Fermentology • Book

Wild Sourdough

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Published on: Mar 31, 2021

Editors note: This publication contains the video of the talk from the Fermentology webinar series, as well as a lightly edited transcript of the lecture. The transcript has been enriched with media, annotations, and links to other material by the digital publication team in order to amplify and extend the content for a reading experience.

Abstract

At NC State's Department of Applied Ecology, Lauren Nichols, Erin McKenney and a team of collaborators are leading a new sourdough science collaborative project, based on insights from the Sourdough Project and questions that the Sourdough Project raised but was unable to answer. They are motivated to embark on this project now because it is a way to do new science, but also to engage a community of people around bread, microbes, and the community associated with reconnecting, whether that be reconnecting with past traditions, reconnecting with each other, or reconnecting with the mysterious microbes on which sourdough bread depends. The team leaders of the new collaborative effort, Wild Sourdough, will discuss these motivations, describe recent sourdough science discoveries and explain the key steps necessary to make a sourdough starter as part of this project. As they do, they will also discuss the science behind each of those steps.

Watch the talk

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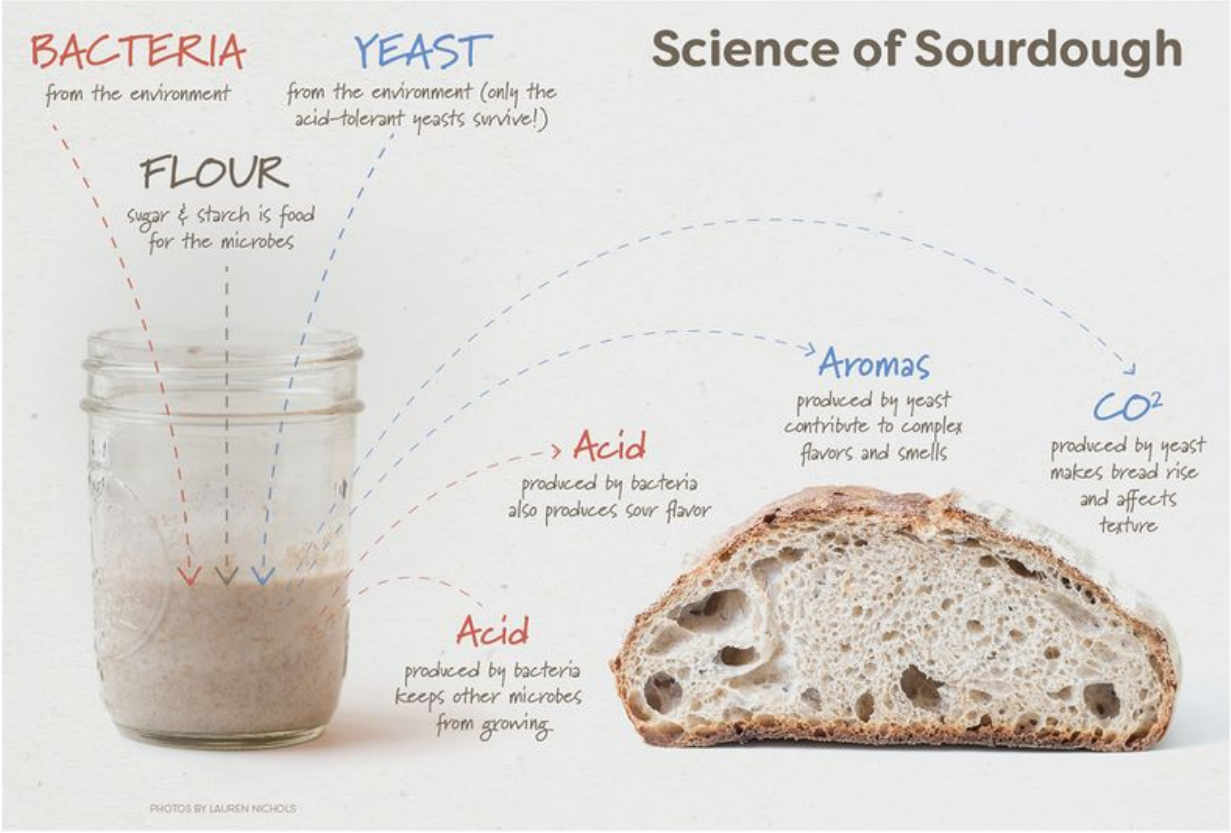
Wild Sourdough | Fermentology mini-seminars

Introduction

The microbial world is full of mysteries. There are millions, potentially trillions, of kinds of bacteria and fungi on Earth. We know more about the deep sea than we do about some of the bacteria and fungi that are most important to us. But luckily for those of us stuck at home, some of the answers might be lurking in your kitchens.

