SPEAKER 1: You're listening to *BrainsOn* where we're serious about being curious.

**SPEAKER 2:** *Brains On* a supported in part by a grant from the National Science Foundation.

**ELEVATOR:** Welcome to *Brains On* headquarters. What floor?

**MOLLY BLOOM:** We should probably go straight to the studio. But I'm feeling super low key, I need to get my energy up.

**NANTEEN BA:** Yeah, we're about to do a show on heat. We need to bring it.

**ELEVATOR:** Did I hear "bring the heat?"

**MOLLY BLOOM:** Oh no.

**NANTEEN BA:** What?

**ELEVATOR:** Coming right up.

**MOLLY BLOOM:** This is our new experimental go anywhere elevator, and let's just say it can take you a bit off course.

**ELEVATOR:** Here you go, Death Valley, California, one of the hottest deserts in the world.

**NANTEEN BA:** So dry. I feel the moisture being sucked out of my body.

**MOLLY BLOOM:** I can't think. Need air conditioning and a drink with a huge ice chunk in it.

**ELEVATOR:** Oh, you want a chunk of ice. Got it.

**NANTEEN BA:** Thank goodness. The heat was melting my brain.

**MOLLY BLOOM:** I have a feeling we're not done yet.

**ELEVATOR:** Here you go. Huge chunk of ice.

**NANTEEN BA:** Wait, you put us on a sinking ship. Oh no.

**MOLLY BLOOM:** Hold the phone. That's an iceberg. Those are old timey people. Is this the Titanic? How did we even get here? This was like 100 years ago.

**JACK:** Rose, I'll never leave you.

**ROSE:** Oh Jack, my heart will go on.

**MAN:** Hey, Jack, I found a boat.

**JACK:** Actually, will you excuse me one second. I just need to--

**ROSE:** What? Get back here, Jack. You scoundrel.

**NANTEEN BA:** We should probably get going.

**MOLLY BLOOM:** Yeah. This doesn't end well. Elevator, how about we just go to the studio?

**ELEVATOR:** Oh, very well, if you insist. Boring old studio coming up. No one here likes to go anywhere fun. Here you go.

**MOLLY BLOOM:** But you know what, that did get my adrenaline pumping.

**NANTEEN BA:** Yeah. I think I'm ready to start the show. Let's do this. Clicking series, here we come.

[MUSIC PLAYING]

**HOSTS:** (SINGING) Chill, chop, mix, heat, reverse the order, then repeat. Heat, mix, chop, chill the recipe for every meal. Chill, chop, mix, heat, reverse the order, then repeat. Heat, mix, chop, chill the recipe for every meal.

**MOLLY BLOOM:** You're listening to *Brains On* from American Public Media. I'm Molly Bloom, and my co-host for this series on The Science of Cooking is Nanteen Ba from New York City. Welcome.

**NANTEEN BA:** Hi.

**MOLLY BLOOM:** So Nanteen, what is your favorite dish to cook?

**NANTEEN BA:** I would say probably breakfast, like a classic, like eggs, bacon, waffles, stuff like that.

**MOLLY BLOOM:** It sounds really good. And when did you first start cooking.

**NANTEEN BA:** I first started cooking when I was seven, and my oldest sister would always make breakfast for me, and eventually, my dad was like, you need to learn how to make breakfast for yourself. And the first time I made it, I burned the eggs and it got stuck to the pan, and we had to soak it in hot water and just scrub and scrub until it would come off.

**MOLLY BLOOM:** Oh no. [CHUCKLES] Did that ever happen again, or was that kind of a one time mistake?

**NANTEEN BA:** It kind of happens now a little bit.

**MOLLY BLOOM:** [LAUGHS] Now and then. So does cooking seem to you scientific or is it more of an art?

**NANTEEN BA:** I see cooking as more of an art because I understand the science that goes into it, like the heat, energy, but like food, it's like fun to make because you can experiment with it a little bit and like you can piece it in a way that you like, so I see it as an art.

**MOLLY BLOOM:** Nanteen clearly knows her food, but she is not the only smart foodie we have helping us with this series. We teamed up with America's Test Kitchen.

**NANTEEN BA:** Or ATK for short.

**MOLLY BLOOM:** They invited us to their offices in Boston where they meticulously test recipes and techniques to find the best ones. Think of it as part kitchen, part laboratory, and all delicious.

