Cook, Taste, Learn: How the Evolution of Science Transformed the Art of Cooking

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[00:00:00] **Michael David:** Hello everyone and welcome to ACS webinars connecting you with the best and brightest minds in chemistry, live every Thursday from Washington D C. Today's webinar is proudly co-produced with the ACS division of agricultural and food chemistry. I'm Michael David, and it is my pleasure to be back for our first webinar of 2020.

[00:00:24] Now today we will be having our cake and understanding the chemistry too. As certified food scientist, author, an ACS member, guy Crosby joins us to share how the evolution of science has transformed the art of cooking. Guy teaches food science as an adjunct associate professor in the department of nutrition at the Harvard T H Chan school of public health, and is also the science editor at milk street kitchen and the author of the recently published cook taste learn.

[00:00:51] Our moderator today will be Brian Guthrie. Who is a Cargill corporate research fellow with a subject matter expertise in food chemistry and a specialization in flavor [00:01:00] chemistry. Brian is very involved with the ACS division of agricultural and food chemistry where he's previously served as chair. And with that, Brian, I'd like to turn it over to you to get today's presentation started.

[00:01:11] **Brian Guthrie:** [00:01:11] Thanks a lot, Michael. Welcome everyone. This is going to be a very interesting presentation. What would be more interesting than the human evolution? Cooking and also science. This is a fantastic area. Guy needs no introduction. He's got 45 scientific papers and 17 patents.

[00:01:29] Early on in his career, he started life getting degrees, BS and PhDs in organic chemistry, university of New Hampshire and Brown university postdoc and Stanford university where I believe that he formulated his interest even deeper in a food and wine and cooking. As you started up a new venture on food ingredients there.

[00:01:48] After that, he went to the FMC corporation where he was a director of R and, D, so he couldn't ask for a person with a better background. You spent a number of years there and then moved on to be vice president of the food [00:02:00] ingredients. And even though he says he retired, his retirement and looked a lot like work to me where he became visiting professor, the Harvard HT Chan School of public health at the same time or roughly the same time, also being an associate professor and lecturer at food science at Farmingham State University. He still maintains his adjunct professor role at Harvard. Guy along the way has had quite interested in, in cooking and science, the interaction with cooking and how that's evolved. He's, he's been an editor and subject matter expert on America's test kitchen. He also helped out with the Cook's illustrated magazine. He recently had symposium at ACS annual meeting at the San Francisco on trends in cooking science. It should be a very interesting lecture. I'm here to help out with questions and without alternative back to guy.

[00:02:48] **Guy Crosby:** [00:02:48] Thank you very much, Brian, for that really comprehensive introduction.

[00:02:52] Just so happy to be here and talk about my book. I have a little bit of a scratchy voice. It's because I had a little [00:03:00] procedure the other day, so hopefully it won't disturb you too much listening to my voice this way. I should say. What really inspired me to kind of write this book after I searched around for a while to figure out what I should be writing and what I'd be interested to write about?

[00:03:14] It was really my fascination with the fact that of all the species living on earth, and there are thousands of them, only humans cook their food, which to me is, is really unusual. And I think I got interested in that topic when I read a book about by Professor Richard Wrangham. Professor of biological anthropology at Harvard University and the name of his book, and you might be interested in reading it.

[00:03:39] It's really fascinating. It's called catching fire. How cooking made us human based on his research around the world came to the conclusion that earliest humans, the homo erectus humans, that evolved about 2 million years ago with the first of our very earliest ancestors to cook food. And he [00:04:00] made his conclusion based on the fact that he saw that during this time and the evolution for the homo erectus species, again, starting about 2 million years ago, there are teeth became smaller, their gastrointestinal tract became smaller and their brains became larger, and he concluded that that really was an indication that that they were beginning to cook food as long ago as 2 million years ago.

[00:04:23] A number of anthropologists don't actually agree with its conclusion. They lean more on the facts and the evidence that fire started about 400,000 years ago in caves. There is still some debate and question about when cooking actually started, but you know, whether its 2 million years ago or 400,000 years ago, it's still cooking.

[00:04:48] Many people believe has had a profound influence on the evolution of humans. And so here's the picture of the cover, which was rather colorful cover. And [00:05:00] you can see on the left hand side is a brightly dressed Cardinal, and he represents the art of cooking. So he's just whipped up a new sauce in the title of this painting is called the marvelous sauce.

[00:05:13] And next to him on the right side is a young chef that looks rather skeptical. And he represents the science of cooking, so he's not so pleased with the sauce. He's going to figure out a better way, kind of a scientific method to be able to improve the sauce. And most of the illustrations you're going to see the slides are in the book, so they'll give you a sense of the art and the illustrations that are in the book.

[00:05:39] The reason why cooking had such an influence on the evolution of humans is because it improves the digestibility of food, especially starch and especially protein from meat. It improves, and this has been demonstrated quite a bit, that cooking does make the food easier to digest, so that provides more [00:06:00] nutrients and more energy for the brain.

[00:06:02] Plus it, as you can see from this early, early cave painting, it was. A mechanism for humans to gather together. And here this early humans are gathering around the embers of a fire. So that had another factor in evolution of humans. And it's interesting to note that from the time that homo erectus first developed 2 million years ago until homosapiens, our group of humans, the brain increased by 60% in volume. So it clearly looks as though there was a major effect of the evolution of humans and cooking most likely played a very important role, especially in the development of the brain.

