NU SCI

ISSUE 44 Spring 2020

EAT

TABLE OF CONTENTS

Supported by the Student Activity Fee

Northeastern University
College of Science

LETTER FROM THE EDITOR

I doubt any of us will forget the spring of 2020, even decades after we've graduated from college. For many of us, myself included, that was the semester that within a few days we abruptly learned we would never sit inside a Northeastern classroom again; the semester we were recalled from global co-ops all over the world; the semester many of us were forced to flee home to continue our studies in the newly unfamiliar chaos of our now confined and claustrophobia-inducing houses.

My family are restaurant owners, with a small, independent restaurant here in Buffalo, NY. For us, this was the spring we learned we would have to shut our doors and turn away the thousands of diners who sat throughout our halls each week — many of whom, in a small city like this, are friends and neighbors.

From then on, the only food we were allowed to serve came wrapped in white paper boxes and clothed in brown paper bags, then hand delivered by our unrecognizable, masked faces to other unrecognizable, masked faces waiting in cars lined up neatly outside our doors. The delivery was impersonal and utilitarian; getting too close to another human was seen as a risk for both them and us. Our role was to feed people, and theirs was to pay us, not to accidentally compromise each other through displays of affection.

Socially, at least, the situation was unnerving. What was a month ago one of the most vibrant and busy venues in our city, filled with hundreds of diners on any given night, was now reduced to a population of five employees: myself, my parents, a chef, and a baker. All the more unnerving was the reality that roughly 100 less-fortunate individuals had to be laid off in order to keep the lights on; though that decision wasn't made lightly.

For the vast majority of small restaurants around the world — ours included — the economic toll of this forced closure so far has been close to ruinous. Though these are exactly the places we need to hope weather the storm — that not only the Applebee's and Cheesecake Factories are around in the summer, fall, or whenever it may be when doors are opened once more.

Food can be art, food can be culture, and for some, food can even be a type of spiritual practice. But for many of us, food is the excuse to find time for the ones we love in our increasingly congested schedules.

And with time, this crisis will end, and some fortunate restaurants will open again. When that happens, cherish those opportunities to meet a colleague for a drink after work, celebrate a birthday at your favorite restaurant, or simply catch up with an old friend over lunch.

Please enjoy the 44th edition of NU Sci: "Eat."

Lucas Principe
Editor-in-Chief

STAFF

Cover Photo by Gus Mueller

SUSPICION OF NUTRITION:

IS EATING ORGANIC REALLY ANY BETTER FOR YOU?

BY ETHAN WAPLE, BIOLOGY, 2023

A growing majority of consumers have begun to make the switch from conventionally-grown to organic produce hoping to feel a bit better about the food they're eating and where it came from, even if it means dropping a few extra dollars each week on groceries. Since the latter half of the 20th century, organic agriculture has been cultivated into a multi-billion dollar industry despite a lack of substantial research backing the very health benefits it promises its consumers, raising the question: is organic produce really any better for you?

To put it simply, numerous studies have shown that there are no significant differences between the nutritional content of conventionally and organically grown produce. On the contrary, organic farming's approach to distancing itself from man-made substances, trading in the use of synthetic pesticides and fertilizers for those found in nature in efforts to lower their dietary and ecological impacts, has introduced several obstacles that stand in the way of its goals as a more natural alternative to conventional farming. In fact, many scientists argue that these naturally derived pesticides are quite often no safer for consumers or the environment. One example of this is copper sulphate, a naturally occurring fungicide that is rapidly bioaccumulated and can be incredibly toxic even in low doses. Meanwhile, animal manure, the primary substitute for synthetic fertilizers, has been shown to greatly increase the risk of contamination by pathogens such as *E. coli*, *Listeria*, and *Salmonella* in crops. This is especially concerning as fresh produce is often eaten raw and without the use of chemical treatment, leaving consumers nearly twice as susceptible to infection when compared to the risks of consuming conventionally grown crops.

This is not to say that organic agriculture is all bad, however. Despite negligible difference in nutritional content, organic produce has been shown to contain higher levels of important antioxidants which, despite having any substantial evidence indicating major health benefits, are generally believed to play a role in combating several forms of heart disease and cancers. In addition, the alternative pesticides used in organic farming are believed to decrease the symptoms in those with mild food allergies who may be allergic to certain types of synthetic compounds. Most of all, the widespread demand for organic agriculture is reassuring, as it indicates a movement towards increased awareness regarding where our food is coming from and what is in it. Organic agriculture done right implies a heightened regard for our bodies and our planet and should the aforementioned obstacles be overcome, true organic agriculture may very well be the farming of future.

DESIGN BY YECHAN YANG, BIOLOGY AND PSYCHOLOGY, 2022
PHOTO BY MALIMAEDER FROM PEXELS

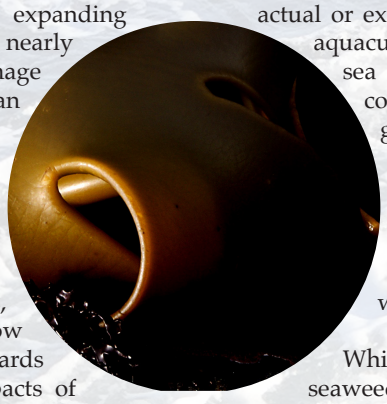
Kelp is the new kale

How seaweed aquaculture is the future of farming

BY JASON DENONCOURT, CHEMICAL ENGINEERING, 2023

DESIGN BY IAN PROULX, BIOENGINEERING, 2022

Livestock and agriculture occupy about 11 percent of the world's land surface while accounting for nearly 9 percent of all global emissions. With a rapidly expanding global population — some estimates reaching nearly 10 billion people by 2050 — and irreversible damage from climate change, scientists are exploring an unexpected solution: seaweed aquaculture.



Plants have four fundamental needs for growth: water, nutrients, light, and temperature. While traditional agriculture requires hundreds of acres of fertile land, millions of gallons of valuable freshwater, and harmful fertilizers and pesticides, aquatic plants have all the necessary means to grow without human input. With a greater shift towards this zero-input food production, the local impacts of traditional farming and ranching, such as soil degradation and drinking water pollution, would bear a far lesser impact.

Packed with essential vitamins and minerals — even containing calcium at higher concentrations than milk — some believe that seaweed has the potential to be the next food craze. Kelp can be used as a healthy pasta substitute, or simply even in salads. In fact, seaweed aquaculture is the fastest-growing component of food production in the world, with a growth rate of 8 percent annually. Despite its health and environmental benefits, many Americans are struggling to adopt the new craze, as seaweed has an unfamiliar dense, slippery texture and ocean flavor.

Even if Americans fail to adopt seaweed from the beach to their plates, seaweed has many applications beyond a health-nut's salad. Simply incorporating seaweed into animal feed can dramatically lower the carbon footprint of ranching. Recent experiments demonstrate that the fermentation of seaweed, which simulates ruminant digestion, substantially reduces the methane emissions of cattle. An addition of only 2 percent of a specific seaweed species to feed can reduce the potent methane emissions of cattle by 99 percent. Furthermore, the prebiotic compounds and essential minerals in seaweed have been found to enhance the health of cattle and decrease their need for antibiotics, helping to address the public health antibiotic crisis.

The Intergovernmental Panel on Climate Change defines climate change adaptation as the process of adjustment to actual or expected climate changes and its effects. Seaweed aquaculture establishes and strengthens existing coastal sea communities, which maintain biodiversity and combat coastal storms. While natural seaweed grows at the benthic or bottom layers of the ocean, aquaculture is suspended in the open water and can disrupt waves, specifically in large storms that are growing in prevalence as a result of climate change. In Norway, kelp aquaculture has been reported to reduce coastal erosions and wave heights by 60 percent.

While trees are planted to sequester carbon dioxide, seaweed is more effective. Seaweed is often referred to as a carbon sink, acting as an important conduit for carbon sequestration from the atmosphere and ocean. As greater volumes of carbon dioxide are released into the atmosphere, it diffuses into the ocean and reacts to form carbonic acid, lowering the pH of the ocean and crippling local ecosystems. Fortunately, seaweed growth elevates ocean pH levels by absorbing carbon dioxide and producing oxygen — locally reducing ocean acidification and de-oxygenation. As a result, seaweed farms have high rates of biodiversity, as areas of dense seaweed aquaculture are ideal locations for the growth of calcifiers like lobsters, crabs, and other crustaceans. GreenWave, a company in the business of harnessing this biodiversity, provides ocean farmers with the information needed to set up a system of 3D regenerative ocean farming. This polyculture vertical farming system optimizes the use of vertical space in the ocean by growing complementary species in close proximity. Seaweed, scallops, and mussels are grown near the top, while oysters and clams are grown at the seafloor.

Seaweed has the potential for significant climate change mitigation and adaptation. It is most certainly not a cure for climate change nor for feeding the world's exponentially growing population, but it is a possible remedy that should not be overlooked. Seaweed is one of the most sustainable foods on the planet and is becoming an increasingly popular cuisine, so don't be surprised if you see kelp avocado sandwiches or a kelp salad soba bowl on the menu in a few years.

Frontiers in Marine Science (2017). DOI: 10.3389/fmars.2017.00100

PHOTOS BY FLICKR AND IAN PROULX

THE BUZZ AROUND BEE NUTRITION

BY LAUREN MACDONALD,
CHEMISTRY & ENVIRONMENTAL STUDIES, 2022

DESIGN BY SOPHIA HITT, BIOLOGY, 2023

It's hard to go very far these days without hearing about the latest diet craze. Humans naturally crave diets high in protein, fats, and sugars because those nutrients, called macronutrients, are needed in the highest volume for our bodies' daily functions. Humans aren't the only ones who rely on those nutrients, and we aren't the only ones who find ways to regulate our intake of them to stay healthy.

Bumble bees need a minimum of each of these things (as well as the two other macronutrients: water and fiber). The majority of a bee's carbohydrates comes from plant nectar. Of all the nutrients, bees primarily need carbohydrates because they are foragers. Foraging is a relatively energy-intensive strategy of food collection, so bees consume a large amount of calories and must replace them in the form of sugars.

> "Bees are actually able to self-regulate what they consume in order to stay healthy."

The other source of nutrients for a bumble bee is pollen, which provides the majority of protein and fat. Each plant species has pollen with different nutritional qualities. Depending on the plant species, the protein content of pollen ranges from 2 to 60 percent, and the amount of fat is between 2 and 20 percent.

A bee must regulate the amount of each nutrient it consumes because its diet, just like ours, has an enormous effect on physical health. Consuming a diet too high or too low in fat, for example, can affect a bee's immune system, ability to reproduce, and tolerance to environmental stressors.

Because of how important maintaining a proper diet is, bees are actually able to self-regulate what they consume in order to stay healthy. Bees are capable of understanding and differentiating the nutritional values of pollen in different plants. They can taste and distinguish high or low fat content and will avoid pollen that is too high in fat. A 2017 study published in *The Journal of Experimental Biology* found that two species of bumble bee, *Bombus terrestris* and *Bombus impatiens*, prefer a diet that has a protein-to-fat ratio of approximately 13-to-1, and will selectively feed from multiple species to achieve that ratio.

It is fairly common knowledge that bees are important pollinators and that they are being threatened. Nearly every fruit and vegetable we eat requires pollination. Pollination allows plants to reproduce and grow fruits or vegetables, and without bees we would have a much harder time pollinating crops. Unfortunately, bee species have been declining in the past decades. In 2017, the first bumble bee species was listed as endangered by the US government after the population declined by 87 percent. Before that, seven other species of bees had been added to the list. They are also becoming locally extinct in areas where they were once abundant.

There are a variety of theories behind declining bee populations. Limited food diversity due to habitat destruction is a factor contributing to the bees' struggle. Changes in plant habit as a result of climate change are also potentially affecting what is available for bees to eat. If bumble bees and other bees aren't able to maintain the correct diet because there isn't enough plant diversity, it could be catastrophic for bee populations and the world.

The impact of bee loss is also dangerous for ecosystem stability. Many food chains rely on insects as the base. If some or all species of bees become extinct, it could have devastating effects on other species of plants and animals in those ecosystems. Given their importance, we need to use what we know about their diets to do everything we can to help bees thrive because when they get the nutrients they need to survive, we get ours too.

Journal of Experimental Biology (2016). DOI: 10.1242/jeb.140772

Reduce, reuse, and consume

BY SHELLEY SEUNGHYE JEON, PHARMACY, 2025

DESIGN BY SOPHIA HITT, BIOLOGY, 2023

The recent movement towards abandoning single-use plastics engenders innovative solutions to challenge the affordability and functionality of plastic. One instigator is the startup Notpla, which develops edible and biodegradable packaging made from brown seaweed. The UK-based company affectionately refers to brown seaweed as "nature's most renewable resource" because of its abundance and cost-effectiveness. It does not require fresh water or fertilizer to grow and even helps offset the acidity from ocean pollution via photosynthesis. Notpla went viral in 2019 for its flexible, transparent sachets that are ideal for a variety of beverages and sauces, including everything from whiskey to ketchup. The sachets — called Oohos, for the sound people make when they see it for the first time — are easily digestible, biodegrade in four to six weeks, and can be produced for just two cents.

The use of seaweed-based packaging is producing major dividends for restaurants, supermarkets, and sport stadiums alike. Thirty restaurants partnered with the U.K. food delivery service Just Eat are currently using Notpla's sachets to hold take-out condiments. Other research also supports the efficacy of algae-based edible films in improving the quality and extending the shelf life of produce, meat, and dairy through the edible film's ability to reduce dehydration, control respiration, and preserve the physical appearance of foods.

To date, Notpla's biggest success remains the 2019 London Marathon, in which approximately 200,000 Oohos containing sports drinks were distributed to marathon runners. The marathoners could pop the sachet in their mouth — a sensation similar to biting a cherry tomato, according to Notpla's co-founder Pierre Paslier — and could choose to eat the sachet's jelly-like membrane or simply spit it out. This project was a drastic improvement from the 2018 London Marathon, during which 910,000 plastic water bottles were handed to runners.

Notpla and related research receive considerable acclaim as potential frontrunners in breaking the food industry's deep attachment to single-use plastics. Future Notpla products currently under development include heat sealable films — to use as wrappers or packets for dry foods, sachets for non-food products, and produce-carrying nets. Despite the seismic potential of the edible packaging industry, issues pertaining to the strength, taste, and hygiene of such edible solutions must be solved before large-scale implementation can occur. Yet considering the widening roles of both technology and environmentalism in today's food industry, a future of zero-waste dining may not be so far away.

Foods (2018).
DOI:10.3390/foods7100170

PHOTOS BY WIKIPEDIA & MICHELLE BAILEY, FLICKR

WASTE NOT, WANT NOT:

Dumpster diving may not be such a bad idea after all

BY SHREEJA DALIPARTHY, COMPUTER SCIENCE & BIOLOGY, 2023

It's a modern tragedy: everything on the menu looks good, you can't help but order way too many appetizers, you eat until you can't breathe, and still your plates aren't even close to empty. The waiter takes everything away, but you don't let it weigh on you too much; maybe next time you'll master the art of ordering the perfect amount of food.

However, habits like over-ordering aren't as harmless as they seem. According to a 2011 study conducted by the *United Nations' Food and Agriculture Organization*, roughly a third of food produced for human consumption is lost or wasted globally. The problem of food waste spans social, industrial, and environmental borders, and it is precisely this intersectionality that makes the issue so pressing. As our leaders struggle to find renewable resources to support our dramatically increasing global population, the food industry in particular faces an urgent duty to effectively combat food waste — there are more mouths to feed than ever, and wasting food has simply become unsustainable.

While food losses are comparable in both developing and industrialized countries, developed nations contribute more to consumer- and retailer-driven global food waste. This distinction can be partially attributed to "consumer culture," wherein citizens of capitalistic, industrialized nations let materials go to waste out of convenience, or in favor of purchasing the next desirable model. Conversely, in poorer regions of the world, sustainability is a necessity — poverty dictates that nothing be wasted. But regardless of the prevalence of food waste in any given region, it directly contributes to food shortages, water stress, loss of biodiversity, and increased greenhouse gas emissions. In an era characterized by the consequences of a disregard for our environment, accepting these detrimental effects is dangerous.

