NOVA scienceNOW
#604

Can I Eat That?

DAVID POGUE: *All animals eat. Some would like to eat us.*

STEPHEN SECOR (University of Alabama)**:** You need to back up.

DAVID POGUE: *But why are humans the only animals that cook?*

I'm David Pogue, and on this episode of NOVA ScienceNOW, I'm on a mission to find out, "Why is cooking so important?"

So amazing!

You eat every day, but do you have any idea what really goes on inside your oven? How does this disgusting carcass become the most delectable meal of the year?

Mon dieu! I have discovered browning!

I'll be diving deep inside my dinner...

BARB STUCKEY (Mattson)**:** Most of flavor comes through your nose.

DAVID POGUE: *Freaking me out!*

...and deep inside the mind to unlock the mysteries behind the foods we crave.

LINDA BARTOSHUK (Smell and Taste Center, University of Florida)**:** The taste system solves problems that, if you don't solve them immediately, you die.

DAVID POGUE: *Is it possible that cooking, in fact, made us who we are?*

RICHARD WRANGHAM (Harvard University)**:** Cooking has enabled us to dominate the earth.

DAVID POGUE: *From the gorgeous to the grotesque,...*

Oh no! They are writhing!

DAN: Now this is really scientific.

DAVID POGUE: *...we are getting the answers. How we got them might surprise you.*

You see the rat in there!

You are doing some kind of brain meld on me.

LINDA BARTOSHUK: You definitely look like a supertaster.

DAVID POGUE: (With mouth open trying to say "Really?") *Weawwy?*

Up next on NOVA scienceNOW, Can I Eat That?

Thanksgiving, America's favorite holiday meal: a golden brown turkey and rich stuffing. Delicious! But a few hours ago, it wasn't such a pretty picture.

Look at this stuff. This is what we make Thanksgiving out of. They're like roots that make you cry, vegetables that are completely flavorless, this stuff. You could set a homerun record with this thing. And we eat dead animals.

Where did this idea come from? Mmmmmmm, what could be more appetizing?

And yet, somehow, through chemistry, through science, this stuff is going to coalesce into this fabulous meal. How the heck does that happen?

To find out, I'm going to a very special laboratory: America's Test Kitchen.

COOK: Welcome to the Test Kitchen. You need to put this on.

DAVID POGUE: *This is where the PBS show and the magazine* Cooks Illustrated *are made. Check out how they test the tenderness of a hamburger!*

COOK: Now, this is really scientific.

DAVID POGUE: *So, it looks like a 4.5 on the splatter scale.*

COOK: That's a really tender burger.

DAVID POGUE: *The bigger the splat, the better the burger!*

Unlike most kitchens, they employ an organic chemist to help figure out what is going on.

GUY CROSBY (*America's Test Kitchen*)**:** When you have the skin on and the bone in you get more variation?

COOK: We get a lot of variation.

DAVID POGUE: *Guy Crosby teaches nutrition at the Harvard School of Public Health. Here, he uses his science to make recipes better.*

Today, the goal is a perfect turkey, filled with succulent juices. But frequently that isn't the case. The dreaded dry turkey is a pop culture cliché, and something we're all probably a little too familiar with.

I mean, this was just a waste of, this was a waste of a Thanksgiving, right there.

So why is that? A raw turkey is made up of about 75 percent water. It's also not very appetizing, and it's potentially lethal to eat, because of the bacteria growing in it. So, of course, you've got to cook it. The problem is that takes hours, and all of that heat can evaporate the water right out.

So, is there a way to get more moisture into the turkey, before cooking it, and keep it there?

I like to use the seasoning injector. It's like a prop from Pulp Fiction*. I can save him! Straight into the heart. Is that a good technique?*

KEITH: I'd recommend brining in a bucket.

DAVID POGUE: *The cooks at* America's Test Kitchen *have discovered one way. They recommend soaking the whole bird in saltwater overnight, a process called "brining," which adds moisture to the meat. More moisture will make the meat more tender and juicy.*

Let's back up and see what is really going on, deep inside the turkey. Meat is mostly muscle, made up of millions of fibers that are like electrical cables bundled together. Each fiber is a long cell, made up of protein and mostly water. When you heat the meat, the fibers contract and squeeze out that moisture. The more you cook it, the drier the meat becomes.

I thought we were just sticking a bird in some saltwater.

GUY CROSBY: Well, we are, but a lot of chemistry is going on in there.

DAVID POGUE: *If you put a turkey into water, the H_2O moves into the meat through a process called osmosis. Osmosis creates a natural force that pulls the water across the cell membrane, from the higher concentration of water to*

the lower one, so they're in balance. Now, meat would also absorb plain water, but the salt is key for a juicier turkey.

GUY CROSBY: The salt will help the muscle fibers to expand, create gaps, and that makes room for more water to get in.

DAVID POGUE: *A few hours later, I get the tough job of analyzing which turkey is juicer, the brined or the unbrined.*

Ladies and gentlemen, Sample A. Okay. That needs some serious gravy. And here we go with the second sample. Wow, that does not even need gravy.

KEITH: So, you can see the brining at work.

DAVID POGUE: *The brined turkey is moist and juicy, while the unbrined…*

KEITH: This…I would not finish that piece. I mean, it's really dry.

DAVID POGUE: *It's super dry.*

KEITH: You'd need a half cup of gravy to choke that down.

DAVID POGUE: *Not all chefs and scientists agree that a brined turkey is tastier. For some, it's even too salty.*

GUY CROSBY: So, we're going to see how tender they are using this instrument called a texture analyzer.