[00:06:44] The other, perhaps most the greatest advances of humans occurred with the evolution of agriculture. About 10,000 years ago. And by evolution of agriculture, I mean that humans began to deliberately domesticate or grow plants for food [00:07:00] and then even raise animals for food. And this occurred about 10,000 years ago, and the scientists that laid the groundwork for most of this discovery was Nikolai Vavilov in the 1930s it appears as though most of the agriculture occurred in seven different independent regions of the world.

[00:07:19] The first being what's known as the fertile Crescent, and that includes Syria, Jordan, Lebanon, Israel, Iraq, and part of Iran. And that was about 10,000 years ago in that region, about a thousand years after that, the next area was in Southern China where they started to domesticate foods, , unique to that area.

[00:07:42] In the fertile Crescent, it was mostly raising wheat and barley, followed by animals, goats, and sheep versus in Southern China, they raised food indigenous to that region, rice and pigs. Finally, and then there were the others. The unfortunate thing is [00:08:00] that Nikolai Vavilov was jailed by Stalin in 1940 because of his rather unusual views on the evolution of agriculture and the evolution of humans. So that was unfortunate for him. And I have a number of stories in the book where some of these key scientists and chefs encountered some unfortunate ends to their life.

[00:08:22] The other thing that's important about the evolution of agriculture, and this was done by study of a biologist at the University of Illinois named Jack Harlan, who did a study in part of Turkey where a lot of wild wheat still grows.

[00:08:37] And he proved in 1967 was a very interesting study that even using crude, harvesting tools of that day, that enough food could be harvested in three weeks using, again, wild wheat as his example, but it could harvest in three weeks to last a family for a whole year. So, I mean, this made a tremendous impact the evolution of agriculture [00:09:00] on both the amount and types of food that could be created in relatively short time where they could save the seeds and plant it the next year and raise these crops , and these animals, it obviously impacted the evolution of the life significantly.

[00:09:16] So here we'll see on this slide a number of anthropologists. Believe that the evolution of agriculture is the single greatest technological advance of all time. The reason being is that because they could produce so much food, they could no longer become nomads and wander around looking for food. They had to find ways, secure ways of storing their food, and so they started to develop permanent settlements where they could store the food.

[00:09:44] Keep it safe for a year and wild wheat, once it's been harvest, has been shown to last at least two years. They could develop these permanent settlements, and when they did this, it created greater safety for the early humans living in these settlements. [00:10:00] It also gave the opportunity for more innovation, but especially for childbirth.

[00:10:06] And so it's not surprising to see that in the five to 7,000 years following the evolution of agriculture. That the population in the world back then grew from what was estimated to be 3 million people living about 5,000 years after the evolution of agriculture. It grew to 100 million people within five to 7,000 years after that.

[00:10:31] So it had a tremendous impact on the growth and development of early humans. And just an example of what we see here on the left side of the screen on the and on the left side, you see an ear of wild wheat before it was domesticated, and you can see some of the kernels of the wheat are separating from the top, which happens when it's harvested. That's the issue with wild wheat is it shatters and loses the [00:11:00] grain, which because it's evolved that way to be able to spread it seeds very readily. But as, as humans develop the wild wheat domesticated it, you can see on the other side, on the right side, they changed it in such a way that the seeds did not scatter in the wind or when it was being harvested.

[00:11:18] And genetically, the reason for this, if you look at the two seed kernels at the bottom of the slide, one on the left, one on the right, you can see the wild seed on the right. Has what they call a wild, small, weak rakish is the term, and that's what connects the seed to the stem. But if you look over at the one right above my name there, the domesticated seed has a very strong short, powerful rakish, which prevented the seeds from scattering in the wind and helped improve harvest yields.

[00:11:52] And across the size of the seed was larger. So it also improved harvest yields. So these are examples. [00:12:00] Of the first plants that were genetically modified through human intervention. We think a lot about some of the GMO plants and crops right now that it's rather unique, but actually going way back to the evolution of agriculture. Humans were genetically modifying plants through intervention and evident in the genetics of the plant that these changes have taken place that improved the harvest stability of the plants. So let's move on. So the next one, and here we have the first audience survey questions. So I'm going to turn this one over.

[00:12:36] **Michael David:** Well, thank you Guy. So the question we'd like to ask all of you today is how many basic tastes are there? Is it four, five, six, seven, or none of those?

[00:12:55] 8% said four 48% said five, [00:13:00] 30% said six. 11% said seven and 2% said none of the above. So with that guy, I'm going to turn it back over to you,

[00:13:07] **Guy Crosby:** [00:13:07] And it's fairly recent that we now recognize six different basic tastes for many, many years that are in fact going as far back as the Romans time. They recognize the four basic tastes of sweet, salty, sour and bitter.

[00:13:22] And then in the year 2000 it was finally confirmed recognizing and identifying the receptor site for umami as the fifth taste that around the year 2000 and in between the years of about 2012 2015 researchers primarily at Purdue University identified a receptor site for fatty acids, which brings the number of basic tastes that we can detect up to six.

[00:13:47] So we get sweet, salty, sour, bitter, or umami and fat. And so that's. A fairly recent development. Let's now move on and look at in the time window now we're talking about when did [00:14:00] the art of cooking began? Most people will in this area, will believe that, you know, with the advent of things like clay ovens and clay cooking vessels, that that really was the time that people began experimenting with developing new methods of cooking.