Despite the complexities of food waste, there's hope for the future. As consumers, it's easy to be overwhelmed — especially by problems driven in part by corporations. But small, conscious choices can help alleviate harm. Composting unused food, deprioritizing the appearance of produce, and repurposing food scraps are all steps that we can take to avoid exacerbating the situation. Increased consumer conscientiousness, coupled with the development of new waste management technologies — such as in France, where grocery stores are banned from disposing of unsold food — can eventually lead to large-scale strategies that effectively handle the problem.
In the meantime, though? Let's agree to stick to just one entree at dinner.

SMART FOOD

BY SANJANA MISHRA, COMPUTER SCIENCE, 2023

DESIGN BY MARISSA KEESEY, ELECTRICAL ENGINEERING, 2022

Whether it's dining at your favorite restaurant or making a bowl of cereal, food is something that connects everyone. But what connects us to our farmers? The entire food industry is built on the need to transport products from our farms to our fridges and then into our stomachs. As of right now, manufacturing, distribution, and retail account for a little under half of edible food waste. Essentially, the food processing and handling industry is horribly disorganized, and it's leading to an exorbitant amount of waste. So how do we make processes like these more efficient? The answer lies in artificial intelligence.

Artificial intelligence (AI) has the potential to revolutionize this aspect of the food industry as we know it today. While automation has become more prevalent in all aspects of the industry, AI takes this a step further by introducing "smart" software. This software can essentially do what humans can do — recognize food, determine quality, etc. — by using sensors, robots, and other kinds of information gathering techniques. From the raw ingredients to the fully prepped meal, AI can help increase efficiency, yield, and consumer satisfaction while also helping corporations maintain superior quality.

At its most basic level, AI can aid the food processing and handling industry by boosting and sustaining customer satisfaction. One way of doing this is by making transportation of food items more efficient and organized. AI can improve the current transportation process by consolidating data about a product as it travels from farm to consumer — making the tracking process much simpler. This benefits customer satisfaction as it increases transparency as well as possibly preventing surplus.

Additionally, AI can make testing a product at every stage of the supply chain simple — a goal that is time and labor intensive with the technology available to us today. AI implemented through automatic testing and sensor checks can make this testing process simpler — again improving consumer satisfaction. This kind of quality control and contamination prevention are two important aspects of food processing and handling, and corporations are already working on improving the process. TOMRA, a sorting and collection solutions provider in Norway, is using x-ray, near infra-red spectroscopy, laser, cameras, and a machine learning algorithm to examine the different features of the objects they're sorting. Essentially, this machine can help ensure that the best quality produce and food items are going to market. TOMRA can pick out unripe, bruised, or bad quality fruit, ensuring that the food company's reputation remains positive; and, in the rare case an orange finds itself in a barrel of apples, TOMRA can put it back where it belongs. TOMRA's goal is to ensure product safety while also making the process of sorting foods more efficient and convenient. This can help food companies prevent huge recalls which cost time, revenue, and additional resources while also damaging a brand. Corporations and agencies can use services like the ones TOMRA provides in order to increase yield and revenue, as well as efficiency.

While TOMRA's algorithm directs the machines, the machines themselves need to be cleaned in order to prevent contamination — this is where AI comes in again. The University of Nottingham developed the Self-Optimizing-Clean-In-Place (SOCIP) which uses optical fluorescence imaging and ultrasonic sensing technologies to collect data and share it with a machine learning algorithm. This algorithm can monitor microbial debris and food particles present in the machines. By implementing this technology, the University hopes to help food companies in the United Kingdom save 133 million pounds a year while cutting equipment cleaning time in half.

At a higher level, AI is used in a more controversial manner: to ensure that basic hygiene is maintained by restaurant employees. In Shanghai, China, the municipal health agency implemented AI enabled cameras in hundreds of restaurants with the goal of helping managers make sure that their employees are following health codes. If a possible violation is detected, the image is extracted and then sent to a manager for investigation purposes — in theory, helping prevent contamination and also maintaining a high standard of quality assurance.

Artificial intelligence is the future of computer science and many other industries — including our food. By working on speech and visual perception, decision making, translation, and more "human-like" skills, computers may be able to solve the problems of the future — like how to make sure the ripest avocado ends up on your kitchen table.

Taming the yeast and preventing a-rye bread

BY BINH DANG, ENVIRONMENTAL SCIENCE & ENGLISH, 2022

DESIGN BY HEATHER WELCH, ENVIRONMENTAL SCIENCE, 2020

One of the simple pleasures in life for the gluten tolerant is a loaf of freshly baked bread. For thousands of years, this culinary staple has sustained civilizations. Although ancient Egyptians mastered sourdough bread making, many people today fail to make even a modestly risen boule. Bread making has been considered an art form for centuries but thanks to science, we have the knowledge to augment every step of the process.

For anyone who's tried and failed to make bread from scratch, you know how fickle dough may seem — sometimes it's over-proofed, other times the gluten didn't develop, and sometimes it didn't rise at all. Troubleshooting these mishaps can be crummy, but understanding the biology and chemistry of bread can help diagnose issues that arise.

The essence of any bread recipe is flour and water. From tortillas to baguettes, these two ingredients form the foundation upon which any dough is built. When the dough is mixed, and ultimately kneaded, two proteins in flour — glutenin and gliadin — interact and form gluten. The water links them together via hydrogen bonds and disulfide linkages into a large, elastic network. Kneading stretches the gluten and strengthens the dough. Not kneading enough is often a recipe for disaster because weak gluten networks can't hold carbon dioxide well, so the bread will end up flat.

> "Troubleshooting all of these mishaps can be crummy, but understanding the biology and chemistry of bread can help diagnose issues that may arise."

Of course, there are deliberately flat breads, which brings up the element that elevates a leavened bread like sourdough from an unleavened bread like matzo: microorganisms. Any baker must be mindful that the yeast (and bacteria in a sourdough starter) are living organisms and can die. Whether one is using active dry, instant, or fresh yeast, the fungi must be alive for bread to successfully rise. When active, they break down the sugars in the mixture and produce carbon dioxide, which causes the bread to rise.

The production of gas by the yeast is called fermentation, or anaerobic cellular respiration. Fermentation is the most difficult part of baking bread — mainly because it involves waiting. Before creating individual loaves, the entire mass of dough is left to ferment, and flavor develops as sugars break down. Another byproduct of fermentation, ethanol, is also produced. This does imply that bread is slightly alcoholic, but the amount is negligible, and most is boiled off as the bread bakes.

After the bulk fermentation, the dough is portioned into individual loaves, shaped, and left to rest again. This is the final rise. The dough must rise twice because, after the initial proofing, the yeast is separated from its food source when carbon dioxide creates air pockets. Reshaping the dough allows the yeast to come into contact with more starch in the flour, continue to develop flavor, and fill in the gluten networks with smaller pockets of air that don't pop as easily as larger ones from the first rise.

Timing when the bread goes into the oven is also crucial to a voluminous loaf. Fermentation takes time to create appropriately sized carbon dioxide pockets. However, the yeast will also run out of food, and when they do, they will no longer produce any gas. This is the moment that bakes or breaks someone's final product. If the bread is over-proofed, then it'll deflate as it bakes and the bubbles will shrink. In addition, the bread will end up undercooked because the gas in the bread retains heat that cooks the interior. However, with smaller bubbles, there is less contact between the gas and the dough, which prevents it from being completely cooked. The key is to put the bread in as it's on the rise and before it's done proofing. This way, the yeast can still produce carbon dioxide in the oven and the loaf maintains the proper structure.

Even when considering all of these factors, ambient conditions such as humidity and temperature also play a minor role in the length of this whole process. This means that every handcrafted piece of bread will be unique. No matter what science says, no recipe can tell you how a loaf will develop until you can be one with the dough itself. So listen to the dough, return to humanity's culinary roots, and get this bread.

PHOTO BY GUS MUELLER, MECHANICAL ENGINEERING, 2023

The fermentation revolution:

How Noma is transforming the future of food

BY BRETON WORTHINGTON, BIOLOGY, 2021

DESIGN BY KYLA VIGDOR, DESIGN, 2021

"**I came all the way across the sea to learn something I can't learn in the States,"** Victor Eng tells me. "This is the place to create new products. We're creating the standard right now. No restaurant in the world is doing this." Eng is studying the formulation of new flavors at Noma, in Copenhagen, Denmark, hailed as 2019's second best restaurant in the world by Restaurant Magazine. As the progressive brainchild of visionary chef René Redzepi, Noma is where art and science intersect to produce the most exotic yet regional dishes known to the culinary arts. Drawing on a philosophy of hyper-locality, the majority of the ingredients come from Noma's own backyard. But it's likely you've never seen them on a plate before: Scandinavian mosses, ants, molds, jellyfish, and pinecones, just to name a few. However, implementing ingredients like these does not explain why Eng left a coveted position at No. 9 Park, one of Boston's most prestigious restaurants. The reason for Eng's pilgrimage was to understand how Noma's fermentation revolution is transforming the concept of food.

> "Noma's food scientists and chefs manipulate microbes to produce an imaginative and astonishing range of ingredients."

Located in a tricked out shipping container, Noma's fermentation lab has housed every imaginable ferment, from moose snout to moldy vegetables. Inside, Noma's food scientists and chefs manipulate microbes to produce an imaginative and astonishing range of ingredients, only five percent of which will see a dish. Despite this, the tedious trial and error proves worthwhile. Unsung but not unused, the discarded ingredients grow Noma's compendium of culinary knowledge, plotting an exploratory path into unknown territories of flavor. The few ferments that succeed are positively transformative. As Noma's Director of Fermentation, David Zilbur, explained at Harvard last October, only a few drops of an ingredient like fermented fish sauce adds an entirely new layer of complexity to a dish, which can intermingle with emotion and memory to produce a powerful dining experience. So essential are ferments to Noma's culinary wizardry, they're incorporated into nearly every dish.

"What they do at the fermentation lab is stuff that people don't really think about," Eng says. "I guarantee

PHOTOS BY GUS MUELLER, BIOENGINEERING, 2022

White Fish with Mushroom Broth, Wild Flowers, and Watercress

Chocolate-Infused Lichen Moss

the guests have no idea how much thought goes into a dish." By introducing new ingredients for microbes to transform, Noma's chefs are tinkering with fundamental metabolic pathways. Typically, Western chefs rely on the Maillard reaction to create new flavors through the heat-driven reduction of sugars and amino acids in carbohydrates and proteins, such as in toasted bread and roasted meat. Microbes, however, expand the possible flavors by decomposing large, less flavorful molecules into smaller, tastier molecules like amino acids, organic acids, esters, sugars, alcohols, and aromatic compounds. This process is as old as life itself. A ferment's flavor is determined by select ingredients, the environment, and the type of microorganism. Kimchi, yoghurt, and cheese, for instance, come from lactic acids produced by the genus Lactobacillus, while acetic acid is churned out for vinegars by Acetobacteraceae. Noma employs these microorganisms and more.

> "Microbes, however, expand the possible flavors by decomposing large, less flavorful molecules into smaller, tastier molecules."

The process of fermentation is as old as civilization. Evidence of the partnership between microbes and people began over 9,000 years ago in the Neolithic village of Jiahu, Henan, China, where organic residue on pottery jars revealed fermented beverages of rice, honey, and fruit. Fermentation drove technological development like agriculture, horticulture, food processing, and preservation. To prevent spoilage, various microbes were domesticated to produce beer, bread, miso, and more. Microbes in turn gained energy present in adenosine triphosphate (ATP) biochemically mined from carbohydrates in the absence of oxygen.

At the heart of all this, Eng says, is "the concept of transforming a great ingredient into something greater." Just as a frying pan is a utensil to transform food, so too is a microorganism. A microorganism, however, goes further than transforming food. It changes our composition. Estimates suggest that people are made up of more microbes than human cells. Inside the gut of every person are trillions of microbes, collectively called the microbiota, with the power to dramatically transform one's health. Pioneering research has found that microbial composition of the gut critically influences neurodegenerative diseases, immune and inflammatory diseases, behavioral and mood disorders, obesity, cardiovascular disease and cancer. In the bestselling cookbook "The Noma Guide To Fermentation," Redzepi writes, "I dream about the restaurants of the future, where you go not just for an injection of new flavors and experiences, but for something that's really positive for your mind and body." Noma's fermentation revolution is not only expanding known flavors, they're reclaiming our right to a healthy microbiome and inspiring a generation of chefs to help reshape who we are.

Peeled and Glazed Radish

Nature Microbiology (2016). DOI: 10.1038/nmicrobiol.2016.39
PNAS (2004). DOI: 10.1073/pnas.0407921102
Current Opinion in Neurobiology (2020). DOI: 10.1016/j.conb.2019.09.016

DO GENES REMEMBER? HOW FAMINE CAN ALTER THE METABOLISM OF FUTURE GENERATIONS

BY PAULA HORNSTEIN, BIOCHEMISTRY, 2020

DESIGN BY YECHAN YANG, BIOLOGY & PSYCHOLOGY, 2022

We often think about evolution in terms of millions and millions of years, yet sometimes new circumstances can result in quicker changes on how our bodies function. Recently, scientists have observed that malnutrition early in life can cause long-term changes in a person's metabolic function, which may even be passed down to their children.

This was studied in an article initially published in 2017 in the *American Journal of Clinical Nutrition*, which has since been supported by additional researchers. In the original study, the authors examined past and present health records, blood samples, and interviews with people who were born during or just after a famine, as well as their children a generation later.

This famine occurred mainly in two provinces of China and lasted for nearly three years from 1959 to 1961. The authors sought to understand how famine, or general lack of nutrition, during prenatal development may result in higher prevalence of metabolic conditions like type 2 diabetes in adults. This trend had been observed for at least three other extended famines in history, including the Dutch famine post-World War 2. While it is assumed that those born during a famine would develop changes in metabolism, the question of whether these changes are genetic, passed down through genes, remained.

Genes are hereditary sections of DNA that code for a specific characteristic. The gene that is most likely to play a large role in the link between nutrition and metabolism is *INSR*, on chromosome 19. INSR is an insulin receptor that affects growth and signaling in the metabolic process, and plays a huge role in processing blood sugar, or glucose, every time we eat. Type 2 diabetes results from an decreased ability or inability to process glucose. Therefore, when metabolic genes like INSR are ineffective, type 2 diabetes can result.

Genes can be silenced by a process called DNA methylation, which occurs when a methyl group blocks that section of DNA from being read and duplicated. This phenomenon of changing gene expression without changing the DNA itself is called epigenetics. The 2017 study found that *INSR* is more methylated in people born during or just after the famine in China. Essentially, the body learns to slow down the processing of blood sugar to decrease the likelihood of starvation. But, when food is readily available again, the body is overwhelmed by the amount of glucose that must be processed, resulting in metabolic conditions like type 2 diabetes. Accordingly, the rates of type 2 diabetes were also higher for people born during the famine.

However, the study also found that the children of those born after the famine had similarly high rates of methylation to their parents who lived through the famine, as well as high rates of type 2 diabetes. This is groundbreaking, as it shows that epigenetic modifications can be passed down from parent to offspring. This is consistent with findings from the Dutch famine that lasted for six months from 1944 to 1945, in which metabolic changes were also observed to have likely been passed down from generation to generation. However, the rate at which metabolic changes were seen in the offspring of famine victims was exponentially higher in the Chinese famine in comparison to the Dutch famine. This is most likely due to the longer duration of the famine in China, although many factors may have affected the different likelihoods of metabolic changes between the populations.