DAVID POGUE: *Guy, always the scientist, puts the turkey to the test.*

You're going to put your turkey into a, into a tender-testing machine?

GUY CROSBY: Absolutely.

DAVID POGUE: *You must be a gas at Thanksgiving.*

At Framingham State University, Guy can measure the force it takes to penetrate the meat.

GUY CROSBY: It's really like chewing in slow motion. So we are directly measuring if it takes more force to chew one versus the other.

DAVID POGUE: *Side by side, we have a winner!*

Whoa!

GUY CROSBY: So, it is about a 20 percent difference.

DAVID POGUE: *The unbrined breast takes 20 percent more force. The tenderness machine agrees with me!*

The Pogue-O-Matic 3,000.

Okay, so we solved one problem, making the meat juicy and tender, but what about flavor?

The perfect turkey is juicy inside, and outside it's got to be crispy golden brown. That color ain't just for looks. It turns out browning the outside of meat is crucial for creating the most delicious flavor, thanks to a complex chain reaction.

Now, if I'm not mistaken, Mr. Food Chemist, there's some food chemistry going on here.

GUY CROSBY: You're absolutely right.

DAVID POGUE: *The key to browning and producing the best flavor is heat, lots of it.*

The cooks show the difference on chicken cutlets, which are a lot easier to brown in a fry pan than a 20-pound turkey.

Heat is a form of energy that is transferred into the food. That energy can speed up the molecules inside the food, causing many possible changes.

One of them that happens quickly, once the surface of the meat gets above 300 degrees, is called the "Maillard reaction."

GUY CROSBY: Maillard reaction was discovered by a French chemist, in the early 1900s, named Louis Camille Maillard, and it….

DAVID POGUE: *Mon dieu! I have discovered browning! Henceforth it should be named after moi, Mallaird.*

I'm sorry I was just thinking of something.

The Maillard reaction happens on the molecular level. As we've already learned, meat is mostly muscle, which is made up of protein. Proteins are made up of molecules called amino acids. The heat from your stove breaks down the bonds in protein chains, releasing the amino acids.

GUY CROSBY: So, it's the actual chemistry that's being driven by the heat, so if you have something that's not going to heat up, you don't see these reactions taking place.

DAVID POGUE: *Next, those amino acids react with sugar that's also in the meat. That sugar was there to provide the turkey's muscle with energy.*

Now, on the sizzling skin, sugar and amino acids combine to create new molecules that give the turkey that delicious roasted flavor we love and the brown color.

GUY CROSBY: You take something simple, a few molecules, sugars and amino acids, and together, when they react, they can lead to the thousand different new flavor molecules created by the Maillard reaction.

DAVID POGUE: *And Maillard's delectable browning chemistry isn't just for meat. You can thank the same reaction for the irresistible flavor of many things we roast, including coffee beans and chocolate.*

This is something you'd see in an automotive factory.

BRIDGET LANCASTER (*America's Test Kitchen)***:** Watch this! It's like *Transformers*. Gone.

DAVID POGUE: *You just don't want to turn it on when it's like that.*

BRIDGET LANCASTER: No.

DAVID POGUE: *It's a little drinking fountain.*

BRIDGET LANCASTER: Clean up on Aisle 4.

DAVID POGUE: *My thirst quenched, we've got to finish off the turkey, and that means it's time for that delicious combination of stale bread, tasteless celery and tear-worthy onion: the stuffing!*

First, you have to battle the onion.

BRIDGET LANCASTER: You know, the way you prepare onions has a huge impact on the end result. I want you to smell this onion.

DAVID POGUE: *Um?*

BRIDGET LANCASTER: You can't really smell anything, right?

DAVID POGUE: *It doesn't have any smell.*

BRIDGET LANCASTER: No.

DAVID POGUE: *Have you done something to this onion?*

BRIDGET LANCASTER: No, no, that's just a regular onion, but I'm going to show you something. So, if I just take this onion and cut it right in half, by taking the blade and slicing, I've started a chemical reaction. And now you can start to smell an aroma.

DAVID POGUE: *Yes, I do.*

BRIDGET LANCASTER: Yeah.

DAVID POGUE: *It smells like onions.*

BRIDGET LANCASTER: Onion.

DAVID POGUE: *The more you cut an onion, the more of that chemical reaction happens and the stronger the taste.*

Inside the cell of an onion there are enzymes. These are normally kept separate from the other molecules by a barrier. When your knife cuts the onion, these chemicals come together to form new molecules. Some make you cry; others create the strong onion flavor.

So you're actually changing the flavor of a vegetable according to the mechanical action of cutting it?

BRIDGET LANCASTER: That's right. The more you go at it and more you release those cell walls, the more flavor and the more pungent aroma is going to come out.

DAVID POGUE: *One of the new molecules is propanethial-S-oxide, a volatile molecule that floats up and can trigger the tears.*

Assuming you survive onion cutting, it's time to move on to the rest of the stuffing.

Bridget, you appear to be the maker of the croutons. So this is how you make real stuffing?

BRIDGET LANCASTER: That's how you make real stuffing.

DAVID POGUE: *I thought it comes in a box, you know?*

BRIDGET LANCASTER: Only if you're desperate. The key to great stuffing is getting the moisture out of bread.

DAVID POGUE: *Unlike the bird itself, where the big challenge was keeping the water in, stuffing presents the opposite dilemma: getting the water out.*

If you fail, you get this: mushy, gummy stuffing.

I hate gummy stuffing.

BRIDGET LANCASTER: That was one of the Pilgrims' top 10 most hated things.