Whereas most microbial systems are incredibly complicated and difficult to manipulate, experimentally, there's one system that's not only easy to manipulate, but is getting more attention than usual right now. And that is sourdough.[1]



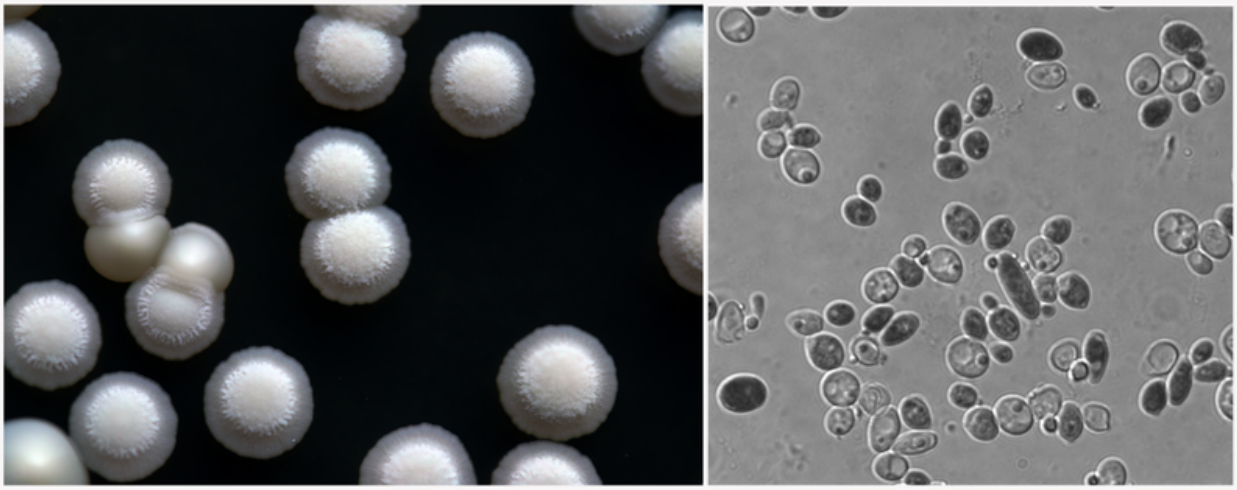
The Science of Sourdough from Students Discover.

Sourdough, Yeast, and our Breads

Sourdough isn't anything new. In fact, humans have been baking bread with sourdough starters for thousands of years. People were baking bread before writing was even invented. But most of the bread that we bake now is not sourdough. It's what we would call yeast bread. Commercial yeast that you can buy at a store or order online and that seems to be in short supply right now is usually only one of three strains of a single species of yeast called *Saccharomyces cerevisiae*.[1] This is the only yeast sold commercially for baking.

Yet we know that there are thousands of species, even hundreds of different genera of yeast that exist in the world. The yeast that you buy in stores has helped us to make bread reliably and quickly. Yet sourdough, that super old technology that was first used by our ancestors is still being produced. But why are some people still using that really old technology rather than modernizing and getting with the times? The reason is that the old way makes *really* good bread.

One of the reasons it makes such good bread is that wild sourdough can take advantage of its yeast diversity and bacteria. In sourdough, the yeast consume starches and sugars as their fuel and simultaneously expel carbon dioxide and alcohols. Lactobacillus bacteria, this bacteria that's special to sourdough and other fermented foods, also consume these starches and sugars, but they also produce acid — contributing to the sour flavor that some sourdough breads have. It also keeps other microbes, unwanted molds and other bacteria, from growing in your starter. These unwanted microbes are unable to tolerate the acid, unlike the sourdough yeast, and so they persist. They eat the sugars and the starches, and they fart delicious gas bubbles. Together, the bacteria and the yeast create a stable ecosystem within the starter.



Wickerhamomyces yeast colonies grown in the lab from a wild sourdough starter (left) and a close up of the individual cells under a microscope (right). Images by Elizabeth Landis from the Rob Dunn Lab.

But as we mentioned, there are hundreds of yeasts and bacteria. Thus, why do we find certain lactobacillus bacteria and certain yeast in some sectors and not in others? And how do different yeasts and starters contribute to the aromas and the textures of the breads you bake in the end?

The Science of Sourdough

At the end of the day, as with most questions related to microbes, despite having thousands of years' worth of experience baking bread, there's still a lot we don't know.[2] There are still lots of yeast, even, that don't have names. We know absolutely nothing about them or what their role in this alchemy of turning flour and water into delicious bread. We know that yeast exist in flour, on the skin of the fruits that are probably in

your refrigerator, and even on our hands.[3] But what determines which yeast and bacteria end up in which starter?