These discoveries are significant because they demonstrate that changes to the body's functions as a result of environmental changes can affect entire lineages. This same phenomenon has been hypothesized for cases of transgenerational trauma, in which higher levels of anxiety and stress can be observed among descendants of historically oppressed and abused groups. The concept of our genes "remembering" the adversities that generations before us faced is not yet fully understood. Our understanding of genes as the only hereditary factor may soon become outdated, as we continue to recognize just how complex genetics can be.

American Journal of Clinical Nutrition (2017). DOI: 10.3945/ajcn.116.138792

TO CHEW OR NOT TO CHEW

BY ALLIE KUO, COMMUNICATIONS AND FOOD SYSTEMS, 2021

DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

While cooking dinner the other night, I found myself engaging in tomato discourse with my roommates. I was trying to unpack why they didn't like the fruit on its own yet liked it in a sauce or salad. What we boiled it down to was the tomatoes' rheological properties — also known as mouthfeel, and even more commonly known as texture.

Rheology is the study of deformation and flow of matter. When applied to food, rheology concerns how food moves and feels during the eating process. From the way it breaks down during mastication — chewing — to how it is digested, food rheology plays a big part in how a consumer perceives what they are eating.

Think about the bright crunch of a freshly steamed green bean compared to a dull, limp bean from a can. Crispy, creamy, and chewy are the most coveted food consistencies, according to food scientist Malcolm Bourne. That crisp bean is preferable because it requires chewing, something that needs to be done with strong, healthy teeth, as opposed to a soft vegetable that needs little work to be consumed. Bourne writes that humans have a "deeply ingrained need to chew," which is one explanation for why fresh produce is preferred over something from a can. But the texture of that fruit or vegetable can also be the difference between something that is evocative of the farmer's market or one's elementary school cafeteria. Whether this is a positive or negative perception depends highly on personal preference, as well as cultural context.

"I don't like the texture" is a common response to why people don't enjoy a particular food. The actual taste of food is not as much of a factor as characteristics like "it's too chewy," "it's too slimy" or "it's too dry." A food can have a pleasant flavor, yet its mouthfeel is enough to drive a prospective consumer away. Marinara sauce is just fine, but a solo cherry tomato can evoke some unsavory feelings.

Tomatoes are not alone in facing this adversity. Octopus is a food that causes hesitation when served alone and given room for its rubbery consistency to shine, but when battered and fried up in a crispy, salty coating, it is warmly received in a slightly disguised state. In something like calamari, the combination of familiar textures — crunchy and grainy — helps bridge that gap to the unfamiliar.

The words used to describe the various mouthfeels of food are also often inadequate. Take "chewy," for example. Al dente pasta is chewy, with just enough resistance to bring some textural interest to a plate of penne vodka. Yet it's a different sort of chewy than boba, the black pearls found in bubble tea, which have a bouncy and smooth bite to them. "Q" or "QQ" is a Taiwanese term that effectively describes this texture, which can be found in many other East Asian foods such as mochi and tteokbokki.

The English language fails to capture the spectrum of food textures, which may be reflective of the highly processed, soy- and corn-heavy food products that dominate American freezer aisles and fast food restaurants. According to food scientist Ole Mouritsen, there are over 400 Japanese words that can be applied to the texture of food, while English only has about 80. This is not to say that Americans are unable to talk about specific textures, but the lack of specificity in language makes it easy to lump, say, all "chewy" foods into one category that overlooks nuances within this category.

This conglomeration of descriptors makes it even easier for one to have a negative reaction to an unexpected mouthfeel. If the standard for "chewy" in American cuisine is a caramel candy or the soft center of a chocolate chip cookie, the kind of chewy that makes a fish cake so delightful may not be received as easily in an American palate than in a Japanese one. Yet this is why open-mindedness is key to appreciating all foods, even when its texture is one that may be surprising — briefly uncomfortable, even.

So while flavor is important, texture just might be the real spice of life. To live in a world where food is textureless would be to live in a world where baby food was the only option—mushy, soft cuisine that requires no teeth. In the same way that there is a joy to the process of making a meal from start to finish, part of the joy of eating is the process of how you experience that food, from the first bite to the very last one.

PHOTO BY PIXABAY

Food, Culture, and Society (2019). DOI: 10.1080/15528014.2019.1638119
Rheology of Fluid and Semisolid Foods (2007). DOI: 10.1007/978-0-387-70930-7_1
Current Opinion in Colloid & Interface Science (2011). DOI: 10.1016/j.cocis.2010.07.003

Corn: A fuel and a sweetener

BY RYAN BRADY, BIOCHEMISTRY & CHEMICAL ENGINEERING, 2022
DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021

The United States of America produced 6.77 billion bushels of corn in 2019, but only a small fraction of this corn was used for direct human consumption. Over 5 billion bushels were processed into ethanol for use as a fuel source, while another 430 million bushels were processed into sweeteners found in a variety of foods. The role of corn in both of these industries is directly tied to its ability to be easily manipulated. The anatomy of a kernel of corn makes it the perfect package of nutrients for both applications.

The nutritional value of corn is what makes it an ideal starting material for fuels and sweeteners. According to the USDA, corn is made up of approximately 18.7 percent carbohydrates and 75.6 percent water. The carbohydrates can be easily turned into energy through both digestion and combustion. The kernel allows for the easy processing of corn into a dry material to be converted into either of the final product.

To make ethanol, the entire kernel is ground into a flour and added to water. Corn is made up of complex sugars which contain hundreds of carbons and their bonds in order to store energy more efficiently. However, in order to effectively use these large starch molecules, they must be broken down. This is done in two distinct steps. The first is breaking them down into simple sugars, such as glucose and fructose, with the help of enzymes. Afterward, the simple sugars are further broken down by the addition of yeast which converts them into the final product: ethanol. Once the molecular ethanol is formed, the remaining steps focus on ethanol purification. Besides removing contaminants, removing water is the most important part of purification. This process is conducted by using a filter which has microscopic pores to filter molecules by size and allow nearly 100 percent pure ethanol to be collected.

While corn sweeteners serve a wildly different purpose, they are manufactured in a similar way. Corn syrup and high fructose corn syrup are both derivatives of corn starch. Corn starch is a powder derived through a process of wet milling. Wet milling involves soaking the kernels in water, then separating the corn and mashing the middle layer known as the endosperm. After the corn starch is produced, the production methods vary based on the type of corn syrup being produced. Corn syrup used to be synthesized by adding acid to corn starch, however, enzymes are now used in a bioprocess to increase the efficiency. One of the key enzymes, amylase, breaks down the starch to simple sugars. Based on the temperature, pressure, and enzymes used, the content of different sugars can be adjusted. For example, high fructose corn syrup is just a variant of corn syrup modified to have higher levels of fructose, which is commonly found in cooking sugar. Additionally, other flavors such as vanilla can be added at this stage before the product is ready for final packaging.

These two products represent integral parts of modern society. The Clean Air Act of 1990 mandated that ethanol be added to gasoline in order to reduce gasoline consumption. Currently, the majority of fuel sold in the United States contains 10 percent ethanol. Ethanol represents a more renewable energy option as it does not need to be extracted from the ground and can be grown each year. However, because combustion is used in corn processing, it still results in carbon emissions and releases greenhouse gases which contribute to global climate change. Regardless, it remains an integral part of meeting the world's energy needs and its role will evolve as humanity deals with its changing energy needs.

Corn syrup and other corn-based sweeteners play an important role in the production of processed foods. The economics of corn syrup make it a cheap alternative to traditional cane sugar on an industrial scale. Many common products such as soda, cereal, and other processed baked goods indicate its versatility. Pancake syrup, for example, is made almost entirely of corn syrup. As people move away from processed food consumption in favor of more natural food choices, the role of sweeteners like corn syrup is projected to decrease. However, research indicates no significant health differences between these corn based sweeteners and cane sugar, so it seems unlikely that its role will diminish entirely. Overall, corn's role in modern society has evolved greatly from its humble roots as a food source.

PHOTOS BY PIXABAY

Structural violence

How institutions create the framework for global health

BY ALISHA KARUVANNUR-SANDHU, BEHAVIORAL NEUROSCIENCE & PHILOSOPHY, 2023 DESIGN BY IAN PROULX, BIOENGINEERING, 2022

When we think of the word *violence,* we tend to picture physical altercations: a slap to the face, a punch to the gut. Or perhaps we might picture something a bit less tangible — say, verbal assault or emotional abuse. At any rate, in each of these situations, the interaction is person-to-person; it is individual perpetrators inflicting harm on others. What happens, however, when the perpetrators aren't so much distinct entities, but rather entire social systems?

Sociologists have dubbed this phenomenon *structural violence*, and it goes beyond the individual. The term was officially coined by Johan Galtung, sociologist and founder of the *Journal of Peace Research*, in 1969; although, public health specialists had long before acknowledged the social determinants of well-being. Structural violence explains what happens when inequalities become institutionalized — think classism, racism, misogyny — and consequently bring harm to vulnerable members of the population. In the context of medical anthropology, structural violence refers specifically to the detrimental health effects brought on by such institutions. Low-income populations experiencing increased malnutrition, avoiding necessary medical care due to lack of financial means, and being subjected to poorer environmental conditions are all examples of structural violence. These inequalities are embedded in our social order (hence the "structural" aspect of the term). Although structural violence is regarded as an "invisible" force, it doesn't take much effort to see the blatant correlation between wealth and health disparities.

Structural violence shows us that well-being goes far beyond the biological basis of disease; the social determinants of health should be an essential component of dialogues about public health. Social forces, shaped by the political and economic climate of communities, greatly influence health outcomes for disease. By understanding the roots of disease in a biosocial context, we can better understand how to tackle treatments in a more holistic way. In a paper by Harvard medical anthropologist Paul Farmer, he explores different studies regarding structural violence and its relation to HIV/AIDS treatments. One study found that eliminating transportation costs and increasing treatment convenience significantly improved health outcomes for AIDS patients in Baltimore, Maryland. In Rwanda, Partners in Health, the nonprofit co-founded by Farmer, has worked to create a model of AIDS treatment that goes further than clinical care. Patients are accompanied by caretakers who can offer medical services and deliver drugs to their homes, allowing for an effective combination of both distal and proximal care.

On the domestic front, the issue of structural violence in healthcare is certainly a pressing issue with the presidential election on the horizon. As millions of Americans live without health insurance — and millions more go underinsured — it may be prudent to keep these large-scale social forces in mind when casting your ballot. Beyond that, though, understanding structural violence on a global scale is critical to changing our perception of healthcare in the developing world.

When we look at developing countries — countries that have been wrought by poverty, political upheaval, and the legacies of colonialism — it's easy for many to look at them as lost causes. But it's crucial to acknowledge the potential in other nations' healthcare systems. Organizations like Doctors Without Borders can only do so much; simply importing first world resources is a temporary fix to a much larger problem. Change has to occur at the governmental level to create long-term solutions. We must recognize that foreign medical systems are more than just charity cases, and health outcomes for impoverished nations can be improved, so long as there is a will to do so.

African Journal of Disability (2017). DOI: 10.4102/ajod.v6i0.274

PLoS Medical (2006). DOI: 10.1371/journal.pmed.0030449

PHOTOS BY FLICKR

Taste the rainbow

The natural way

BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

Bright blues, radiant reds, and glimmering greens. Thanks to food dyes, we can expect a rainbow of selection each time we enter the grocery store. Not only does the added pigment attract the eye, but it also helps food maintain its shade as it ages as well as produce color-consistency within brands. We can rely on finding the same shade of ketchup no matter the location or season.

However, there is more behind what colors your food than meets the eye. A color additive, as defined by the Food and Drug Administration (FDA), is any dye or pigment that impacts the color of a product. They fall into two categories of additives: synthetic and natural. Synthetic dyes are any color additive not from a natural source. The most popular — Red #40, Yellow #5 ,and Yellow #6 — account for 90 percent of all dyes used and can be found in everything from cereals to crackers to yogurt. Natural dyes are a subgroup of additives with natural sources, such as vegetables, minerals, or bacteria.

Why were synthetic colors used in the first place? Their chemical structure is very stable, making them soluble in water, and able to be implemented at any temperature with the same resulting color. Conversely, natural dyes are much more variable. Because this type of food dye is categorized as anything with a natural source, they differ widely in pH, temperature, light tolerance, and solubility. They are also much more challenging to implement into a wide range of products than synthetic dyes and are more prone to fading.

The FDA certifies artificial dyes as safe and mandates that each batch of dye is certified, but scientists and consumers alike are concerned about side effects from consuming large quantities of these colorings.

Over a decade ago, a study by the University of Southampton linked artificial food dyes with increased hyperactivity symptoms in children. Over 250 children were given juice concentrates containing the equivalent of at least five bags of fun-size Skittles packs. Their activity was monitored and compared to weeks when they consumed no additional artificial dyes. Overall, the mean amount of hyperactivity increased when the children consumed artificial dyes. Shortly after, the European Union (EU) mandated food labels to indicate if products contained one of the six food dyes investigated in the Southampton study. Many brands in Europe also have phased out synthetic dyes entirely.

Since then, additional studies, such as a 2012 meta-analysis in the *Journal of the American Academy of Child and Adolescent Psychiatry*, have supported the conclusion that food dyes have an effect on hyperactivity in children. However, the U.S. has not reacted to this information as rapidly as Europe did. As of now, the FDA website says the agency has "reviewed and will continue to examine the effects of color additives on children's behavior." Even researchers investigating the effects of dyes on children can see where the hesitation comes from.

"The literature here is so sparse that on the one hand you can sympathize with those who want to take a wait-and-see attitude," meta-analysis co-author Joel Nigg said to Scientific American in 2015. "But, on the other hand, when we do look at the literature we have, it's surprising that we do see effects that seem to be real."

While foods in America still contain many synthetic dyes, many companies are slowly transitioning to natural substitutes, citing consumer desire to purchase products made with natural dyes. These companies include Kraft (and its iconic orange mac and cheese), Taco Bell, and General Mills. Should the U.S. follow in the EU's footsteps and take artificial colorings more seriously? Keep watch over your grocery store offerings to find out.

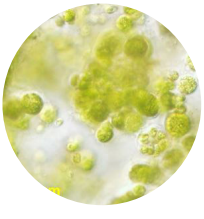
Journal of the American Academy of Child and Adolescent Psychiatry (2012). DOI: 10.1016/j.jaac.2011.10.015
The Lancet (2007). DOI: 10.1016/S0140-6736(07)61306-3

NATURAL FOOD DYE SUBSTITUTES

Natural food dyes are created from a variety of sources; from the vegetables grown in your garden to a bacteria extract, they provide a plethora of color alternatives to chemical dyes.

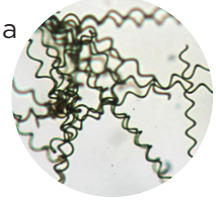
Red
Tomatoes

Yellow
Turmeric



Green
Chlorella

Blue
Cyanobacteria
Spirulina



Red-purple
Beets

Brown
Caramel

PHOTOS BY PIXABAY AND WIKIMEDIA

FOOD FOR OUR FUTURE

BY ANUSHKA BISWAS, CELL & MOLECULAR BIOLOGY, 2023

Hundreds of miles south of the North Pole, 390 feet deep inside Platåberget Mountain, lay 490 million seeds waiting to be planted. At the world's northernmost airport, there sits only one destination: the Svalbard Global Seed Vault.

Formed in collaboration with the Norwegian government and international non-profit The Crop Trust, the seed vault is a preventative measure to preserve agricultural diversity and protect global food security. Situated upon the frigid Svalbard Archipelago, this arctic agricultural collection is only one of 1,700 biorepositories that store both seeds and unique cuttings of plants known as gene banks. Each gene bank serves as a fail-safe for when war and natural disaster jeopardize the produce of a nation.

The very same reasons that encouraged the creation of seed vaults in general — war, drought, natural disaster — led to one specifically in Svalbard. The Crop Trust felt as if most gene banks were vulnerable to catastrophe and the hope for the future must lie in a remote location, away from public intervention.