[00:14:15] And you can see the picture here of the. Chinese clay cooking vessel that's about 3,500 years old from the Metropolitan Museum of art in New York, and over on the right side is what's known as one example of what's known as the Acadian tablets. You can see it printed down below almost 4,000 years old.

[00:14:35] These are a collection of tablets at Yale university in their Babylonian collection came out of the area of Mesopotamia, and two of these tablets show the first ever written record of recipes. This is the first time they've ever uncovered everything with recipes, and they show an amazing number of food items here.

[00:14:56] In fact, some of these recipes, most of them are stews [00:15:00] and they contain things like meat and fish and legumes, vegetables, spices, herbs, honey oils, beer, bread, wine. Just an amazing collection of foods. By this time, 4,000 years ago. So you see, there was a great development from the time agriculture was first developed five, six, 7,000 years ago until 4,000 years ago, an amazing increase in the number of foods that people were able to cook. And so we see what a tremendous development during this brief period, population was growing and human development was increasing. And this Acadian tablet is quite a record of. The types of foods that have become available by that time.

[00:15:43] Here we have a walk and it was the Chinese were the first to produce iron from iron ore about between 2,700 2,500 years ago. Soon after that, about 2000 years ago, they developed the first cast iron walk and that was created [00:16:00] during the Han dynasty when they were very creative. In developing new methods of cooking and new foods.

[00:16:06] In fact, here, stir frying as back as is 2000 years ago, and you see it there. Stir frying in the walk here, noodles and you might think, well, gee, noodles aren't that old. But actually the Chinese first developed noodles for using millet, which is a very, very high starch cereal. They could actually produce a flower and make noodles from that.

[00:16:28] Earliest ones had been recorded by. Radiocarbon dating to be about 4,000 years old, and that's about 2000 years older than the first noodles ever developed by the Romans about 2000 years earlier, developing them from wheat. This is quite an advance, again, in the style and art of cooking. When do the actual science or cooking come along to influence the art of cooking, which obviously is one of the themes of the book.

[00:16:58] During the [00:17:00] development of the Greek philosophers, they really set the tone that changed the whole direction of science, if we want to call it that, around. As you can see, 2,600 2300 years ago, the Greek philosophers at that time, like Aristotle who believes that all matter was compared just four elements that they call air, fire, earth, and water, and they further belief that.

[00:17:24] The properties of matter are interchangeable. For example, their example was you can take water, which is a liquid. You can freeze it into a solid, like the earth, or you can boil it into steam like air. So they thought all these properties of these four elements were interchangeable.

[00:17:42] And then if that's the case, they could probably interchange other periods and create gold. And so of course, the great search for gold started in that, created the whole pursuit of alchemy in terms of gold, and because of that, because of the belief of [00:18:00] these elements that were not correct at the time, you know, there was really a very, very little science, true science created until about the 16 hundreds. So there was a big gap in there when the art of cooking started to, when there was any real science that could influence the art of cooking.

[00:18:17] And you can see, here's the painting on here by Peter Bruegel, the elder. Done at 1558 raise, kind of the expressions on all these people kind of mocking backs in alchemy, which really wasn't refuted until the 16 hundreds until we come to Robert Boyle, who was professor at Oxford University and through his studies.

[00:18:39] He really started to break down and destroy Aristotle's concept of the elements, earth, fire, water, and so on. Those four elements. I can see the apparatus and the left side of the screen is the first vacuum pump that boil, developed and boil, of course was the scientist who is responsible for the hit that [00:19:00] boils gas law, but in this equipment, which Auto Von Garrick, which is a German person first developed the.

[00:19:06] The vacuum pump and boil came up with this variation where if you look at the bottom of the pump, there's a handle there, and if you crank the handle, you could literally pump the air out of and create a vacuum in the glass ball that's at the top of it. And because he made this other glass, it could create a vacuum there.

[00:19:25] He was able to observe how combustion behaved in the presence of various gases. And he did this, for example, by burning sulfur in air, proved that fire was a process that required air for combustion. So it was not an element as Aristotle and the other Greek philosophers had believed that it was really a process of combustion, which he proved and presented this evidence in 1661 so this was really the first major breakthrough of when science was developed that we still [00:20:00] understand today, rather than how the Greek philosophers understood it way back in their time 2,500 years ago, for example. So the next survey question, sorry, Mike, if you're going to ask this one, here it is.

[00:20:13] **Michael David:** [00:20:13] Which method of cooking meat makes it juicer? Is it braising roasting either or? Neither.

[00:20:26] 58% said braising 16% said roasting. A 10% said either, and 16% said neither. So with that guy, I'll turn it back over to you.

[00:20:36] **Guy Crosby:** [00:20:36] Neither one, because both of them brazing and roasting caused meat to lose moisture. And if you look at the first line of numbers at the top, it says, total cooking lost. Under braise, you can see it's almost 30% moisture is lost, and look at the roasting, 28% moisture is lost.

[00:20:55] So they both lose about the same amount of moisture by different [00:21:00] processes. The braised meat by evaporation, the roasted meat by drip loss. The reason why they both lose about the same amount of meat is if you look at the information at the bottom it says, this is an eye of round of beef cooked to an internal temperature of 158 degrees Fahrenheit or 70 degrees centigrade.