**NANTEEN BA:** They're the perfect partners to help answer your many, many cooking questions.

**MOLLY BLOOM:** And you've written us with so many cooking queries, we couldn't fit them all into one episode. We needed five.

**NANTEEN BA:** We're going to be looking at all different aspects of cooking, chill, chop, mix, and a special episode that brings it all together where you can cook along with us.

**MOLLY BLOOM:** But today, we're on fire because we're talking heat.

**NANTEEN BA:** Is it hot in here, or is it just me?

**MOLLY BLOOM:** Whether it's stove top or oven, grilling or steaming, open flame or microwave, heat is a very important part of cooking.

**NANTEEN BA:** And we're kicking our series off with this question.

**KAI:** My name is Kai, and I'm from Los Angeles, California. And my question is, why does meat darken when it is grilled or cooked?

**MOLLY BLOOM:** We visited Dan Souza at America's Test Kitchen to find the answer.

**DAN SOUZA:** So there's a couple of different things when food's turning brown in your kitchen. The first is a little bit simpler, and it's caramelization. So that's just a reaction with sugar and heat. So it's really simple to do. You take sugar, put it in a pan, put it over the heat, and it starts to turn brown. That's a very simple technique.

The science behind it is actually a lot more complicated. But what you're basically doing is breaking down these big sugar molecules into smaller ones. They react with one another and you develop tons of really delicious flavors. So nuttiness, and butteriness, and it's a really great flavor, we love it on popcorn. So that's caramelization.

**MOLLY BLOOM:** So sugars can give food a nice brown coat. But Dan says that's not the only thing that does that.

**DAN SOUZA:** If you add protein into the equation, you get something totally different. And that is the Maillard reactions. So it actually comes from a French chemist named Louis Camille Maillard. He discovered this reaction in 1912. And it's a really fun word to say, and you spell it M-A-I-L-L-A-R-D.

So the Maillard reaction is what we see when we cook something like a steak. So you're searing it on the stovetop or roasting a piece of meat in the oven and you get browning and you get tons of great flavor. But the difference is you have protein involved. So the building block of proteins are amino acids. And when proteins break down to those amino acids, they can react with sugars to undergo the Maillard reaction.

**NANTEEN BA:** These molecules, the building blocks these proteins and sugars are made of, start rearranging themselves and making new compounds.

**MOLLY BLOOM:** And these new compounds make new smells and new tastes. And remember, protein isn't just in meat, it's in grains and dairy products and lots of other foods.

**NANTEEN BA:** So it's the Maillard reaction that helps brown a steak and give a nice brown crust to your bread.

**MOLLY BLOOM:** A recipe that is a great example of the Maillard reaction is an American classic, the grilled cheese sandwich. We invited brother and sister Seila and John Kim to come to America's Test Kitchen with us to learn how to make the perfect grilled cheese from Dan.

[MUSIC PLAYING]

**DAN SOUZA:** OK, so I've got a tablespoon of melted butter. I've got two slices of white sandwich bread. So you can really use a lot of different types of bread for this recipe. You want to make sure that it's not too thick, because it's going to take too long to melt the cheese inside.

OK, so I'm going to take this pastry brush, and I'm going to go into the butter here first. And you can see how it picks up a bunch of that butter. Then I come over to my bread and I'm just going to make a nice even layer spread it over.

So it's nice to use melted butter because it's very easy to spread. If we use butter right out of the fridge, you know how hard it is, right? And that tears the bread. It's very hard to distribute. Wherever that butter is, it's going to brown really well.

**MOLLY BLOOM:** What is the purpose of the butter?

**DAN SOUZA:** Butter is really interesting because it's not just a pure fat, it also has protein and sugar in it. And that comes from the milk that it's made from. And so butter actually has kind of a built in system to be really, really good with the Maillard reaction.

So all right, so now it's time for our cheese. And so you can see that I've shredded this cheese. This is a 1/2 a cup of Monterey Jack. You could also use a mild cheddar here. We want a cheese that melts really well. And so I flipped over one of the slices of bread so the butter is facing down. And now I'm mounding this 1/2 a cup of shredded Monterey Jack right in the middle.