Besides large-scale threats, gene banks are also vulnerable to poor management, faulty technology, and a lack of resources, all of which Svalbard anticipated. While a consistent temperature of -18 degrees Celsius is required for optimal storage of seeds, the permafrost and thick rock of the mountain offers the vault a natural, cost-effective, and soundproof method of cooling. If the electrical mechanisms were to fail, it would take several weeks for the facility to match the -3° degrees Celsius temperature of the surrounding sandstone mountain and two centuries to reach zero Celsius. Beyond the mountain, seeds are custom sealed and wrapped in three layers of foil, sealed in boxes, and stored on shelves. Heightened shelter from natural forces keeps seeds in a low-moisture environment while regulating metabolic activity to be minimal, ensuring the longevity of the seeds.

Distant from harm, the Svalbard vault protects 986,243 conserved samples — 124,772 of which were deposited by the United States, a top contributor to the bank investing 50 million USD worth of seeds. With a maximum capacity of 4.5 million varieties and 2.5 billion seeds, this international insurance policy is only a work in progress. It will be long before other gene banks can adequately multiply crop stocks and regenerate enough seeds to build the arsenal housed at Svalbard. Hopefully, it will be even longer before we must resort to removing them.

A zero-gravity snack:

Astronauts bake the first cookies in space

BY CARA PESCIOTTA, PHYSICS, 2022

DESIGN BY MEGAN LI, COMPUTER SCIENCE & DESIGN, 2023

Two hours, raw ingredients, and a zero-gravity oven. With these resources, astronauts baked the first cookies in outer space.

Last December, Luca Parmitano and Christina Koch, stationed at the International Space Station (ISS), baked five chocolate chip cookies from frozen dough to determine cooking times and temperatures in zero gravity and why they differ from Earth. While the experiment appears to be just a fun study, it has important consequences in long-term mission food solutions and astronaut mental health.

Koch tweeted, "We made space cookies and milk for Santa this year. Happy holidays from the @Space_Station!" Often missing planet Earth, astronauts look for ways to stay connected to loved ones back home. Fresh food could be a solution to the issues of low morale and isolation in longer space missions.

NanoRacks and Zero G Kitchen, companies that specialize in commercial space products, are designing tools to help accomplish this goal. The zero-gravity oven used in this experiment operates much like a toaster oven, using electric heating elements inside an insulated chamber. It was pushed to its limits on the ISS, with the cookies baking longer and at higher temperatures than they would on Earth.

The first four cookies were baked at a standard 300 degrees Fahrenheit, with oven time increasing from 25 minutes in trial one to 120 minutes in trial four — the first to begin browning, even releasing the aroma of warm cookies into the station. The fifth and final trial was baked for 130 minutes at 325 degrees, the oven's maximum temperature, and was reported to be the most successful cookie — visually and aromatically resembling those on Earth.

Further experimentation is needed to answer why the cookies took six times longer to bake than on Earth; however, other characteristics remained mostly constant. Scientists had speculated that microgravity could shape the dough into spheres, but DoubleTree, the experiment's cookie dough supplier, stated they appear circular and raised like regular cookies. The smell also retained its familiar warmth, bringing the astronauts aboard a reminder of home.

Regarding taste, the three cookies that returned to Earth must be tested before consumption to ensure their safety, even though they are expected to pass this test. As a treat for us on Earth, we may be able to see the first space-baked cookies on display at the Smithsonian National Air and Space Museum, where DoubleTree has donated one of the cookies.

PHOTOS BY PIXABAY

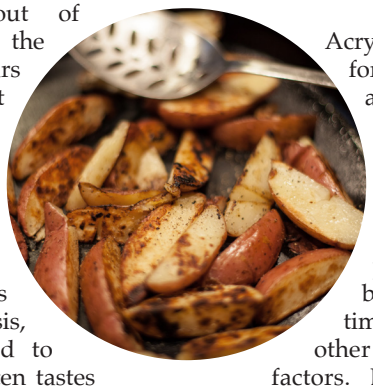
The chemistry of delicious flavors, enticing aromas, and possibly cancer

BY CAILEY DENONCOURT, BIOENGINEERING, 2022 DESIGN BY HEATHER WELCH, ENVIRONMENTAL SCIENCE, 2020

Waking up to the smell of sizzling bacon and crispy toast can be a delicious way to start your morning. The bacon's slight curls with crispy edges and the bread's golden brown coloring are both caused by the same chemical reaction. Also known as the "browning reaction," the Maillard reaction occurs during many different cooking processes — frying, toasting, roasting meat, baking cookies — and is critical for the aromas and flavors in cooking a variety of food groups.

The Maillard reaction is a nonenzymatic chemical reaction that occurs between an amino acid and a reducing sugar. The reactive carbonyl group, a carbon double bonded to an oxygen atom, usually reacts only at temperatures greater than 290 degrees Fahrenheit with the amino group, a nitrogen bonded to two hydrogens, on the amino acid to produce molecules that strongly contribute to why food smells and tastes so good.

This reaction usually occurs under specific conditions. In baked goods, baking soda can increase the dough's pH, making the environment more basic and thus speeding up the reaction. When pan searing, higher temperatures and drier pans cause the water to quickly evaporate out of the food, increasing the concentration of sugars and also speeding it up. Although high heat is needed for this reaction to occur, when it surpasses around 350 degrees Fahrenheit, the Maillard reaction is overtaken by pyrolysis, which causes the food to burn. This charring often tastes bitter and appears black, which is neither desired by chefs nor eaters.



With 20 different amino acids, a variety of products can be made, such as pryzazines, furanones, and pyrroles. These products account for roasted, caramel-like, and cereal-like aromas and flavors, respectively. In any one food, multiple amino acids are present in varied amounts. The small differences of amino acids concentrations are responsible for the difference between the smell of bacon versus the smell of toast.

Though French chemist Louis-Camilla Maillard discovered the reaction in 1912, the mechanisms and the cooking implications were not truly understood until the 1950s. Even to this day, there still lies some mysteries in the mechanisms of certain products.

As a major chemical reaction in almost all cooked foods, it is extremely versatile and thus has many benefits along with some detriments. Some Maillard reaction products are known to be antioxidants, but one in particular, acrylamide, has been ruled a probable human carcinogen by multiple agencies including the International Agency for Research on Cancer, the US National Toxicology Program, and the US Environmental Protection Agency.

Acrylamide is the product formed from asparagine, a major amino acid in certain starchy foods like fries, potato chips, cereals, cookies, toast, and coffee. However, the amount of acrylamide produced greatly ranges based on the cooking time, temperature, and other minute environmental factors. Due to the specificity of the conditions, when studying the average intake of acrylamide in humans, it is difficult to determine exactly how much acrylamide people intake from potatoes, since it depends on how it was cooked.

There have only been a few studies since acrylamide was discovered in food in 2002. Most of these studies exploring the carcinogenic effects of acrylamide were conducted on rats and mice with very limited research on its effects in humans.

In a review by the National Toxicology Program, two-year studies were conducted on the carcinogenic properties of acrylamide in male and female rats and mice. The male rats showed clear cases of malignant mesothelioma along with some other rare forms of cancer. In females, fibroadenoma — or benign tumors — formed, along with some neoplasms, or abnormal cancer-like growth, of the oral cavity and skin were also observed. Similar results of carcinogenic activity were also found in male and female mice. However, the concentrations of acrylamide injected into the rats proportional to their mass is greater than the concentration that would typically be seen in humans.

Humans can be exposed to acrylamide not only through oral intake from certain cooked foods, but also from direct smoking, secondhand smoking, toiletries, or other household items. Thus, in humans, developing cancer due to acrylamide is from a combination of factors including environmental carcinogens.

The minimal research on acrylamide and the specific conditions for the Maillard reactions seem to suggest that it is only a mild carcinogen and not concerning enough because of the low production. Still, acrylamide is only one product of the Maillard reaction. Other products are essential for multiple stimulations in cooking and eating, which would make food quite dull and distasteful without them.

PHOTOS BY FLICKR

Nutrition and Cancer (2014). DOI: 10.1080/01635581.2014.916323

EAT

A PHOTO EXHIBITION BY GUS MUELLER

Here, I have captured a variety of foods in both static moments and in motion. As a novice food photographer, these photos were repeatedly iterated over the course of the spring semester. After many wine pours, coffee cups, and cheeseboard compositions, these are the frames I've chosen as the best.

I hope for this series of pictures to illustrate the power of texture in photography — one of the more under-appreciated components of an image. Texture brings vibrance and detail to an otherwise flat and noisy photo. The combination of soft light, a tack sharp lens, and framing can yield vibrant, granular, tactile feeling. Please enjoy my work in NU Sci's first ever photography exhibit.

- Gus

A GUT FEELING:

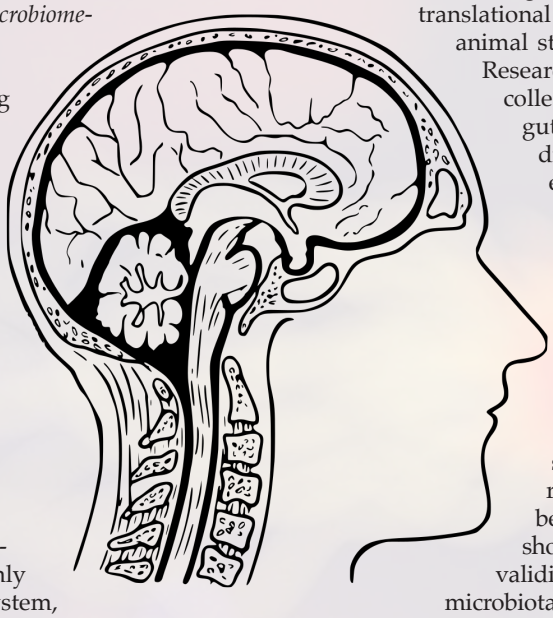
THE BACTERIA IN YOUR GUT MAY BE CONTROLLING YOUR BEHAVIORS

BY RACHEL LINES, BEHAVIORAL NEUROSCIENCE, 2023

DESIGN BY HEATHER WELCH, ENVIRONMENTAL SCIENCE, 2020

Think back to the last time you gave a presentation; were you nervous? Did you lose your appetite for the day? When it was time to present, did your stomach somersault?

When considering physical responses to stressful situations, there is a clear connection between behavior and the gut. In anxiety-stimulating situations, the body can respond with gastrointestinal discomfort and can even lead to gastrointestinal disorders, including irritable bowel disorder. It's a common phenomenon to lose one's appetite before a stressful event, and this relationship has been found to be bidirectional; gut health may affect human mental health. This communication was coined the *microbiome*-gut-brain axis.



The gut microbiota is a term describing the plethora of life that exists in the human digestive system. Nearly 100 trillion organisms live in the human gut, making bacteria incredibly important to digestion and absorption of nutrients. Microbiota can be influenced by the food and medications we consume, and communicates with the brain through a nervous connection called the vagus nerve.

The vagus nerve is significant to the gut-brain axis because it is involved in parasympathetic control of the digestive tract. The parasympathetic nervous system opposes the fight-or-flight response and is commonly referred to as the "rest and digest" system, encouraging the body to relax and recover. The vagus nerve has also been shown to have both afferent and efferent signaling ability; in other words, signals can be communicated from the brain to the gut or from the gut to the brain.

In behavioral studies performed on mice, neuroscientists Dr. Jane Foster and Dr. Karen-Anne Neufeld found that changing the gut microbiota of mice caused significant effects on their anxiety and depressive behaviors. In the presence of a normal gut microbiota, animals exhibited a reduction in anxiety- and depression-like behavior when administered probiotics. Animals raised in the absence of a gut microbiota showed reduced cognitive function in learning tasks. This evidence has revealed the possible use of the gut microbiota in treatment of anxiety and depression, but more research is needed in this field.

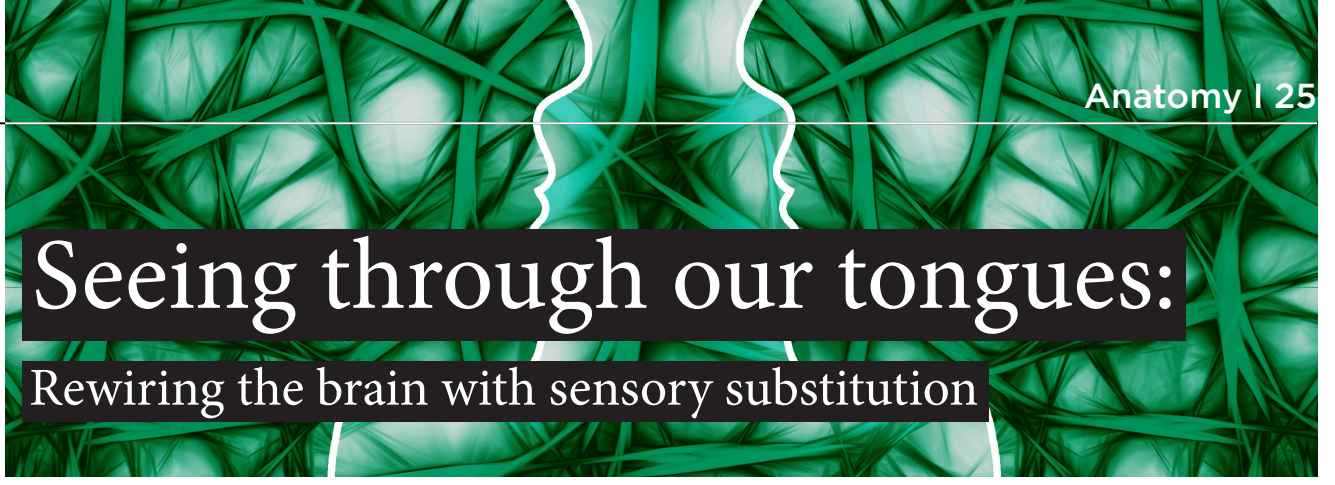
The gut microbiota has also been linked to brain-derived neurotrophic factor (BDNF), an important influencer on neuron survival, differentiation, and supportive memory functions. In the hippocampus, an area of the brain associated with memory, decreased levels of BDNF were shown in mouse models of infection in the gut. These mice also expressed an increase in anxiety behaviors. A probiotic treatment was shown to control BDNF levels, which identified a possible use of this treatment for anxiety disorders.

Although most behavioral research has been performed with mice, some of the data regarding the gut-brain axis has high translational validity, the ability of data from animal studies to be applied to humans. Researcher Emeran Meyer and his colleagues explained that the human gut-brain axis is fundamentally different from rodents' because expansion of the regions in the human brain involved in emotional regulation. However, new data has revealed associations between gut microbial alterations and a variety of illnesses including irritable bowel syndrome, infant colic, depression, and even Parkinson's disease. Additionally, perinatal stress models — animal models regarding a small window of time before and after birth — have been shown to have high translational validity as well. Alterations in the gut microbiota during this window of time have been shown to contribute to adult behaviors, but more research is required in this area before it can be implemented in human clinical populations.

Overall, it has been shown that the brain and gut microbiota communicate, affecting the behaviors of an animal. So, should you eat probiotic yogurt before your next presentation? Although the mouse models may indicate that this action would be beneficial, the human brain and emotional regulators are more complex than that of a mouse. More research in this area is required before the gut microbiota can be utilized to treat mental health disorders and other illnesses.

Trends in Neurosciences (2013). DOI: 0.1016/j.tins.2013.01.005
The Journal of Clinical Investigation (2015). DOI: 10.1172/JCI76304

PHOTOS BY PIXABAY AND SVG SILH



Seeing through our tongues:

Rewiring the brain with sensory substitution

BY EMMA TUSUZIAN, PSYCHOLOGY, 2023

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING, 2023

Do we need our eyes to see and our ears to hear? Science points to "no." Modern developments in sensory substitution indicate the incredible flexibility of our brains. If our brains can use one functioning sense to perceive another malfunctioning sense, the possibilities of rewiring seem limitless. American neuroscientist Dr. Paul Bach-y-Rita was one of the first to push this concept of neuroplasticity, demonstrating the power of our brains to constantly change and strengthen new neural pathways. He pioneered the field of sensory substitution, identifying the tongue as an "ideal interface to the brain" and designing wearable technology that demonstrated the brain's adaptiveness.