[00:21:19] And the amount of moisture loss depends on the internal temperature of the meat and how much the muscle fibers contract or shrink. When it's heated to this temperature. So when meets heated to the same temperature, regardless of how it's heated there, the amount of moisture that will be squeezed out by the shrinking muscles is the same.

[00:21:38] And it all depends on that internal temperature that you cooked me too. Okay, so let's see. We'll move on here and we'll talk now about some more interesting developments that science developed in cooking. In this picture. You see here is the first pressure cooker. That was ever invented. And this was done by [00:22:00] a French scientist named Dennis Papin, and he actually developed this one that's shown here in 1680 even though it's just 1679 when he first started to develop them, developed this concept for a pressure cooker.

[00:22:13] Well, working with Robert Boyle, he went over and studied with him for like three years and became to understand his gas pressure and realize, of course, that. You could heat a liquid in a closed container and the pressure would increase causing the liquids, the boiling point of the liquid, obviously, to increase in the container.

[00:22:34] Again, this is one of the first ones that he developed in 1680 and the problem is, of course, if you heat it too high in a container like this, even though it's made out of metal, it would explode. So he had a lot of incidents of this occurring while he was trying to develop it. And you'll see the arms sticking out at the top with a weight on it, on the left hand side of the pressure cooker.

[00:22:55] That is the first pressure relief valve that he created. And he was the first one to create a [00:23:00] pressure relief valve so that when he heated the water inside, the pressure container up to a high temperature, eventually, the weight with open the valve and released the pressure. So he no longer was blowing up all these containers.

[00:23:13] So it actually became very popular. As a way of cooking if you could afford it. And many people could use this as a way of cooking so it could cook really tough cuts of meat and meat, and make them very tender. It could even cook and soften bones and so on. So this was quite a development came about again, from Boyle's work and Dennis Papin, who worked with him for several years to develop this.

[00:23:38] One other thing about Dennis Papin is that he also developed, based on this work, the first piston driven steam engine, which was then used to power a panel driven boat. So he didn't just stay here, you know, in this limited area. He expanded his inventions and use of pressure and steam. Unfortunately, even with [00:24:00] those developments, which you think might make him quite famous, and even quite rich, he died a pauper and he was buried in a pauper's grave.

[00:24:07] So this was another ending that did not go well or very favorable, or a scientist who is working in developing some useful. Creations for, for people. Let's now move on and then we're going to go now to about a hundred years later and talk about Antoine Lavoisier who not only proved that, combustion was a process and not an element.

[00:24:30] Like Aristotle believed, but he, he was the one that proved that oxygen was required for combustion. Others. Such as Joseph Priestley and others had identified oxygen, even though they didn't know what it was, but Lavoisier actually proved what it was and that it was required for combustion. And as part of this work, he developed a law of conservation of matter, and he did this very brilliantly by taking a mercuric oxide, and he heated it up under extremely [00:25:00] intense heat and broke the mercuric oxide or red solid down to oxygen and liquid mercury.

[00:25:07] And what he showed was, when he ran in one direction and measured all the products formed, and then when he ran the reaction in the reverse direction in a closed container and carefully measured the weights again of all the products form, you know, the mercuric oxide, mercury, oxygen, that they were the same.

[00:25:25] And so he proved that there was no loss of matter that matter was neither created nor destroyed. And so this came about as the law of conservation of matter, which he published, as it said in the late 1770s and again, another tragic ending here to Lavoisier. He was executed by the guillotine towards the end of the French revolution because when he was much, much younger, he started to collect taxes for the Royal government.

[00:25:54] And then when the revolutionary war started, they banned all former tax collectors [00:26:00] are what they call tax farmers. And he was sentenced to death and he was executed by the guillotine. And one year later, his wife is in the picture here. One year later, the Revolutionary French government informed his wife that he had been exonerated.

[00:26:16] And it had been falsely convicted of any crime. And so unfortunately, it's a tragic ending, again, somebody who made brilliant contributions to science at that time, and again, proving that combustion is a process of oxidation, producing energy in the form of heat and light. And this is a very important, because obviously we can't understand heat without combustion, and we can't understand cooking without understanding heat and combustion. So these were very, very important developments to our understanding of, of how cooking and heating food affects it.

[00:26:52] Not too long after Lavoisier made his great discoveries come to Benjamin Thompson, [00:27:00] who was quite a brilliant statesman and scientist, born in Massachusetts at that time, 1798 when he was there. Scientists mostly believed that he was a way weightless fluid, a substance that they called caloric. But now Benjamin Thomson actually was cited with a bridge during the revolutionary war and escaped with the British army over in 1776 and went to England from America. And from there he went to Bavaria and became responsible for drilling cannons through solid metal with a drill bits and realized that there was a tremendous amount of heat generated while he was drilling the cannons from solid metal. And he realized then that it couldn't be, the heat that's generated couldn't be a weakness, fluid like caloric with the properties that people thought it had.

[00:27:53] And so he conceived that heat was actually a form of mechanical energy. And that's the first time. Anyone [00:28:00] understood heat to be something other than a weightless fluid, but actual mechanical energy. And as a result of his work with heat in ways of generating it, he developed one of the precursors to sous vide cooking, which is now very, very important.

