

Have you ever eaten coffee while drinking biscotti? Or used a syringe while eating a salad? Or even eaten a restaurant menu? These things are now possible thanks to creative chefs who are part of a growing movement called molecular cooking, experimental cuisine, or avant-garde cooking.

The movement started in 1992 when scientists and cooks met at an international workshop held in Erice, Italy, to discuss how cooking recipes work and how they could be improved by studying the physics and chemistry behind them. The workshop was run by Nicholas Kurti, a Hungarian-born physicist who taught in Oxford, United Kingdom; Hervé This, now a professor of molecular gastronomy at the French National Institute of Agronomical Research (INRA) in Paris; and Harold McGee, an American science writer.



Hervé This (left) and Pierre Gagnaire taste one of Gagnaire's new dishes.

In these workshops, Kurti and This introduced a new field called molecular and physical gastronomy—later shortened to molecular gastronomy—to investigate the science behind cooking. The two scientists tried to understand, for example, whether adding ingredients in a recipe needs to follow a specific order. They also questioned long-held assumptions about the time it takes to cook certain meals or why temperature should be lowered or increased over the course of a meal preparation.

Over the years, Kurti and This's work generated interest from chefs, cooks, and food enthusiasts, who decided to look at cooking recipes from a new perspective too. An increasing number of chefs are now experimenting with equipment similar to that found in physics or chemistry laboratories with the goal of creating original, yet savory dishes. These dishes are now served in a few restaurants around the world, including wd-50 in New York City, Moto in Chicago, and The Fat Duck in Bray, a village located 25 miles west of London. People can also learn these new cooking techniques by attending workshops.

"There is a lot that we don't know about what happens to food as it is cooking," says

Wylie Dufresne, chef at wd-50. "But by scientifically studying the cooking process, you can learn new things that can help you combine ingredients in new ways and come up with new flavors. Also, by experimenting with food, you can make cooking more fun and you can unleash your creativity."

Molecular gastronomy

Molecular gastronomists are scientists who study what happens to food when it is cooking. They study the chemicals in food, how these chemicals change when food ingredients are mixed together, and the transformations that happen to food during cooking. Their work can be used in the kitchen to improve recipes through a better understanding of the underlying chemical composition of food.

"We want people to be able to cook creatively and not have to blindly follow recipes without knowing why

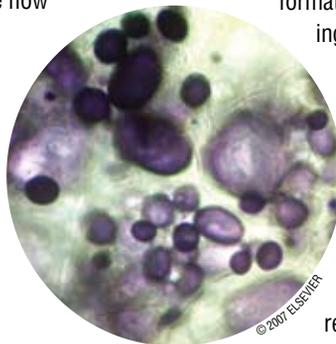


Figure 1. Potato cells observed under an optical microscope. The starch grains are stained deep purple.

you need to mix such and such ingredients in a specific order or for a specific length of time," This says.

This developed a way to describe the chemical ingredients of food using a set of symbols similar to mathematical symbols. Food is divided into different phases—liquid, gas, or solid—and the various food components have one of four dimensions: a dot, a line, a plane, or a volume.

"Food usually has the consistency of a colloid—a substance in which small particles are randomly dispersed," This says. "Potatoes, for example, consist of cells with starch granules dispersed inside them, and the cells themselves are dispersed in the solid that makes up the potato (Fig. 1). Another example is ice cream—it consists of gas bubbles, ice crystals, proteins, sucrose, and fat dispersed in water."

In his laboratory at INRA, This and colleagues conduct scientific experiments using differential equations (mathematical equations used in physics, engineering, and economics) and nuclear magnetic resonance machines (the same machines that provides

BRINGING *Chemistry* to the *Kitchen*

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images of different parts of our body). They investigate various cooking processes, including how a carrot stock is done and why the color of green beans changes during cooking.

These scientists also suggest how to apply techniques usually found in chemistry and physics laboratories to the study of nearly everything that you can buy in the supermarket: vegetables, fruit, pasta, salad dressing, mayonnaise, etc.

“We are interested in understanding how food changes in consistency, color, and structure when it is cooking, in the hope of finding processes that haven’t yet been explained by chemists, physicists, and biologists,” This says.

In 1996, This conducted an easy experiment to show that the strongest chemical forces that occur in cooking egg whites are disulfide bonds. Before he did his experiment, This was wondering how an egg white cooks.

“Raw egg white is full of tightly coiled proteins,” This says. “When you start cooking

This works closely with restaurant chefs to ensure that his research results are used in the kitchen. For the past 10 years, he has been working with Pierre Gagnaire, a well-known French chef with restaurants in many cities—including Paris, London, Dubai, Tokyo, and Hong Kong—to help him create recipes based on his latest findings.