As Bach-y-Rita famously noted, "you don't 'see' with your eyes, you 'see' with your brain." In 1998, he founded Wicab, Inc. and BrainPort Technologies. The BrainPort Vision Pro is an oral electronic vision aid that allows for tactile-visual sensory substitution through electro-tactile stimulation. The device translates visual information through a wearable camera to touch sensations on the tongue. Video feed is converted to pulses, allowing pixels on the camera to be felt through an array of electrodes sitting on the tongue. Black, white, and gray shades are distinguished through different pulse intensities. This helps blind patients with orientation, movement, and object recognition.

Wicab, Inc.'s research efforts to understand the tongue's accuracy with electro-stimulation consisted of many experiments including tongue mapping, spatial summation, and two-point spatial discrimination. Results demonstrate that there is variation in task performance between individuals based on their tongue perception ability. The tongue has a range of capabilities, and it is suggested that customized equipment is the most effective mechanical development for improved results. Tests for two-point spatial discrimination, or the ability to distinguish two nearby stimuli as separate points rather than one, can determine the device's most efficient electrode spacing. While the average spatial discrimination is 0.75 millimeters, some tongues can detect more precise spacing at 0.25 millimeters or less. Spatial and temporal acuity vary greatly between people, thus creating opportunities to train individuals whose bodies allow high performance across modalities and adapt information to specific performance. Stimulation location and number of vibrational stimuli also affect tongue sensitivity, which affects design and power requirements. The nuances speak to the many dimensions of the tongue and its ability to recreate signals that brains can interpret as images.

The BrainPort device offers a non-surgical solution that opens doors to further advances in sensory aids. Still, this new technology calls for further investigation and may only be effective in controlled conditions with required training. In a 2014 study by Nau et. al., patients were only able to effectively use BrainPort after participating in a one-week training protocol. Using BrainPort alone did not prove to be intuitive. Therefore, implementing it into daily use requires extensive training and optimized programs. Professionals like occupational therapists can provide critical skills in successfully transitioning to a visual aid, especially in the emergence of artificial sensory technologies. A combination of accommodating physical thresholds and training can achieve success in its performance.

> "These devices act as mediators between modalities, changing lives by rewiring brains that already know what to do."

Similar endeavors in sensory substitution since Bach-y-Rita's research highlight the vast potential of neuroplasticity when involved with sensory aids. Neuroscientist David Eagleman and student Scott Novich developed the Versatile Extra-Sensory Transducer (VEST) device, a wearable vest that allows those with hearing impairments to recognize auditory information through vibrations on the torso. Research efforts in this area focus on maximizing information held by the skin, such as determining the most effective vibration patterns. Another non-invasive sensory aid is Peter Meijer's "The vOICe," a free software that enables users to recognize shapes by translating grayscale images into sound. Each pixel is converted into sound based on its luminance, horizontal position, and vertical position, which correspond with volume, time, and pitch, respectively.

Despite individualized nuances and training requirements, BrainPort and other sensory aids consistently remind us of our brain's seemingly infinite capabilities. These devices act as mediators between modalities thus changing lives by rewiring brains that already know what to do.

The American Journal of Occupational Therapy (2014). DOI: 10.5014/ajot.2015.011809
Frontiers in Behavioral Neuroscience (2016). DOI: 10.3389/fnbeh.2016.00079

Crying over spilled milk:

Why humans are lactose intolerant

BY GABRIELLE HERNANDEZ, BIOCHEMISTRY, 2022

Grilled cheese. Pancakes. Chocolate. Cake. All of these delicious treats contain one key ingredient that can prevent nearly 65 percent of the human population from comfortably eating them: lactose. Lactose is a sugar found in high amounts in milk. Almost all young mammals utilize milk, and therefore lactose, as a developmental agent. The consumption of milk at a young age allows for intestinal development, resistance to inflammatory diseases, and hormones for neurological development. Lactase is the enzyme that breaks down lactose further into glucose within the small intestine. After birth and development, adult humans lose a significant and continuous amount of lactase over their lifetime. The cause of this phenomenon is currently unknown. Some people experience a more significant loss of lactase than others, leading to lactose intolerance, or an inability to digest large amounts of lactose.

Without the presence of the enzyme, various gut bacteria digest the lactose, leading to the infamous symptoms of intolerance: bloating, cramps, and diarrhea. However, symptoms can vary from these common characteristics, as there are varying severities of hypolactasia, which is the clinical name for malabsorption of lactose. Adult hypolactasia is the most common form of acquired intolerance, followed by secondary hypolactasia, in which damage to the small intestine caused by other diseases (e.g. celiac disease, gastroenteritis, cystic fibrosis, diabetic gastropathy) leads to intolerance. Chemotherapy has also been shown to decrease lactase activity, and lead to a developed intolerance. Finally, congenital lactase deficiency prevents newborns from properly digesting lactose, leading to severe diarrhea and problems gaining weight.

All of this has to do with the *LCT* gene, or the gene that codes for the lactase enzyme. A local regulatory element, MCM6, influences the expression of this gene. As previously mentioned, lactase production naturally decreases overtime, so lactase persistence is the more unusual trait in humans. For an illness that causes discomfort for many, little is known about its evolutionary pattern, or why humans evolutionarily developed the ability to drink milk into adulthood.

> "With many different hypotheses, it is clear that the evolution of lactose persistence is as murky as a milk-saturated cup of tea."

When it comes to better understanding lactase persistence, surprisingly, it varies significantly among different ethnic groups. Lactose intolerance affects the majority of populations descending from East Asia, West Africa, Greece, and Italy, while it is least prevalent in people of Northern European descent. Many scientists attribute the high frequency of the persistent *LCT* allele in these Northern European populations to the amount of unfermented milk regularly consumed by this group. On the other hand, an opposing hypothesis proposes that lactase persistence is simply preadaptive, meaning the ability to digest lactose became a useful function as environmental factors changed for Neolithic Europeans. Using bone and tooth matter from specimens found in Eastern Europe, scientists in Germany and London used DNA extraction and sequencing to evaluate the origins of the allele. They concluded that dairying in Europe likely led to the persistence of the *LCT* gene. Despite their research, little is known about the origins of dairy farming in Europe. Predictions typically range from the introduction of cattle to Europe to when Europeans began to regularly digest unfermented milk.

Nonetheless, some of these hypotheses do not fit every population. For example, lactose persistence is not common in the group of Somali people in Ethiopia, despite their lack of uncomfortable symptoms while consuming half a liter of milk each day. Furthermore, there could be significantly more environmental factors at play in the pressure for lactose persistence rather than simply the practice of dairying. Drought and famine could have evolutionarily played a role in the need for milk consumption, and therefore lactose persistence. The lack of an arid climate, where less sunlight necessitates a vitamin D- and calcium-rich diet (luckily, milk contains both), could also be a factor. With many different hypotheses, it is clear that the evolution of lactose persistence is as murky as a milk-saturated cup of tea.

With evolving technologies in gene therapy, and well-preserved DNA from different eras of human evolution, the question as to why humans are both lactose intolerant and tolerant can be answered through diligent research. For now, all we can do is kick back with cookies and a glass of milk (but oat milk for those who lack *LCT* expression).

American Family Physician (2002). DOI: 12018807 (PMID)
Proceedings of the National Academy of Sciences of the United States of America (2007). DOI: 10.1073/0607187104
Philosophical Transaction of the Royal Society B (2011). DOI: 10.1098/rstb.2010.0268

PHOTO BY SHUTTERSTOCK

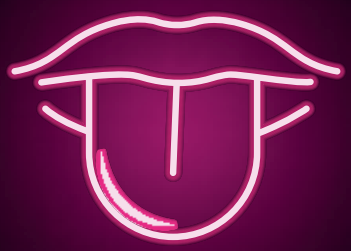
DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

MYTH-BUD-STERS:

Debunking your taste buds

Do they really change every seven years?

BY SUNITA PFITZNER, INTERNATIONAL AFFAIRS AND ENVIRONMENTAL STUDIES, 2022



Taste buds are key factors in preserving human life. Along with our sense of smell, they detect bitter poisons and the sour taste of rotten food to defend us from potential harm. The average adult has thousands of taste buds stored in papillae, which are small nodules on the surface of the tongue. Taste buds are comprised of basal cells, columnar cells, and receptor cells. Receptor cells contain proteins that react with certain chemicals in food, generating sweet, salty, bitter, or umami flavors. Every person's taste buds are different, which is why one person loves fish while another person hates it. Occasionally, people find themselves enjoying foods and flavors they used to hate, begging the question: do taste buds actually change?

Taste buds die off and regenerate every few weeks, but their short life cycles don't explain changes to one's flavor profile. At around 50 years old, cell production decreases and taste buds become less likely to grow back, causing a deterioration in one's ability to distinguish between different flavors. For younger people, a variety of other factors, including habits, upbringing, culture, and memories, may cause certain foods to taste worse than others. A positive mindset and trying new flavors in a safe environment is sometimes all it takes to start liking a new food.

Since the life cycle of a taste bud is every few weeks, where did the misconception that taste buds change every seven years stem from? All of the cells in the body change at different rates, with stomach cells regenerating every few days and bone cells regenerating after nearly ten years. On average, most people fully regenerate an entire set of cells every seven years, which is likely where the truth about taste buds was misconstrued. In reality, it is more important to continue to try new things, instead of writing foods off or waiting for the "seven-year cycle" to begin anew.

Progress in Molecular Biology and Translational Science (2010). DOI: 10.1016/B978-0-12-375003-7.00008-X

A gut feeling:

How microbes in the gut can influence our mood

BY ASHLEY LUO, PHARMACEUTICAL SCIENCES, 2023

The human body is a grand hotel for trillions of microbes. Microbes in the gastrointestinal (GI) tract, collectively known as the gut microbiota, partake in a mutualistic relationship with humans by assisting in functions that maintain human health. However, the gut microbiota can be affected by factors such as diet, genetics, antibiotics, and probiotics, to name a few. This causes gut dysbiosis, or a disruption of the symbiosis between the microbes and their human host.

Dysbiosis in the human gut microbiota has been linked to changes in mood and mood disorders, such as major depressive disorder and bipolar disorder. The gut microbiome has the ability to produce or stimulate the production of neurotransmitters, which are important to emotions and behavior. In fact, 90 percent of serotonin in the human body is produced in the gut. These neurotransmitters may in turn influence the central neurotransmitters in the brain through what is known as the brain-gut-microbiota axis (gut-brain axis). The gut-brain axis is a bidirectional communication system between the enteric nervous system, which is the nervous system of the GI tract, and the central nervous system, which is made up of the brain and spinal cord. If the composition of the gut microbiota is altered, then there could be an effect on activity in the brain, which can manifest as alterations in one's emotional state.

An example of a possible correlation between the gut microbiota and mood can be seen in a study involving the transplant of gut bacteria. In the study, scientists separated rats into groups: rats that cope better with social stress (resilient), rats that do not cope as well to social stress (vulnerable), a non-stressed control group (control group), and a placebo group. Within the vulnerable rats, the scientists found that specific bacteria, such as Clostridia, were present in higher amounts than in the other groups. The microbiota of the stressed rats were moved by fecal transplantation to new groups of rats that had not been stressed. The results showed that the group with the fecal transplant from the vulnerable rats exhibited signs of depressive-like behaviors while the behaviors of the other groups did not change.

Although studies such as the one mentioned show promising results supporting the relationship between gut bacteria and mood, there is much research to be done before the relationship can be solidified as causation rather than correlation. If causal relationships are established, the treatment for psychiatric disorders could take a new and exciting turn.

Frontiers in Genetics (2019). DOI: 10.3389/fgene.2019.00098
Molecular Psychiatry (2019). DOI: 10.1038/s41380-019-0380-x

DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

PHOTOS BY SHUTTERSTOCK

GOOD MOLD, BAD MOLD:

Is the mold in blue cheese really safe to eat?

BY ANSON HUANG, CHEMISTRY, 2021

DESIGN BY KYLA VIGDOR, DESIGN, 2021

When we leave fresh fruit or bread lying around just a little too long, we may find it begins to grow white, green, or other funky-colored molds. Some brave souls will cut around the mold and eat the rest, while others will throw it out on the spot. But mold isn't always the enemy; humans have even used mold intentionally in cooking for centuries. That unappealing splotch on your neglected clementine isn't too far off from the fungus that gives blue cheeses like Stilton or Roquefort their unusual colors and flavors.

"Blue cheese is made by injecting *Penicillium* mold into cheese. This happens after the cheese has been molded and before it is aged," says Sean Flannery, co-president of Northeastern University's Cheese Club. *Penicillium roqueforti* is the species of mold commonly used in blue cheeses like Stilton and Roquefort, while other *Penicillium* molds are used for cheeses like Gorgonzola, Brie, and Camembert. "Penicillin is derived from the same mold, but due to the cheese's enzymes, those with allergies can still eat blue cheese."

But not all molds in the *Penicillium* family are safe to eat. Like most living organisms, mold consumes nutrients to survive and generates metabolic byproducts after digesting them. Many molds produce mycotoxins, which are metabolic byproducts that are toxic to humans. Plus, when present on other foods, mold can induce some serious allergic reactions. But when it comes to the mold in blue cheese, you don't have to worry about mold allergies or toxins. Though *P. roqueforti* has been found to produce some mycotoxins, they are either chemically unstable in cheese or not present in high enough amounts to be dangerous to humans.

In fact, the unusual digestive processes of *P. roqueforti* are what give blue cheese its unique flavor. As the mold feeds on the fatty acids in the cheese, it breaks them down into various methyl ketones, organic compounds that give blue cheese its distinctive taste. "Blue cheese is definitely the diva of the cheese world, demanding that you give it attention. It's salty, pungent, and creamy, which is why it is also best paired with other bold flavors — think dark chocolate, a floral honey, or even buffalo wings," says Allie Kuo, co-president of Cheese Club.

So when you're cutting a slice of that soft, stinky blue cheese, don't let mold's bad reputation turn you away. It's meant to be there — enjoy it!

This article was written as a collaboration with the NU Cheese Club. Catch them on Instagram at @nucheeseclub!

Foods (2020). DOI: 10.3390/foods9010093

PHOTO BY GUS MUELLER, BIOENGINEERING, 2022

> "As the mold feeds on the fatty acids in the cheese, it breaks them down into...organic compounds that give blue cheese its distinctive taste."

Peppered with positives:
The health benefits of spices

BY MAYA KRAUSE, ENVIRONMENTAL SCIENCE, 2022

DESIGN BY MARISSA KEESEY, ELECTRICAL ENGINEERING, 2022

When my 81-year-old grandmother first told me she was taking turmeric to help her arthritis, I was skeptical. To me, turmeric was the orange spice that sometimes came out of the cabinet when curry was on the menu. Was my grandmother's venture into the spice world for medicinal solutions based in fact? She reassured me that she had been prescribed turmeric pills by her physician, and that there is research to support the use of turmeric to treat inflammatory disorders such as joint arthritis.

Turmeric contains a molecule called curcumin, which soothes arthritis due to its anti-inflammatory properties. In the immune system, protein NF-κB regulates protein TNF-α, which induces inflammation, among other immune responses. Substances that activate NF-κB, such as cigarette smoke, viruses, and stress, have been shown to increase inflammation; likewise, substances that downactivate NF-κB have been shown to decrease inflammation. A study by Biomedicine and Pharmacotherapy showed that, when taken in a daily dose of one gram, curcumin blocks NF-κB activation, therefore reducing TNF-α production and, subsequently, inflammation. Many other spices, such as ginger, red pepper, and garlic, also have anti-inflammatory properties.