[00:28:15] But he did this, and in 1799 demonstrating this at one of the scientific organizations over there that you could cook very tough cuts of mutton. Meet like this and make it extremely tender and it became very popular then. So again, this was quite a significant contribution to the method of cooking and applying this, the study that had done on heat and so onto cooking,

[00:28:40]One of the most important advances in science of all time was done by John Dalton, who was a meteorologist living in Manchester, England, who developed the atomic theory in 1805. And he was a meteorologist. And as a result of that, he wondered about the composition [00:29:00] of the gases that make up the atmosphere.

[00:29:02] And he became curious about them. And so through his developments and research, he envisioned that the gasses were made up of incredibly small particles that he, even though the Greeks had coined a term similar to this, he named them atoms, these particles making up the guests, and that the atoms of each of the gasses were different. And that. Furthermore, the differences determined how the different atoms in the gases would combine with each other. So for example, he came up with the concept that one carbon atom would combine with two oxygen atoms always and formed carbon dioxide. Or that one carbon atom would combine with four hydrogen atoms to form nothing gas or what they call the Marsh gas back then.

[00:29:48] So he made this advanced. This was really the point in which we could move forward and begin to at least begin to understand food and cooking at the molecular level, which has [00:30:00] become extremely important. We'll see some examples towards the end of this. Here is and I mentioned Robert Randoms book you might be interested in, but there's another book.

[00:30:09] It's probably one of my favorite books by Jacob Banowsky that he published in 1973 called the ascent of man and talking about, Dalton's contributions. To the atomic theory and so on. He made this statement, which is printed down here. Gronouski said, the essence of science ask an important question, and you're on the way to the pertinent answer, which to me, I thought it was just a marvelous way of describing what John Dalton had done by his simple question of wondering how the gases in the atmosphere were composed in their properties.

[00:30:45] We'd come to the next audience survey question.

[00:30:48] **Michael David:** [00:30:48] Which is hotter at 74 degrees Celsius. Would it be water, olive oil or they are the same.

[00:31:03] [00:31:00] 75% of the audience said they are the same. 14% said olive oil and 10% said water. So with that Guy, I'll turn it back over to you.

[00:31:11]**Guy Crosby:** [00:31:11] I think you can see it visually with these two. Sauté pans with exited been dropped in, but. Water in theory is hotter because of the heat capacity of water versus olive oil.

[00:31:23] And water has a heat capacity twice that of olive oil. And by heat capacity, we mean the amount of heat that you must add to a substance to raise its temperature by a certain amount. So if you take olive oil or water at room temperature and you both raise them to the same temperature, 74 degrees centigrade, it will take twice as much heat.

[00:31:45] To bring water up to that temperature of 74 degrees, center eight and then it will all avoid, and all that heat that's present in the water is going to be transferred to food when food is cooked in it. So you can see here's water at [00:32:00] 74 degrees centigrade on the right side, sauté pan, and you can see it's beginning to, hopefully you see it on your screen.

[00:32:05] It's beginning to coagulate. It's beginning to cook, whereas dropped into olive oil at exactly the same temperature. It has not started to coagulate at all. Because again, water has about twice as much heat energy added to it in order to bring it to that temperature than olive oil requires. And so each substance has its own heat capacity, and it's important to keep that in mind in terms of how effectively is going to cook food.

[00:32:32] Finally, get into a very, very well known, extremely important chef who was involved with the science of cooking. And he became, this was Maria Antwan Careme. A French chef who became really the true first celebrity chef. He was known as the King of chefs because he created nouvelle cuisine or modern French cooking in the 1810s to 1830s in that timeframe.

[00:32:56] And it's interesting. It's about the same within a relatively short [00:33:00] period from when Lavoisier made some of his great discoveries. So there were, there was a connection of which Careme applied to some of his cooking. And he claims himself that his exquisite cooking was based on science. And if you want to put some more stock into that, and you can look at a quote from Escoffier, and I'm sure all of you are familiar with who said the fundamental principles of the science of cooking, which we owed a Careme will last as long as cooking itself.

[00:33:29] So he was believed in very much in applying science to cooking. At the bottom right of the slide, you'll see some of the incredible confections that he was known for, big products, and he understood a lot about the science of sugar. And what happens when you cook sugar and make some of these masterful dishes as well as other dishes.

[00:33:48] And he cooked for many, many well known people such as Tony Ron, who was the foreign affairs minister under Napoleon's reign. He cooked for this Tsar of Russia. He cooked for Baron de Ross shield. All the [00:34:00] great chefs back then worked in private homes, his private chefs rather than commercial kitchens. And he was considered to be the leader of his time.

[00:34:08] So kind of an interesting example again, where finally, science was. Was being made available and chefs like Careme were taking advantage of it. First woman to make it really major contribution to cooking science. And that was Emma, Emma Eaton, Kellogg, and she was the wife of Dr. John Harvey Kellogg of the Kellogg cereal family, who was obviously quite well known.

[00:34:32] And she wrote the book called "Science in the Kitchen," published in 1992 and it's quite a lengthy book. It's over 600 pages long. She really showed and paved the way how to cook food to provide a healthy diet. John Harvey Kellogg had started a Sanitarium to care for invalid soldiers, and she became in charge of cooking all the food and developing all the recipes to provide healthy food for them.

[00:34:58] And I will just [00:35:00] read to you from the preface of the book that was published in 1892 and it said , it said on science in the kitchen. New methods of cooking. The book is about new methods of cooking, which are the result of the application of scientific principles of chemistry and physics to the preparation of food to make it more nourishing, more digestible, and inviting to the eye and the palette.