DAVID POGUE: *Most recipes call for using stale bread, but, at* Cooks*, they have discovered a problem with that. In stale bread, the water actually gets trapped inside the crystal structure of the starch granule. So while the bread may feel dry, it actually has lost very little of its water.*

BRIDGET LANCASTER: So, if you were to reheat this, you know wrap it in foil, you could actually bring back this baguette and it would be really nice and moist and you could eat it. But for a stuffing it is still going to be too moist. That's going to make the stuffing gummy.

DAVID POGUE: *So how do you avoid the gummy curse?*

BRIDGET LANCASTER: So you want to cut the bread into cubes, and then we dry these on a really low oven, about 250 degrees, and that's perfect because it's going to basically dehydrate the bread.

DAVID POGUE: *So now, inside the starch granule there is much less water.*

BRIDGET LANCASTER: So, you can see it's still moist, but the cubes are not turning to paste.

DAVID POGUE: *Thanksgiving saved.*

So that's our science lesson in the chemistry that will be happening in your kitchen, when you cook your turkey.

Mmmm, that is delicious, Bridget.

From making a tender and golden brown, delicious turkey to yummy, not gummy, stuffing.

Sometimes, cooking is essential for survival…
Take the cassava root…
It contains a chemical called linamarin
Inside your body, it becomes…
Cyanide!

But cook it properly…
And you get…
Tapioca.
That's right.
Cooking can turn poison into pudding!

DAVID POGUE: *Now that I know a thing or two about how to cook, it makes me wonder why do we even cook at all?*

Throughout history, man has sat around a fire, cooking and eating, but we humans are the only animals that eat cooked food. Surely there is a good reason for it.

RICHARD WRANGHAM: Cooked food gives you enormously more energy, and so for a certain amount of food, you get many more calories.

DAVID POGUE: *Richard Wrangham is a primatologist in the Department of Human Evolutionary Biology at Harvard. He thinks that cooking was essential to human evolution. He says cooked food is easier to digest, and so, humans evolved to use their food more efficiently. This is the skeleton of an ape, and he is comparing our anatomy with our ape cousins.*

RICHARD WRANGHAM: The typical ape has got this very broad rib cage going right out there and flaring out, foreshadowing the fact that it's carrying a big gut down here.

DAVID POGUE: *You're not talking about a potbelly, you're talking about…?*

RICHARD WRANGHAM: We're talking about the small intestine, the large intestine, all of the stuff that is actually responsible for the digestion.

DAVID POGUE: *So the simple invention of cooking produced these enormous changes in our skeletons.*

RICHARD WRANGHAM: Yeah. It paid us, once we ate cooked food, to get rid of all of this gut, because that's expensive. So it's efficient to get rid of that.

DAVID POGUE: *How can cooking change who we are? Understanding that and how we get energy out of our food is what Stephen Secor studies.*

STEPHEN SECOR: They have the potential for killing you, simply from constriction around the neck.

DAVID POGUE: *Secor, a biologist at the University of Alabama, works with a creepy, crawly, dangerous array of animals.*

STEPHEN SECOR: You need to back up.

DAVID POGUE: *He is trying to understand how all animals get the energy they need from what they eat.*

Check out how a python chows down.

Here I am. Here snakey, snakey, snakey.

In the case of these guys, the food is very raw. These rats come frozen as snake food.

STEPHEN SECOR: Okay, there we go. There we go. There we go. There we go. There we go.

DAVID POGUE: *One of Secor's favorite animals to study is the Burmese python.*

It's suppertime.

STEPHEN SECOR: It is.

DAVID POGUE: *Down the hatch in one big bite!*

Pythons can eat more than a quarter of their body weight at one sitting.

How is the digestive system different from ours?

STEPHEN SECOR: Most of their digestion is identical to ours. It's just all very long and slender.

DAVID POGUE: *A python is basically one long gut, so to see inside, we take one to a nearby veterinarian's office for an x-ray.*

Hey, look, snakes welcome!

TECHNICIAN: Ready?

STEPHEN SECOR: Yep, yep.

DAVID POGUE: *Wow, you see the rat in there!*

STEPHEN SECOR: Ah, it's perfect.

DAVID POGUE: *Sure enough, there it is: the python's dinner.*

STEPHEN SECOR: The head of the rat is in the pit of the python's stomach, and the stomach extends back, and from this point on, that's esophagus.

DAVID POGUE: *Inside the stomach, acids break down the rat, bones, blood and all.*

Secor x-rayed the python over two weeks. Bit by bit, the rat disappears, and all but the hair is absorbed by the python.

Understanding where the disappearing rat goes can help us understand how our food nourishes us, minus the bones and fur, of course.

To make this point, Secor says, it's useful to compare the rat with a cupcake. After all, to a python, a rat is basically a triple-layer German chocolate cake.

STEPHEN SECOR: Here we have the cupcake and the rat. Both of these have energy stored in them.

DAVID POGUE: *Now, even though we don't find these two treats equally appetizing, from the point of view of digestion, what they have in common is that they both are full of potential energy, or calories.*

To understand what kind of difference cooking can make to your food, you need to first understand a calorie.

STEPHEN SECOR: Calories represent the amount of fuel that's present with either one of these food items.

DAVID POGUE: *Calories are a way of measuring the energy in food, energy your body or a python needs to function.*

Think of this cupcake as fuel, like a log on a fire. If we burn it, that fuel will increase the heat of the fire. A calorie is way to represent that increase.

Let's burn the cupcake.

STEPHEN SECOR: Okay.

DAVID POGUE: *So it is actually burning…*

STEPHEN SECOR: Yes.

DAVID POGUE: *…like a charcoal briquette or something.*

STEPHEN SECOR: Yes, like a, like a log.