This has proposed to create an “abstract” cuisine, in which people would not be able to recognize the food ingredients used for making a given dish. This concept is inspired from abstract art, a style invented by painters Wassily Kandinsky and Piet Mondrian that does not represent real people or things but is an arrangement of shapes and colors.

This is also encouraging other countries to create their own molecular gastronomy

of food and how the outside environment affects how people appreciate food. In other words, Barham not only combines science with the art of cooking, but he adds psychology to the mix.

Barham and colleagues at the University of Copenhagen’s Food Science Department have conducted various experiments on people eating various foods.

One of their main findings is that people associate the taste of food to memories related to these foods. For example, the researchers used the fact that changing the color of food can make people think they taste

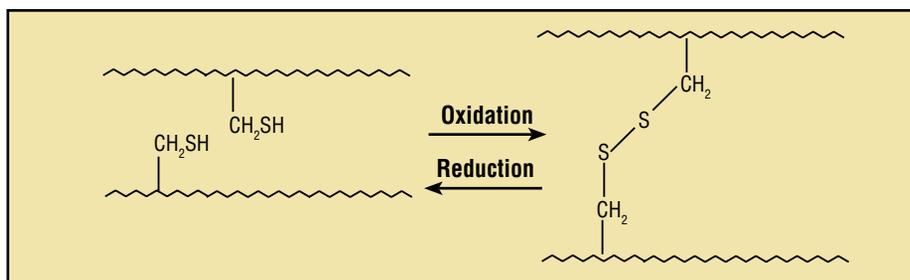
different. The scientists made jellies with red beets that were colored either orange or deep red. People who ate the orange jellies usually thought that they should taste like an orange. They didn’t recognize the beet flavor and didn’t like the jellies’ taste. But when they ate the red jellies, they recognized the taste and liked it.

Barham and colleagues are also trying to understand what makes people feel full after they eat. The scientists have shown that people may be more interested in the complex texture of food rather than its good taste.

“Some people love chocolate, cheese, or Coca Cola, so you can assume that the more of these foods you give them, the happier they will be,” Barham says. “But what we noticed is that if you give people food with an unusually good taste, they usually will savor it in their mouth longer, and end up eating less overall than if had given them, say, chocolate.” The reason this happens, Barham adds, is that people may be more interested in experiencing new tastes than tasting the same thing over and over again.



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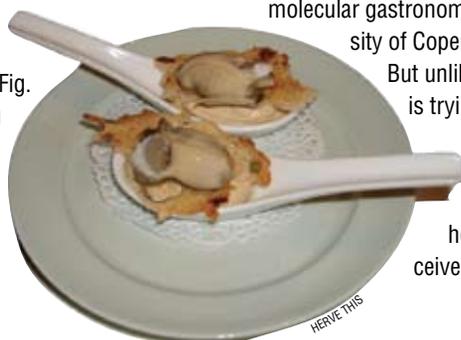
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Figure 2. Egg white hardens because molecules (wiggles) inside egg white proteins bind to each other by forming disulfide (S-S) bonds (right).

egg white, some proteins in it start to unfold, and thiol groups (molecular group consisting of a hydrogen and a sulfur atom bound together) form covalent bonds between neighboring molecules inside each protein.”

These strong, stable bonds are called disulfide bridges and result from a chemical reaction in which the hydrogen atoms from each thiol group are removed and the two remaining sulfur atoms bind with each other (Fig. 2). This cross-linking between molecules inside egg white proteins causes the molecules to form networks, so the egg hardens.

So This used reducing agents to cut the disulfide bridges (reduction reaction in Fig. 2), and he noticed that the egg was “uncooked.” This experiment showed that the formation of disulfide bridges was the key process explaining the cooking of an egg.



HERVE THIS

programs. Such programs are now underway in the United States, Argentina, Cuba, and many European countries, including the United Kingdom, Italy, Spain, and Ireland. The people involved in these programs interact with each other to compare notes on their latest findings.

Psychology of food

Another molecular gastronomist is Peter Barham, a teaching fellow in physics at the University of Bristol and a professor of molecular gastronomy at the University of Copenhagen, Denmark.

But unlike This, Barham is trying to understand what makes food taste good. He is interested in how people perceive the color and tex-

Avant-garde meals

The easiest way to experience avant-garde or experimental cuisine is to go to one of a handful of restaurants that exclusively serve this type of food. One of them, which I experienced, is Moto Restaurant in Chicago. It was unique and unusual.

For starters, Moto’s menu offers only two meal choices: a 10- or a 20-course meal. After you make your choice, you can eat the menu, which tastes like a thin slice of tortilla chip!