[00:35:25] Emma Eaton Kellogg really pioneered the role that we're seeing evolving now for cooking science, which I'll finish off in this presentation just a little bit, but how we can apply cooking science to teach us how to make more nutritious food, a healthy food. So we'll come to that towards the end.

[00:35:44] I will also talk about John Edward Hodge, who is a USDA chemist, for over 40 years. And he really, really turned the world of flavor chemistry, upside down with his important publication. He [00:36:00] published a paper in the first volume of the journal of Agricultural and Food Chemistry, and it was published in 1953 in volume number one of 1953. His paper is, still the most cited paper in all of the journal of agricultural and food chemistry.

[00:36:18] And what he did was he basically looked at and evaluated and published lots of information about the Maillard reaction about how it was affecting the flavor of food the discover Louie Camille Maillard, who discovered the reaction. It was named after him, really discovered how it was involved in Browning food.

[00:36:40] So that was the major purpose of his publication, but it was John Edward Hodge. Who found that the chemistry that was going on was responsible for so many of the flavors in food and really started people thinking about all the chemistry involved in this reaction? So because of this, I think he deserves as much credit [00:37:00] as Louis Camille, Maillard, who originally discovered the reaction, and really justifies naming the reaction to Maillard-Hodge reaction.

[00:37:09] To recognize some of the contributions that he made as an African American, especially to the chemistry of flavor. Happens to be a picture of me in front of a mass-spec HPLC instrument. And the point of this slide is that in a Potter's day, it was a very tedious process to isolate flavor molecules and such very tiny amount and identify them.

[00:37:33] And one of the biggest developments. That's made it possible to better understand flavor chemistry and the effect of cooking on flavor and also on nutrients is the availability of modern instrumental analysis like gas chromatography and mass spectroscopy and high performance liquid chromatography. So with that and the atomic theory developed, we were able to really understand more about flavor and texture, how they're created and [00:38:00] what happens to nutrients.

[00:38:01] When food is cooked. So that made a big beginning in the middle, 1950s on right up to now. Big impact on how we can analyze what's happening to foods or cooking it. Perhaps the last audience survey question. So Mike, here you go.

[00:38:18] **Michael David:** [00:38:18] Does the Malliard hard reaction proceed faster at a pH of five. Seven nine the pH does not affect the speed or the speed is the same, but all those different levels,

[00:38:37] The pH of five and the pH of nine got almost the same response with 35 and 36%. pH of seven only got 7%. 12% of people said it not did not affect the speed, and 10% said that it was, the speed was same for, excuse me, that the speed was the same for all of them. With that Guy. I'll turn it back over to you.

[00:38:57] **Guy Crosby:** [00:38:57] The Maillard reaction is about 500 [00:39:00] times faster and more alkaline. pH nine, and it is at pH five. That's a significant effect of pH on the rate was my, our reaction. So, and you could see a dark Brown cookie. And when you add baking soda, which is going to make it alkaline to the dough to make cookie, it enhances not only the flavor, but it enhances the Brown color.

[00:39:20] As we mentioned, that was the original discovery, but the Maillard reaction was that it colored food and made food Brown. And so if you add baking soda to a cookie. And bring it to pH up around nine it's going to be a lot darker than if you don't add baking soda and the pH is more acidic. So pH does make quite a dramatic effect on the rate of the Maillard reaction.

[00:39:45] Okay. So, I want them to point out here, you'll notice that each one of these questions are in gold, and I probably should've wanted to point out a little earlier in the book that I write. There's a bunch of history, as we've been going through on science. [00:40:00] And cooking, and they're all painted on white pages.

[00:40:02] But there are 22 science sidebars that go into all these different topics on food and cooking and science, and they're all painted on gold pages. So you can tell whether you want to read more about the history on the white pages or read some of the cooking science that's in there on the gold pages, and then there are recipes in there that are on blue pages.

[00:40:21] So you can tell the difference by the color of the page. And the book. How cooking effects nutrients. This is a table that shows the effect of cooking methods on nutrients and broccoli. And so here's broccoli that's been cooked by three methods, steaming or boiling or frying and four different nutrients.

[00:40:38] There were analyzes. This was an excellent study that was done in Italy at the University of Parma. And you can see the carotinoids polyphenols, vitamin C are all antioxidants, very strong antioxidants. And the last one down, glucosinolates are very important for deterring the risk of various types of cancers.

[00:40:57] And you can see that if we steam [00:41:00] broccoli, we can actually release 32% more of these carotenoids from the steamed broccoli than would be available if you eat raw broccoli. Or if you boil them, 19% more carotenoids are released from the broccoli compared to eating raw broccoli. And the other one that's increased rather than decrease is that the glucosinolates by steaming releases these nutrients, because they are generally tied up with proteins and cell walls and so on, and the cooking helps to release them.

[00:41:30] So you get more of them absorbed into your body. Some methods of cooking, actually decrease the amount of nutrients while and other types of cooking actually increase the amount that's available and can be absorbed into the body. Why is this important? It's important because in the example of the carotenoids, and you can see that the carotenoids protect long-term health because if you have a low intake of carotenoids, and these are the colored pigments in fruits and vegetables, if you have a low [00:42:00] intake of carotenoids, they are associated with all of these harmful effects, macular degeneration, all-cause mortality, cognitive decline, cardiovascular disease, high blood pressure, various types of cancer, inflammation, reduced immune function. All of these can come about if your intake of carotenoids is low. So when you're cooking these colorful vegetables and fruits, you're going to release more carotenoids that will be absorbed more readily into your body by a fairly significant amount as the previous slide shows.