To answer this question, a group formed to find out more about the science of sourdough. We reached out online and implored bakers to send us a sample of their precious sourdough starters — and we were absolutely blown away by the response. Over 500 people ended up sending us sourdough starters from around the world. Some of these starters were only a few weeks old. Others have been passed down from grandparents to grandchildren and divided and shared throughout the years. Some were regarded as some sort of family heirloom pet. It was amazing.[4]

Once we had these starters, we used the latest advanced DNA sequencing techniques to study the entire microbiome, compiling a complete list of everything living in each starter. What we found was that, while many of the starters were dominated by *Saccharomyces cerevisiae*, what we know as baker's yeast, we found 70 different kinds of other yeasts in the starters.[2]

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A visual aid from the research showing dough rise analysis using a common garden sourdough starter approach.

Even for the *Saccharomyces cerevisiae*, that baker's yeast, we found that there's diversity in the strains, much more than any of the commercial varieties that are available. In addition to the yeast, we found 70 different types of lactobacillus bacteria. Sometimes a sourdough was dominated by a single type of lactic acid bacteria, and sometimes there were multiple species coexisting in a single starter.

> **By including sourdough starters, our repertoire of yeasts expanded from three varieties of a single species to dozens of species.**

Let's just put this into perspective: if yeasts were dogs, then bakers today largely work with three breeds of dogs in the vast majority of baking. We'll call them the yellow Labrador, the black Labrador, and the chocolate Labrador. But when you look at diversity in sourdoughs, we learn that there is a vast diversity of different breeds of dogs. There are Poodles, Basset Hounds, and Great Danes. We discovered German Shepherds, Chihuahuas, and an occasional Afghan Hound. But it's not just the breeds of dogs. There are also other species. We encounter wolves, African wild dogs, and foxes — and not just one type of fox. We find red foxes and fennec foxes. The more we

look at sourdoughs, the more varieties and species we encounter, and we realize how little we know about any of them because we've been spending our time trying to learn how to work with Labradors and trying to figure out what the difference is between a yellow Labrador and a chocolate Labrador, rather than trying to figure out what makes a grey wolf different from a Pug.

Geography and Yeast

Once we knew which microbes were in each of the starters, we used information that the bakers had shared with us, including where their starter lives, where it was created, and how it was maintained. This helped us to figure out why we see certain microbes in some starters and not in others. So far, we have found that yeast tend to vary depending on your geographic location. We think that this is because of the climate where you live.

We found in other studies that geography tends to be a pretty good predictor of fungal diversity, and this makes sense because yeasts are a type of fungus. The bacteria in starters, however, do not seem to follow the same geographic rules that yeasts do. Instead, they seem to vary depending on factors within your home, like what kind of flour you feed your starter and whether you keep your starter on the counter or in the fridge. But we're still tweaking these models, so it's still preliminary.

With this, we could start to ask other questions, questions that we thought we knew the answer to already, such as: Is San Francisco sourdough actually different from other sourdoughs? There is a common understanding that it's different because it has a specific kind of yeast called *Lactobacillus sanfranciscensis*.[3] So it's even its namesake. But when we looked at global starters that we received, we found this bacteria in sourdoughs as far and wide as Australia and Germany and France. Therefore, if San Francisco sourdough is special, it's not because it has this one particular kind of bacteria after all.

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Following the 1971 identification of Lactobacillus sanfranciscensis, the Agricultural Research Service released the report “Consumer products by design : a report on new foods, fabrics, and materials from agricultural research", which proposed the possibility that science and distribution of commercial cultures “would make San Francisco-type sourdough bread available anywhere bakers want to produce it.”

Learning and Building with Sourdough

Even though we're learning more every day about the microbes in sourdough starters, this project has also been incredibly humbling. For every question we answer, 15 more pop up that we don't have any idea what the answer is. Apart from the wonders of microbial discovery, we've also discovered an incredible community of people through our partnerships with bakers across the world. We met at a baker in California who shared the story of Herman, a Yukon starter that has survived earthquakes and family tragedy. We've met professional bakers eager to share their trade secrets and partner with us as scientists to learn more about the glories of bread. Together, the participants have formed an incredible, welcoming community online where stories and wisdom are shared by both seasoned and aspiring bakers across the globe.

And yet, despite all of this work, we still have questions about these microbes and how they affect breed. That's why we need your help. We want you to make wild sourdough starters at home.