Making a Spherical

Carrot Cake

One of Ben Roche's most popular desserts is the spherical carrot cake. Instead of using a large bowl, a whisk, and an oven, his tools consist of nitrogen (in both liquid and gas forms), a balloon, and a syringe.

First, Roche fills up the balloon with nitrogen gas until the balloon reaches a spherical shape. Then he uses the syringe to fill up the balloon with 60 cubic centimeters of a liquid carrot cake mix made of carrot juice, eggs, sugar, ginger, and walnuts. Then he adds a little bit of nitrogen gas to create pressure inside the balloon so that the liquid inside is forced outside the balloon.

Then Roche freezes the balloon inside liquid nitrogen. He spins the balloon around in the liquid nitrogen, causing the liquid carrot cake to freeze on the inside surface of the balloon, forming a shell. Then Roche slices the balloon with a knife, and ends up with what looks like an Easter egg. All you need to do is break it like an egg and eat it!

To make this and other desserts, Roche uses gloves and goggles. "Safety is very important when using this equipment," he says. "We don't recommend that students make this carrot cake in their kitchen. Instead, you may want to try this recipe with an experienced chef or a person trained with chemistry lab equipment."

You can watch a video of Ben Roche preparing the spherical carrot cake on the *ChemMatters* Web page: <http://www.acs.org/chemmatters>.



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The dishes on the menu sound familiar, but the way they are displayed and how they taste are not. "Greek salads," for example, consist of an octopus salad—with an octopus imported from North Africa—with a salad dressing served in a syringe. You first eat the salad, and then you squeeze the syringe into your mouth, which gives you the taste of a Greek salad. (Note that these syringes are made especially for Moto restaurant, so you shouldn't use a syringe from a chemistry laboratory for that purpose!)

Other items on the menu include a "BBQ beans and slaw," which consists of a soft beef brisket cooked for 12 to 16 hours and coleslaw that melts as you eat it (because it was pureed and then frozen); a scallop filled with a liquid made from saffron (an iris-like herb) served on a tofu and vanilla puree and an orange on the side; and seared Shuteye—a broadbill swordfish from Hawaii—with tofu puree, braised seaweed, and popcorn.

The menu includes three desserts or more, depending on the type of meal that you pick. The desserts include a chocolate truffle filled with liquid Cracker Jack and popping candy, nitrogen-frozen raspberries, and a ball of white chocolate filled with a popcorn sorbet

which, when put inside the mouth, feels like popping popcorn. At the end of the meal, a waiter serves you blended biscotti in a cup and coffee that is hardened and shaped like biscotti.

The desserts are the creations of Ben Roche, Moto's pastry chef, who is as passionate about his new creations as Steve Jobs is about the new iPhone 3G. "I like to change people's expectations about food," he says. "I try to push the boundaries of baking by mixing ingredients or changing the texture of fruit. It's very rewarding when you come up with a dessert that tastes good that nobody else had tried before. But obviously, the customers are the best judges."

Interested in doing avant-garde cooking?

Most chefs who do avant-garde cooking followed a traditional cooking training. But in addition to this training, they have also learned about the science of food through books or from other chefs. They also enjoy experimenting with food ingredients to come up with dishes that taste, smell, and/or look differently than what people expect.

"We want to break the boundaries of cooking techniques by being cavalier but serious," says Daryl Nash, executive chef at Otom, Moto's "sister" restaurant in Chicago. "We look at a pie, a vegetarian dish, or a cheeseburger, and we wonder, 'How can we make it look different but taste the same?' or 'How can we make the familiar look unfamiliar or taste better?'"

One of Nash's favorite dishes on Otom's menu—which offers a mix of traditional and contemporary meals—is called a Bacon-Lettuce-and-Tomato (BLT) sandwich, except that doesn't look like a sandwich. Nash uses the same ingredients as in a BLT sandwich, but he prepares them differently. He makes a jam out of tomatoes, black pepper, and mayonnaise, creates a Romaine lettuce puree, and adds pieces of sourdough bread to the mix. "In the end, what you see is nothing like a BLT sandwich yet it tastes exactly like it," Nash says.

In some cities, such as New York and Paris, people who haven't been trained as chefs can meet with avant-garde chefs and food scientists, thanks to public outreach programs. For example, since April 2007, New York University has been organizing public meetings in which chefs, scientists, and food enthusiasts meet and talk about the latest findings in experimental cooking.

During each meeting, invited speakers make presentations on their current activities and then answer questions from the audience. The meetings are part of a program called Experimental Cuisine Collective.

If you would like to enjoy some new and unusual food, you can try to locate an avant-garde restaurant near you. You can also contact the Experimental Cuisine Collective to know more about molecular gastronomy and experimental cooking by going to their Web site: <http://www.experimentalcuisine.org/>. ▲

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