**JOHN KIM:** That's a lot.

**DAN SOUZA:** It does look like a lot, but it's shredded, so it kind of clumps up and there's a lot of air in here right now. So we're going to press it down a little bit. And then I'm going to take my other slice of bread, and this one, I'm going to put on with the butter facing up.

Yeah, so Monterey Jack or a mild cheddar are great for melting. And that gets a little bit into cheese science and why those are really good at melting and other ones aren't. So all cheese starts off as milk. And then the cheese making--

**SEILA KIM:** Really?

**DAN SOUZA:** It all starts as milk, yeah. Isn't that interesting? All cheese starts out as milk. And the cheesemaker adds an enzyme to the mix. And what that does is it causes one of the proteins called casein to form clumps. So it forms these curds. And then cheesemaker takes those curds out and they usually age them, sometimes for months, sometimes for even years.

**JOHN KIM:** That's weird.

**DAN SOUZA:** It is. But that's what develops a ton of flavor. So if you have a cheddar that's really sharp and really intense, it's aged for probably six months, eight months, maybe even a couple of years. Some cheeses, they don't age very long at all. So they're much milder. But a really key thing is that they actually melt a lot better.

So this is where it's good to think about people. So cheese is a lot like people. So you think about you guys are really young, right? And you're really flexible. Whereas when you get a little bit older, like me, I'm much less flexible than you guys are, and probably 20 years from now, I'll be even less flexible.

**SEILA KIM:** Unless people train for it.

**DAN SOUZA:** Yes, unless you train for it, exactly. So when it comes to cheese, when they start out really young, they're very flexible so they melt really easily. But as they get older, the protein--

**JOHN KIM:** Get more stale?

**DAN SOUZA:** Yeah, kind of stale in a way. It gets--

**JOHN KIM:** It's harder for it to melt?

**DAN SOUZA:** Exactly. It's harder for it to melt. So you end up getting the fat melting out. You ever seen cheese that breaks into like fat and then curds?

**JOHN KIM:** It's really crumbley.

**DAN SOUZA:** Exactly. And so we don't want to use those cheeses. We want to use the young, mild cheeses, like cheddar and Monterey Jack.

[MUSIC PLAYING]

You guys ready to cook this thing? All right. So we're going to transfer it over a 10 inch nonstick skillet over here. And I'm putting it in while the skillet is just at room temperature. So it's not hot yet. The sandwich goes in and then I'm going to turn the heat on to medium low.

It's going to take three to five minutes for the exterior to get brown on the bottom and through the cheese to start to melt. And then we're going to flip it. Let's go ahead and take a peek.

**JOHN KIM:** Why is it making that fizzy sound?

**DAN SOUZA:** So that sizzling sound is usually there's fat involved, so you have oil in the skillet or something like that, and then you have water, some kind of water. And that's actually the sound of the water vaporizing. Yeah, so if you put a stake in a skillet, you hear all that sizzle. That's because there's water droplets on the surface and they're like-- they're heating up where they're like, I want to get out of here. So they just want to escape. And that escape has a sound to it, and that's that sizzle.

Now I'm going to pop it down on the other side. You're going to hear a little sizzle.

**JOHN KIM:** I'm hungry. This is making me so hungry.

[MOLLY LAUGHS]

**DAN SOUZA:** All right, so I'm going to turn the heat off. It's important when we're done cooking to make sure we turn that heat off. And then I'm going to transfer the sandwich.

**MOLLY BLOOM:** Oh my.

**DAN SOUZA:** See that bottom looks good too?

**JOHN KIM:** Looks so good.

**DAN SOUZA:** Right onto the cutting board.

**JOHN KIM:** I want to eat that so bad.

**DAN SOUZA:** Should we eat this thing?

**JOHN KIM:** Sure. This is so good.

**DAN SOUZA:** It's really good, isn't it? So it's crispy on the outside. You get that the bread is really soft inside, which is nice. And then tons of gooey cheese.

**JOHN KIM:** Cheese is like the best part.

**DAN SOUZA:** Cheese is the best part, yeah.

**NANTEEN BA:** You can find a full recipe for this delicious sandwich at our website, brainson.org.

**MOLLY BLOOM:** If you want more recipes like this one, the America's Test Kitchen Kids newsletter brings recipes and hands on activities for kids straight to your inbox. Go to americastestkitchen.com/kids to sign up and learn more about their upcoming cookbook for young chefs.