Your Sourdough Starter

Luckily, you only need a few materials to grow a microbial garden:

1. Flour
2. Water
3. A paper towel
4. A jar
5. Some spoons
6. A little bit of time and patience

We will help guide you through it the whole way. We have instructions on our website and an interactive Facebook group where you can ask questions any time and get advice from expert bakers who've been handling sourdough longer than any of us have.

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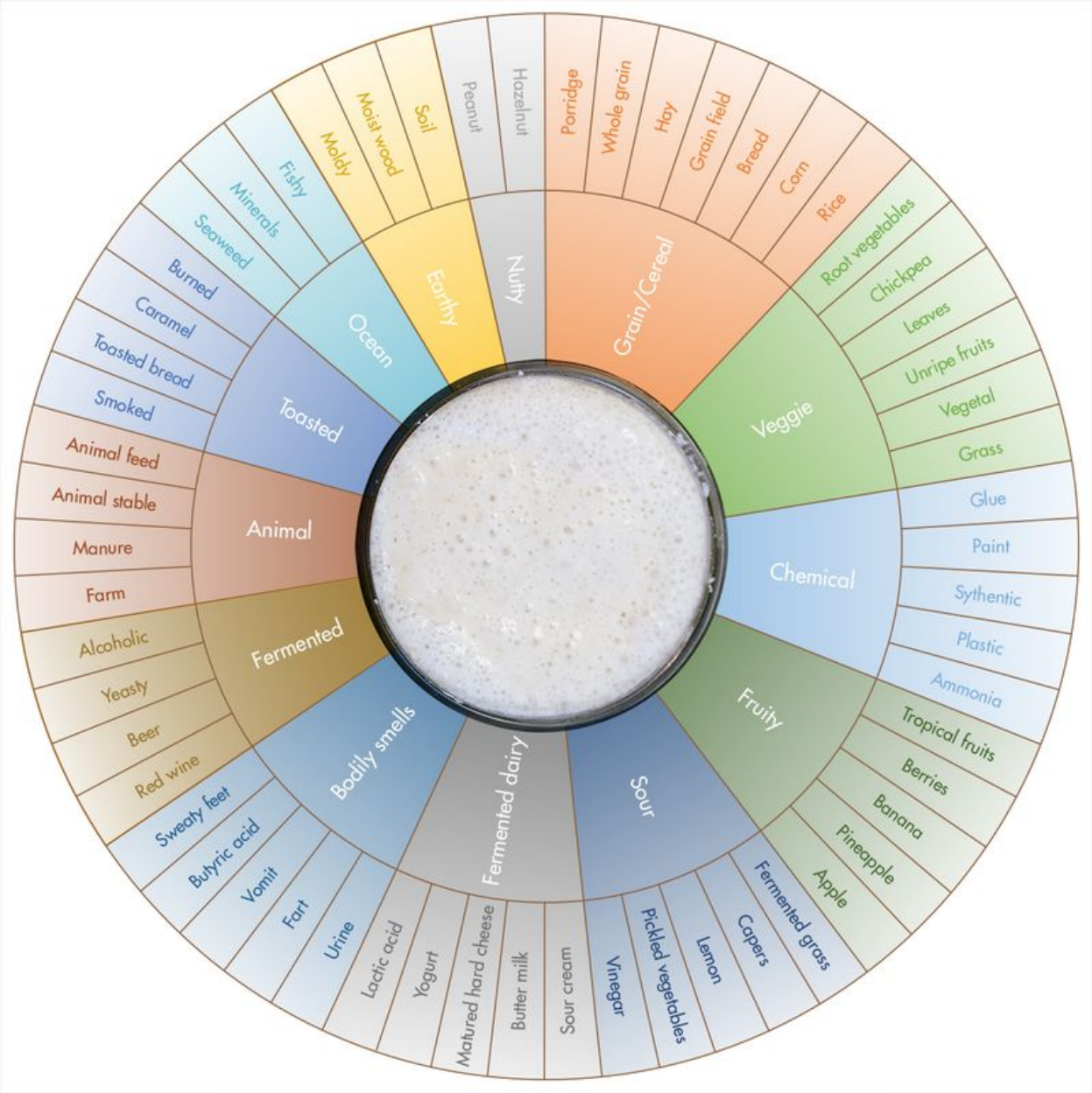
@NatGeo on *Twitter*.

After you've fed your starter 14 times, you'll take a few measurements. [A note: For most of you, this will be on your 15th day, but because some starters have faster metabolisms, so you might get there before the 15th day.]