DAVID POGUE: *Burning the cupcake like this, in the open air, it's impossible to measure the heat it gives off, so Secor shows me the right way to do it, using a machine called a bomb calorimeter.*

Items put in the bomb calorimeter must first be dehydrated, since water doesn't burn. Luckily, Secor is prepared for that.

STEPHEN SECOR: This is a dried rat that has been ground up…all the water out of it…kind of mix it all up and then formed a pellet.

DAVID POGUE: *All right, well, bring on the bomb calorimeter.*

A portion of the dried rat goes into the bomb calorimeter, where it's burned in a special tank, sensitive enough to measure the heat, or calories, in the rat.

We do the same thing with our pink cupcake: dehydrate it, grind it up, make a pellet and, as the grad students like to say, "bomb it."

Okay, professor. A nation of eaters awaits the results.

The bomb calorimeter says that seven ounces of cupcake has twice as many calories as seven ounces of rat: impressive and disgusting.

Now, let's take it one step further. Those calories come from the basic elements of eating: proteins, carbohydrates, which are simple sugars, and fats. Secor has calculated the percentage of each in our cupcake and rat.

No matter what we eat, whether it be a cupcake or a rat, those are the things your body is going to extract?

STEPHEN SECOR: That's right, and how they differ and how all meals differ is the relative proportion of each of these elements.

DAVID POGUE: *What's amazing is the quantity of sugar in this thing. It's almost the entire cupcake by volume. And you know the fat is quite a, quite a dollop, too. And over here we have so much protein and far less sugar and fat. The rat looks like it would be healthier lunch than the cupcake.*

STEPHEN SECOR: Right.

DAVID POGUE: *Fat, sugar and protein give me the energy to fuel my activity, and Secor can see how much I need by measuring my oxygen use.*

It turns out that the act of digesting a meal takes energy, too, like that big plate of barbequed ribs. Even as I lie here, my body is working to break down that dinner.

And that energy I burn digesting takes away from all the fuel in the food. Some of the calories are always lost in the process, and that is where cooking comes in. Cooking made digesting easier.

RICHARD WRANGHAM: When food is cooked, our body doesn't have to work as hard to digest it.

DAVID POGUE: *Wrangham says that cooked food gave humans extra energy, compared to their primate relatives.*

RICHARD WRANGHAM: And where are we putting it? Here is one big place. This brain is about three to four times the size of this brain.

DAVID POGUE: *The human brain requires approximately half a cup of sugars a day to function. That's a lot of calories.*

So it was our brain, the largest, proportionally, of any primate, that Wrangham believes benefited most from a nice cooked meal.

It seems we humans have always figured out clever ways to fill up with less effort!

WORKER AT RESTAURANT DRIVE UP WINDOW: Can I take your order?

DAVID POGUE: *Can I have the Number One Burger, no skin, bones or feathers, please?*

No not that way!

Thanks a lot.

But with tools, like spears or knives, as well as cooking.

Wrangham says getting more energy out of food with less sweat was a key factor in human evolution. Cooking was a real timesaver!

RICHARD WRANGHAM: It takes a lot of time to chew. So if we were a great ape, like a chimpanzee or a gorilla, we estimate that we would have spent about six hours a day just chewing.

DAVID POGUE: *What?*

RICHARD WRANGHAM: Yeah.

DAVID POGUE: *Wow. Their floss budget must have been immense.*

RICHARD WRANGHAM: Humans are completely off the curve.

DAVID POGUE: *Now, there is one problem with Wrangham's theory: there is no evidence they built fireplaces suitable for cooking until around 400,000 years ago. And we know that the human brain was already evolving, long before that: about 1.8 million years ago.*

Wrangham is confident that older evidence of cooking fires will eventually turn up. But, in the meantime, he's hunting for other evidence to support the theory. When he heard about Stephen Secor's work, he wondered if the snakes could help to illuminate just how much energy cooking actually saves.

Secor can easily measure the energy it takes a python to digest food, just like he was able to measure how many calories it took for me to digest that plate of ribs. But there was a problem: pythons don't eat what we do; they like their meals furry.

So how do you make a python eat a steak? That was a challenge for Secor and his grad students. Believe it or not, this is what they figured out. They sewed a rat's face onto a steak.

You have little meat stick rat puppets.

STEPHEN SECOR: That's right.

DAVID POGUE: *Why not just take a cooked rat?*

STEPHEN SECOR: We wanted to use a food that was similar to what we might be eating. So we need to sort of entice them to eat the steak.

DAVID POGUE: *Clearly, science takes ingenuity.*

You could tape the face of a cupcake onto a big piece of broccoli and feed it to children.

Success! Once full, on that rat-faced steak, Secor put his python into this Tupperware®, a makeshift oxygen tank, so that he can measure exactly how much oxygen the snake consumes while it's digesting.

Kind of like when I was on the treadmill with the thingy?

STEPHEN SECOR: Same principle.

DAVID POGUE: *But they don't make treadmills for snakes, so…*

And with that, he can figure out the caloric cost of digesting the raw versus cooked meat. The result? It turns out that cooked steak takes 12 percent less energy for the python to digest than raw steak.

Say what you will, the rat-faced-meat experiment worked.

So what about vegetables? Not even a rat's face will make a python eat broccoli. Fortunately, bearded dragons love vegetables, raw or cooked.

The bearded dragon experiments show that cooked vegetables take 40 percent less energy for them to consume than raw ones.

So the python and the bearded dragon help to show that eating cooked food takes less work to get the energy from the fat, protein and sugar in our food.

There is still the unsolved mystery of when campfires and cooking started, but we know that the impact of cooking has been enormous.

