# STHE NEW YORK ACADEMY OF SPRING 2020



A look at challenges and opportunities in food and nutrition science research.



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# Announcing New Leadership for our Third Century: **Dr. Nicholas Dirks**

By Jerry Hultin, Chair, New York Academy of Sciences Board of Governors

Many of you may recall that about three years ago, as the New York Academy of Sciences celebrated its 200th anniversary, Ellis Rubinstein announced his decision to retire from his role as President and CEO.

Finding a replacement for Ellis was likely to be daunting, especially because the Board wanted a leader who could leverage our heritage, attract new donors, increase our impact, and strengthen our finances. The Search Committee, headed by Vice Chairman Thomas Pompidou, interviewed a talented cross-section of qualified candidates. But one candidate stood out as especially exciting — Dr. Nicholas (Nick) Dirks. So I am pleased to announce the appointment of Dr. Nicholas B. Dirks as the next President and CEO of the New York Academy of Sciences. Nick has already begun his work during this transition period, and will join the Academy full-time in June. Dr. Dirks is Professor of History and Anthropology at the University of California, Berkeley, as well as the Franz Boas Professor Emeritus of Anthropology and History at Columbia University. He has taught at Caltech, the University of Michigan, Columbia, and Berkeley.

A strength of the Academy has been its status as a neutral and respected convener. As a result, over the past 200 years it has been able to bring together a highly diverse range of experts to address the most pressing scientific and technological challenges of the day. Moreover, the Academy's founders believed that opening membership to people of all ages and backgrounds, not just academics or other STEM professionals, was the best way to achieve this goal.

Nicholas Dirks, Ph.D.
President and CEO,
New York Academy
of Sciences

Nick Dirks' whole career reflects this vision. At the University of Michigan, he merged anthropology with history to create a new interdepartmental Ph.D. program, fostering a whole new approach to both disciplines. At Columbia, he rebuilt several departments, increased the diversity of the faculty, and promoted the internationalization of the university. As the 10th Chancellor of the University of California, Berkeley, he led major initiatives in undergraduate education, global outreach, and interdisciplinary and cross-institutional research. His work spanned disciplines, but focused in particular on the fields of neuroscience, biomedical sciences, and data science. Most recently, as Chancellor of Whittle School & Studios, Nick has introduced a unique and comprehensive approach to K-12 education. For more information about Nick's impressive career, go to nicholasbdirks.com.

Nick Dirks joins the Academy at a crucial moment in science and technology. As we go to press with this edition of the New York Academy of Sciences Magazine, the country — indeed the world — is in a battle with a novel and deadly coronavirus, COVID-19. Regardless of the outcome of this pandemic, our experience with such diseases reinforces our core belief that society depends on good science and technology.

I believe that Nick Dirks is the right leader for the Academy in its Third Century. His grasp of the issues facing science, technology, and society, along with his close relationships with scientific and technology communities, policy makers, and leaders in business, philanthropy, and government, will take the Academy to a whole new level.

I'm thrilled to have such a distinguished academician and leader in education join the Academy as President and CEO, so please join me in welcoming Nicholas Dirks. In the coming months we will be hosting a series of programs where you'll have an opportunity to learn more about his vision for the Academy. Check our website at nyas.org for more to come!

Jh Att

Jerry Hultin Chair, New York Academy of Sciences Board of Governors





### AN IMPORTANT MESSAGE FOR OUR MEMBERS: THE ACADEMY'S RESPONSE TO COVID-19

The New York Academy of Sciences is working hard to support the research community and health experts in the worldwide response to the COVID-19 crisis.

Through webinars and other programming, we are taking on key topics: the expected course of the pandemic; differences in the spread of COVID-19 in the U.S. and other parts of the world; the impact of different approaches to social isolation; the use of large-scale data in the search for therapeutics and to predict the spread of the disease; and research toward a vaccine.

Other initiatives include a collaboration with Sana Labs in Sweden on an Al-based learning platform to "upskill" nurses to work in intensive care units, and to provide training to volunteers to assist medical staff in hospitals.

The Academy is also engaging young people. A thousand students from over 50 countries are participating in our COVID-19 Innovation Challenge. It's a work-fromhome activity to help students sharpen critical thinking skills as they develop technology to address the outbreak.

For educators we are distributing lesson plans and multimedia instructional content. And to remind STEM professionals of the importance of their work, we're sharing stories of their engagement in the global battle against COVID-19.

Find our resources and programs here: https://www.nyas.org/Coronavirus

We are proud of our community, and know that our collective action in science, technology, engineering, mathematics, and medicine (STEMM) is the world's most powerful force for change in this difficult period.

We hope you and your respective colleagues and families are safe and well.

Brooke Grindlinger, Ph.D.

Chief Scientific Officer, Scientific Programs and Awards New York Academy of Sciences

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# Contents

### **COVER STORY:** SUSTAINABLE SOLUTIONS FOR THE WORLD'S DINNER TABLE

**TACKLING THE BIGGEST CHALLENGES IN FOOD AND NUTRITION SCIENCE** 

> The New York Academy of Sciences nutrition team is becoming a center of reference on nutrition issues.

### **OLD MCDONALD'S FARM CHANGED THE CLIMATE**

Agriculture doesn't have to be at odds with the environment.

### IS "BEYOND MEAT" REALLY THE NEXT SUSTAINABLE **FOOD SOURCE?**

Researchers are coming up with innovative ways to make plantbased meat more appealing to consumers.

### 12 **CANNABIS AND SCIENCE: BETWEEN THE HYPE AND** THE HOPE

CBD has become the ingredient driving a billion-plus dollar market of consumer products.

#### **BRED TO BE WILD** 14

Improving crops by conserving their wild relatives.

### **FOOD ALLERGIES ARE** 16 **GETTING WORSE**

Researching new paradigms for treatment.

#### **REDUCING THE WASTE-LINE** 18

Researchers are looking at ways to reduce the amount of organic waste in landfills.

### 20 HOW NUTRITION SCIENCE IS ENSURING A HEALTHY **START IN LIFE**

Addressing multiple micronutrient deficiencies in pregnant women and their babies for treatment.

### **ACADEMY NEWS**

### 22 TALENT SHOWCASE

The Blavatnik Awards for Young Scientists honorees in Israel and the U.K.

### 24 PARTNERSHIP SPOTLIGHT

The New York Academy of Sciences and the Aspen Brain Institute celebrate a decade of collaboration.

#### **OPINION** 25

Investing in teachers yields smart returns for students.

### PROFESSIONAL DEVELOPMENT

- 26 The case for mentoring as a pathway to promote student interest in STEM.
- Building an effective network to achieve your career goals.
- 28 **ACADEMY eBRIEFINGS**
- 30 **ANNALS HIGHLIGHTS**

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By Carina Storrs, Ph.D., NYAS Contributor

According to the United Nations, malnutrition is "a trap from which people cannot easily escape." And it is a trap that affects every country in the world. In 2015, ending hunger and ensuring access to nutritious food was named one of the U.N.'s 17 Sustainable Development Goals (SDG) for 2030. Efforts to reduce malnutrition stretch back decades and have taken many forms. These include global initiatives that increase access to nutritious foods; government policies that promote healthy diets and set nutrition standards; nonprofit groups that operate food pantries and kitchens; and researchers who study malnutrition and evaluate interventions.

