see that part of these two structures are the same — both structures have a sulfur atom that is attached to a carbon, and on both sides of the carbon atom are nitrogen atoms attached to hydrogen atoms.



Phenylthiocarbamide PTC

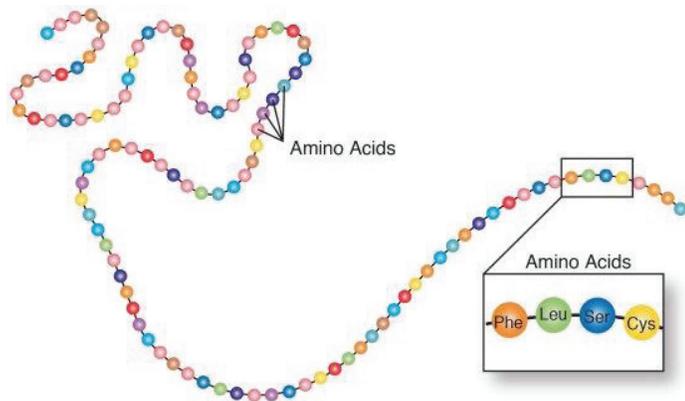


Propylthiouracil PROP

# A look inside the PTC tasting gene

The gene for the ability to taste PTC is named **TAS2R38**. A gene is made up of a long sequence of the four different DNA nucleotides (cytosine, guanine, adenine, and thiamine). This sequence of nucleotides determines which amino acids will be linked together (and in what order) to form a protein.

**Simply stated, a gene is the DNA instructions for making a specific protein.**



Amino Acids

Ala: Alanine	Gln: Glutamine	Leu: Leucine	Ser: Serine
Arg: Arginine	Glu: Glutamic acid	Lys: Lysine	Thr: Threonine
Asn: Asparagine	Gly: Glycine	Met: Methionine	Trp: Tryptophane
Asp: Aspartic acid	His: Histidine	Phe: Phenylalanine	Tyr: Tyrosine
Cys: Cysteine	Ile: Isoleucine	Pro: Proline	Val: Valine

**A protein is a long string of the 20 possible amino acids.**

Scientists have figured out that the taster (T) and non-taster (t) alleles of the **TAS2R38** gene have differences in three nucleotide positions on the gene. Because the nucleotide differs at those locations, the amino acid coded by that part of the gene will be different. The end result is that people with taster allele end up making a different protein than those with the non-taster allele.

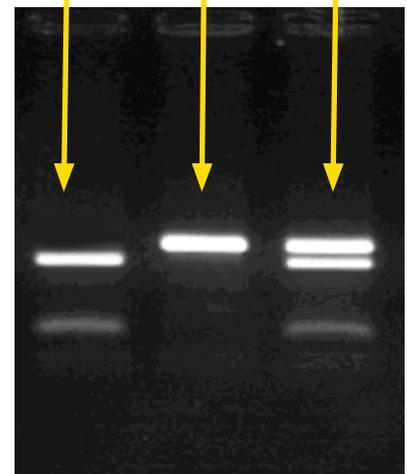
Nucleotide Position #	Taster Allele "T"		Nontaster Allele "t"	
	nucleotide	resulting amino acid	nucleotide	resulting amino acid
145	C	proline	G	alanine
785	C	alanine	T	valine
886	G	valine	A	isoleucine

## Pretty as a picture

If you are a fan of crime TV shows such as CSI, you may have seen a crime analyst hold up a black piece of film with white bars on it, like the one shown here. It is called an electrophoresis gel. The technology for preparing DNA samples for electrophoresis has become so affordable, that even some high school laboratories have this equipment and run these gels.

The electrophoresis gel creates a pattern that indicates whether the genes from two DNA samples are the same or not. A process called PCR (polymerase chain reaction) is used to increase the amount of DNA available to be analyzed. In this electrophoresis gel, a section of the **TAS2R38** gene that includes nucleotide position #145 was analyzed. After treatment with an enzyme, the taster version of the allele breaks into two fragments, but the non-taster allele stays in one piece. The gel shows whether the test sample had one, two, or three pieces of DNA.

non-taster "tt" one fragment  
 taster "TT" two fragments  
 taster "Tt" three fragments



Electrophoresis gel of the **TAS2R38** gene.