[00:42:29] So this obviously is an important aspect of improving the nutrient quality of food by cooking. Another example where this is important as we come to the wrapping this up, is that. Cooking releases a lot more lycopene from tomatoes than eating fresh tomato. So lycopene is a powerful antioxidant and all the carotenoids are fairly effective antioxidants.

[00:42:53] It's against singlet oxygen free radicals, which can be very harmful. Lycopene in terms of [00:43:00] its antioxidant affects against singlet oxygen free radicals, it's 10 times more potent than vitamin E. So they are very, very effective at this role. And when you cook tomatoes, for example, tomato sauce, tomato paste, you get four times more of lycopene absorbed from the cooked tomatoes, and you would from fresh tomatoes.

[00:43:20] And if you cook the tomatoes in olive oil because the lycopene and the carotenoids are oil soluble, you get another 80% absorbed into the blood. And the reason why this is important, again, it's been shown. Quite a number of studies, but especially the ones that the Harvard school of public health. And do you have a new chief in his research that two to three servings of sauce per week, tomato sauce reduce the risk of prostate cancer by 35 to 56% and carotenoids have also been shown to reduce the risk of colorectal and pancreatic cancers and coronary heart disease.

[00:43:54] So. And this is very important that you can release more carotenoids through [00:44:00] cooking and you eat by eating the fresh food because it breaks down their association with cell wall components, for example, in the chloroplast when they are located within the food.

[00:44:11] This is a conclusion from the book on the future of cooking science, and as I write in the book at the very end, that's science driven changes in the way we cook will help reduce the risk of developing chronic diseases such as heart disease and stroke, obesity, type two diabetes, dementia, and many forms of cancer. And this is all because if we learn to cook the food properly, we can actually not destroy a number of nutrients and even increase the number of some of these beneficial nutrients like the carotenoids and the glucose scintillates that are in food.

[00:44:44] So I do believe that the application of cooking science will enhance the quality and joy of life because eventually being able to teach us a ways in which we can actually improve the nutritional quality of food. I'm really pleased that you had a chance to listen, and this is [00:45:00] the first book I've written all on my own.

[00:45:02] The other two books I wrote with America's test kitchen, but this one is published by Columbia University Press, and the one that I very important took me two years to write it, so hopefully maybe some of you will be interested in buying the book. You learn about it. As I say, I was only able to touch on a small portion of all the topics that I cover in this book itself.

[00:45:23] So we should wrap it up here for sure. Because of the timing situation. If

[00:45:27] **Brian Guthrie:** [00:45:27] you are interested in these topics that guy spoke about and they cover so many different fields from. Reaction kinetics and food cooking, transfer and analysis, these kinds of things. I would say if you don't know about the journal of Ag and Food Chemistry in a chemical, American chemical society, then you should really take a look at this.

[00:45:45] We're an organization of people who study food and those things like student competitions. We have annual meetings and the, the Journal of Ag and Food Chemistry is our flagship kind of publication. So I would encourage you to take a look at that and [00:46:00] join. It'll change your life. I'm going to do my best to consolidate the questions.

[00:46:04] We don't have a ton of time. but the here goes nothing. So one set of questions I would say guy is around taste, our taste receptors and our olfactory receptors different. Where do they live? What tissues? How do we sense metallic, spicy and calcium, these kinds of things?

[00:46:21] **Guy Crosby:** [00:46:21] Okay, well, let me make a distinction, and because taste and smell and flavor, the other part of it are really all very distinctly different.

[00:46:31] I think probably most people do know that we have receptors on the papilla. Those are the bumps on your tongue. Protein receptors in the taste cells that are there that bind with. Molecules that trigger them, that send an electrical signal to the brain smell. They're located in the nose, and the vapors that come up, especially through the back of the mouth, called retro nasal smell, triggers the smell senses, which are vastly more sensitive than the taste receptors.

[00:47:00] [00:47:00] But both the taste and the smell send their signals to three different parts of the brain. And flavor is actually created as an image in the brain. So it's not something we taste or smell, but it's something that's created in our brain from the signals coming from our taste receptors in the mouth and the smell receptors in the nose.

[00:47:20] It's interesting that, you know, as I point out in the book, it samples that we can smell many molecules at less than. Less than a part per trillion and a part per trillion is same thing as one second in 32,000 years. To give you an idea of what a tiny amount this is and whereas tastes were much, much, much less sensitive to taste, probably because they evolved for survival and we need to detect certain things in rather larger amounts that might be poisonous for sugar, for sweetness, and so on for energy.

[00:47:54] **Brian Guthrie:** [00:47:54] just, things like metallic taste, like, you know, size and then calcium.

[00:48:00] [00:47:59] **Guy Crosby:** [00:47:59] So the cells that, that detect pain and heat chemos thesis, it's called the process. They surround the taste cells in the taste buds. So where there are taste buds containing the cells that detect the taste of food. They are surrounded by the cells that can detect sensation of heat and pain and so on, called the process called some of the chemist's thesis. So capsaicin, which is a very perceived as a very, very hot molecule, triggers those receptors. So you'll generally find that people that are what we call super tasters are very, very sensitive to bitter tastes. They have more receptors for bitter taste, and they also, because of the surround these receptors, they all tend to be a lot more sensitive to. Spicy molecules like capsaicin, whereas those that are considered non tasters that don't have nearly as many tastes receptors are not as sensitive to the various tastes like bitter, but they're also not as sensitive to capsaicin.