Within the vast landscape of approaches to combat malnutrition, the New York Academy of Sciences Nutrition Science Program has been focusing on where it can make the greatest contributions to nutrition science research. Over the last four years, it has focused on important nutrition science interventions, including the control and prevention of thiamine and micronutrient deficiencies and bolstering evidence-based nutrition models. These activities support a priority for the Academy — addressing global issues such as food security that affect infants, adolescents and the aging population. "Today we can say that the Nutrition Program at the New York Academy of Sciences has become a center of reference on a number of those issues," said Gilles Bergeron, Ph.D., Senior Vice President for Nutrition Science at the Academy.

This issue of the New York Academy of Sciences Magazine looks at the impact of some of the Academy's own activities, as well as the work of other research and aid groups, in tackling the biggest nutrition science challenges. It also explores efforts to accelerate progress toward both food security and safety — from addressing environmental impacts of commercial farming, reducing food waste and promoting plant-based meat alternatives, to understanding the most common food allergies and the long-term health effects of ingested cannabis-based products.

The Academy's reputation as a neutral convener of experts

representing all sides of an issue, makes it the ideal catalyst to assess current scientific evidence writ large. In the case of the Nutrition Program, it also actively evaluates data, and participates in ongoing research needed to design future large-scale programmatic activities. For its research on thiamine deficiency, a problem that mainly occurs in low and middle-income countries (LMIC) due to insufficient dietary intake of the B<sub>1</sub> vitamin, the Academy's nutrition science team, together with the Bill & Melinda Gates Foundation, convened a task force in 2017 to take stock of existing data. The team is now collaborating with researchers internationally on several projects to fill in knowledge gaps, determine best solutions to tackle this public health problem, and to assess the prevalence of thiamine deficiency in understudied regions of Africa, such as Madagascar and The Gambia.

Thiamine deficiency can easily go unrecognized, as it did for decades in parts of Asia such as Bhutan and Northern India, because the symptoms are so vague, ranging from the loss of appetite in infants and children, to tingling in hands and feet in adults. But left untreated, thiamine deficiency can rapidly lead to death, and there is increasing evidence that subclinical cases — which almost never get detected — can cause long-term cognitive delays and motor skill problems. "We are starting to work on strategies to prevent thiamine deficiency and

to raise awareness of its prevalence, which is much, much broader than I think anyone expected," said Megan Bourassa, Ph.D., a biochemist and the Academy's Associate Director of Nutrition Science.

The Academy's Nutrition Science Program has brought much-needed attention to the issue of thiamine deficiency, according to Frank Wieringa, M.D., Ph.D., senior researcher at the Institut de Recherche pour le Développement (IRD) in Montpellier, France. "In 2012, we knew as much about thiamine deficiency as we did in 1950, there was hardly any progress in those 60, 70 years," said Wieringa, who served on the Program's task force and is part of its Scientific Advisory Group. Wieringa found a high prevalence of thiamine deficiency in Cambodia, even though the problem has generally been less well recognized by the medical community there than in other parts of Southeast Asia such as Laos. He and his collaborators, including the Academy nutrition team, are currently testing the optimal dose of thiamine to give lactating women in Cambodia. Early data will be available this spring and the hope is to eventually fortify salt with the optimal thiamine dose, much like salt is already iodine-fortified.

On a separate but related front, the Academy has taken on the challenge of trying to improve the myriad of computer models that can guide policy makers, researchers and aid groups in deciding how to tackle malnutrition despite limited resources. The models, which have been developed by academic, governmental and humanitarian groups, can make predictions about important policy questions such as: which nutrition issue is the most pressing in a particular setting?; should attention be directed at certain micronutrient deficiencies or on bigger issues of stunting and underweight populations?; which intervention(s) would be most cost-effective?; what is the best mix of interventions to achieve multiple concurrent objectives? With competing models, policy makers may only use the tools that are promoted by the donor they work with (be it The World Bank, USAID or other); and not necessarily the one that is most appropriate for their goals. There needs to be a greater recognition of the diversity of needs and the fit-forpurpose of specific modeling tools to the specific task.

Over the last three years, the Academy, with funding from the Bill & Melinda Gates Foundation, has brought together various modelers and launched the Nutrition Modeling Consortium to try to increase awareness of the models in LMIC. Such a partnership was developed to foster collaborations and shared experiences between countries regarding the use of models in decision making. The Consortium has given modelers the "unique opportunity to sit down and really dig into what these models can do," said Stephen Vosti, Ph.D., Adjunct Professor at University of California, Davis, and member of the Consortium. Vosti and his colleagues created MINIMOD, a tool to help plan and manage the most cost-effective micronutrient interventions in LMIC. So far, the researchers have identified strategies for reducing vitamin A deficiency in Cameroon and plan to deploy the tool to look at other micronutrient deficiencies in countries such as Malawi and Nigeria. MINIMOD could also be used to assess the risk of interventions leading to overconsumption of micronutrients, which is a particular concern in the United States and other developed countries, according to Vosti.

With more than 800 million people around the world experiencing undernourishment in 2017, the stakes for the Nutrition Science Program, as well as the many other efforts featured in this issue, could not be higher. Ensuring that all the world's people have access to adequate nutrition achieves multiple societal objectives. Healthy people are productive people who can work and contribute to long-term economic sustainability. And a proper diet is foundational in enabling people to fight off disease. It is arguably a gender issue as well. In societies where male children are often more valued than females, girls may not receive adequate nutrition in their formative years, which will impact their ability to bear healthy children of their own.

"Access to nutritious food is a common thread to all population segments," said Bergeron. "What we do at the Academy is not just about starving children in remote parts of the world, although we recognize the need. Obesity, antibiotics in animal food production, adolescent women nutrition as well as nutrition for the aging, are issues that need to be addressed in developed countries as well. Here in the United States, it is estimated that one in every 10 adults who are 20 years or older has diabetes. For seniors (65 years and older), that figure rises to more than one in four. The cost of diagnosed diabetes is an estimated \$245 billion — money that could go to crucial nutrition programs both in the U.S. and around the world for a healthier society at large."



# Old Mcdonald's Farm Changed the Climate, but Agriculture Doesn't Have to Be At Odds with the Environment

By Alan Dove, Ph.D., NYAS Contributor

What should we eat? This fundamental question has bedeviled humanity throughout our history, spurring a series of urgent, society-changing innovations. For centuries, agriculture changed little, from the hunter-gatherer tribes who lived off the limited bounty of subsistence farming and the hunting of wild animals, to the open-field system of farming performed by village serfs. But these approaches could not produce enough food to feed a growing population. The enclosures of the common lands in 16<sup>th</sup> century England caused massive civil unrest, but it made the land more productive. The industrial revolution introduced such innovations as the combine harvester, as well as storage and shipping technologies that allowed the cultivation of a greater variety of food for an even larger population. Today "agribots" and other Al-based technologies are helping farmers to keep pace with the demand for food production as the global population balloons into the billions.

Unfortunately, these innovations have come at a steep environmental cost. Modern farming guzzles fossil fuels and scarce water reserves, emits hazardous chemicals, and overturns entire ecosystems. The planet can't sustain this pace much longer, so we're faced with the prospect of refereeing the interests of commercial farmers with those who believe the health of people is only as good as the environment in which they live. With environmental laws now being weakened, farmers and researchers will need to work together more closely to develop new long-term sustainable food production systems while preserving fragile eco-systems.