**NANTEEN BA:** This fall, ATK is launching America's Test Kitchen kit. It will feature books and hands on activities designed to excite the next generation of curious cooks and engaged eaters.

**MOLLY BLOOM:** You're probably hungry right about now for a mystery sound.

**GIRL:** Mystery sound.

**MOLLY BLOOM:** Here it is.

[MYSTERY SOUND]

OK, do you have any guesses about what that might be?

**NANTEEN BA:** Was it opening a can?

**MOLLY BLOOM:** That is a very, very good guess. You're going to get to hear it again and guess again in just a bit, and we'll also be back with the answer.

[MUSIC PLAYING]

**NANTEEN BA:** Do you have a mystery sound you want to share with us?

**MOLLY BLOOM:** Go to brainson.org/contact to send them in.

**NANTEEN BA:** You can also share your drawings and questions there too.

**MOLLY BLOOM:** Brainson.org/contact. That's what Lilly did when she sent us this question.

**LILLY:** My question is, how does coffee keep you awake.

**NANTEEN BA:** We'll be back with the answer to that question during our a Moment of Um at the end of the show.

**MOLLY BLOOM:** Plus the most recent group of listeners to be added to the Brains Honor Roll.

**NANTEEN BA:** Those are the listeners who have written in with their fabulous ideas and questions.

**MOLLY BLOOM:** If you want to be listed on the Brains Honor Roll, it's easy. You can go to brainson.org/contact and submit questions, mystery sounds, ideas, or drawings.

**NANTEEN BA:** We can't wait to hear from you.

[MUSIC PLAYING]

You're listen to *Brains On* from American Public Media. I'm Nanteen Ba.

**MOLLY BLOOM:** And I'm Molly Bloom.

**NANTEEN BA:** Hope you all have a cool glass of water to drink because today's episode is on fire.

**MOLLY BLOOM:** Fire is used a lot in cooking, but there's one method of heating up food that seemed mysterious to many of you.

**ZIRIN:** I'm Zirin. I live in Laramie, Wyoming, and I'm 12 years old. My question is, how do microwaves work. How can something that's not hot heat up things.

**NANTEEN BA:** Microwaves are called that, because they actually produce energy in the form of what are called microwaves. These waves are part of the electromagnetic spectrum.

**MOLLY BLOOM:** Visible light, the light we can see, is also part of the spectrum. It runs from low energy radio waves on one end to the higher energy gamma rays on the other end.

**NANTEEN BA:** Here's a little song we wrote to help you remember all the waves in the electromagnetic spectrum.

[MUSIC PLAYING]

**HOSTS:** (SINGING) Radio, microwave, infrared, visible, ultraviolet, , X-ray gamma, yeah, here we go. Space between waves gets shorter and shorter. Electromagnetic spectrum, that's the order. Radio, microwave, infrared, visible, ultraviolet, X-ray, gamma. Radio, microwave, infrared, visible, ultraviolet, X-ray, gamma.

**MOLLY BLOOM:** Catchy, right? Anyway, microwaves, not the ovens, but the radiation, were originally used by military radars in World War II.

**TUCKER SHAW:** But the other thing that a microwave can do is heat up molecules in food or actually speed them up, at which time, they create their own heat and they cook food.

**NANTEEN BA:** That's Tucker Shaw, an editor at America's Test Kitchen.

**TUCKER SHAW:** But the discovery of that was quite by accident.

[TUNE PLAYING]

Well, there was a guy named Percy Spencer.

**PERCY SPENCER:** Me? [CHUCKLES] I'm nothing special. Just your average kid who grew up poor in rural Maine, dropped out of grade school, taught himself electrical wiring, joined the Navy, taught himself radio technology, and physics, and trigonometry, and metallurgy, and some chemistry, calculus, and eventually became a world expert in radar tubes. Typical story. Guys like me, dime a dozen.

**TUCKER SHAW:** He was working on this product called the magnetron, which is something that produces these microwaves. And while he was working on this project, he also used to take a lunch break every day, as we all do, or we all wish we did, and he would carry a peanut cluster bar in his pocket.

**PERCY SPENCER:** I liked breaking up that candy coated bar and feeding pieces to squirrels. [CHUCKLES] Those little buggers are so cute. I want to pinch their fat cheeks.

