Interview with Professor Matt Francis

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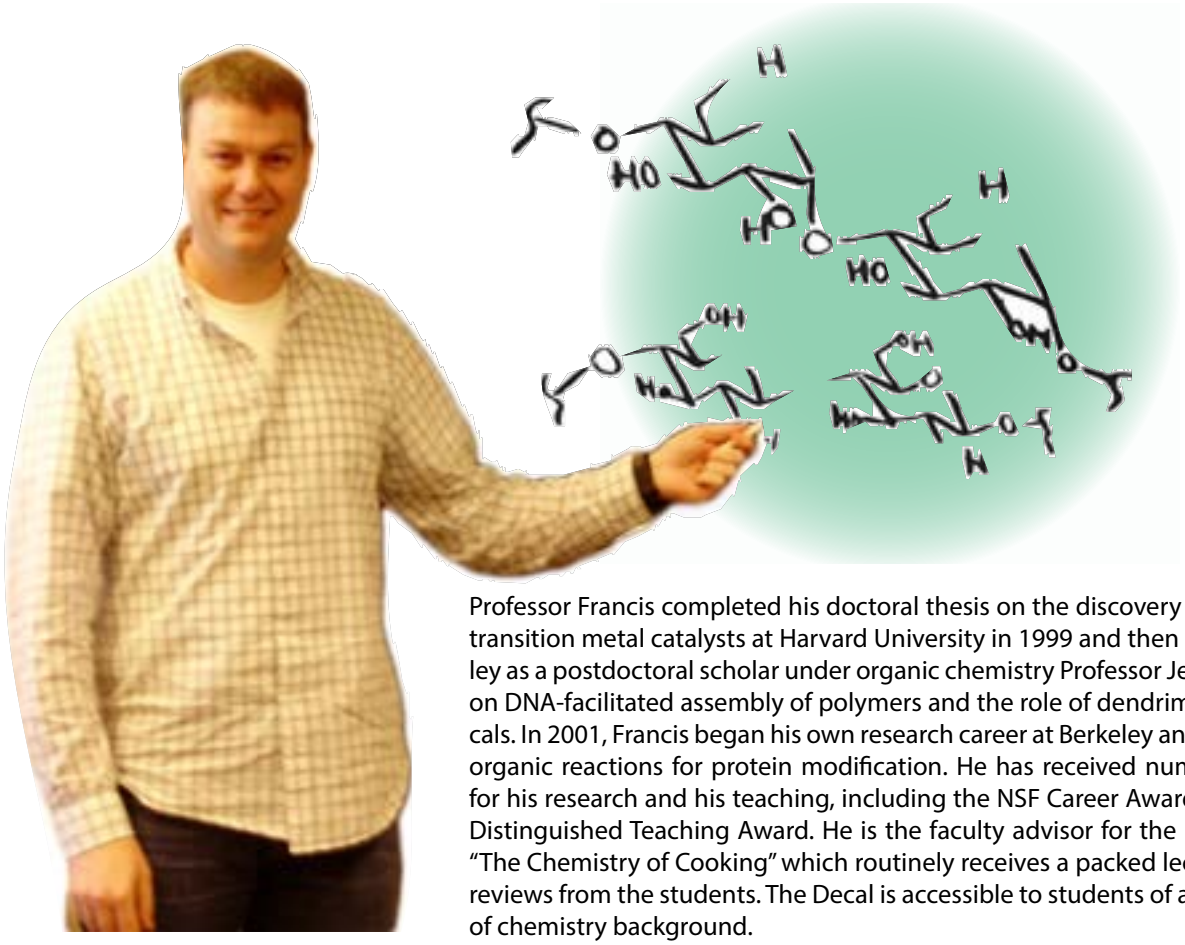

Professor Francis completed his doctoral thesis on the discovery and optimization of transition metal catalysts at Harvard University in 1999 and then moved to UC Berkeley as a postdoctoral scholar under organic chemistry Professor Jean Fréchet, working on DNA-facilitated assembly of polymers and the role of dendrimers in pharmaceuticals. In 2001, Francis began his own research career at Berkeley and has been studying organic reactions for protein modification. He has received numerous awards both for his research and his teaching, including the NSF Career Award and the University Distinguished Teaching Award. He is the faculty advisor for the Decal Chemistry 98, "The Chemistry of Cooking" which routinely receives a packed lecture room and rave reviews from the students. The Decal is accessible to students of all majors, regardless of chemistry background.