[00:49:00] [00:48:59] So they tend to prefer food that is going to be a lot spicier rather than the super tasters that kind of picky eaters and don't like spicy hot food and what calcium is a, is another important, ion. That's very important in the mechanism involving taste that is becoming even more important in terms of its role in increasing the sensitive nature of taste and even improving things like sweetness and molecules and so on.

[00:49:29] **Brian Guthrie:** [00:49:29] Great. Move to a topic under the, I would call food evolution, and there was many questions about how our crops and whatnot evolved with us. There were several questions around wheat, you know, for example. Is there a record of intermediate forms of wheat from wild ancestors to modern and, even the evolution of gluten is modern wheat hiring gluten.

[00:49:51] Has this led to more intolerance with using yeast in the baking process? Has this changed fermentation patterns [00:50:00] and what do you know about this? And then, at GMO crops or GM crops, we reduced diversity in our species.

[00:50:08] **Guy Crosby:** [00:50:08] Wow. Okay. Let's see if I miss anything. Come back and catch me on it though. But it's, so the first varieties are wheat, very, very old varieties called emo corn and icorn wheat coming from areas like the Fertile Crescent.

[00:50:20] They were evolved and raised by humans who, as I say through their selection, change the genetics of these various types of wheat. And then there were other types of cereal grains that grew from grass. In terms of, I think the effect of this evolution on gluten in wheat and things of that sort of, that was the next one, and talking about the journal of agricultural and food chemistry not too long ago, I'm trying to think back, maybe only two or three years ago, there was a paper published there where they had gone back, the researchers and looked at all the protein structure in nature, various recent and very old forms [00:51:00] of wheat.

[00:51:00] Found that there was no apparent correlation with any changes in the protein content of the wheat that they surveyed from very old varieties to new varieties that had any effect on celiac disease. So it does not appear as though the changes that may have occurred as we evolved over time was really associated with increasing the incidence of celiac disease.

[00:51:24] I think that may be true. I know there was another paper recently I looked at not too long ago that that did look at, I think the effect of the, gluten in terms of its baking properties present in there. I can't recall exactly what they found. Any significant difference in the gluten and the baking properties from these different evolved forms of wheat.

[00:51:46] I'd have to go back and look that went up again, I don't recall that they found anything significantly different though.

[00:51:52] **Brian Guthrie:** [00:51:52] Okay. I'd like to move on to questions around human evolution. One of the questions that was interesting, you know, with humans kind [00:52:00] of evolving to deal with varsity, you know, lack of food.

[00:52:03] Could you summarize the evidence if there is an influence on, on gut hunger hormones like leptin, CCK, how we change as a species and, and, has cooking change brain growth?

[00:52:14] **Guy Crosby:** [00:52:14] Well, this is another thing that I, addressed in the book. It does appear though, that there were changes. Of course, we now know, and we don't know how far back this goes, but we do know that our gastrointestinal system now contains receptors for a number of like glucose sweet molecules and other molecules that control the influence of leptin and how much we eat and whether we're hungry or whether it's satisfied that these are receptors in like the ones that are mouth, but they're in our gastrointestinal tract. Now, when these evolved, it's not clear in whether they put additional demand on the brain that may have helped the brain develop and become larger.

[00:52:55] That's. One of the things I speculate on and talk a little bit about in [00:53:00] the book, but that's, you know, it's interesting. I never came across any research that showed how long ago these receptors in the GI tract may have evolved in humans, but it's interesting point to consider it that it's probably not as long ago as our tastes receptors, which were really clearly there for our survival in terms of making sure we ate enough sweet things. Because as I point out in the book, also, the brain requires roughly 120 grams every day of glucose. Cause that's the only energy really that the brain evolves on. It's on glucose is its major source of energy and so it's, it's about 120 grams every day that you must have taken just to keep your brain operating. So, you know, there are certain large amounts of foods that we hit, we need to detect. So whether this carried over to evolving at the same time in our gastrointestinal systems or much later, it's not clear. I didn't come across an ending that [00:54:00] suggests that it was on a different time frame

[00:54:03] **Brian Guthrie:** [00:54:03] Guy, thanks a lot. Finally, if there's one important lesson our listeners should learn. From your presentation, what would it be?

[00:54:11] **Guy Crosby:** [00:54:11] I think cooking itself and in the science of cooking and the food connected with it is a great way of teaching science. I mean, I encounter a number of people in teaching organizations and schools and locations that they want to learn a lot more, especially in in the public schools. They would like to learn a lot more about cooking science. And about food because they find their students are so interested in food, they're interested in cooking, and generally they are a lot more open to learning about science and find it interesting science and math when it's done in terms of food and cooking.

[00:54:44] So it's just a great vehicle for, for teaching this whole approach to science and food and cooking and getting people to appreciate science.

[00:54:59] **Michael David:** [00:54:59] Thank [00:55:00] you for watching this presentation. ACS webinars is provided as a service by the American Chemical Society as your professional source for live weekly discussions and presentations that connect you with subject matter experts and global thought leaders concerning today's relevant professional issues in the chemical sciences, management and business.