**TUCKER SHAW:** But one day he noticed that when he was standing near the magnetron and it was producing the microwaves, that his peanut cluster bar in his pocket had sort of melted.

**PERCY SPENCER:** Ah yes, the gooey pocket day. Excellent for science, terrible for my pants.

**TUCKER SHAW:** And he realized, eventually, that the microwaves were somehow getting into that peanut cluster bar, speeding up the molecules, and causing them to melt.

**PERCY SPENCER:** Not what I had planned, but shucks. When something that interesting happens, you go with it.

**TUCKER SHAW:** He figured he was on to something, so he took an egg, and he pointed the magnetron at the egg, and Lo and behold, the egg exploded.

**PERCY SPENCER:** Science is cool. We get to blow stuff up.

**TUCKER SHAW:** So there's another mess. He's on to two messes. Some of these great inventions I think involve a lot of messes. The third thing he pointed it out was popcorn kernels. Popcorn was really popular at the time. This was in the middle of the 20th century. And they popped, just like popcorn. So you may have microwave popcorn in your house right now, it really operates in the same way.

**PERCY SPENCER:** That's when I knew we were on to something big. I mean, popcorn in a minute? [CHUCKLES] Wait till my squirrel friends hear about this.

**MOLLY BLOOM:** Eventually, designers found a convenient way to keep those rays contained in a metal box so your pocket snacks wouldn't melt. And thus, the modern microwave was born.

**NANTEEN BA:** But what's actually going on inside this magical maker of meals in minutes?

**MOLLY BLOOM:** Well, your microwave uses electricity to power a small magnetron.

**NANTEEN BA:** That magnetron sends out high powered microwaves inside the box. And that humming sound you hear, that's the fan that keeps the magnetron cool.

[MICROWAVE TIMER BEEPING]

**MOLLY BLOOM:** When the waves produced by the magnetron hit the metal walls of the microwave oven, they bounce back, like light reflecting off a mirror.

**NANTEEN BA:** But the waves pass through the food.

**MOLLY BLOOM:** And the food in your microwave is made up of all sorts of different molecules. Those are the building blocks that make up everything. You, me, air, food, just about everything is made of molecules.

**NANTEEN BA:** And when the waves pass through the water molecules in that food, since most food has at least some water in it, those little guys go crazy.

[MUSIC PLAYING]

**MOLLY BLOOM:** They start wiggling and jiggling like a molecular dance party.

**NANTEEN BA:** This creates friction, and friction creates heat. Kind of how when you rub your hands together--

[HANDS RUBBING TOGETHER]

--they get warm. Microwaves do that on a molecular level.

**MOLLY BLOOM:** And since the microwaves go through the food, it heats pretty evenly, as opposed to a normal oven where the food gets heated from the outside in. The other molecules in food, like fat or starch, those also absorb the microwaves to a smaller degree, but it's really the water molecules that do the work of heating your food.

**NANTEEN BA:** How cool is that. So next time you microwave a burrito, imagine all the water molecules inside starting an epic molecule dance party.

[MUSIC PLAYING]

But wait a second, you said the walls of the microwave are metal?

**MOLLY BLOOM:** Yeah, one of our listeners noticed that too.

**CALUM:** Hi. I'm Calum from El Cerrito, California. My question is, why do microwaves not allow metal even though they're made out of metal.

**MOLLY BLOOM:** Excellent question. Sacha Marx from America's Test Kitchen has an answer for us.

**SASHA MARX:** The main issue isn't necessarily that metals and microwaves don't mix at all, because after all, the walls of your microwave are made of metal, it's what the surface of the metal that you would put in a microwave is shaped like.

**MOLLY BLOOM:** You see, microwaves don't penetrate metal. So when they hit the metal walls, they just bounce back.

**NANTEEN BA:** But it's different with thin, crinkly, or irregular shaped metal.

**MOLLY BLOOM:** Think of an aluminum foil ball.

**NANTEEN BA:** When the microwaves are reflected in these little nooks and crannies, their electric fields can build up a lot and create a little bit of electrical current in the metal or in the air between sharp metallic edges.

**MOLLY BLOOM:** As we learned in our electricity series, electrical current is all about the movement of tiny particles called electrons. And with crumpled foil or the prongs of a fork, those electric fields and currents can be very close to each other.