Francis: Eunice Lee (UCB class of 2010) first started this Decal course as Chem 98 in 2009. This class was originally her idea. There has been a growing number of people who signed up for the course over the past five semesters. We're now offering two types of classes; one for student who have had organic chemistry and one for those who have not.

BSJ: Are you an avid cook?

Francis: Yes, I am and I find it a great stress relief. My favorite dish to cook is pizza and I'm very serious about it. My favorite dish to eat is probably nachos (not too sophisticated). That being said, I cook a good deal of French food because of all the molecular gastronomy involved—particularly in making the emulsions required for French sauces.

There has been a greater focus in the past decade on molecular gastronomy and its chemical influences on foods. For example, sous-vide cooking (French for "under a vacuum") is popular in fancy restaurants right now and is discussed in class as well as experimented with in the lab. It is the process of cooking foods to the proper temperature using a water bath and sealed bags, then searing it at the end. Many other types of heat transfer are also discussed. An example of where this is important is if of you compare cooking a Rock Cornish hen and a turkey. You would sear the small hen at 425˚F while cooking a large turkey at a 350˚F, knowing that the time it would take for the heat to transfer to the center of the bird would be vastly different for the tiny hen vs. the turkey. In the lab portion of the class, they experiment by cooking the same recipe—banana bread for example—in different compositions of pans, such as glass and aluminum.

Lots of newer trends in molecular gastronomy include the use of liquid nitrogen – for example, one can use it to turn something like crème fraiche into snow. Also, the use of alginate polymers allows you to encapsu-

late foods into flavored droplets using edible polymers. I do not believe that knowing these techniques necessarily makes one a better cook, but there is a lot of thinking about the chemistry that can help with the difficulties in cooking your food. For instance, if you understand pH a bit, you can do a better job cooking vegetables and understanding that dressing a salad at the last possible second is preferable. This minimizes the loss of magnesium from the chlorophyll, which makes vegetables turn grey.

BSJ: Why is it that if you cook broccoli and put it in ice water does it stay bright green?

Francis: Shocking it by putting it in cool water rapidly stops the cooking process. By not overcooking the broccoli, it will not turn color. Recently, I have read that the broccoli does not need to be shocked in an ice bath, with simple cool tap water giving the same results. I have found that this is actually true.

I do think that understanding molecular gastronomy can create a greater appreciation of the art of cooking. There are a lot of geeky food blogs around now. Alton Brown has a good show, and I really like Cooks Illustrated, which is written like a science journal – troubleshooting what went wrong and providing something like experimental procedures. Another online blog, Serious Eats, discusses in-depth cooking experiments as well. As an example, they had a great article on whether you should mix salt into your burgers before grilling them. They determined that you should not because it breaks down the fibers of the meat, making it mushy.

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BSJ: So the two different classes that are offered, the lower division and the upper division, are both of them really popular?

Francis: Yes, but most people get in either the semester they want or in the next semester. Like all Decals, people shop around and some people decide it's not for them and they go to something else. It's not to be confused with an authentic cooking class though. The labs are such that you have to cook on your own in your apartment or dorm, but we can't do that all together given the lack of central facilities. We don't have a kitchen that we can actually hold the class in. It'd be fun if we could.

BSJ: Yeah, I actually like your lab procedures because I'm the sampler. I remember they had to make cookies with 3 or 4 different kinds of flour.

Francis: Did they also deal with cakes?

BSJ: I don't think they did it with cakes.

Francis: Cakes would be cool for that comparison, too. The main thing about flour is that it's got different amounts of gluten in it, which is a protein. As you work flour like you're kneading bread, the friction unfolds the proteins and they start to stick to each other to form long, ropy fibers. That's why it becomes elastic, and why when you knead bread and you poke your finger in it, it pushes it back. That ultimately gives a loaf of bread or a bagel its chewy texture.

As another bread example, whole-wheat flour has a lot of gluten too, but it also has the fat of the wheat grains. This is an important difference because when you have fat, it inhibits the agglomeration of the gluten molecules. That leads to a more crumbly texture, which is why whole-wheat pasta is terrible (in my opinion!).