So, my grandmother's turmeric prescription is backed by science. But what about other spices? Curcumin is in a category of organic compounds called polyphenols. Many plant-based foods, including other spices, have high concentrations of polyphenols. Studies strongly suggest that long-term consumption of these foods can help prevent cancer, diabetes, and other diseases due to the antioxidant properties of the polyphenols. For example, a study by Richard Anderson of the United States Department of Agriculture tested the effect of cinnamon on subjects with type 2 diabetes, a disease causing high blood sugar. The study found that taking cinnamon capsules for 40 days lowered the fasting blood sugar in the test subjects by up to 29 percent. This occurred because cinnamon polyphenols activate insulin receptors, and increase the number of insulin receptors in the blood, leading to more efficient blood sugar transportation.

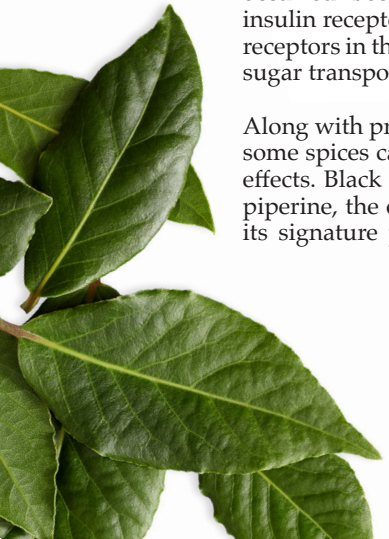
Along with providing solutions to common diseases, some spices can work together to enhance their own effects. Black pepper consists of five to nine percent piperine, the organic compound that gives the spice its signature pungent smell. Piperine increases the absorption of other nutrients by inhibiting liver glucuronidation, a process which makes molecules more water-soluble, which allows the liver to expel substances through urine. Combining pepper with other spices, such as turmeric, can significantly increase the absorption of the beneficial compounds provided by those spices. A study published in Planta Medica found that levels of curcumin were very low in subjects who solely consumed two grams of curcumin, but subjects who also consumed 20 milligrams of piperine had much higher concentrations of curcumin in their blood.

Turmeric, black pepper, and cinnamon can be useful to individuals suffering from specific ailments. However, spices can help with simple health problems too. Ginger root has been used for thousands of years to treat a variety of ailments, and has recently become a common solution to stomach problems. Consuming one gram of ginger root per day has been shown to decrease nausea and vomiting in pregnant women. This occurs because ginger root acts within the gastrointestinal tract to block serotonin receptors. While serotonin is known as the "happiness molecule," its purpose in the digestive system is to make the gut contract around food. When there is too much serotonin in the gut, food can be digested too quickly, causing feelings of nausea or an "upset stomach." Ginger root helps to stop excess serotonin by inhibiting the action at serotonin receptors, therefore preventing the adverse effects of excess serotonin on the digestive system.

Spices have been used for medicinal purposes for generations all around the world, but only recently has the research developed to support the discoveries of the past. Turmeric, cinnamon, pepper, and ginger are just a few of the many spices which contain chemicals that can help address our ailments. So the next time you open the spice cabinet, not only are you helping your taste buds, but the rest of your body as well.

Journal of AOAC International (2019). DOI: 10.3390/foods6100092
Biomedicine and Pharmacotherapy (2016). DOI: 10.1016/j.biopha.2016.05.037
Proceedings of the Nutrition Society (2008). DOI: 10.1017/S0029665108006010
Oxidative Medicine and Cellular Longevity (2009). DOI: 10.4161/oxim.2.5.9498
Planta Medica (1998). DOI: 10.1055/s-2006-957450
Integrative Medicine Insights (2016). DOI: 10.4137/IMI.S36273

PHOTOS BY SHUTTERSTOCK



Have your cake and eat it too

(Even if it's not gluten free/paleo/keto/vegan friendly)

BY LOUISE HOLWAY, ARCHITECTURE AND CIVIL ENGINEERING, 2022

It's nearly impossible to go to the grocery store and not get overwhelmed by diet labels — "vegan friendly," "keto this," "paleo that." Conflicting information and social trends may leave you wondering, "which one is healthiest?" As it turns out, the healthiest diet may not be one at all, for both your physical and mental health.

The connection between your brain and gut serves many purposes, one of them being weight regulation by sending hunger and fullness hormones to your brain. When your body is low on energy, your gut sends hunger hormones to your brain that stimulate appetite. When you eat, these hormones are suppressed, and fullness hormones are sent so you feel full. In addition, your gut and brain work together to promote energy storage. Seems simple, right?

When you fast, it is a whole different story. A drastic decrease in caloric intake results in an increase in hunger hormones and reduction of fullness hormones. Your body is fighting to regulate energy storage by telling you to eat more. Dieting mimics the starvation state, whether it is a lack of calories or macronutrients. As a result, you become much hungrier.

A study from the New England Journal of Medicine had participants complete a 10 week dieting period. They found that 12 months after completing their diet, their hunger-fullness hormones had not been regulated, and many were still experiencing what some call, "extreme hunger." Other studies have shown that 95 percent of dieters that initially lost weight gain it back, and two-thirds gained more than they lost.

Not only does dieting have an adverse effect on your body, it can negatively impact your mental health. Dr. Kiera Buchanan and Dr. Jeanne Sheffield from the University of Queensland in 2015 studied the psychological effect of dieting, why dieting as a whole does not work, and how detrimental it can be. To start, many of the participants valued their self-worth based on their compliance with the diet. When compliant, dieters tended to think positively of themselves; however, Buchanan and Sheffield write, "When they deviated from their intended plan however, they described themselves negatively (i.e. 'I'm weak', 'I have no will power', 'I'm a failure')." Unsurprisingly, the study found that most dieters were motivated by wanting to change their body image. When participants failed to lose weight, they felt defeated. This failure not only pertains to their dieting efforts, but to other aspects of their life: romance, career, and fitness to name a few.

> "As it turns out, the healthiest diet may not be one at all, for both your physical and mental health."

The feeling of failure contributed to another major theme in their finding: the impact of dichotomous thinking; if dieters ate food non-compliant with their diet, they had failed in their efforts. Dieters reported missing major social events like weddings and birthdays out of fear that non-diet-compliant food would be present. This all-or-nothing thinking can also result in binge eating, eating to extreme fullness without the sense of control. Not only can binge eating result in physical discomfort and GI issues, it enhances the feeling of defeat and lack of self-worth.

With all of the conflicting information surrounding diets and health, it's hard to tell what's beneficial. The high-carb vegan diet and low-carb keto diet are both highly praised, even though they are nearly opposite. It's not surprising that 95 percent of dieters regain the weight they lost through short-term diets, given the mental and physical impact of inadequate nutrients. While it may be tempting to indulge in these restrictive trends, it's a whole lot healthier (and yummier) to eat the treats that your body is craving.

Journal of Health Psychology (2015). DOI: 10.1177.159105315618000
New England Journal of Medicine (2011). DOI: 10.1056/NEJ-Moa1105816

DESIGN BY NICHOLAS BERRY, MECHANICAL ENGINEERING, 2024
PHOTO BY PIXABAY

Should you count on calorie counters?

BY ERICA YEE, INFORMATION SCIENCE & JOURNALISM, 2020
DESIGN BY KYLA VIGDOR, DESIGN, 2021

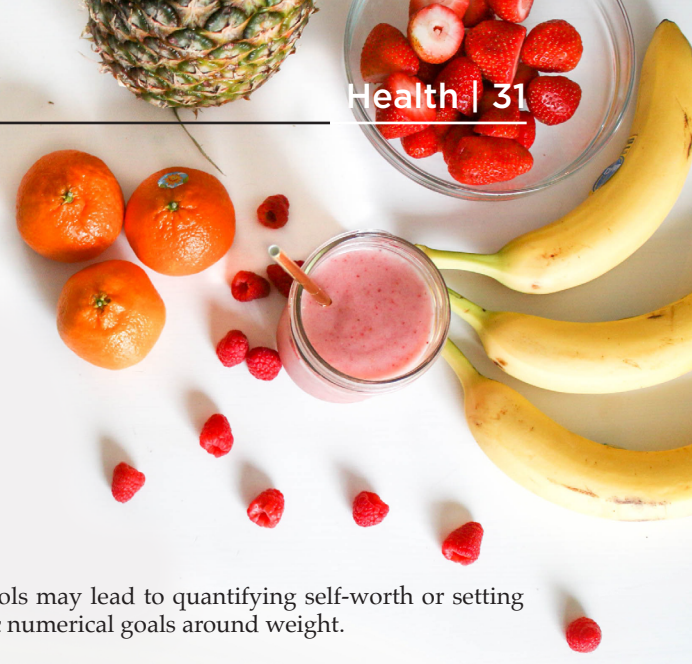


PHOTO BY UNSPLASH

The logic of calorie counting checks out in principle: if you intake more calories — energy from food — than you burn, you gain weight. If you intake fewer calories than you expend, you lose weight.

Searching "calorie counter" or "calorie tracker" on an app store will show hundreds of hits. These apps enable a user to record daily dietary consumption, and may also provide features to track body weight and set calorie goals. However, the apps that many people use to log their food to calculate caloric and nutrient intake may not work as simply as they suggest.

Because such apps rely on self-reported behavior, inaccurate estimates of food intake may make it difficult for individuals to lose and maintain desired weight loss. People can be trained to more accurately estimate portion size and food intake, as shown in a 2007 study of overweight adult participants published in the British Journal of Nutrition. Yet evidence-based strategies to train users and affect long-term behavior change are beyond the scope of most popular apps.

A 2013 assessment of the top-rated free diet and nutrition apps in the Health and Fitness category of the Apple App Store gave all evaluated apps low overall scores for inclusion of behavior theory-based strategies. The authors of the study, published in the American Journal of Preventive Medicine, expressed concerns about whether widely available apps incorporate evidence-based content and strategies for promoting behavioral changes for health habits.

Researchers from Brigham Young University executed a similar study in 2016. When reviewing the ten most popular free calorie counting apps on the App Store on how well they integrated health behavior theory, the highest score given was 15 out of 60 — and two received scores of zero. As this study found, widely-used calorie counting apps do not integrate much health behavior theory. This indicates a low potential to influence behavior long-term, an unfortunate reality for users who want to adopt an ongoing healthier lifestyle.

Aspects of behavior theory assessed in the study included knowledge, self-monitoring, goal setting, social support, and stimulus control. For example, the apps may have provided general information, but failed to assess the user's knowledge in order to change it. The authors suggest a relatively easy way for apps to implement self-rewarding, which can motivate people to persevere when results are not immediate, would be to send an individualized email to remind users to reward themselves for counting calories. Beyond the potentially ineffective methods of apps, research has also shown that there is potential for users of calorie tracking applications to trigger or exacerbate symptoms associated with eating disorders. Because these trackers require close monitoring of behavior, extreme use of such tools may lead to quantifying self-worth or setting unrealistic numerical goals around weight.

Results from a 2017 study in the journal Eating Behaviors suggest that such trackers can do "more harm than good" for some users. Researchers explored possible relationships between the use of calorie counting and fitness tracking devices with eating disorder symptomatology. Among a survey of undergraduate students at a large university, those who reported using calorie trackers had higher levels of eating concern and dietary constraint when the results were controlled for BMI.

At a national level, a 2013 Pew Research Center study found that seven in ten U.S. adults track a health indicator for themselves or for a loved one, with the majority tracking a weight, diet, or exercise routine. Notably, there were statistically significant findings that women are more likely to track any health indicator for themselves or others than men, and individuals aged 18 to 29 years old are more likely to use an app or mobile tool than older adults.

This is concerning because in a large national sample of over 36,000 U.S. adults, a 2018 study published in Biological Psychiatry found that odds for diagnoses of three eating disorders were significantly greater for women than men, adjusting for demographic factors. The disorders, as defined in the DSM-5 standard for assessing mental disorders, are anorexia nervosa, bulimia nervosa, and binge-eating disorder. Though the study did not discuss possible reasons for this disparity, other research suggests that women are more likely than men to report weight dissatisfaction, dieting for weight control, use of purging, and body checking behaviors.

Put together, these studies highlight the need for communication and cooperation between health education experts and app developers. The use of health tracking devices like calorie counting apps is based fundamentally on research that self-regulatory behavior plays a pivotal role in making healthy food choices. There is much opportunity for widely-available apps to improve their offerings with evidence-based behavioral strategies and nutrition education.

Eating Behaviors (2017). DOI: 10.1016/j.eatbeh.2017.02.002
British Journal of Nutrition (2007). DOI: 10.1017/S0007114507708802
JMIR Mhealth Uhealth (2016). DOI: 10.2196/mhealth.4177
Internet Interventions (2017). DOI: 10.1016/j.invent.2016.12.003
Biological Psychiatry (2018). DOI: 10.1016/j.biopsych.2018.03.014
American Journal of Preventive Medicine (2013). DOI: 10.1016/j.amepre.2013.07.005
International Journal of Eating Disorders (2008). DOI: 10.1002/eat.20625

WATER AND MENTAL HEALTH

BY THY NGUYEN, PHARMACY, 2023

DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

July is the peak of the summer with an average high temperature of 81 degrees Fahrenheit. During this time, hydration is extremely important, for it prevents us from feeling tired and fatigued. Water is vital to life, as it keeps our bodies functioning normally. However, people usually overlook hydration as a stress reliever. The human body consists of 70 percent water, so losing two percent of bodily water can cause noticeable mental and physical changes.

Scientists at the University of Connecticut's Human Performance Laboratory revealed a correlation between dehydration and brain dysfunction in a recent study. In the study, participants included healthy adults with an average age of 23 years old. Participants were active individuals who exercised daily for 30 to 60 minutes. Before evaluation, all subjects hydrated to ensure the accuracy of the test results. Proctors asked them to walk on a treadmill to induce mild dehydration. Later, each participant completed cognitive tests measuring concentration level, reaction time, vigilance, and memory. The results showed that the dehydrated subjects experienced fatigue, tension, anxiety, negative changes in mood, and difficulty concentrating. They also committed 12 percent more total errors.

So how does dehydration affect our mental health?

Mild dehydration is approximately one and a half to two percent loss of water volume in the human body. We often mistakenly think that thirst is an alarm reminding us to drink water. However, this is a dangerous belief, since we might be dehydrated by then. Prior to physical symptoms and awareness, the brain detects dehydration, which then impedes the cognitive process and energy production.

The brain and blood are the main water reservoirs, and water insufficiency can particularly impact circulation rate. A lack of oxygen and blood flow may result in inefficient physical and mental functions. Moreover, water can alter hormone levels in the brain. Serotonin is an important neurotransmitter that regulates emotion. It forms from the amino acid tryptophan and water. Therefore, dehydration can decrease serotonin production in the brain. Besides serotonin, dehydration can fail to reduce the plasma levels of norepinephrine. A high level of norepinephrine may lead to psychosomatic depression. Dehydration also elevates the activation of the hypothalamic-pituitary-adrenal (HPA) axis through the increased release of antidiuretic hormone, sometimes resulting in mental disorders.

Dehydration can also cause significant elimination of electrolytes through urination. As the body tries to balance the osmotic pressure of fluids across cellular membranes, it excretes sodium and electrolytes. As a result, a reduction of blood sodium occurs in a condition known as hyponatremia, which can lead to hallucinations and brain dysfunction.

In addition, experts associate water deprivation with panic attacks. When individuals consume an insufficient amount of water, organs have difficulty keeping up with bodily demands. Organs send a panic message to the brain communicating that something is wrong with the body. Before the brain knows how to respond, an individual may already be experiencing a stress or anxiety attack.

Experts recommend people drink eight glasses of water every day. However, this rule might not apply to everyone since hydration needs depend on personal weight. Here are some tips that can keep us hydrated throughout the day:

1. Reduce the intake of caffeinated beverages because caffeine acts as a diuretic, or a substance that increases the production of urine.
2. Bring a water bottle to work or school.
3. Consume more foods with a high water content like watermelon, tomatoes, and soup.
4. Monitor urine color frequently to check hydration status. Urine should be pale yellow, or colorless. Dark yellow urine, however, often indicates great dehydration.