1. You'll watch your sourdough over the course of the day, keeping track of **how fast it rises**. Ultimately, the measurement that we want you to send us is the maximum height your sourdough eventually reaches and how long it takes to get there.
2. We'll also ask you to sniff your starter and tell us a little bit about its **aroma**. Maybe it smells like bananas or vinegar. Maybe it smells like smelly feet, and maybe it even smells like beer.
3. Finally, we will ask you to send us **two photos**: one from the aerial view of your starter and one from the side when it's at a peak bubbly height.



“Characterize aroma” from the Rob Dunn Lab.

Together, your data can help us to answer questions that we couldn't answer before. As we mentioned before, yeast tends to vary with geography, but we still have a lot of unresolved questions about how geography affects your starter.

Click to submit your data!

Our original study was an exploratory study, not necessarily a controlled experiment. Below is a map of the places where each starter had migrated from across its life from its original place of creation. Some starters stayed close to home and others traveled halfway across the globe.

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"Sourdough Starter Results Map" by Lauren Nichols and Neil McCoy

There's a lot of variability here that we couldn't control in the original experiment that included starters of different ages and life histories. With the new Wild Sourdough Project, by growing new starters from scratch and all in your own homes, we'll be able to compare your starters directly without having to tease apart age or migration. We won't know which microbes are in your starter, but the rise and aroma of your starter can tell us a bit about the metabolism and microbes. Through this, we can learn something about how geography ultimately affects the rise and aroma of your sourdough.

We're also curious about different flour types and how that might affect your sourdough starter. From some of our previous work, we know that different bacteria and yeast are present in different types of flour, but we don't know how these different inputs might affect the mature starter. Therefore, if you have several different types of flour at home, we'd love for you to grow several different starters and compare them to help us explore how different flours affect your starter.

At the same time, we understand that people are concerned that there's a limited access to flour. The project only requires a cup and a half of flour to grow a starter. This is perfect if you only have a little bit or if you have random leftovers of some flours in the back of your cabinet that you don't know how to use. But if you only have time to make a single starter, that's fine, too.

Sourdough: Building Community

We're excited for the data, but we're really excited to share in your experience along the way as well. By sharing your questions and observations, we can come up with new experiments and directions together, emphasizing our goal to make this a collaborative approach.

Ultimately, we're all stuck at home, too. We're locked out of our labs without our lab equipment. As such, we want to join you in exploring ways to continue being curious about the world and solving microbial mysteries together at home.[5]

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From NPR.

> **As humans, we've been baking bread forever. It is what it has always been: all about communities, communities of microbes, communities of scientists, communities of bakers, and communities of people.**

While we're all practicing social distancing, we can still come together as community. Please join us as a community of scientists, bakers, and microbes.

For Teachers

Please consider using this project to build lesson plans or learning modules about chemistry, history, biology, evolution, or ecology. We've made resources that span science, math, and language arts. In doing so, we imagine a world in which everything could be taught through fermentation. Of course we do.

Footnotes

1. To learn more about sourdough, please also read "The funky science of yeast, the gassy microbe behind your pandemic bread" from *National Geographic* and "Sourdough Starter, America's Rising Pet" from *The New York Times*. ↩
2. To learn more about all there is to learn about sourdough, listen to Gastropod's "Secrets of Sourdough" episode. ↩
3. To learn more about the role our hands play, please read "Sourdough Hands: How Bakers And Bread Are A Microbial Match" by Lindsay Patterson from NPR. ↩
4. Metadata, along with sequence data and taxonomy, for the 500 samples reported in this study are available on Figshare, with fields stripped to preserve participant privacy. ↩
5. Marcus Woo's "Discovering The Science Secrets Of Sourdough (You Can Help)" from NPR explores the role of public science in learning more about sourdough and

in “So Your Sourdough Starter Failed? That's OK, Science Needs It,” Brianna Scott and Christopher Intagliata (embedded below) talk about making sourdough, and even the failures of making bread, with the Wild Sourdough Project. ↩

Citations

1. *Saccharomyces cerevisiae* Meyen ex E.C.Hansen, 1883 in GBIF Secretariat (2019). Global Biodiversity Information Facility Backbone Taxonomy. https://doi.org/10.15468/39omei ↩

2. Landis, E. A., Oliverio, A. M., McKenney, E. A., Nichols, L. M., Kfoury, N., Biango-Daniels, M., … Wolfe, B. E. (2021). The diversity and function of sourdough starter microbiomes. *ELife*, *10*. https://doi.org/10.7554/elife.61644 ↩

3. *Lactobacillus sanfranciscensis* in GBIF Secretariat (2019). Global Biodiversity Information Facility Backbone Taxonomy. https://doi.org/10.15468/39omei ↩