## "OH, THE FARMER AND THE [RESEARCHER] SHOULD BE FRIENDS ..."

A central problem in restructuring global agriculture is the sheer scale and diversity of the industry. Ideas that work well in an lowa corn field are irrelevant to an Indonesian rice paddy, which in turn bears little relation to beeves grazing on Argentine range land.

That's why the United Nations' Sustainable Development Solutions Network launched the Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium in 2017. "The idea was that we need to build the capacity in many countries ... to do some long-term analysis of the food and land systems in order to design policies," says Aline Mosnier, scientific director of FABLE in Paris, France. Based mostly at research institutes, each of the 22 current FABLE country teams focuses on analyzing and modeling a specific country's agricultural systems.

FABLE released its first report in 2019, a comprehensive overview that identified "pathways to sustainability" for different countries and types of agriculture. Consortium teams focused on strategies to increase food security while reducing greenhouse gas emissions and deforestation, tailoring them to local conditions. "It's very important to have this being driven at the country level," says Mosnier, adding that "studies before this were just at the global level."

The FABLE models suggest that with appropriate policies and careful implementation, farming doesn't have to come at the expense of the environment. "It seems feasible that we could reach many of our targets toward greater sustainability ... it's feasible by 2050 if we have some proactive measures implemented by the different countries," says Mosnier.

However, sustainability requires political will to follow the science. Brazil, for example, achieved significant, rapid reductions in deforestation in recent years. But in 2018, a far-right government took over, appointing pro-industry administrators to top posts and setting aside many of the previous recommendations by scientists. Deforestation rates in the country have since skyrocketed.

### THIS LAND IS MY LAND, THIS LAND IS YOUR LAND ...

Problematic land use changes aren't limited to the clearing of rainforests. Indeed, all forms of agriculture entail some degree of ecosystem engineering. "There's such a variety of approaches, and they vary in how much they sort of coerce the ecological system," explains Craig Allen, Director of the Center for Resilience in Working Agricultural Landscapes at the University of Nebraska in Lincoln.

Clear-cutting forests to make room for farms can extirpate many native species, but even converting grasslands to similar -looking fields of wheat or corn can disrupt an ecosystem. And while many environmentalists argue — correctly — that modern animal farming can be quite destructive, not all meat is the same. "Here in Nebraska we have extensive range lands, and those are pretty much native prairie, managed quite well and fulfilling habitat requirements for a wide range of species," says Allen.

The fundamental problem is that any ecosystem can only support a finite number of organisms, so growing plants or animals for human consumption will always carry some environmental cost. "Our landscapes produce a wide range of ecosystem services, and one of those services is food production," says Allen, adding that on land dominated by modern

monoculture farming, biodiversity inevitably suffers.

Experts project that by the year 2050, the growing global population will need as much as 70 percent more food than the world's farmers currently produce. One solution is to farm existing agricultural land more intensely. New irrigation, fertilization, and crop breeding strategies are already boosting yields in many areas. "I'm relatively optimistic about our ability to increase productivity, but of course the planet's becoming smaller and smaller," says Allen. He adds that pollution from some of the fundamental inputs of intensive agriculture, such as nitrogen fertilizers and fossil fuels, may soon strain the planet's ecological limits.

In the meantime, farmers in many areas are already running up against another critical limit: water scarcity. While drought has been a hazard to agriculture throughout history, growing demand and climate change exacerbate the problem. "Water supplies are becoming increasingly erratic, and that's a function of the rainfall and the snowfall and changes in dry times, but more importantly, it's becoming less predictable from year to year," says Todd Jarvis, director of the Institute for Water and Watersheds at Oregon State University in Corvallis.

That volatility is a problem for scientists as well as farmers. Researchers such as Jarvis have long built their prediction models based on stationarity, the idea that past trends will continue into the future. With droughts and floods becoming more erratic, that approach doesn't work anymore.

Worse, the changing climate will have radically different effects in different parts of the world. "Everybody makes reference to climate change as global drying, and that's not the case. In just the Midwest of the United States alone, the change in climate is resulting in more water in some places," says Jarvis.

Adapting to these changes will require different approaches, depending on the types of water problems each region is facing. Infrastructure such as dams and reservoirs built to handle floods may have to be expanded or modified, while irrigation systems designed for current droughts may prove inadequate in the future. As with changes in land use, infrastructure shifts may also have unintended consequences.

"A lot of the infrastructure that's been constructed over the past 50 to 100 years was in response to building the agricultural of thin air.

industry and settling lands, and today we're having a completely different bundle of challenges," says Jarvis. As an example, he cites the flood-control dams of the Pacific Northwest, which are now considered threats to the region's salmon fishery.

### THE ANSWER MAY NOT NECESSARILY LIE IN THE SOIL

The difficult tradeoffs involved in farming have led some scientists to explore a different approach to food production: fermentation. Microbes growing in industrial scale fermenters can produce vast quantities of proteins, carbohydrates, and fats in a matter of days. The idea of turning this nutritional bonanza into food isn't new. Marmite, a popular sandwich spread in Britain made from leftover brewer's yeast, was developed in the 19<sup>th</sup> century.

More recent efforts to brew staple foods have focused on other microbes, especially soil bacteria that can grow on simple inputs. Solar Foods in Helsinki, Finland, is at the leading edge of this field. "We want to disconnect food production from agriculture," says Pasi Vainikka, the company's CEO. The core of Solar Foods' system is a fermentation process that runs on hydrogen, carbon dioxide, ammonia, and a few minor nutrients such as calcium and phosphorous. The hydrogen comes from splitting water molecules. For energy, the company relies on solar-generated electricity.

"From a physicist's point of view, we're just converting electricity to edible calories," says Vainikka. Based on current solar electricity production capabilities, Vainikka has calculated that a kilogram of Solein, the company's food product, uses one-tenth the land area required for a kilogram of soy protein, and one-hundredth the land area needed for a kilogram of beef. The production process also uses orders of magnitude less water than conventional agriculture.

Solar Foods' pilot plant in Helsinki now produces about a kilogram of Solein per day. The company is using that material to carry out the testing required by regulatory agencies in the U.S. and E.U., while refining the fermentation process. Vainikka hopes to scale up to a full-size factory by 2025, to supply Solein as a protein-rich additive for various food products worldwide.

If that happens, humanity may soon be pulling food out of thin air. ◀



# Is "**Beyond Meat**" Really the Next Sustainable Food Source?

By Sara Donnelly, Ph.D., NYAS Staff

Researchers are coming up with creative new ways to make plant-based meat alternatives more appealing to consumers.

Vegetarianism and even veganism are not new ideas — in fact one of the first mentions of vegetarianism comes from Pythagoras in 500 BCE. Buddhists and other religious groups have long advocated the practice for humane reasons.

The term vegan was coined more recently in 1944, to distinguish those who do not eat any animal-derived products from those who still consume dairy and eggs. Veganism has long been viewed as an extreme lifestyle choice, however, in recent years, the popularity of plant-based diets has been on the rise.

In 2017, six percent of U.S. consumers identified as vegan. While this is still a tiny percentage of the population, it represents a 600 percent increase over the previous three years.

People may choose not to eat meat due to health reasons or concern over animal welfare, but growing awareness of the contribution of food production to climate change has begun to expand the conversation around the need for the broader adoption of a plant-based diet.