**SASHA MARX:** And so if you have an object in there like a crumpled up piece of foil or a fork or something like that, the electrons will build up and an arc can jump between these little metal pieces and create a spark.

And what's interesting is that that can actually happen with things that aren't metal at all. We've made stuff in the Test Kitchen, especially recently made a recipe for kale chips, but we found that if we used curly kale, which has all of those pointy edges kind of like a crumpled up piece of foil, those could actually create those arcs of electrons and spark themselves and create a fire. So we had to nix curly kale chips in the microwave for that reason.

[MICROWAVE TIMER BEEPING]

**MOLLY BLOOM:** Are your ears ready for a spark of excitement? Because it's time to go back to the mystery sound again. Here it is one more time.

[MYSTERY SOUND]

OK, so last time you thought it was opening a can. Do you have any new guesses, or are you sticking with that?

**NANTEEN BA:** Someone eating from inside a can, then they took the utensil, that happened to be made of metal, and put it down.

**MOLLY BLOOM:** You are really very close. Here is the answer.

**MOLLY BIRNBAUM:** So I'm Molly Birnbaum, and I'm the Editor in Chief of America's Test Kitchen Kids. And that was the sound of a live scallop being shucked.

**MOLLY BLOOM:** So do you know what shucking is?

**NANTEEN BA:** It's when they take it out of its shell?

**MOLLY BLOOM:** Exactly. So that was a scallop being taken out of its shell. So it sounds a lot like a tin can because those two shells that the scallop is inside are rubbing together, and that metal utensil you heard, that was Sacha Marx using a knife to open that scallop up. So you were very, very close, I would say. Excellent ears.

So the shells that a scallop come in are sort of those classic shells you might think of, the ones that you might see mermaids wearing as a bikini top in cartoons, those are the shells. And they're big, like as big as an adult hand. So when you see a scallop that you're going to eat, it's a white little disk about the size of a silver dollar or a checker piece. Here's Molly Birnbaum again.

**MOLLY BIRNBAUM:** This is the part we eat. It's called the adductor muscle. And it's only one tiny part of the whole scallop. But so when scallops are in these big shells, the adductor muscle is what they use to open and close that shell. And they can swim in the ocean. They use that muscle to open and close their shell and move water through so they can be propelled forward. There are a bunch of other parts, including a mantle and gills.

Scallops have eyes all around the edge of their shell, kind of around the edge of the mantle. And they don't just have one or two eyes, they have a hundred or more eyes. And each eye has its own lens, retina and optic nerve. So these are simple eyes, but they can see light, they can see shadow, and they can see movement.

**CHILDREN:** Play time!

**NANTEEN BA:** We've learned a lot today about what happens to food when you heat it. But why. Why do we even bother. Why not just eat everything raw.

**MOLLY BLOOM:** That's a great question, and it turns out, a really important one.

**SUZANA HERCULANO-HOUZEL:** So it turns out that the cells in our brains, or neurons, cost a lot of energy, probably much more than other types of cells in the body. And that means that the only way you get to keep those cells, to keep a large number of those cells, is if you have plenty of energy from the food that you eat.

[MUSIC PLAYING]

**MOLLY BLOOM:** That's Suzana Herculano-Houzel, a neuroscientist at Vanderbilt University. And she says cooking helped our brains become bigger and helped us evolve into humans. Before cooking, it took us a long time to get the nutrients we needed to live.

**SUZANA HERCULANO-HOUZEL:** The limitation is that we are animals, so we have to eat every single bit of energy that powers our body. And if you cook your food before you put it in your mouth, the heat makes it softer, the heat starts breaking the food down for you before it even touches your teeth. That saves an enormous amount of time and that helps you get so much more energy from the same food that you eat.

[MUSIC PLAYING]

Why do we care? Why worry about having enough neurons in our brain? Because you can think of neurons as the LEGO pieces, let's say, that put brains together, except that these are really cool LEGO pieces because they do stuff. They're the ones that with every extra neuron that you get to keep in your brain, you have extra power to process information, to do stuff, to understand what's going around you, to plan ahead and think of what you want to do next. But you only get to do that if you have enough energy from what you eat.