Increasing daily water consumption can greatly elevate health and reduce mental issues such as stress, panic, and confusion. Staying hydrated is a simple, but vital way to maximize our well-being.

World Journal of Psychiatry (2018). DOI: 10.5498/wjp.v8.i3.88

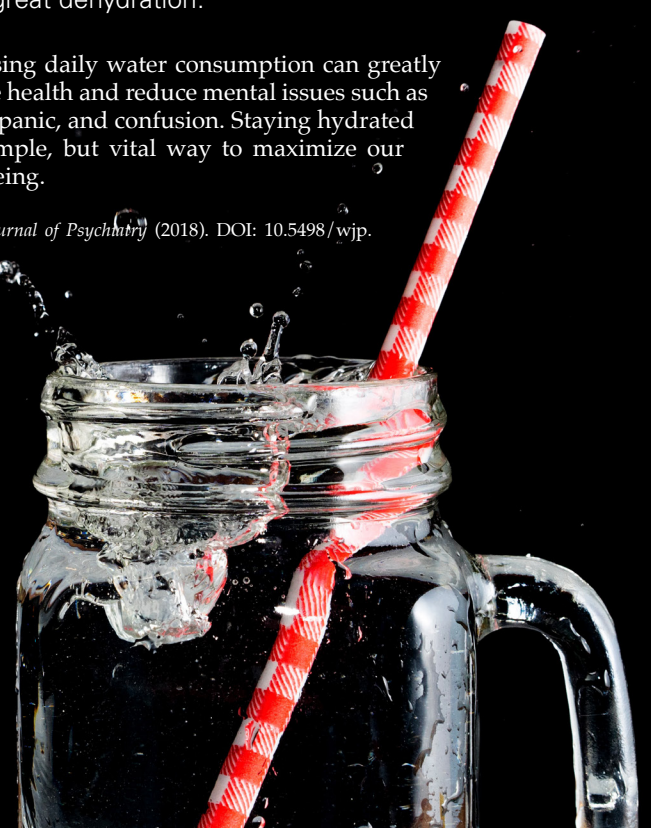


PHOTO BY UNSPLASH

ONE TOUGH NUT

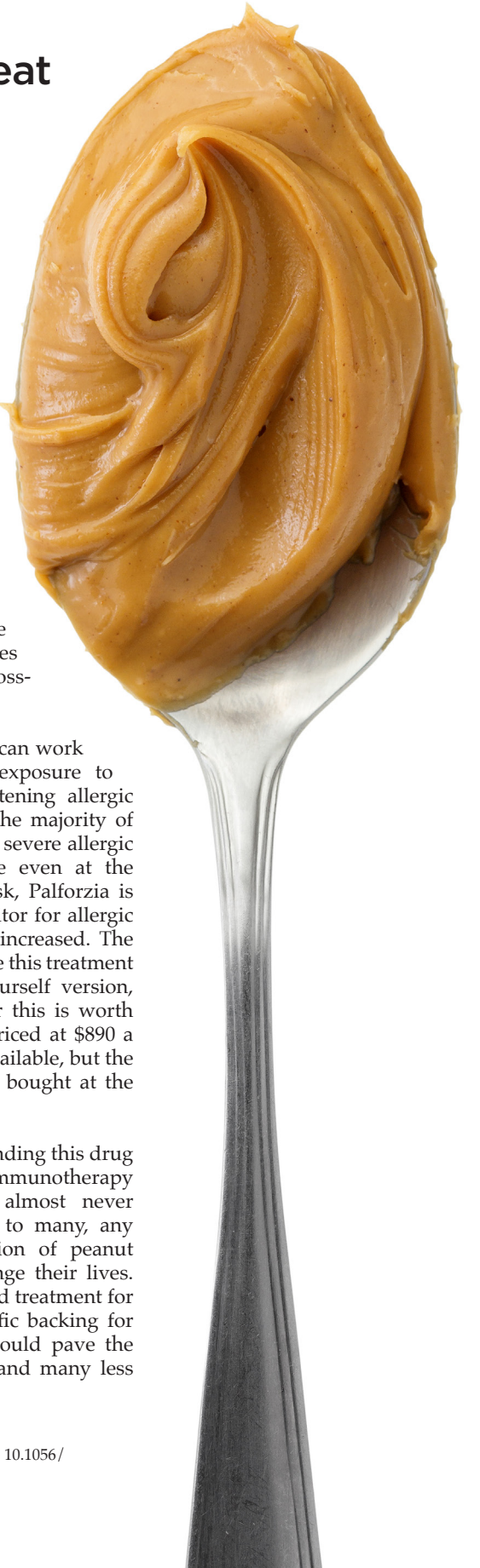
A new exposure-therapy drug could treat one of the most common allergies

BY AMANDA ZAVALA, CELL & MOLECULAR BIOLOGY, 2020
DESIGN BY KRISTI BUI, COMPUTER SCIENCE, 2021
PHOTOS BY SHUTTERSTOCK

Some people love eating peanut butter and jelly sandwiches, and some could go into anaphylactic shock if you eat one in the same room as them. Peanut allergies are one of the most common food allergies in the United States, and are particularly dangerous because peanut products are highly prevalent, making the risk of cross-contamination high. The severity of symptoms and allergen tolerance can vary from person to person, making food allergies hard to manage for the most sensitive, who can have allergic reactions to small concentrations of airborne particles. The current management standard is avoidance, and that often isn't feasible if someone can't even be in the same room as the allergen. Palforzia, the first drug approved by the United States Food and Drug Administration (FDA) for food allergies, could offer some relief for the most severely allergic.

An allergic reaction is caused by the immune system overreacting to a foreign protein that isn't actually dangerous, like peanut protein. Immune cells have millions of receptors to identify different foreign proteins and mount a response to eradicate them, although typically, the receptors are cultivated to not react with harmless things, like your own cells or peanut proteins. When immune cells mistakenly develop receptors that recognize peanut proteins, they respond to the apparent threat by releasing IgE, the antibody responsible for allergic reactions, and inflammatory molecules like histamine. After the first reaction, the immune system remembers the threat and will continue to respond in the same way once enough of the allergen is detected to be considered a threat. The goal of oral immunotherapy treatments like Palforzia is to prevent reactions by increasing the threshold to trigger an allergic reaction.

Palforzia is given as a pill containing a very low dose of peanut protein. The lowest dose is given continuously until the immune system becomes more tolerant, then the dose is increased and the process repeats. After several months of this treatment, 67.2 percent of children were able to ingest 600 milligrams of peanut protein with no or mild allergic symptoms. Before treatment, the children could only tolerate on average 10 milligrams. This will not enable patients to intentionally eat peanuts, but is expected to be sufficient to minimize responses to airborne particles or cross-contamination of foods.



Building tolerance to an allergen can work for some people, but regular exposure to something that causes life-threatening allergic reactions isn't necessarily safe. The majority of patients in the trial experienced a severe allergic reaction during treatment, some even at the lowest dose. To minimize the risk, Palforzia is given in a clinical setting to monitor for allergic reactions every time the dose is increased. The highly standardized dosages make this treatment potentially safer than a do-it-yourself version, although some question whether this is worth the price tag. Palforzia will be priced at $890 a month when it is commercially available, but the peanut flour it's made of can be bought at the grocery store.

Ultimately, the arguments surrounding this drug can be highly personal. Oral immunotherapy doesn't always work, and it almost never works without side effects, but to many, any improvement in the concentration of peanut protein they can ingest can change their lives. Palforzia is the first FDA-approved treatment for any food allergy, and the scientific backing for building tolerance to allergens could pave the way for many more treatments and many less allergic reactions.

New England Journal of Medicine (2018). DOI: 10.1056/NEJMoa1812856

The world's golden drink

BY BEIYU (PAM) LIN, BIOLOGY, 2021

DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

It sits in a perfectly organized row within many supermarkets today: kombucha, the world's golden health drink. Its bright, aesthetic labels pull in consumers, but the promises of amazing benefits keeps them hooked. These claims may explain the drink's ubiquity in the modern day—from being on tap at startup companies to bottled in the refrigerators of millennials, kombucha is everywhere.

Kombucha is a fizzy fermented tea that has dominated the health food world for years. It's believed to have been derived from ancient Chinese medicine and is made from a mixture of green or black tea, sugar, and a Symbiotic Colony Of Bacteria and Yeast (SCOBY). SCOBY is used in the production of a variety of other foods and drinks, such as sourdough bread and ginger beer. Kombucha is claimed to have a wide range of benefits, which include reduced risk of diabetes, blood pressure, and heart disease.

The fermentation of sweetened brewed tea by SCOBY not only causes kombucha to taste slightly alcoholic, but is also the heart of its claimed health benefits. As the fermentation process occurs, vitamin B, antioxidants, and probiotics are produced. Experts believe that the probiotic portion of the drink is what allows it to be beneficial to human gut health; this bacterial quality can improve body processes such as digestion and metabolism.

To what extent is there actual scientific evidence to back up these health claims? Tea itself has natural antioxidants, suggesting anti-inflammatory and anti-microbial benefits when ingested. However, there are surprisingly no conclusive studies that can confidently back any of the special health benefits kombucha claims to have outside of normal tea. For starters, the bacteria present in kombucha are still only believed to be probiotic, therefore the health claims associated with the human gut are yet to be confirmed. In addition, most clinical studies that have examined the effects of kombucha have been either animal or in vitro studies, not direct trials on human patients. While one study did investigate a direct relationship between kombucha and human health in non-insulin dependent diabetics, the research did not have proper controls or randomization. As it stands today, most of the drink's bold claims are still only mere speculation.

> "It's believed to have been derived from ancient Chinese medicine and is made from a mixture of green or black tea, sugar, and a Symbiotic Colony Of Bacteria and Yeast (SCOBY)."

Aside from its unconfirmed benefits, kombucha may even have potential harmful effects due to its low pH. Clarisa Gastelum, a professor at Stony Brook School of Dental Medicine, believes that the acidity of kombucha can be comparable to soda — both drinks can be problematic for an individual's teeth. Higher acidity can affect the durability of tooth enamel and increase discoloration, leading researchers to recommend drinking these beverages out of a straw.

What all of this means isn't that kombucha is necessarily bad for you, but that it may not be as magical as some believe it to be. There still exists the possibility that the beverage truly does have all the perks that it claims, such as aiding digestion, diabetes, and even cancer. However, it's also critical to recognize that none of this has been scientifically proven just yet when purchasing the trendy drink. As for the future of kombucha, retailers are hopeful that, even if it may not be confirmed to have those additional health benefits, it can still be used as a replacement for high sugar soda. Additionally, kombucha has been starting to be produced in combination with cannabidiol, otherwise known as CBD, from the cannabis plant for pain management purposes. It's clear that, regardless of the amount of concrete research, kombucha is going to stay in supermarkets for a while.

PHOTO BY MEGUMI NACHEV ON UNSPLASH

Eating for pleasure:

How enjoying your food can make it healthier

BY KRISTEN KILGALLEN, PSYCHOLOGY, 2022

DESIGN BY MEGAN LI, COMPUTER SCIENCE & DESIGN, 2023

Food is often viewed through the lens of cultural dogma — good or bad, healthy or unhealthy — but what scientists have been able to interpret from previous studies is that we may be looking at food's relative nutrient composition in a bottlenecked way. Certain foods contain varying amounts of macronutrients, vitamins, and minerals, but just because our food is made up of these elements does not mean that every individual who consumes them will utilize the chemical makeup of such food in the same way. The environment and context in which these foods are consumed seems to play an important role in the absorption of such compounds.

> "Just because our food is made up of these elements does not mean that every individual who consumes them will assimilate and utilize the chemical makeup of such food in the same way."

A study published in the *American Journal of Clinical Nutrition* tested iron absorption between two groups of women, one from Thailand and the other from Sweden. When given a meal from the opposite country, as compared to a traditional meal from their native country (keeping iron levels between meals constant), it was found that the women absorbed vastly more iron when they enjoyed the food from their own country. The study also then tested the same women's iron absorption when divided into two subgroups; one which had the original native meal, and the second group was given that same meal after being blended up into a brownish, clumpy slop. The latter barely absorbed any iron, presumably due to the fact that the meal was not very enjoyable to have.

This is because the process of digestion begins in the brain, not the mouth. When your brain is anticipating and eager to consume foods, it sends signals to your taste receptors, your salivary glands, and down your digestive tract through the vagus nerve, or the gut-brain axis, to begin the production of enzymes which will break down food. The lining of the digestive tract with neurons is known as the enteric nervous system or "second brain" due to its powerful impact on digestion. Additionally, a study published in the *Journal of Cellular Physiology* found that the neurotransmitters in the brain "regulate and control not only blood flow, but also affect gut motility, nutrient absorption, GI innate immune system, and the microbiome."

A movement of dieticians who are trained in intuitive eating take into account the role of satisfaction and pleasure in eating. They attempt to understand the influence it has in maintaining a homeostatic energy balance, or eating in the case of an energy deficit rather than for psychosocial reasons. This can be explained by the brain processes that take place during food consumption. Cholecystokinin is a neurotransmitter that is released when we eat. One of its roles is to signal to our brain when we are full or satisfied. It also stimulates pleasure and sends signals to the digestive system to begin the breakdown and absorption of ingested foods — proving the intimate relationship that exists between pleasure, digestion, and satiation.

Additionally, the environment in which food is consumed, the body, is a major contributor in whether or not nutrients are efficiently absorbed. If the body is in a stressed out state (sympathetic, "fight or flight"), blood flow is directed towards the extremities and away from the digestive organs, making food harder to digest and causing digestive distress. This is why taking the time to bring the body into a relaxed and pleasurable state (parasympathetic, "rest and digest") before eating is important for proper digestion.

It is important to note that the studies referenced are not representative of a causal relationship between pleasure and nutrient absorption, but do prove that our consumption of food is not a simple equation of inputs and outputs. The human body is a complex system and the chemical reactions that occur include many confounding factors — the black and white thinking of food as either physiologically beneficial or psychologically pleasurable is proving to be not entirely accurate. Although concerns among professionals often circulate about the relative pathways that drive the motivation to eat, the hedonistic or homeostatic pathways, people can still find pleasure in what they eat whilst also eating to meet the body's biological needs. Enjoying your food is not hedonistic, but rather a way to get the most nutritional bang for your buck.

American Journal of Clinical Nutrition (1978). DOI: 10.1093/ajcn/31.8.1403
Flavour Journal (2015). DOI: 10.1186/s13411-014-0029-2
Endocrinology Metabolism Clinics of North America (2008). DOI: 10.1186/s13411-014-0029-2
Journal of Cellular Physiology (2016). DOI: 10.1002/jcp.25518
The Journal of Nutrition (2009). DOI: 10.3945/jn.108.097618
American Journal of Physiology (2011). DOI: 10.1152/ajpgi.00387.2010

PHOTO BY PIXABAY

In the *mood* for *food?* Could be a change of scenery

BY ANNABELLE MATHERS, CIVIL ENGINEERING, 2022

DESIGN BY MARISSA KEESEY, ELECTRICAL ENGINEERING, 2022

The restaurant industry thrives from its promise of a sensory experience that enhances the consumption of food. Whether it be the ambient lighting, the flaming flat top grills visible behind the counter, or the aroma from the kitchen, these restaurants may truly be onto something. The intake of food often involves more than just taste, but also sensory stimuli, social factors, and psychological inclinations. An individual can effectively be influenced by the environmental ambiance surrounding a meal, creating nuanced eating patterns that are a part of everyday life.

In this culinary context, ambiance often consists of tastes, smells, colors, and, among other present stimuli, social pressures. These external stimuli inadvertently create a chain reaction within an individual's psychological and physiological state, which may then influence consumption patterns. Unfortunately, the extremely nuanced and variable nature of these stimulated responses make studies difficult to control and validate.