According to the Food and Agriculture Organization of the United Nations, food production is responsible for 14.5 percent of worldwide greenhouse gas emissions. It is estimated that if everyone in the U.S. were to give up eating meat and dairy, it would reduce the country's carbon emissions by 70 percent. Reducing the prevalence of meat and animal products in the American diet will not be easy, as ideas and preferences about food are deeply rooted in cultural and societal norms. Even with greater understanding of the health and environmental implications, many people struggle with the idea of replacing their Thanksgiving turkey, or their celebratory steak, with a plant-based alternative.

Eating meat is also associated with increasing wealth, and as the standard of living has increased over the last 50 years in countries such as China, so too has their meat consumption, despite government policies advocating for lower intake.

A number of new plant-based meat alternatives have recently been developed that aim to ease the transition for those who want to make the switch. Several of these products have garnered significant media attention, but why all the hype? What makes the Impossible Burger "impossible?" and why would you want to go "Beyond Meat"?

### THIS IS NOT "MYSTERY MEAT"

While they take different approaches, companies such as Impossible Foods and Beyond Meat aim to create plant-based products that are almost indistinguishable from the real thing, which they believe will lure even the most die-hard meat eaters away from animal-derived products.

According to Principal Scientist, Dr. Laura Kliman, of Impossible Foods, "You can't just tell people to stop eating meat, so at Impossible we're not redesigning the product. We're just redesigning the process to make it, and we're delivering all the deliciousness, the nutrition, the versatility, that people expect out of meat but we're making it from plants, which is inherently more sustainable."

Impossible has a lofty mission to "replace the need for animal farming by the year 2035". To do that, they take a rigorous scientific approach to replicate the taste and texture of meat. As Kliman says "taste is only a small part of it, flavor is mostly aroma." In order to identify and recreate the aroma of meat, she uses the Gas Chromatography-Olfactometry technique, in which beef is broken down into its component chemicals and each of those is associated with a particular smell. The scientists then turn their attention to the plant world to find plant-based compounds with the same characteristics. For Impossible this means they now have a "technology platform, or pipeline" that allows them to do the same for other meat products — for example the recently released Impossible Pork. A similar pipeline approach is used to replicate the texture of meat.

For Impossible, their "secret sauce", what Kliman says



provides the "explosion of meaty flavor" is heme, a chemical found in all plants and animals. In humans, it forms part of hemoglobin, the protein complex that carries oxygen around the body in the bloodstream. To replicate the taste of animal heme, Impossible scientists turned to leghemoglobin, a variant that naturally occurs in soy. They then devised a way to produce it in genetically modified yeast, in order to meet production demands and minimize its environmental impact. According to the company, their process uses 87 percent less water, 96 percent less land, and emits 89 percent less greenhouse gases than it takes to produce traditional beef burgers.

Plant-based alternatives to meat are produced from soy, potato, rice, mung bean, or pea protein and also contain fats to give them the appealing sizzle as they hit the pan. While eating a plant-based diet is often viewed as the healthier option, it is important to realize that eating "Beyond Meat" or an "Impossible Burger" is not necessarily beneficial for health.

These products have a similar fat content to beef burgers, and while they have less cholesterol and more fiber than a typical meat patty of the same weight, they do contain more sodium. Professor Kent Kirshenbaum is an organic chemist at New York University, and former scientific advisor to Beyond Meat, who is currently on the board of the Good Food Institute, a non-profit that promotes alternatives to animal food products. "There is no easy way to answer this question," he says. "Is it potentially beneficial to move to plant-based sources of food rather than animals? Yes, and I could spend a lot of time telling you why, especially moving away from red meat. However, for those people who are concerned about ultra-processed foods as potentially having deleterious health consequences, they're absolutely right, this could turn out to be a problem. We don't know what it is about processed foods that gives rise to health problems, so we really don't know what the long-term effect is going to be."

### **TODAY'S CHEF SPECIALS**

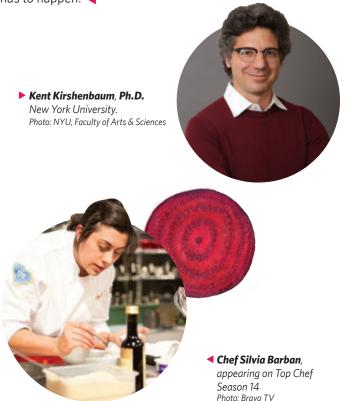
From restaurants like David Chang's Nishi, to Burger King and Dunkin' Donuts, the Impossible Burger and Beyond Meat products are widely available, and Taco Bell recently announced it will offer plant-based fare within a year. However, not all restauranteurs are so enthusiastic. Chef Silvia Barban, former "Top Chef" competitor and current proprietor of LaRina in Brooklyn, N.Y., offers many vegetarian options on her menu, but none of them contain plant-based meat alternatives. Barban prefers to use her culinary skills to turn locally sourced vegetables into a delicious meal. "I want to sustain the local farmers. I want to try to make great dishes with everything that we have around", says Barban. However, in her personal life she finds these plant-based products an easy substitute in dishes like tacos or ramen, when she needs a quick and tasty lunch or late meal after work. While Barban thinks that plant-based meat alternatives are a great

addition to fast food, or fast casual restaurant menus, she has no plans to incorporate them in her own menu: "I just use vegetables and I treat them the right way and make it super flavorful. For example, I like to do a beet tartar. It's vegetarian. It looks like meat, but it's not — it's beets and it's delicious!"

### **EATING OUR WAY TO SUSTAINABILITY**

It is clear that for our health and the environment, we need to rethink what we eat and how we produce our food. A recent report from EAT-Lancet Commission states that achieving a sustainable and healthy diet worldwide is possible by 2050, but will require a dramatic shift in our approach to eating and agriculture as well as require significant effort and investment from all sectors. While the report suggests that meat consumption should actually increase in parts of the world where malnutrition is prevalent, in North America, there needs to be a substantial decrease in the amount of meat and dairy consumed. Thus, solutions to the problems of developing a sustainable global food supply chain will take many forms. In western nations, hi-tech plant-based meat alternatives, will almost certainly play a major part in this revolution.

"This is here to stay. Even if part of what's going on is some element of hype, we don't have any choice but to drastically reform our food systems, it has to happen," says Kirshenbaum. "The population is just growing too quickly. Economies around the world are expanding and people are becoming wealthier, which has generally been associated with greater consumption of meat. Just from a global sustainability standpoint, this has to happen."



### Cannabis and Science

By Sonya Dougal, Ph.D., NYAS Staff

CBD has become the ingredient driving a billion-plus dollar market of consumer products — researchers are sorting the hype from the hope.

Enter any drugstore, vitamin chain, big box store, e-commerce site, gas-station convenience store or street corner bodega and you'll find CBD products — in shampoos, oils, vapes, gummies and even treats for people and pets. Many of these products come with creative claims of the therapeutic benefits of CBD, true or not.

Such mass market hype and wishful thinking aside, Epidiolex®, an FDA-approved breakthrough treatment for rare drug-resistant epilepsies, is currently the only CBD product (cannabidiol) demonstrated to be effective by controlled studies in people.

CBD was previously known as the non-intoxicating sibling of the psychoactive intoxicant THC (tetrahydrocannabinol) — both cannabinoids produced in the marijuana plant. Traditional medicines have used cannabis for millennia, yet the United States first placed legal restrictions on its use in the 1920s and 1930s. In 1970, marijuana became illegal under Schedule I of the U.S. Controlled Substances Act.