Now imagine if you go to somebody's wedding and they have pulled out a bread knife and saw away to cut the cake. This normally does not happen because cake flour has very low gluten content, and you usually do not knead the batter. There is also a lot of oil that is added to cakes. This keeps the fibers from forming, leading to a more tender mixture, but the flour really matters. The more gluten, the more chewy the item will be. I have always wanted to see how terrible is would be to mix these procedures up, but I don't actually know. I've been trying to get them to do it in lab.

The other one that I always try to get them to do is to make biscuits with melted butter. Butter is about 10% water, which produces tiny pockets of steam when baked in the oven. This process makes baked goods fluffy and flaky, like puff pastry. The key to getting this to work is to keep your butter cold while mixing the dough. If you melt the butter, all the water separates out (because the oil and water don't mix) and you lose this effect, but I actually don't know how bad it gets if you break this rule, as I've never tried it that way.

BSJ: So you could ask them to do that?

Francis: I think I will.

BSJ: Do you talk about any of the nutritional values behind food in that class?

Francis: We do. We do talk about the basic proteins, fats, and carbohydrates in food. We also have a whole lecture on artificial sweeteners, and we talk a little bit about vitamins as well. There are some discussions about organic food and conventional food and whether one is really better for you. Many of these topics are pretty complicated and they can be subjective in nature, but we do discuss a lot of issues and concerns involved.

BSJ: And have you heard of NST 108? It's a very similar class; we talked about a lot of nutritional stuff and we also had a lab section where we actually did some of the experiments that you are doing.

Francis: Yeah! A regular class like that will go into more detail than the Decal has time to do. We do talk a lot about the popular press surrounding nutrition, and again some of it is subject to interpretation. A lot of nutritional aspects are not fully understood, research-wise. For example, trans-fats – we talk about what that term means and where they come from. Many people consider excess trans-fat to be at least suspect in terms of health effects, but it's a little bit up in the air as to exactly how bad they are. What is the connection they have with cardiovascular disease? We discuss many of the current hypotheses, but we also try to treat these aspects as open-ended questions, because in many cases, they still are.

BSJ: Are there any strategies to keep the food fresh? How to store it?

Francis: It depends on what it is. There are actually entire papers on bread and about how it goes stale. It's actually pretty complicated. Most people think it just dries out, but in fact, if you take stale bread and put it in the microwave for a few seconds, it returns mostly to normal (unless it's really far-gone!). One thing that actually happens as it goes stale is the crystallization of the starches, which quick heating can reverse. You should also try to keep excess moisture out of things, because mold can grow if there is water available.

Another way to preserve food is to keep the oxygen out, because it will cause many fats to go rancid. That's actually the major thing limiting the shelf lives of many baked goods. If you are trying to preserve something you cooked, make sure you heat it well to kill the bacteria, seal it up, and put it in the fridge immediately after it cools down to room temperature.

BSJ: Tips for dorm and apartment life, essentially? (Laughs)

Francis: Yeah! I remember those days. (Laughs) It's amazing I survived. You have the room temperature pizza and that might last half a day. It depends on how hungry you are, whether you will eat one of those slices or not. Certainly if you put it in the refrigerator or seal it up in the plastic wrap it should last a lot longer.

BSJ: What sort of foods do you teach about in the course? Do you delve into ethnic foods?

Francis: We tend to be pretty neutral about that. We don't really focus on one style of cooking versus another style of cooking. Also, if we give an example of how a type of cooking would take place with meat we try to also discuss another high protein food, such as tofu or eggs. Some people eat dairy, and some do not. However, there is an entire lecture on dairy, because there is a lot of interesting science involved that could apply to other foods. There's an entire lecture on brewing and fermentation, but of course not everybody drinks alcohol.

One of the great things about living here is that you are exposed to every type of cuisine that there is on the planet. And it's all really good here. Are you from here? Are you from California?

BSJ: Yeah, I'm from California.

Francis: From where?

BSJ: San Diego.

Francis: All over California, we have so many kinds of meals. I grew up in Ohio, which did not have much in terms of different kinds of food, and when you are here, you really appreciate that.

BSJ: I'm from China.

Francis: Okay, very different. Where in China?

BSJ: Beijing.

Francis: I was just in Beijing. I had really, really good food there. I've heard it's even better in Hong Kong and Shanghai, but I haven't been there yet. Hong Kong is next on my list. They're noodle people right? More noodles than rice?

BSJ: It depends. The northern people prefer rice. Southern people prefer noodles.