Wrangham says cooking changed many things for humans, by giving us more time and energy to communicate around a fire or even more time to make babies.

RICHARD WRANGHAM: So, cooking really has astonishingly diverse impacts on our lives.

DAVID POGUE: *Cooking? A little thing like cooking has produced these enormous specieal changes?*

RICHARD WRANGHAM: Cooking seems like a little thing until you go without it. I think of this as the most significant increase in the quality of food in the history of mammals and maybe in the history of life. I mean this was enormous. It has enabled us to dominate the earth.

DAVID POGUE: *And it's delicious, too.*

Did you know there are ingredients in mother's milk that babies can't even digest?
They're complex sugars called oligosaccharides.
But who could they be feeding?
Bacteria!
Inside the baby's intestine...
...those weird sugars help grow microbes crucial for human survival.
Got to keep those bugs happy...
After all, they make up 90% of the cells in a human body!

DAVID POGUE: *For me, the most important thing about food is, of course, the way it tastes. But how come different things taste good to different people? Like some people go nuts for French fries, while others salivate over salad.*

I want to know what's going on, so I've come to San Francisco on a mission and it's not just to eat at great restaurants.

Hi.

MONICA MARTINEZ (Don Bugito)**:** Hi.

DAVID POGUE: *I'm David.*

MONICA MARTINEZ: Monica.

DAVID POGUE: *Monica Martinez is cooking up something new that has me freaked out!*

MONICA MARTINEZ: So, this is my kitchen.

DAVID POGUE: *The central ingredients have just arrived from FedEx?*

Please don't tell me these are air holes?

MONICA MARTINEZ: Yes.

DAVID POGUE: *They're alive?*

MONICA MARTINEZ: They are alive.

DAVID POGUE: *Oh, god! Oh, no, no, no. They're writhing!*

And it's not just wax moth larva. In box number two…

MONICA MARTINEZ: This has to be done fast, because they jump out.

DAVID POGUE: *…crickets. That's...I have no words.*

Monica is drawing on her Mexican heritage to develop a signature snack and prepping for tonight's foodie event, called "Off the Grid."

MONICA MARTINEZ: When I cook them, I just pan fry them.

DAVID POGUE: *The recipe is simple: take two homemade tostadas, add avocado and zucchini and then, for the bit that makes my taste buds tremble, a generous sprinkling of crickets.*

Here's to all our six-legged friends!

MONICA MARTINEZ: They taste amazing! Crickets have their own flavor, so they taste really good.

DAVID POGUE: *It's not the food, it's the concept. It's the thought of what I just saw come out of that hideous FedEx box.*

MONICA MARTINEZ: Yes.

DAVID POGUE: *But if you hadn't told me, I'd say these were some of the best tacos I've ever had.*

Eating bugs reveals there is more to taste than just taste buds. So what really does go on?

BARB STUCKEY: Would you mind taping your nose?

DAVID POGUE: *Excuse me?*

BARB STUCKEY: Just close it, like this. I'll do it with you. You're just going to take one of your nostrils and kind of plug it, and then...

DAVID POGUE: *Okay.*

BARB STUCKEY: …plug the other one, and…

DAVID POGUE: *Oh, my gosh.*

Barb Stuckey is a professional taster for a food product company called Mattson, near San Francisco.

Okay.

BARB STUCKEY: So, now, go ahead and swish it around your mouth.

DAVID POGUE: *Okay: water.*

BARB STUCKEY: Take another swish, and this time, when you are swishing, let's take the tape off.

DAVID POGUE: *Okay. Oh, my gosh, it turned into brown butter.*

BARB STUCKEY: Most of flavor comes through your nose.

DAVID POGUE: *...freaking me out! Wait a minute, but it was inside my mouth. I couldn't have smelled it.*

Oh yes, I could. Inside our mouths there is a back channel to our smell receptors. Volatile molecules, or vapors, rise off food in our mouths and trigger our sense of smell.

But if your nose is blocked, the vapors aren't pulled up into the nasal cavity and you don't smell them. It turns out our nose plays a big role in the creation of flavor, the total experience of food.

BARB STUCKEY: It feels like the flavor is coming from your mouth, but, in fact, it's coming from your mouth through your nose, and the aromas are detected in your nose.

DAVID POGUE: *And smell isn't our only sense at work.*

Barb asks me to try a new juice they've just created.

It's definitely not fresh-squeezed.

BARB STUCKEY: What would you say if I told you that was apple juice?

DAVID POGUE: *Wait a minute. You are doing some kind of brain meld on me. This is clearly orange juice, but it tastes like apple juice, so what have you done here?*

BARB STUCKEY: All we have done is taken apple juice and added a little bit of orange color.

DAVID POGUE: *You're kidding.*

BARB STUCKEY: So it looks like orange juice.

DAVID POGUE: *Gosh, I am such a sucker! I can't believe I fell for that. It is perfectly good apple juice.*

BARB STUCKEY: It is very good apple juice, yeah.

DAVID POGUE: *Barb says not only smell and vision, but even sound can influence taste. So I'm blindfolded to see if cold water sounds different from hot water.*

Wait a minute. I could tell that the second one was hot! How could I tell that the second one was hot?

BARB STUCKEY: All right, take your blindfold off. The second one was hot.

DAVID POGUE: *I know. I could hear that it was hot, but that makes no sense! It had a hot water sound.*

Believe it or not, hot water has a different pitch when it hits the cup than cold water does.

BARB STUCKEY: Everyone gets it right.

Sound gives us information about, not just temperature, but freshness, crispiness, crunchiness, texture, fat content.