CBD, though, received an enormous boost when the Farm Act of 2018 allowed the legal growth and sale of hemp products which include CBD. However, THC remained illegal, along with CBD produced from marijuana. These changes have only added to the ambiguity of CBD's status from the perspectives of both law and science.



### Research Director of the UCLA Cannabis Research Initiative and Associate Professor in the Jane and Terry Semel Institute for Neuroscience and Human Behavior. Photo credit: UCLA Health

▲ Margaret Haney, Ph.D. Professor of Neurobiology at Columbia University Medical Center

## "IMAGINE YOU'RE A CAVEMAN" — THE HUMAN ENDOCANNABINOID SYSTEM

In the 1980s and 1990s, researchers identified cannabinoid receptors in humans (CB1 for THC and CB2 for CBD). What they were uncovering was the human body's own endocannabinoid system (ECS).

"It's a system as ancient as our immune system and our central nervous system. They co-evolved and our endocannabinoid system acts as a bridge between the two," says Yuval Cohen, CEO and Director of Corbus Pharmaceuticals. "It's designed to help us recover from trauma and is absolutely essential to life."

To illustrate his point, Cohen said: "Imagine you're a caveman and you just got mauled by a saber-toothed tiger. You are injured, you're bleeding, you're going into shock, you're scared, you're in a ton of pain; the wound is swollen and tender. You're a hot mess. And that is where your endocannabinoid system kicks in. Without it, you're going to die in that cave. It's that simple."

He is describing what many CBD promoters claim as general benefits of CBD in any form: pain management, seizure control, physical and psychological trauma relief, and tissue healing. Cohen, himself, sees the endocannabinoid system as an increasingly more explored therapeutic target for new treatments of disease.

Corbus is rationally designing synthetic signaling molecules to target the human ECS receptor molecule CB2 more selectively than a plant molecule could. Corbus' lead product candidate, lenabasum, is designed to resolve chronic inflammation and fibrotic processes without interfering with the central nervous system.

### **PATIENT-DRIVEN ADVANCES**

Elizabeth Thiele, M.D., Ph.D., Director of the Pediatric Epilepsy Program at Massachusetts General Hospital, has firsthand experience with the pain and courage of parents who have exhausted existing medical options for treating extremely ill children. "I think what has really set this whole CBD story apart is that it was the patient community that drove the interest. It wasn't big pharma saying 'Here's this drug we had in trials'," she said.

Dr. Thiele has direct knowledge of a couple of related cases. One family moved from Maine to Colorado so they could access a CBD product for their daughter's debilitating, treatment-resistant epilepsy. A second family, from California, became interested in medical marijuana when their son had trouble with the restrictions of dietary therapy. But they encountered the same difficulty many experience with extracts: consistency of the product. Eventually, the California boy became patient one for Epidiolex

in the United States.

"When I first got involved with this, one of my colleagues told me I was risking my career and another that I was wasting my time," said Thiele. "But my approach has always been that I get parents who are desperate for treatments for their child and I need to support them."

Still, Thiele firmly warns against trying CBD products whose contents you cannot confirm: "Right now, the only data we have is that purified CBD can be effective in helping children with refractory epilepsy. Parents should be very leery of claims of CBD curing or being good for everything."

### **ABOVE AND BEYOND CAVEAT EMPTOR**

When states legalize something, people assume it is safe. But experts at government agencies and university-affiliated research institutes continue to seek accurate data about potential health risks associated with cannabinoids, especially for people who may be more vulnerable because of age, neurological development, pregnancy, or interactions with other medications.

THC can affect fetal and adolescent neurological development, but CBD's effects are still being determined. Data collected during studies of Epidiolex, for example, revealed that CBD affected availability levels of the antiepileptic clobazam, requiring dosage adjustments.

Scientists are actively studying the therapeutic potential of CBD with the removal of hemp from Schedule I.

Among her responsibilities, Susan Weiss, Ph.D., National Institute on Drug Abuse, Director, Division of Extramural Research, represents NIDA in talks on cannabis, marijuana and CBD. "Our goal is to get a better understanding, to get more knowledge and to be able to present evidence in an unbiased fashion," she said. "We are also interested in developing therapeutics for cannabis use disorder."

But NIDA research is not immune to legal ambiguity, jurisdictional conflicts, and their consequential impact on science. "Our researchers can't actually purchase products from dispensaries because they would be in violation of federal law," Weiss said. "As a result, NIDA must depend on people self-reporting what they're using. But we don't have access to those products to get a good sense of their dangers."

Margaret Haney, Ph.D., Professor of Neurobiology, Columbia University Medical Center, is a leading researcher on cannabis use disorder but also explores the science behind specific areas of therapeutic value for THC and CBD. "I feel like there's an antiscience moment right now where people are just believing," she said. "They're distrustful of pharma but not of the person selling them CBD at the farmer's market. People aren't aware that it's just snake oil all over again."

According to Haney, what most stands in the way of largescale rigorous clinical studies is the DEA Schedule I status for cannabis and cannabinoids, which essentially shuts down the ability to conduct these studies. "If scientists could treat cannabis and its constituents as Schedule II, that would open things up tremendously," she said.

### THE ENTOURAGE EFFECT

Ziva Cooper, Ph.D., Research Director of the UCLA Cannabis Research Initiative and Associate Professor in the Jane and Terry Semel Institute for Neuroscience and Human Behavior, understands the strong arguments for the purity, precision and predictability that synthesized THC or CBD molecules can provide in a rationalized drug design approach. But as a pharmacologist she wonders if potential benefits may be lost the further away a drug molecule moves from the whole plant.

"You want to know what the individual constituents do. but then there is this idea that the whole plant can offer greater therapeutic potential because it has all these different chemical components — some call this the entourage effect," said Cooper.

"This hypothesis hasn't really been tested in the clinic yet." We're hoping to begin studying that very soon to determine if these different molecules in the plant work together to improve the potential therapeutic effects of cannabis. Will the combination of these chemicals be effective? What can we expect it will do? What are the risks we should be aware of? I'm confident that over the next 10 to 15 years we'll actually be able to answer some of these questions," said Cooper.

Dan Zenowich, a freelance health writer, contributed to this story.

Register for "Targeting the Endocannabinoid System for Treatment of Human Diseases" at: www.nyas.org\ECS20. ◀



### For more information: Contact Kate Desulis:

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### **LEAVE YOUR MARK ON SCIENCE**

Lyceum Member Joel Kirman and his wife, Liora, recently joined the New York Academy of Sciences **1817 Heritage Society** by naming the Academy as a beneficiary in their wills.

Their future gift will make a lasting impact by supporting the Academy's programs that are helping to develop the next generation of rising stars in science. And it doesn't cost them anything today.

Remember the Academy in your estate plans and join Joel and Liora in making your mark on the future of science!



### Bred to Be Wild

By Carina Storrs, Ph.D., NYAS Contributor

Researchers are improving crop traits by conserving their undomesticated relatives.

In the 1960s, some wild beans were collected from the sides of roads and other patches of wild land in Mexico and stored in aluminum pouches in freezers at one of the seed banks maintained by the United States Department of Agriculture (USDA), in Pullman, Wash. There they stayed for the next four decades until 2012 when Paul Gepts, Ph.D., a professor of plant sciences who had just taken over the grain legume breeding program at the University of California, Davis, exhumed them.