Francis: In Beijing, I had Szechuan food, and that was re-

ally good. I have had it here, but it's not the same thing. There's this pepper they use. It makes your face go numb but only for a couple minutes and then it comes back. It's kind of a dare to see how much of it you can eat. I need to find out what the active compound is.

BSJ: The class is taught by undergrads?

Francis: Yes, most of it. I do about three lectures, usually about the organic chemistry of food because that's what I specialize in. The rest of them are given by undergraduate instructors, who do a terrific job organizing and administering the course. They also choose the labs. This semester we've added some outside speakers, which has been interesting. We had the head chef from Gather here a week ago. He lectured on sustainability and the chemicals aspects of their cooking. Once we had a panel discussion with a chef from Chez Panisse and a chemical engineer who works at Del Monte. Talk about two opposite ends of the culinary spectrum! It was really interesting to consider how they achieve their very different goals. At a large production facility, the end product always needs to be the same, and at a high-end restaurant, each meal should be unique.

What was your favorite lab?

BSJ: The cheese lab because it was horrible.

Francis: (laughs) It was nasty, I agree.

BSJ: I actually did try it but it tasted extremely sour because we added too much ascorbic acid.

Francis: Yup, that would do it. Low pH is sour-tasting.

BSJ: Yeah, it exploded in the entire microwave. We had fun cleaning it up.

BSJ: If my roommate comes back with the cheese lab, I know to leave the apartment. (laughs)

BSJ: There are more and more chemical additives coming into food. How do we evaluate the benefits and the toxicity of the chemicals in food?

Francis: Unfortunately, the toxicity is not something you can evaluate for yourself very easily. From one perspective, it is not necessarily true that all chemical additives are bad. In fact, one could make an argument that BHT, di-tert-butyl hydroxytoluene, which is an additive is many kinds of baked goods, is a very good antioxidant. On the other hand, many pesticides and growth accelerants (such as Alar on apples) that were widely used were later found to have carcinogenic properties. It really depends on the context, the amount you actually consume, and in many cases, the results of lots of long-term scientific studies that have yet to be conducted.

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But for a lot of these things, I think our biggest problem as Americans is we tend to overdo it. Take MSG for an example, which is a controversial flavor enhancer. Some people seem to be sensitive to this compound, but many others are fine with it. I think that in many cases, the problem is that the people who use it use tons of it. Or high-fructose corn syrup. That one is getting a lot of press right now. From a biochemical point of view, the caloric content of fructose and glucose is the same, and fructose is half of what you have in sucrose, which is table sugar. Fructose also occurs naturally in many fruits, but the principal problem is that the very low cost of fructose coming from corn encourages the addition of very large amounts of it to all kinds of food. It is in everything and is currently the number one source of calories in the American diet (mostly from soda). Personally, I really like the Michael Pollan philosophy, which is "Eat food, not too much, mostly plants." That sums it up incredibly well.

BSJ: Stick to vegetables? (laughter)

Francis: I know it is hard to eat right when you are eating in the dorms, and when I was your age my diet was absolutely terrible. Now that we can make some choices about what we eat, my wife and I try to eat as much fresh food as we can. We buy meats and vegetables from Berkeley Bowl or wherever and fix them ourselves. Very little of what we eat comes out of cans. One of the reasons for that is because many canned foods are loaded with sodium that you can't even taste. Also, I do try to avoid trans-fat. In fact more specifically, rather than just avoiding trans-fat, I avoid anything that says "partially hydrogenated" on the label, because this is the process that makes them. The FDA regulations say that if an item contains less than half a gram of trans-fat, the manufacturer can call it 0 grams. As a result, many things that say they don't have trans-

fat actually can have appreciable amounts, and what they sometimes do is report the nutrition information for very small serving sizes. I can probably eat about 10 servings of chips or crackers, so that would potentially give me several grams of trans-fat, even though I was eating none.

BSJ: I remember that in the class last semester, you mentioned that you and your friends used to get together once in a while to make bread.

Francis: Oh yeah, that was when I was in graduate school.

BSJ: Would you be willing to divulge your secret for the perfect bread?

Francis: I would certainly be willing to, but I don't know if I have it. I can give you recipes and stuff like that, but in general, it's more the technique than any specific recipe. As a good place to learn, I just got an excellent book called "Crust." The author is originally from France and has a very different way to knead the dough than I have seen before. He says the way we normally make bread is the English way. So basically, he is suggesting that you could keep baking like the English or buy his book to learn to bake like the French. That's an easy one. I bought the book on the spot. A lot of his recipes have turned out really well for me.

