

Kombucha: Microbial Worlds & Materials in a Jar



**Kombucha is a
system, a story,
and a biomaterial.**

Inside the Jar:

This is a living system that
tells us stories about
microbes, biochemistry,
design, and more!



About RockEDU Science Outreach

Toward a future where all of humanity can shape and benefit from science

RockEDU Science Outreach represents the collective science engagement and research education efforts at The Rockefeller University. The RockEDU team works in collaboration with our communities to produce programs and resources that promote inclusive science learning. We are known for our research mentorship skills-building programs for scientists, undergraduates, and high school students, as well as day events that serve as an invitation for kids and teens to feel curious about science. As always, we approach our work by supporting people first, science second.



The RockEDU Sandbox: Discovery science anywhere

We first developed the RockEDU Sandbox to support mentors and mentees participating in our longstanding research program, the Summer Science Research Program (SSRP). Now, we are bringing our model out of the lab and into your hands! Use this guide on your own, or to help guide a group of learners along a road of scientific discovery in a way that is practical and accessible.



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Get to know kombucha from the inside out: what it's made of, how it ferments, and what the SCOBY does. Discover the science behind the living culture at the heart of every jar.

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Kombucha Systems Thinking

Dive into kombucha as more than a drink. Explore how microbes, environments, and human choices all interact, and learn how small changes in one part of the process ripple through the whole.

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SCOBY as a Biomaterial

A SCOBY is a living layer in kombucha that can be dried and transformed into a strong, flexible material. Artists, designers, and scientists are using it to imagine sustainable futures and create everything from fashion to packaging.

Model Systems

A model system represents a small, focused way to explore a specific concept or phenomenon. It helps us to observe, test, and learn.

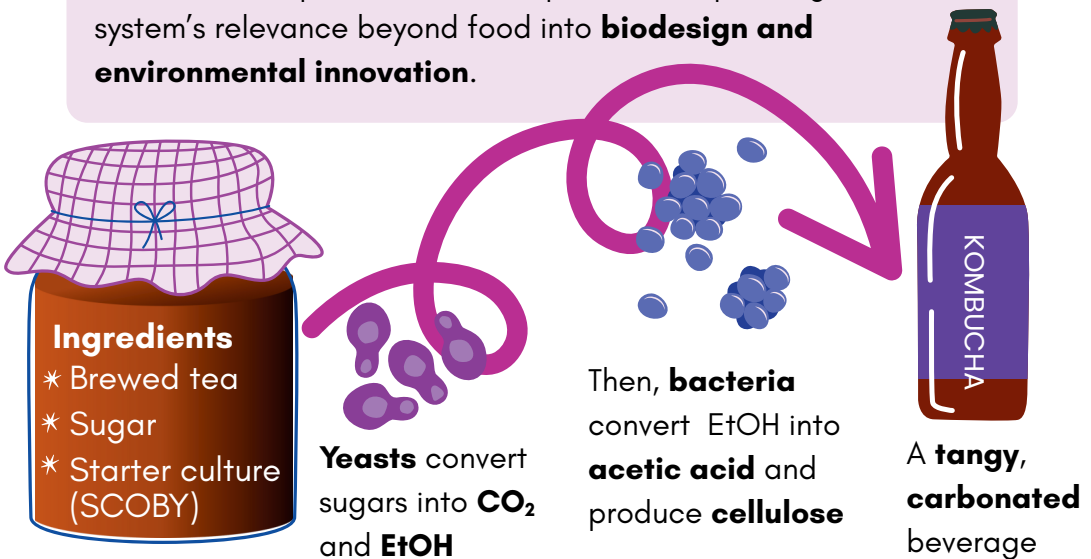
The RockEDU Sandbox

Our Sandbox model offers accessible scaffolds for exploring complex science through model systems. Teachers are supported and earners follow their own curiosities, test ideas, and explore how systems connect.

What is kombucha?

Kombucha is a fermented tea made using a **symbiotic culture of bacteria and yeast (SCOBY)**. It's a living microbial ecosystem that transforms sweet tea into a tangy, carbonated drink through fermentation, offering a dynamic model to explore microbial growth, metabolism, environmental conditions, and systems of food production and preservation.

In addition to being biologically interesting, the **SCOBY itself is an emerging biomaterial**. Once dried, it becomes a strong, flexible sheet of cellulose that can be used in **textiles, packaging, or even leather alternatives**. This introduces the idea of **microbially derived materials** as sustainable alternatives to petroleum-based products, expanding the system's relevance beyond food into **biodesign and environmental innovation**.





Thinking in Systems – What's Really Going On in the Jar?

WHAT IS VISIBLE, AND WHAT IS INVISIBLE?

WHAT ARE THE BOUNDARIES OF THIS SYSTEM?

WHAT ARE THE LIMITATIONS IN TERMS OF WHAT WE CAN STUDY?

Microbial Ecology

Yeast + bacteria live in balance — competing, cooperating, and adapting. As acid builds, yeast slows down, reshaping the community.

HOW CAN THIS SYSTEM BE PERTURBED?

WHO ARE THE PEOPLE WHO CAN TEACH US ABOUT THIS SYSTEM?