Gepts reasoned that the archival beans, originating from plants growing in dry regions, might be more drought tolerant than their domestic cousins, an important trait considering that most of the farmed beans in the world face drought stress. After growing the seedlings in a greenhouse in the dead of winter to simulate the long nights where the plants grow in Mexico — and crossing the wild plants with domestic varieties — Gepts and his colleagues hit upon a new line that thrived and produced high levels of seed even under the stingiest of irrigation conditions.

It's just one example of the desirable traits that food crops we depend on can derive from the wild relatives they descended from. But much depends on collecting and properly preserving those wild relatives in one of the nearly 2,000 seed banks around the world. "I call it insurance. You don't know when you are going to need [a crop wild relative], but once you have it you are pretty glad," says Gepts.

In another example, during the 1980's, scientists at CIAT, a research organization in Colombia that also maintains a seed bank, realized that wild beans collected from a different part of Mexico in the 1960s, harbored resistance to weevils, a serious pest that can decimate dried bean seeds. "When you put these kinds of stories together ... it paints a picture of diversity that is still present in the wild types, but that has been left behind in the domesticated types," Gepts says.

Farmers have been selecting plants for qualities such as high crop yield for thousands of years. Exactly what kind of diversity a wild relative has is impossible to know until researchers working with the seed banks start growing it, and examining such traits as crop yield, drought resistance or taste. Increasingly in recent decades, researchers have also been studying the seeds using single nucleotide polymorphism (SNP) analysis.

To bring more diversity into those seed banks, the USDA and governments of many countries with high agricultural production, as well as international groups, fund trips to collect crop wild relatives, often targeting parts of the world that



have not been well explored. In many cases, they are racing to get there before plant habitat is lost to development and climate change related threats.

Although collection trips have been widespread since the 1960s, researchers have typically focused on locating wild ancestors and taking a few individual specimens from accessible areas — hence the popularity of roadside collections. In the early 1990s, Gepts participated in a USDA-sponsored trip to collect wild beans in Bolivia, but the team was forced to leave some terrain un-sampled because it was too difficult to traverse. "In many parts of the world, researchers need to return to the same locations repeatedly to do more thorough collections of plant tissue as well as study the impact of local environments upon the plants," said Gepts.

Researchers have put some rough numbers on how well crop wild relatives are represented in seed banks, and generally they support the assertion that we need to collect more. Out of the approximately 1,000 taxa, or broad categories, of wild ancestors in the world, an estimated 30 percent of relatives of a total of 63 crops cannot be found in any of the plant repositories; another 24 percent are only represented by samples from fewer than 10 different populations.

An unexpected silver lining of the research, however, is the finding that crop wild relatives might be a bit better conserved in nature than in seed banks because much of their habitat is within national parks and other protected areas. "[But] a plant being in a protected area does not actually mean that a particular type of plant is all that protected. [Unless these plants are managed], people not paying attention to them, might think they are weeds [and] try to eradicate them," says Colin Khoury, Ph.D., who studies crop diversity for CIAT, (International Center for Tropical Agriculture) part of an international agriculture research network called CGIAR, (Consultative Group for International Agricultural Research).

Khoury was involved in studies estimating conservation of crop ancestors. Along with stepping up efforts to collect and store plant materials in seed banks, Khoury says that we need active management programs to ensure conservation of crop wild relatives in protected areas.

Another source of crop diversity is the crops themselves, both the commonly farmed varieties that acquire mutations as they grow and the so-called landraces, or ancestral varieties of domesticated crops that some farmers still cultivate. Unlike their wild relatives, many of these varieties have been stored in seed banks by researchers and farmers, as their importance for breeding crops with new traits has long been recognized, whereas the traits that wild relatives can lend crops is comparatively unchartered territory.

Although it might seem reasonable that farmers could handle conservation of these crops just by growing them in the field season after season, seed banks play an important role because there are "fewer farmers growing a smaller number of plants," says Denise Costich, Ph.D., a senior scientist and head of the maize collection at the germplasm bank, which archives seeds and other plant tissue, at International Maize and Wheat Improvement Center (CIMMYT), a Mexico-based CGIAR center.

Research by Costich and her colleagues found that many farmers in Morelos, a state in central Mexico, stopped cultivating landrace varieties of corn over the last half century in favor of hybrid varieties, which are less genetically diverse but often produce higher yield and have other economically advantageous traits. In addition to conserving germplasm, CIMMYT and the other CGIAR seed banks, as well as certain government-operated seed banks including the USDA system, share plant materials internationally with academic researchers and private companies working to breed varieties with new traits.

As important as it is to collect germplasm from crops and their wild relatives and maintain them in seed banks, it is only half the story. It is critical to grow these seeds in experimental field stations and characterize them so researchers know which ones have desirable traits and have them at the ready to breed with crops, in case of an emergency such as southern corn leaf blight, which wiped out much of the U.S. corn in 1970, says Seth Murray, Ph.D., professor of soil and crop sciences at Texas

A&M University. "Otherwise it's just like having a library where nobody is reading the books," he says. These efforts are happening to some extent. For instance, Costich's team at CIMMYT has characterized most of the corn samples they have added to the germplasm bank vault in the last decade. The USDA does some characterization, but "given the value of agriculture and crop diversity, there is definitely not enough money spent on that," Murray says.

The work of trying to breed new varieties can quickly grow to an unmanageable scale. In his applied breeding program, Murray crosses U.S. corn varieties with crops that were collected in Mexico and South America, but then has to test their progeny in many different field conditions over several years to understand how they behave under different environments before they are ready for farmers. In research that earned him the recognition of Finalist for the 2019 Blavatnik National Awards for Young Scientists, Murray and his collaborators have been using drones to photograph plants as they grow, and developing computer algorithms to analyze the images to make predictions about the crop's yield and other properties. According to Gepts, who has also turned to drone surveillance to monitor bean plant traits, it is not enough to have an ever-expanding font of crop genetic diversity to scour for new traits. "The other trend is making breeding more efficient whether it is through the use of drones or different ways of phenotyping progenies," he says.



# **Food Allergies are Getting Worse**Researching New Paradigms for Treatment

By Robert Birchard, NYAS Contributor

Fans of the popular TV show "Big Bang Theory" may remember the oft-cited peanut allergy by the Howard Wolowitz character who traded on it for jokes. But the reality is no laughing matter.

Food allergies are a serious condition that impair the lives of patients and their caregivers. According to a study conducted by the National Center for Health Statistics, the prevalence of food allergies in children under 17 increased by more than 50 percent from 1997 to 2011. The rate is even higher in low-income minority groups. And it's a health issue with a hefty price tag. A study in *JAMA Pediatrics* put the economic cost of food allergies at \$24.8 billion annually, or \$4,184 per year per child.

The overwhelming majority of allergies are linked to eight foods: milk, eggs, peanuts, tree nuts, soy, wheat, fish and shell-fish. As an ailment of the immune system, allergies cannot be cured, but individuals can be desensitized to tolerate small amounts of allergens. So the consensus among allergists is that treatment should shift, to focus on how to better mitigate the immune system's response to allergens.