Researchers commonly struggle to decide between using the artificial environment of controlled laboratory studies, or the more authentic, but less controlled, method of self-reported results in restaurants and homes. Furthermore, the complexity of how different people perceive and respond to stimuli increasingly complicates experts' ability to pinpoint factors of causation and effect. Here, distinctions between appetite, hunger, and palatability are important. In many studies, experts designate appetite as a general feeling associated with an inclination to eat, whereas hunger presents as a physically irritating quality. Palatability measures the subjective, sensory enjoyment of food. Even with all of these complications, research on this topic continues, as it remains a valuable key in combating unhealthy eating tendencies that can lead to obesity and other health issues.

First and foremost, social circumstances can create emotional responses that manifest themselves in eating behaviors. Social facilitation occurs when the sheer presence of other people encourages greater, prolonged consumption. Many studies indicate that increased group size correlates positively with increased palatability and consumption. When surrounded by peers, people often have the inclination to eat impulsively, break regular eating patterns, and lengthen mealtime. On the contrary, other studies find that overall consumption and mealtime do not increase, indicating that research is still inconclusive.

Studies focused on culinary presentation yield similarly complex conclusions. An effective visual presentation of food, especially when combined with a sense of familiarity and subsequent expectation, often causes the brain to release a neurotransmitter called dopamine. This chemical induces sensations of pleasure and reward, and the resulting association of such sensations with food produces a greater inclination to eat. Prior knowledge of how the food tastes increases expectation, and can strengthen the physiological response. Many individuals increase consumption when the visual impression of the food is personally pleasing, but report no change in sense of fullness. The lack of fullness, even when overeating, may be concerning with respect to the rise in obesity. In a study using pizza, visual presentation alone augments appetite and salivation in overweight individuals and increases hunger in healthy individuals. It is this increase in casual appetite, regardless of hunger, that shows how trained chemical responses in the brain can increase consumption despite a lack of physical need.

Other visual stimuli, including interior design, contribute greatly to ambiance. Studies comparing psychological reactions to food in different venues propose that the preconceived notions that people have about a venue can affect palatability. Eating in a plain cafeteria seems to elicit less positive reactions to food quality than eating in an elegant restaurant, regardless of the actual food quality. Interior lighting may also influence eating patterns, in that a dimmer ambiance often results in impulsive, less restrained consumption. Moreover, the color of restaurant decorations and furnishings may influence hunger, thirst, and disposition. Adults typically prefer soft, subdued colors inside restaurants, which include calming cool hues, and stimulating warm hues. Even the color of food itself, particularly its increased variety, can escalate consumption; buffets exemplify positive correlation between appetite and color variety.

Last but not least, eating largely involves a sense of smell, the effects of which people often struggle to distinguish from taste. A scent can activate gastric secretion, and influence perceived taste and appetite. Studies demonstrate that a hungrier person perceives a better scent, and thus a better taste. Beyond analytics, the consumption of food is likely not a simple and unbiased decision process. Something other than taste makes us love our local eatery, even though it may lack a Michelin Star. A large part of life revolves around mealtime, so an enhanced understanding of its nuances can elevate our appreciation of the meals we make.

Nutrition (2004). DOI: 10.1016/j.nut.2004.05.012
International Journal of Obesity (2003). DOI: 10.1038/sj.ijo.0802391

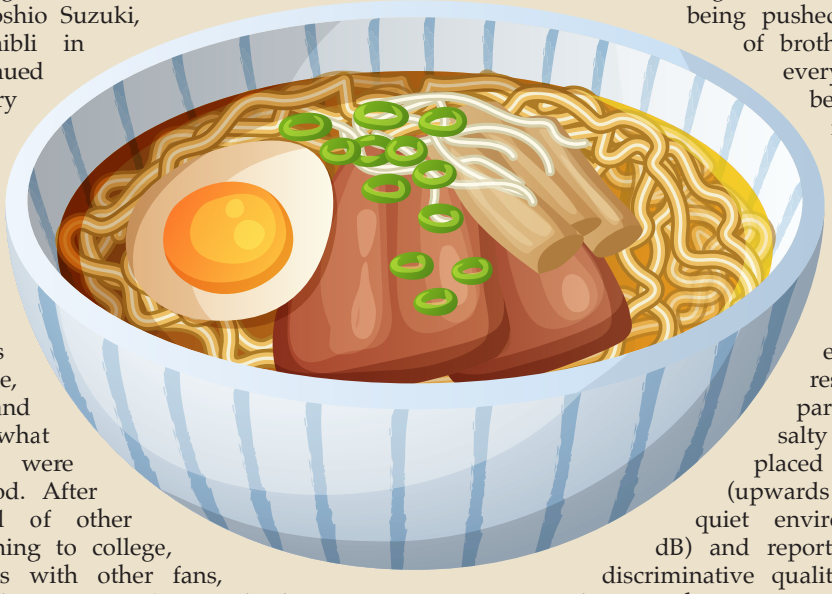
Miyazaki's masterful meals:
Adding meaning to food in film

BY SAGE KUMAR, BIOLOGY, 2023

DESIGN BY KYLA VIGDOR, DESIGN, 2021

What comes to mind when you imagine an appetizing spread? Vivid colors, thoughtful plating, perhaps some steam rising off the table. Zoom out and think of some other components. Deep aromas fill the room, perhaps with some ambient music and light chatter. Are you enjoying this meal with family and friends? Or are you eating alone and reflecting after a long day? Through curation of a carefully-tuned combination of all of these stimuli, plus the story and characters that experience them, director Hayao Miyazaki manages to imbue meaning into every meal depicted in his movies.

Miyazaki's most famous work has come out of Studio Ghibli, an internationally-recognized, Japanese animation giant. Miyazaki, along with co founders Isao Takahata and Toshio Suzuki, founded Studio Ghibli in 1985 and have continued to crank out legendary films ever since. The first Ghibli film that I can recall watching was "Ponyo," a 2008 movie about the friendship shared between a magical goldfish and a human boy. After the movie's heartwarming storyline, stunning imagery, and lovable characters, what impacted me most were its renderings of food. After watching a handful of other Miyazaki works, coming to college, and comparing notes with other fans, I've found that his culinary eye and ear make for scientifically-optimal cinema.



Animation's inherent malleability when it comes to imagery and sound lends itself to psychological satisfaction. In a 2016 study geared toward comparing the modern human's preferences when visually evaluating food, participants were shown a variety of food and non-food images, then asked to rate how appetizing they found each image. The results demonstrated a positive correlation between an increase in red-brightness and appetite, and a negative correlation between increasing green tones and interest. Subsequently, Studio Ghibli artists play into human evolutionary desires by tailoring their color palette toward warm tones and away from greens and cooler colors. This preference can be traced back to our roots as a hunter-gatherer society, and even further back to our living and extinct primate relatives who depended on trichromatic vision to detect the ripest and most nutritious fruits, which are usually more red-tinted and vivid than their unripened counterparts. The arrangement and plating of Ghibli meals is also conducive to a pleasant reception. The two-dimensional nature of this kind of animation requires food to be arrayed in a horizontal plane, which a 2018 study on food presentation confirmed to positively influence consumer interest, willingness-to-pay, and perception of portion size.

Encompassed within the food-centric scenes Miyazaki purposefully includes in many of his films is the preparation of the meal. Miyazaki enhances this otherwise mundane process through the fluid movement of the home cook, and most effectively, the sounds that come along with the act of cooking. This is especially evident in a scene from "Ponyo" where the mother of one of the protagonists prepares a hearty bowl of ramen. A storm is raging outside, yet tones of soothing music layered over bok choy being pushed into a boiling pot of broth make it seem like everything is as it should be. A study conducted in 2010 concerning the effects of ambient restaurant noise and music affirms the therapeutic effect that this scene has on viewers. The increase in noisy, crowded establishments pushed researchers to ask participants to sample salty and sweet foods when placed in loud environments (upwards of 70 decibels) and quiet environments (under 60 dB) and report back the "sensory-discriminative qualities of the gustatory stimuli" in each scenario. Subjects reported back that the loud background noise dampened the sweetness and saltiness of biscuits and potato chips respectively, demonstrating the influence that one's surroundings has on taste experience, and explaining the positive effect that light music and calming sounds have on filmgoers.

The last component that Miyazaki includes seals the deal: the people that the food is enjoyed with! Many of the scenes highlighting a meal have a unifying or comforting purpose, with family and friendship being heavily emphasized during that moment. The characters' satiated verbal and nonverbal responses to enjoying the meal and being with loved ones are the proverbial cherry on top of Miyazaki's multisensory experience. While only being able to reach viewers through sight and sound, his work manages to warm all five senses, plus, if you believe in it, the soul.

Scientific Reports (2016). DOI: 10.1038/srep37034
Appetite (2018). DOI: 10.1016/j.appet.2018.06.005
Flavour (2014). DOI: 10.1186/2044-7248-3-9

PHOTO BY SHUTTERSTOCK

How spatial mapping in the brain incorporates tastes

BY CATRIN ZHARYY, BEHAVIORAL NEUROSCIENCE, 2023

DESIGN BY KYLA VIGDOR, DESIGN, 2021

If your bed seems like the ideal spot to munch on your favorite snack, or if a particular booth beckons to you every time you walk into your favorite diner, it's probably because you already have some tasty memories associated with that location. Whether we like it or not, many of our autonomous "decisions" are actually governed by memories from past experiences that were sneakily stored away by our brains in order to be used again someday. The connections our noggins make between location and food are particularly important because, after all, we're animals, and remembering where a good meal can be found is highly advantageous for our survival.

This may seem intuitive, but it doesn't mean much in the world of science if there isn't experimental evidence to back it up. A study conducted on rats that was published in April 2019 identified cells in the brain's hippocampus (a major memory-making structure) that activate in response to both the body's spatial position and tastes experienced at that location. This is an amazing discovery, but it wouldn't have been possible without research on spatial mapping in the brain that began almost forty years ago.

In 1971, Master's student Jonathan Dostrovsky and 2014 Nobel Prize laureate John O'Keefe published a study entitled "The hippocampus as a spatial map," which has been cited in academic papers 2,997 times since its publication. Through observation of the rat hippocampus, O'Keefe discovered "place cells." These neurons fire differently depending on the animal's location, effectively creating a mental spatial representation of the environment it is currently inhabiting. Each place cell has a "place field," which is the specific spatial position the organism must be in for the place cell to fire.

In recent years, numerous studies have found that place cells in the hippocampus can also encode sensory information like odors, visual cues, auditory tones, textures, and time. When a place cell responds to such a stimulus, it produces a change in its firing rate on top of the firing rate it is initiating to signal spatial position.

A study conducted in 2019 recorded neuron activity in the CA1 region of the hippocampus, where many place cells are found, in five male rats. While measuring their brain activity, Herzog et al. gave the rats one of four water solutions, each with a different chemical added to elicit a certain taste — sweet, salty, bitter, and neutral (just water) — to observe the effect they would have on place cell activity. Each rat received every kind of solution in a random order, throughout many rounds. Out of the 395 place cells the scientists found in CA1, 58 (or 14.7 percent) of them were "taste-responsive." It turns out that these place cells respond to a taste if it is administered within its place field — evidence of a connection being created by neurons, in real time, between place and taste. Furthermore, some place cells could distinguish *between* tastes, firing differently in response to a particular one. Of the neurons that responded strongly to one taste, the taste was usually either the most "palatable" (rewarding) or most aversive taste. This was perhaps the most significant finding of the experiment: place cells, which have long been understood only as spatial mapping cells, can additionally distinguish between tastes based on palatability.

With respect to other taste-responsive structures in the brain outside of the hippocampus, place cells react to palatability relatively late, most likely too late to produce immediate changes in the individual's eating practices. Thus, their purpose must not be to change an organism's behavior in real-time but to form more long-lasting associations between location and reward to help animals locate food sources in the future.

As the field of neuroscience exponentially grows and diverges into subfields, it becomes clearer that many brain structures have more functions than previously thought. This includes the hippocampus, which was first identified for its roles in memory and learning, later for its role in spatial mapping, and now for its role in feeding behavior. To have made it this far in evolutionary history, the human brain must have a plethora of neurological secrets we've yet to uncover. Hopefully one day, the progress of the field will allow us to understand our own complexity.

Brain Research (1971). DOI: 10.1016/0006-8993(71)90358-1
Annual Review of Neuroscience (2008). DOI: 10.1146/annurev.neuro.31.061307.090723
Trends in Neuroscience (2009). DOI: 10.1016/j.tins.2009.01.009
Journal of Neuroscience (2019). DOI: 10.1523/JNEUROSCI.2478-18.2019

PHOTO BY UNSPLASH

FAREWELL TO OUR SENIORS

As is tradition, we present to you the NU Sci class of 2020. While small in number, this team has had a disproportionate hand in shaping the culture and direction of our magazine over the past few years, and we wish them the best of luck after graduation this May. Now, in their own words, read about their time spent with our publication.

LUCAS PRINCIPE

Editor-in-Chief | Philosophy & Environmental Science

I began my time with NU Sci four years ago. I can still remember the joy of having my first article published, and how excited my friends and family were when I shared it with them. That's been one of my favorite aspects of this job — helping new members who don't see themselves as "good" writers produce high quality stories. This year, as Editor-in-Chief, I've been incredibly impressed by the wealth of talent around me, and I'm proud of the way in which we've continued to innovate and grow as a publication. For that reason, I have no worries about the future of the magazine, and I'm looking forward to seeing where it's headed next year. After graduation, I have no professional plans as of yet, though I'm planning to begin work on my first novel this summer.

MOUSTAFA ABDELAZIZ

Treasurer | Computer Science & Finance

From coordinating panels and submitting budget requests to throwing e-board parties and arguing over favorite pizzas, I have enjoyed all of my time with NU Sci. Getting a publication like ours up and running is not an easy process. We definitely got down to business and were good at what we did. But the best part about our team was that we were able to have fun in the process, and I'll always miss that. It's been real NU Sci. Till next time.

ERICA YEE

Editor | Information Science & Journalism

I am very blessed to have been part of NU Sci since I was a freshman. Some of my favorite articles gave me the chance to profile the NU Toys club and a Northeastern professor who uses comics to teach chemical engineering concepts. As one of only a few journalism majors in NU Sci, I've enjoyed working with and learning from science majors as they take opportunities to expound about topics they find fascinating. A big shout-out to all the awesome people I've met and worked with in NU Sci. Your hard work, dedication, and passion for science communication is inspiring! After graduation, I'm planning to work in data-driven and interactive journalism.

PAULA HORNSTEIN

Editor | Biochemistry

I have been a writer for NU Sci since my freshman year, and I feel so lucky to have found such a wonderful organization so early in my time at Northeastern. I am grateful for all of the kind, creative, and talented friends I have made and for all they have taught me. Each and every person that I have worked with has helped me to grow as both a writer and a scientist. My favorite memories were working with brand new writers, and, of course, our celebrations at the end of the semester. I have absolutely loved my time writing and editing for NU Sci, and am looking forward to reading future issues!

AMANDA ZAVALA

Editor | Cell & Molecular Biology

I got a relatively late start with NU Sci for someone who enjoys writing so much, but I've been continuously impressed by how efficiently we're able to put a professional magazine together and how friendly everyone is while doing it. I was welcomed right into the fold as a new editor, and it's been a great year of bonding with the team, honing my writing skills, and learning about all sorts of fascinating science. I'll miss it all very much, and I treasure all the memories associated with the articles I've written and edited for. Post-graduation, I've secured a research position at TCR2 Therapeutics, an immuno-oncology biotech company in Cambridge, where I'll be doing biomedical research in the same vein as the things I tended to write about.

DESIGN BY LILLIE HOFFART, ENVIRONMENTAL SCIENCE, 2022

NU SCI

Follow us: @nuscimag
Read our work: nuscimag.com
Subscribe to our newsletter: bit.ly/nusci
Contact us: nusciencemag@gmail.com