But key things: the oven temperature is crucial to get right, the oven humidity is important, and if you want sourdough, then you have to have a good starter recipe.

BSJ: What's your take on molecular gastronomy?

Francis: Too be honest, I think some of it is a fad. I think a lot of things you see in fancy restaurants result from them trying to be different or distinguish themselves from other places. I'm not sure a lot of it has an impact on taste. There are some interesting aspects to it, such as people thinking very carefully about how the food is cooked, and how they get exactly the texture they want, but people have been cooking more or less the same food for a couple of hundred years. A lot of this has already been figured out. We will see where it all goes, but I do think there is an inherent connection between cooking and understanding a little bit of science and chemistry in particular. This will probably always be around.

BSJ: So we are also a research journal. We would be remiss if we didn't ask about your research. Can you give a quick summary of what you've been doing for the last couple of years?

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Francis: My lab specializes in the development of new chemical reactions that can be used to modify proteins. We do this to combine them with synthetic molecules that can be made in the laboratory, such as colored dye molecules, polymers that would have long circulation times in the body, or tracers that you can image in hospital patients. As one example, we can take harmless viruses and modify the inside surface of their hollow shells with MRI tracers or PET tracers. We then modify the outside with groups that can target to specific tissues, such as tumors. We would like to use these materials for cancer diagnoses and for drug treatment. We have also used the protein arising from a different virus to position various pigments into synthetic light collection centers. These could be used as components of artificial photosynthetic systems. Another application that we are investigating is the use of proteins found in nature for the binding of toxic metals in the environment, like cadmium and mercury. By connecting the proteins to polymer strands, we are able to process them and work with them. So in all cases, we are using organic chemistry reactions to connect the artificial molecules to specific locations on the natural proteins. This lets us take the structure and function of proteins and put them into the material context.

NO-FAIL Soufflé Recipe
Adapted from a Julia Child recipe by Matt Francis

Materials:
7 eggs
4 Tbsp butter
4.5 Tbsp flour
1.5 cups whole milk
8 oz Gruyere cheese
Nutmeg, paprika, salt, pepper

Stand mixer or a whisk
Soufflé dish
Oven

1. Separate seven eggs, keeping six egg yolks in one bowl and all seven egg whites in another. Discard the seventh egg yolk.

2. In a small saucepan, melt 4 Tbsp of butter. Mix in 4.5 Tbsp of flour and stir with a whisk to make a roux. Let it cook while stirring for about 60 seconds, but don't let it darken.

3. Add 1.5 cups of whole milk to the butter and flour mixture and stir over low heat until it becomes very thick. Do not let the mixture boil. This is the béchamel sauce. Grind in a little nutmeg, and add a pinch of paprika. Add salt and pepper to taste.

4. Remove from heat. Add the six egg yolks to the béchamel sauce and stir immediately. It is important that the heat is off during this step so the mixture doesn't curdle.

5. Use a mixer to beat the egg whites, or mix them by hand with a whisk. Adding a pinch of cream of tartar will help speed up this process. Continue mixing until they are very fluffy and in the "stiff-peak" stage. This is when the mixture is able to stand up on its own after a portion is lifted gently.

6. Grate 8 oz of Gruyere cheese into a separate bowl.

7. This is the important step. There are a lot of YouTube videos showing how to do this, if you need examples. Combine 1/3 of the beaten egg whites with the yolk mixture by gently lifting and folding with a rubber spatula several times. Do not over stir. From this mixture, take 1/3 and add it back into the remaining egg whites. Add in a handful of grated cheese and gently mix by folding with the spatula. This process must be done gently so as not to crush the bubbles that were created by beating the egg whites. Add the next third of the egg white mixture, followed by another portion of cheese. Fold again to combine. Repeat with the remaining egg yolk mixture and cheese. Fold until just combined, and then stop.

8. Gently pour the mixture into a buttered 6 to 8 cup soufflé dish. Bake at 350-375 degrees Fahrenheit for 45 minutes.

9. The soufflé is done when a bamboo skewer can be poked into the middle and pulled out cleanly. The soufflé will not collapse as long as you do this carefully. Also, you do not have to tiptoe around the kitchen while it bakes. This is a myth.

10. Serve immediately, as the soufflé will fall within a couple of minutes after it is removed from the oven.