### WHAT WE DO AND DON'T KNOW

Allergies are an immune system reaction to a foreign substance that enters or comes into contact with the human body. According to a 2018 report from Blue Cross and Blue Shield, the number of children in emergency departments with serious allergic reactions went up 150 percent between 2010 and 2016. Most of the life-threatening reactions are to foods such as peanuts and tree nuts, according to the claims data. But while the increase in emergency room visits adds to the abundant evidence of the higher prevalence of food allergies in children, the question about the underlying cause for their increasing severity is more difficult to answer.

Reactions in individuals can range from mild to life threatening, yet much is still not understood about how allergies develop. "We still do not understand the origins [of the] allergy as an immune system problem," explains Alkis Togias, M.D., Allergy, Asthma, and Airway Biology Branch Chief in the Division of Allergy, Immunology, and Transplantation at the National Institutes of Health. "We have a lot of theories, but we are not certain whether a single hypothesis can provide the answer."

According to an article published in *Allergy, European Journal* of *Allergy and Clinical Immunology*, the rapid increase in food allergy has been attributed to both environmental and genetic factors. In those genetically predisposed to allergy, environmental factors such as lifestyle, exposure to pollutants, better hygiene, and use of antibiotics can increase risk of food allergy.

"What we understand is that the kind of immune response that leads to allergies is the same kind of immune response that a lot of parasites are dealt with by the human body," says Togias. "There is an idea that, as humans have improved their living conditions, the immune system found itself without those stimuli, and has somehow deviated towards attacking environmental elements that are not truly of any risk to the human body, but share antigenic properties. In other words, they have molecular similarities to things that our immune system used to recognize and attack."

The rise of allergies is perhaps better understood in the context of the rise of immune-mediated diseases, suggesting more widespread dysfunction of the human immune system. "It may not just be the type of immune response that is involved in an allergy, but part of a general immune dysfunction related to changes in the environment that human bodies have been exposed to," says Togias.





➤ Stephen A. Tilles, M.D. Senior Director of Medical Affairs, Aimmune Therapeutics, Inc.



### **RETHINKING OLD GUIDELINES**

The reaction of the human body to these changes in the environment are best taken into account by the hygiene hypothesis, which posits that early childhood exposure to some microorganisms is beneficial and can protect against allergies by building up the immune system. A lack of exposure to some of these microorganisms could lead to gaps in the immune system and explain the increased prevalence of food allergies.

"The use of antibiotics, disinfectants, the increased rate of C-sections, a pro-inflammatory diet compared to more vegetable-based diets like those in the Mediterranean region, and dietary practices that delay the introduction of highly allergenic foods to infants have all been identified as driving factors for food allergy, particularly peanuts," explains Anna H. Nowak-Wegrzyn, M.D. Nowak-Wegrzyn is a pediatrician at NYU Langone Health in New York, N.Y., who specializes in preventing and treating children's allergies. "This is such a multifactorial phenomenon that if you want to put your finger on one driving force, it's probably not possible," she continues. "Too many things are converging together and leading to the rise in food allergies."

Reflecting these new perspectives, updated guidelines have been developed to take into account new research, like the ground-breaking National Institute of Allergy and Infectious Diseases (NIAID)-funded LEAP study. The LEAP study demonstrated that the introduction of peanuts into the diet of children with severe eczema (a symptom of high allergic risk) during their first year reduced their risk of peanut allergy by 80 percent. These results upended previous guidelines that had advised caregivers to avoid all contact with peanut allergens.

Prior to the LEAP study findings, general consensus held that since the fetal immune system is not fully developed at birth, it would be best to avoid the introduction of highly allergenic foods to high risk infants — identified as those who have one parent or sibling already diagnosed with a food allergy. "Unfortunately, this previous recommendation was not evidence-based," says Nowak-Wegrzyn. "It was a consensus opinion and it turned out to be totally wrong because as developed countries embraced those recommendations and delayed the introduction of peanuts until the age of three, there was a simultaneous increase in the incidence of peanut allergy." In 2017, revised U.S. guidelines issued by NIAID recommended the early introduction of peanut to infants at high risk of developing a peanut allergy.

### A ROADMAP TO THE FUTURE

In 2011 representatives from the Food and Drug Administration, National Institutes of Health, patient advocacy groups, industry representatives, and other stakeholders met to discuss ways to marshal resources and plan the best path forward to develop new food allergy treatments. This meeting led to the eventual formation of Aimmune Therapeutics, Inc., a biopharmaceutical company focused on developing treatment options for different types of food allergies. Earlier this year, Aimmune received FDA approval for PALFORZIA<sup>TM</sup>, the first successful FDA-approved

treatment for patients with a peanut allergy.

PALFORZIA is an oral immunotherapy administered in increasingly larger doses to patients aged 4 to 17. "PALFORZIA is a complex biologic medication that is derived from peanut protein sources and is highly characterized for all component allergens," explains Stephen A. Tilles, M.D., Senior Director of Medical Affairs at Aimmune. "[It] is hopefully going to become the latest example of what allergists have been doing for many decades with other forms of effective allergy immunotherapy."

The results were first demonstrated in the PALISADE Study, published in *The New England Journal of Medicine* in 2018. The initial median highest tolerated dose of patients enrolled in the study was only 1/30<sup>th</sup> of one peanut. Twelve months into the study the median highest tolerated dose had risen to the equivalent of three to four peanuts. At 18 months the data showed that the median for highest tolerated dose had risen to six to eight peanuts. "What is remarkable about immunotherapy is that the effectiveness or efficacy continues to increase over time," says Tilles. "For example, a patient will initially receive a dose of 1/600<sup>th</sup> of a peanut, which is then gradually increased under medical supervision to the equivalent of one peanut per day."

As a next step, Aimmune is developing an egg oral immunotherapy and is in the early stages of a tree nut program. "This is an exciting time for the peanut allergic patients and their families because they actually have a choice. We now have a roadmap for how to get a robust clinically effective treatment approved by the FDA," says Tilles.



# Reducing the **Nation's Waste Line**

**SEPA** 

By Charles Ward, NYAS Contributor



Bertha Jimenez wasn't a beer drinker when she came across spelt grain for the first time. A mechanical engineer by training and now the CEO of Rise Products, Jimenez recounted her tour of Brooklyn Brewery, a craft beer brewery located in the Williamsburg section of Brooklyn, N.Y. "I'm interested in how waste from one industrial activity is usable in another," she said. "So as we walked around the plant, I wanted to know what happened to the source grains after the beer was made." With-

in a year, Jimenez founded Rise, a start-up that converts used spelt grain into specialty flours sold directly to bakeries.

Rise developed a proprietary conversion process, slogged through prototypes and proof-ofconcepts, and learned about food safety standards. She built a regional B2B customer base, secured grants, raised private capital, and signed a Service Provider Agreement with Anheuser-Busch. "People like to feel like they're doing something sustainable, something good," she said. "But at the end of the day we don't eat ideology, you know?"

Jimenez is just one example of the way the scientific community has deeply engaged with the challenge of food waste: as entrepreneurs, researchers, academics, regulatory policy specialists, or NGO advisors.

The U.S. Department of Agriculture (USDA) estimates 31 percent of food produced in the U.S. is loss, with an annual economic value of \$161.6 billion. Globally, the U.N. Food and Agricultural Organization (FAO) estimates 1.3 billion tons of food are lost every year in agricultural production, post-harvest storage, processing and distribution, and consumption.