DAVID POGUE: *You don't actually put thought into the sound these foods are going to make do you?*

BARB STUCKEY: Of course, very much so.

DAVID POGUE: *Here at Mattson, they're trying to make treats so delicious that you will crave them and buy them.*

And, Honey, there's no fat! There's no sugar!

To do so, they use their understanding of how flavor works and food science to engineer flavors that appeal to all your senses.

BARB STUCKEY: Flavor, that concept, comes through many different senses. Really, when you're experiencing food, and you say you like the taste of something, you really like the way it looks, the way it feels, the way it sounds, the way it smells and the way it tastes.

LINDA BARTOSHUK: You have a gorgeous tongue.

DAVID POGUE: *Thank you.*

To get a better understanding of the difference between taste and flavor, I'm having my tongue examined by the guru of taste: Linda Bartoshuk, of the University of Florida.

LINDA BARTOSHUK: You never see taste buds. They are not visible on the tongue. Taste buds are buried in the tissue of this little mushroom-like structure, fungiform papillae.

DAVID POGUE: *Do I have that?*

LINDA BARTOSHUK: Yes.

DAVID POGUE: *Is there a cure for it?*

LINDA BARTOSHUK: You don't want a cure for it.

DAVID POGUE: *Okay.*

LINDA BARTOSHUK: Those things are really good.

DAVID POGUE: *The surface of your tongue is covered with mushroom-shaped structures called fungiform papillae, which house the taste buds.*

Bartoshuk uses a card with a hole about the size of a pea, and then counts the number of spots on my tongue. Her blue dye reveals the fungiform papillae.

LINDA BARTOSHUK: Oh, wow.

DAVID POGUE: *Some people taste things more strongly for the simple reason that they have more taste buds. Bartoshuk calls them "supertasters."*

LINDA BARTOSHUK: Wow. You are up between 50 and 60 fungiform papillae. This is very, very high.

DAVID POGUE: (With mouth open trying to say "Really?") *Weawwy?*

LINDA BARTOSHUK: From what I can see now, you definitely look like a supertaster. So that's a pretty well-endowed tongue.

DAVID POGUE: *Sweet! Literally. To see how it works, let's zoom into a taste bud, where there is a sweet receptor. If we drink some of that orange apple juice, the sugar molecules in it bind with a sweet receptor. That then sets off a series of chain reactions that sends a signal to the brain that you are eating something sweet.*

LINDA BARTOSHUK: When you eat a piece of candy, you're experiencing more sweet than I am. And you have, not only more taste buds, but you, in addition, have more pain fibers, because every taste bud is surrounded by a basket of pain fibers. So if you eat jalapeño peppers, you are going to be at least twice, perhaps three times as intense burning as I would get.

DAVID POGUE: *That explains so much. I can't tell you the number of dinners I have had where everyone is like, "Oh, you are so a hot pepper wuss, Pogue."*

LINDA BARTOSHUK: Yeah.

DAVID POGUE: *It's not that. It is just that I am suffering four times more!*

LINDA BARTOSHUK: Yes, yes. You are experiencing considerably more burn.

DAVID POGUE: *I think I got it all!*

Certain tastes are hardwired in your biology. These basic tastes are the ones that trigger receptors that you have on your tongue: sweet, sour, bitter and salty. Some also think that the savory flavor of meat or cheese is a fifth basic taste, called "umami."

LINDA BARTOSHUK: The brain is built to make sure you experience those tastes. It's wired that way. And the reason you are wired to like sweet is so that a newborn baby will nurse immediately, without having to learn, because mother's milk is sweet. At the same time, the reason you want to build in a dislike for bitter, is so that, if you put anything in a child's mouth that's toxic—and most toxins are bitter—the child will spit it out and make a fuss.

DAVID POGUE: *Bartoshuk says these basic tastes were key in our evolution.*

LINDA BARTOSHUK: The taste system evolved as the true nutritional sense. It solves problems that, if you don't solve them immediately, you die.

DAVID POGUE: *As basic as flavor is, there is an awful lot we don't fully understand about how it works. And at research centers and universities there are a lot of people working to figure it out.*

Gordon Shepherd, of Yale University, is mapping how our brain gets involved in processing flavor.

GORDON SHEPHERD (Yale University)**:** Flavor's not in the food that we eat. Flavor is not in the molecules. The perception of flavor is created by the pathways in the brain.

DAVID POGUE: *Thankfully, instead of dissecting my brain to prove his point, Shepherd kindly uses colored tape.*

GORDON SHEPHERD: This is representing the pathway of smell. Next comes taste.

DAVID POGUE: *Each different color represents the pathway inside the brain that information from our different senses travels, like the signal from the taste buds.*

GORDON SHEPHERD: Here we go with sight, hearing, touch.

DAVID POGUE: *These pathways run throughout the brain.*

It's mind-blowing. You are saying that the simple act of eating, the simple pleasure of eating something, involves circuits all over my brain, zipping everywhere at once.

GORDON SHEPHERD: The way that the brain creates flavor engages more of the brain than almost any other behavior that we take part in.

DAVID POGUE: *As we try to understand the power of the brain in creating flavors and creating our cravings for those flavors, the science of taste is moving into new frontiers.*

LINDA BARTOSHUK: The problem is our evolutionary mechanisms did a great job to make us survive, but evolution didn't know we were going to live so long, eventually.

DAVID POGUE: *Our system of taste evolved for a world where food was scarce and starvation was a real threat. In today's world, the bigger problem is coping with the abundance of food; one where our evolutionary craving for fats and sugars can be a liability. Even so, delicious foods are one of life's great pleasures, even foods we never thought would be delicious.*

Monica! I can't believe you have a line here.