Environmental Inputs

Temperature, oxygen, tea type, and container shape all shift how the system behaves.

WHERE DO WE SEE THIS SYSTEM IN OUR WORLD?

Human Culture... Cultured

Human choices shape kombucha — from DIY jars to industrial brews. It reflects culture, access, and the stories we pass on.



Quick Facts

Microbial Ecology

- A SCOBY is mostly made up of cellulose that is made by bacteria
- Yeast make alcohol and bacteria turn this into acid
- When there is too much acid, it slows down yeast growth
- Microbial communities undergo cycles of succession

Environmental Inputs

- Different teas can impact microbial growth in different ways
- Microbial growth is sensitive to oxygen levels and temperature
- The shape of your jar can impact airflow in the jar
- Factors like sugar and brew time can impact microbial growth

Human Culture... Cultured

- The earliest evidence of fermentation of food products by humans dates back to 5000 B.C.
- Food fermentation represents a combination of science, craft, and human culture, past and present

Discovery Awaits!

Easy Ideas for Discovery Research with Kombucha

Table 1: Selected measurement, tools, and variables associated with using kombucha as a model system (there are more out there!).

Metric	Tools	Variables
pH	pH strips pH meter	Brew time Tea type Brand differences
SCOBY Growth	Ruler Scale Tensile Strength Tester	Temperature Jar Shape / Surface Area Sugar Type / Concentration Additives
CO ₂ Production	Balloon on jar Water displacement method Gravimetric method CO ₂ Probe / Sensor	Temperature Jar Shape / Surface Area Sugar Type / Concentration Additives
Smell / Taste	Observation and descriptive vocabulary	Temperature Jar Shape / Surface Area Sugar Type / Concentration Additives Brand type



Microbes will continually adapt to their dynamic environments

Tea Type

Different teas contain different things

Global access to diverse teas lets you manipulate and measure the system. How does changing tea type affect microbial growth, flavor, or fermentation speed? what are other questions you can ask?

Sugar Type

Sugars are a class of molecules

How do the different molecular structures contained in different sugars impact how kombucha microbes grow? You can try different things like honey, maple syrup, corn syrup, table sugar, and more!

Sugar Level

Sugar can be just right, or it can be toxic

How much sugar you add to your kombucha brew can have significant impacts on the growth of your SCOBY. If there is too little sugar, the yeast will be limited in how much "food" they make for bacteria. But if you add too much, you might overwhelm the yeast. What to do!

Temp.

Microbial growth depends on temperature

The enzymatic processes that sustain the microbes that make up a kombucha SCOBY are very sensitive to temperature. Temperature influences the efficiency of these enzyme, so has an impact on overall growth and metabolism.



SCOBY as Biomaterial

When dried, the SCOBY forms a strong, flexible sheet of bacterial cellulose — a biodegradable, breathable material offering a possible alternative to plastics and leather

SCOBY Engineering: What People Are Making

Around the world, artists, designers, and scientists are growing SCOBY into functional materials:

- In fashion labs, SCOBY sheets are dyed with plants and shaped into jackets, shoes, and accessories — no plastic, no waste.
- At design schools, students are creating SCOBY lampshades and wall panels that mold to custom shapes as they grow.
- In community kitchens, people are testing SCOBY as a biodegradable packaging for food or cosmetics.
- Some researchers are blending SCOBY with other fibers to make wearable tech prototypes or eco-textiles.

Our mission is to support students, educators, research trainees, and scientists in building technical and professional skills, confidence, and impactful STEM community connections.



INFORMATION ABOUT ON-CAMPUS PROGRAMS

Science Saturday

- Free, ticketed science festival for families
- Features authentic science learning
- Kids get to interact with local scientists!

- STUDENTS IN GRADES K-8
- REGISTRATION REQUIRED
- OCCURS ANNUALLY

Talking Science

- Free, day-long event bringing together Rockefeller researchers with students and teachers from the Tri-State area
- Topic is focused on research presented by a Rockefeller Head of Lab
- Students can explore topic through lectures and hands-on activities

- HS STUDENTS & TEACHERS
- REGISTRATION REQUIRED
- OCCURS ANNUALLY

Jumpstart

- Free, combined after-school and summer science research experience centered on scientific research skills development
- Students who have had limited access to, or have been excluded from adequate STEM opportunities are strongly encouraged to apply

- HS JUNIORS & SENIORS
- COLLEGE FRESHMAN
- APPLICATION PROCESS
- MARCH - AUGUST

Summer Science Research Program (SSRP)

- Seven-week, team-centered basic science research program
- Students receive diverse mentorship guiding the development of research skills, professional networks, and research communication
- Students ask their own research questions, encouraging confidence and independent thinking

- HS JUNIORS & SENIORS
- COLLEGE FRESHMAN
- APPLICATION PROCESS
- JUNE - AUGUST

Lulu Wang Scholars

- Undergraduates team up with research scientists across 2 consecutive summers to co-create, teach, and refine a basic science research course for other undergraduate students
- This course will be offered to neighboring Hunter College students

- COLLEGE JUNIORS & SENIORS
- APPLICATION PROCESS
- SUMMER & WINTER

THE ROCKEFELLER UNIVERSITY

Science for the benefit of humanity





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