# Its a bird, its a plane, its super-taster!

Some people experience the sense of taste with much more intensity than average. Sounds great, right? Everything will be more delicious! It turns out to not be such a great thing.



Coffee might taste too bitter, cake too sweet, and chili peppers too hot.

These people have been dubbed “supertasters” by experimental psychologist Linda Bartoshuk. Her research explores genetic variation in taste perception and how taste perception affects health. The cause of being a supertaster is not fully understood, but does seem to be related to the presence of the taster allele (T) of the TAS2R38 gene and also an increased number of fungiform papillae on the tongue. (The fungiform papillae have taste buds embedded in their surfaces.) People of Asian, African and South American descent are more likely to be supertasters.

## Who cares if PTC is bitter?

Although our friends Fox and Noller enjoyed arguing over whether they could taste PTC, you may wonder why biomedical scientists still care about whether individuals can taste PTC or PROP. They care, because the ability to taste bitterness may influence not only what foods people tolerate or enjoy but may have health implications.

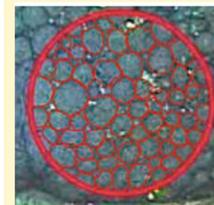
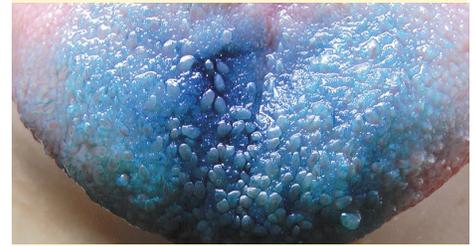
Scientists want to know whether the perceived flavors of some foods influence how much of those foods people eat. For example, people who are more sensitive to bitterness in common foods such as grapefruit and broccoli may naturally consume far less of these foods. Consuming fewer fruits and vegetables may make people more susceptible to diseases such as colon cancer. To make these foods easier to eat, it may be possible to develop vegetables with flavor profiles that are perceived by people who are sensitive to bitter foods as less bitter, while maintaining the beneficial nutrients.



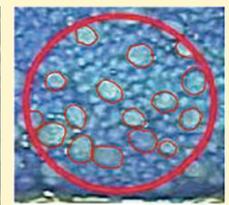
**So, is there is a gene for liking broccoli?**—Broccoli, along with Brussels sprouts, cabbage, kale and other cruciferous vegetables contain the compound sulforaphane which is becoming known for health benefits. But another compound in vegetables that later becomes sulforaphane (called a precursor) may taste bitter to some people. People with the “TT” or “Tt” genotype for the TAS2R38 gene may be more sensitive to bitterness in broccoli and dislike eating it. Those with the “tt” genotype may not find broccoli bitter and may enjoy it more. In a sense, they have a gene for liking broccoli!

## Are you a supertaster?

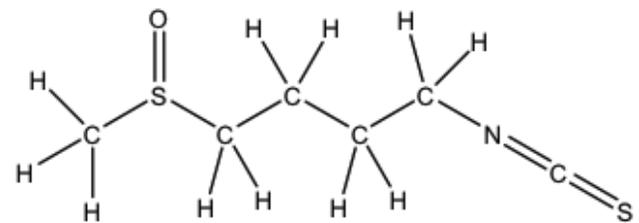
One way to identify supertasters is look at the number and closeness of fungiform papillae on the tongue. To make the tiny bumps easier to see and count, researchers put blue food color on people’s tongues.



supertaster



non-supertaster



Sulforaphane

Developed by

**FIGHTING**  
WITH **FOOD**

Good nutrition to battle environmental toxicants.

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**SEPA** SCIENCE EDUCATION  
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Supported by the National Institutes of Health

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