MONICA MARTINEZ: I don't believe that.

DAVID POGUE: *Maybe I was giving the bugs short shrift. Maybe there's something to this.*

New research shows that the more choice we have, the more likely we are to overeat, like gorging at a buffet or here at the San Francisco foodie event, Off the Grid, because variety sparks our interest.

One bacon and egg popsicle!

It's like what Gordon Shepherd said as he was putting colored tape on my head: experiencing flavor probably engages more of our brain than almost any other activity we do.

Wow, so amazing.

Shepherd believes that would include exercise, work or even sex.

Basically I think what it boils down to is superior lubricity and retronasal olfaction.

Think of that next time you take a bite!

Think sugar receptors are only on your tongue?
They also exist…
in your intestine!
Research in mice reveals that receptors in the gut sense sugar…
And send messages to the brain, saying, "Eat more of that!"
So be careful about "listening to your gut."
It's possible that it likes sugar and is not afraid to say so.

DAVID POGUE: *Meet Nathan Myhrvold. He makes his living as a technology business mogul, but this is where he comes to indulge his real passion.*

NATHAN MYHRVOLD (Author, *Modernist Cuisine*)**:** I've been interested in food my whole life…very enthusiastic eater, and interested in all aspects of creating it.

DAVID POGUE: *And now he wants to revolutionize the way we cook, by bringing cutting-edge science into the kitchen.*

NATHAN MYHRVOLD: We aren't just trying to do our grandma's recipes. We're trying to focus on understanding the scientific basis for what is this thing we call cooking.

DAVID POGUE: *Nathan is making wild, new concoctions, like cotton candy that tastes like grilled cheese; or butter made, not from cream, but from peas; and short ribs that he cooks in warm water for three days.*

SCOTT HEIMENDINGER: Some people call him Willy Wonka. Some people call him mad scientist.

STEPHEN COLBERT (*The Colbert Report*/TV Clip)**:** Please welcome Nathan Myhrvold.

DAVID POGUE: *And his Wonka-esque flair has made Nathan a regular on the talk show circuit.*

NATHAN MYHRVOLD: We've been cooking this pastrami for 72 hours, just for you.

STEPHEN COLBERT: Am I going to die from eating this meat?

NATHAN MYHRVOLD: Let's find out.

STEPHEN COLBERT: Why don't we find out?

NATHAN MYHRVOLD: I got into this by trying to understand it myself.

DAVID POGUE: *So he's become a gourmet evangelist, writing his own cookbook, one that's really, really big: 43 pounds of science that's so heavy it comes with its own Plexiglas bookcase.*

JIMMY KIMMEL (*Jimmy Kimmel Live*/TV Clip)**:** Was the idea to publish something that you couldn't possibly shoplift?

NATHAN MYHRVOLD: That was it.

DAVID POGUE: *Its 2,400 pages lay bare just about every aspect of cooking, like what makes meat tough or tender? How does a microwave work? And what's the best way to cook broccoli?*

It's all the culmination of Nathan's lifelong love affair with food.

NATHAN MYHRVOLD: When I was about nine years old, I announced to my mother that I was going to cook Thanksgiving dinner. And I went to the library and got this whole pile of books. I'd love to say it all turned out great. It didn't. But, sort of, from that point on, whenever there was serious cooking at home, I was the one who did it.

DAVID POGUE: *But Nathan soon fell under the spell of another passion.*

NATHAN MYHRVOLD: I remember once I saw an episode of *Doctor Who*, the British science fiction series. The doctor is being asked by this guy, "What are you?"

VILIAN: (*Doctor Who*/TV Clip)**:** Are you some kind of scientist?

(*Doctor Who*/TV Clip)**:** I'm every kind of scientist.

NATHAN MYHRVOLD: I thought that was so cool. So, I wanted to be every kind of scientist.

DAVID POGUE: *So Nathan went on to earn degrees in economics, math and physics.*

NATHAN MYHRVOLD: Ultimately, my Ph.D. is in mathematical physics, focusing on quantum field theory and curved space-time, and I worked with Stephen Hawking.

DAVID POGUE: *And Nathan taught himself about even more topics by obsessively reading about them, every book he could find.*

CONOR MYHRVOLD: For a while, he was Amazon's number one individual customer.

CHARLIE ROSE (*Charlie Rose*/TV Clip)**:** Since the '80s he has been at Microsoft, where he's in the advanced technology group. What we're talking about is all the world's computers connecting to each other.

NATHAN MYHRVOLD: It's all the world's people connected to each other, with the computer simply as the means.

DAVID POGUE: *Nathan was a visionary in the hottest field of the day, computers, but he never forgot about his first love, food. He still wanted to understand the science of cooking.*

NATHAN MYHRVOLD: I thought, "Well, there must be some big textbook that says all this." Not only was there no single book, there was no stack of books.

DAVID POGUE: *Nathan decided he would find answers on his own. He would use science to push the boundaries of cooking in the form of a book.*

NATHAN MYHRVOLD: I'm writing the cookbook that I wish I could have just bought.

DAVID POGUE: *Nathan started by hiring a team of experts and turning a warehouse into a Wonka-esque playground.*

SCOTT HEIMENDINGER: It's one of the best-equipped kitchens in the world. We've got a rotary evaporator, freeze drier, combi oven. We've got an industrial jewelry bath that we use to make our ultimate French fries.

NATHAN MYHRVOLD: A whole variety of homogenizers.

SCOTT HEIMENDINGER (*Modernist Cuisine*, Business Manager)**:** Blowtorches, liquid nitrogen.