**MOLLY BLOOM:** So thanks to cooking, we have enough energy to support all the neurons in our brains and more time to do things that don't involve chewing.

[TUNE PLAYING]

**NANTEEN BA:** Applying heat to our food made us human, allowing our brains to grow and spend time on things other than chewing and finding food.

**MOLLY BLOOM:** Heating some foods causes the Maillard reaction, which breaks down proteins and sugars into new compounds that produce different flavors, smells, and colors.

**NANTEEN BA:** Microwaves heat up food using radiation, exciting the water molecules in the food and creating heat.

**MOLLY BLOOM:** And you never know when feeding the squirrels will lead to a breakthrough.

**NANTEEN BA:** Like the microwave oven.

**MOLLY BLOOM:** That's it for this episode of *Brains On.*

**NANTEEN BA:** *Brains On* is produced by Marc Sanchez, Sanden Totten, and Molly Blum.

**MOLLY BLOOM:** We could not have made this Science of Cooking series without the help of our friends at America's Test Kitchen, Molly Birnbaum, Kaitlin Keleher, Sasha Marx, and Dan Souza.

**NANTEEN BA:** Again, you can check out the cool stuff they have in the Works For Kids by heading to americastestkitchen.com/kids.

**MOLLY BLOOM:** And we had help this week from Cindy Kim, Christina Lopez, Brandon Santos, Joan Coyle, Tony Hillary from Harlem Grown, Julie Williams, Katiatu Ba, Swami and Natha [INAUDIBLE], Julia Majors, John Maylin, Eric Wrangham, Vicky Kreckler, Alex Simpson, and Jen [? Leudki. ?]

**NANTEEN BA:** And engineering help from Erik Stromstad, Veronica Rodriguez, and Sarah Bruguiere.

**MOLLY BLOOM:** And if you want that recipe for Dan's delicious grilled cheese sandwich, head to our website, brainson.org.

**NANTEEN BA:** Now before we go, it's time for our Moment of Um.

- Um.

**LILLY:** Hi. My name is Lilly Willette. And I'm from Phoenix, Arizona. My question is, how does coffee keep you awake.

**MARIA CRUZ:** So my name is Maria Cruz. And I work as the dietitian, or nutritionist, at Williams College in Massachusetts. Coffee has a chemical called caffeine, and caffeine is the chemical that actually keeps us awake. And it works through our bodies through the brain and the adrenal glands. And the way that it works on the brain is by increasing a chemical called serotonin, which increases our mood, so it's a kind of a mood stimulator, as well as covering up these little cup-like receptor sites for adenosine.

And adenosine is a chemical that's produced after we exercise or think or use energy in any way. Now adenosine goes to the central nervous system, or brain, and covers up its receptor sites. And by doing that, this interaction causes sleepiness or grogginess in us and it helps us sleep. Now caffeine looks just like adenosine, so it's like its twin sister or brother. And so it blocks those receptors and keeps us awake.

Another way that caffeine affects us is by increasing adrenaline from our adrenal glands. And so adrenaline makes us really hyper. It's a chemical that we secrete when there's stress around or we need to run from something, so when we're afraid of something. So that can actually be kind of a negative thing because we feel anxious or stressed when the adrenaline is secreted.

**MOLLY BLOOM:** I'm wide awake and ready to speed through this list of names. It's time for the Brains Honor Roll. These are the kids who make this show what it is by sharing all their remarkable questions, ideas, mystery sounds and drawings with us. If you want to get on the Brains Honor Roll, head to brainson.org/contact. Here they are.

[LISTING HONOR ROLL]

[MUSIC PLAYING]

**HOST (ROBOTIC VOICE):** (SINGING) Brains Honor Roll. Bye-bye.

**NANTEEN BA:** Want more *Brains On* fun? Join the *Brains On* fan club by heading to brainson.org. It's free to join and you'll get resources to go along with our episodes as well as our monthly surprise.

**MOLLY BLOOM:** I love surprises. And you can keep up with us on Instagram and Twitter. We're Brains_On. And we're on Facebook too.

**NANTEEN BA:** And if you like the show, consider reviewing us an Apple podcast. It helps other people find out about the show.

**MOLLY BLOOM:** We'll be back soon with more answers to your questions.

**NANTEEN BA:** Thanks for listening.

[MUSIC PLAYING]