NATHAN MYHRVOLD: A centrifuge is fantastic.

Normally, you'd never get this special layer that we call "pea butter." Oh, my god, does it taste good.

DAVID POGUE: *Nathan wanted to figure out exactly what's happening, from a scientific perspective, when we put flame to food.*

NATHAN MYHRVOLD: Our goal was to show people a vision of food they hadn't seen before.

So, I had this idea of …let's cut all these things in half, and show a picture of the food in the pan, in the oven.

DAVID POGUE: *So they revved up their table saws and began hacking open every appliance they could find and every type of meat.*

PHOTOGRAPHER: We want both of the holes through the muscle.

DAVID POGUE: *This junkyard of cracked open grills, microwaves and gas ranges gave Nathan new tools to show how heat moves through food and irreversibly changes it.*

NATHAN MYHRVOLD: They're all things that happen so fast that when you look at it, it's like, oh, it just, it happened. If you slow it down, you see how and why it happens.

DAVID POGUE: *One recipe Nathan was determined to dissect: how to cook the perfect steak.*

NATHAN MYHRVOLD: Here we're looking at what happens when you sear meat, to see what that structure is inside that crust.

DAVID POGUE: *Nathan became obsessed with the Maillard reaction. That's the one I learned about in the test kitchen, in which high heat releases amino acids and creates delicious flavors.*

Meanwhile inside the steak, other forces are at work.

NATHAN MYHRVOLD: The physics of water is central to cooking, because food is mostly water. All steak that you cook is actually boiled on the inside.

DAVID POGUE: *The problem is that the boiling interior cooks more slowly than the edge of the steak near the flame. So chefs have to make a choice: do you undercook the inside or overcook the outside?*

Nathan searched for a way to have it all. And he heard about chefs who were experimenting with a technique that was first used in the most unlikely of places: hospital kitchens.

NATHAN MYHRVOLD: So they invented this technique in France, where it's called "sous vide," where you vacuum-seal food into a plastic bag, then you cook it inside that plastic bag.

DAVID POGUE: *And here's how it works.*

NATHAN MYHRVOLD: This is a chamber vacuum machine. When I close this, it's going to start pumping the air out.

DAVID POGUE: *Nathan then drops the sealed meat in a computer-controlled bath, which will heat the whole steak to the exact temperature of the water. So you can make the entire cut of meat 130 Fahrenheit for medium rare, no part over- or undercooked.*

SCOTT HEIMENDINGER: Sous vide cooking recognizes that when you have two goals—perfect doneness on the inside and a nice crust on the outside—that you should treat those two goals with two different cooking methods.

DAVID POGUE: *When the meat reaches the exact temperature Nathan wants, it's Maillard time! Nathan's weapon of choice? A blowtorch or a new technique: "cryo-frying."*

SCOTT HEIMENDINGER: Cryo-frying means that we make something very cold and then we fry it. We want to protect the interior of the food from overcooking as we fry, and you're left with beautifully brown, crispy exterior and perfect interior.

DAVID POGUE: *Nathan had cracked the code for the recipe for a perfect steak.*

And sous vide wasn't the only page that Nathan lifted from the industrial cookbook. He went back to the supermarket to peruse the aisles of ice cream and chocolate sauce. He wasn't looking for a guilty pleasure, he was joining other avant-garde chefs who were questioning the widespread fear of chemical ingredients.

NATHAN MYHRVOLD: Lots of folks think of this as, "Oh, my god, there's chemicals in my food!" Well, I'm here to tell you that food is made of chemicals; those chemicals are made of elements; and that's the way it is here on planet Earth. Everything actually is a chemical.

SCOTT HEIMENDINGER: Nathan uses chemicals the way a composer uses notes. It's about building something. Just because an ingredient has a lot of syllables or your grandmother didn't cook with it, that doesn't make it bad.

DAVID POGUE: *Nathan studied how these chemicals could give him even more control in the kitchen, like how you can use agar to create hot fruit gels, or how xanthan gum can thicken your sauce. And it all went into the book.*

This culinary bible grew into the encyclopedic Modernist Cuisine, which requires four pounds of ink to print.

Determined to spread his message as widely as possible, Nathan soon wrote a follow-up book.

NATHAN MYHRVOLD: We then decided; "Hey, let's make one for the home." We call it *Modernist Cuisine at Home*, and that book has got a whole new set of recipes that are all designed, that anybody can do them at home.

DAVID POGUE: *These science-based recipes don't require an industrial strength kitchen; rather they tell you how to make the perfect mac and cheese by using a*

pinch of sodium citrate or how to sous vide a steak using a cooler of lukewarm water and a really hot grill.

But the question remains, can all this science actually create food that tastes good?

JIMMY KIMMEL (*Jimmy Kimmel Live*/TV Clip)**:** It's cold!

DAVID POGUE: *Nathan shared his cryo-fried hamburger with Jimmy Kimmel, his 72-hour short rib pastrami with Stephen Colbert,…*

STEPHEN COLBERT (*The Colbert Report*/TV Clip)**:** Oh, my god!

DAVID POGUE: *…and salmon cooked in a Ziploc® bag with Martha Stewart.*

MARTHA STEWART (TV Clip)**:** Oh, my gosh!

WOLFGANG PUCK: This is a new beginning of science and technology and creativity all mixed together to really create great flavors.

NATHAN MYHRVOLD: We're trying to show people what's possible. If you understand how cooking works, and you understand these great techniques, you have a much wider range of possibilities.

DAVID POGUE: *So remember, the next time you take a bite of something, the taste isn't just in here, it's in here and most of all up here.*

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That's our show. See you next time!