New policy priorities reflect an emerging consensus among food production experts that these are unacceptable numbers for a global food system already stressed by a growing population and climate change. Goal number 12 of the U.N.'s Sustainable Development Agenda is to "ensure sustainable food consumption and production patterns." Targets include cutting per-capita global food waste in half at the retail and consumer level by 2030, and reducing food loss from production and supply chains. The U.S. Environmental Protection Agency (EPA) and USDA share a similar goal, to cut food loss and waste in half, also by 2030.

### **MULTIPLE MISSIONS**

Food Recovery Hierarchy

Source Reduction

Feed Hungry People

For Elise Goland, Ph.D., Director of Sustainable Development for the USDA, food waste is a resource efficiency challenge. She works closely with colleagues at the EPA, and references the EPA's well-known "Food Recovery Hierarchy" inverted pyramid, which visually represents the flow of food from "upstream" agriculture source to "downstream" table, and the parallel opportunities to conserve resources at every stage of the chain.

"We look at reasons for waste, and ask if there are cost-effective ways to reduce it," she explained. "If we're producing food that is wasted, [by reducing it] we can conserve the land, water, chemical- and non-chemical inputs that go into

interventions, Golan notes, are prompted by opportunities to create efficiency all along the value chain. As one relatively upstream example, she points to a pilot collaboration between the USDA's Agricultural Research Service and The Wonderful Company, a California-based producer of pistachios. The project has the potential to turn mountains of discarded pistachio shells into "carbon black" for use in plastics as an alternative to cost-effective, energy saving way," said Golan. "It is really is a big win for the environment."

# Feed Animals Divert food scraps to animal food that food." The USDA's more active food recovery Industrial Use petroleum-based compounds. "They've done it in a very

### **FOOD WASTE AS AN ECONOMIC CATALYST**

If the USDA is working on food waste from the top down, Juan Guzman, Ph.D., is working from the bottom up. Guzman is the head of Capro X, a Cornell University spin-off that uses bioconversion technology to turn the acid whey left over from Greek yogurt production into specialty chemicals. In commercial terms, Capro X is what is classically called a "category creator."

Guzman thinks of himself first as an entrepreneur, and speaks in terms of business cases: return-on-investments, stakeholder buy-in, and use of science-based innovation to create entirely new markets. When he started Capro X, the commercial imperatives were self-evident: New York yogurt manufacturers needed cheaper ways to get rid of large quantities of acid whey, which they had to truck long-distance for waste-water treatment. At the same time, dairy farmers, generally, were under pressure to develop new products as milk consumption declined. And global agribusiness giants, like Nestlé, Archer Daniels Midland and Cargill, are always seeking alternative sourcing for industrial products, like commercially farmed palm oil, which Capro X intends to produce.

"I just see so much opportunity in using biology to extract value out of things that people are willing to pay to get rid of," said Guzman, pointing to the historic precedent of ethanol, which made the planting of corn on previously surplus or marginal farm acreage a hugely viable commercial proposition. "For yogurt manufacturers, we're talking about waste streams measured in the millions of pounds, with one facility alone generating a quarter of a million pounds a day of pure lactose sugar for conversion," Guzman continued. "And there are hundreds of plants in the U.S.".

For the market to scale, investor interests will have to see the opportunity, and put in capital. In the meantime, Guzman is building his new market one customer at a time. Capro X's value proposition includes installing the acid whey treatment equipment at dairy farms. He keeps the specialty products, and farmers are spared the expense of trucking away waste. Guzman said he has learned that farmers like the idea of sustainable waste practices, but they are not necessarily willing to pay a price premium for them.

### **IDENTIFY, MEASURE, ATTEMPT TO SOLVE**

Mary Muth, Ph.D., is an agricultural economist who serves as the Director of Food, Nutrition, and Obesity Policy Research at RTI, a not-for-profit organization dedicated to using science for good. Muth has conducted food waste research from every angle: malnutrition, resource efficiency, economic impact, and ethical imperative. She believes that scientific interest in the problem of food-waste is still cresting. She also points

out that that commercial application of food-waste research is still largely voluntary. Some companies see it as a reputation management opportunity, a way to promote corporate social responsibility. A few others have developed niche products. Seismic economic incentives for waste-aware practice don't yet exist. "It will probably take some significant disruption in the food supply to bring around big scale change," Muth said.

Christine Beling, a project engineer and New England regional director of Brownfields and Sustainable Materials Management at the EPA, is as good a witness as any to what seems to be an incremental and steady advance towards reduced food waste. The EPA prefers composting as an alternative to landfills for food waste, and Beling says that a sign of progress is landfill bans of organic waste by four of the six New England states in her region. She notes that in 2015, the EPA calculated that just 5.3 percent of 39 million tons of food waste was diverted for composting; two years later, the figure was 6.3 percent. "That's a relatively big jump," she observed. "If you go back to the late '90s or early 2000s, it was one percent. I think you can see the trend."

Beling points to a variety of legislative, academic, and NGO attention on food waste and recovery. In 1996, President Bill Clinton signed the Bill Emerson Good Samaritan Food Donation Act, which provides liability protections to nonprofit organizations when they donate food. In 2019, Harvard University launched its Food Law & Policy Clinic, which trains students in the use of legal and policy tools to address food system issues. Beling also calls attention to the birth of new NGOs like ReFed, founded in 2015, to bring data- and economics-driven tools to help solve food waste problems. And in 2016, the Ad Council and the Natural Resources Defense Council co-sponsored the "Save the Food" national public service campaign. "The emphasis may be different depending on what part of the world you're in, but overall there's a whole shift," said Beling. "Ten years ago, people didn't want to deal with food waste. Now, everybody's dealing with it because it's in the mainstream conversation."



# How **Nutrition Science** is Ensuring a Healthy Start in Life

Nicholette Zeliadt, NYAS Contributor

About a decade ago, pediatrician Philip Fischer, M.D., began to hear heartbreaking stories about babies in Cambodia who were believed to have "beriberi," a vitamin deficiency so uncommon in the U.S. that he knew of it only from textbooks as a scourge of the 19th century. He went to Cambodia to learn more and try to help his colleagues there. They encountered infants so deathly ill, listless, and short of breath that they were often unable to cry and incapable of feeding. And yet miraculously most of them would make a full recovery within thirty minutes of receiving a shot of the vitamin they were lacking: thiamine, also known as vitamin B<sup>1</sup>

Fischer and his colleagues found that about six percent of babies in Cambodia don't live to see their first birthdays, and up to half of those deaths could be attributed to thiamine deficiency. "That was pretty concerning to us," said Fischer, professor of pediatrics at the Mayo Clinic in Rochester, Minnesota. The team is now working to determine the extent of the health problems caused by thiamine deficiency in babies and establishing guidelines for diagnosing it.

The body can't make its own thiamine, so it has to get it through the diet. Whole grains, nuts, and pork are particularly good natural sources, and today some staples such as wheat flour are typically fortified with it. In Cambodia, however, as in many countries in Southeast Asia, more than half the diet is made up of white rice, which contains little thiamine, largely due to the processing of the rice, which involves removing the outer layer containing the thiamine. Newborn babies typically get their thiamine through breastmilk, but if their mother is deficient, then the breastmilk is, too.

The most recent estimates suggest that at least 38 percent of infants in Cambodia are thiamine deficient. Similar deficiencies have been found elsewhere across Southeast Asia, parts of India and Bhutan, and several countries in Africa. "This is more widespread than we thought," said Kyly Whitfield, Ph.D., assistant professor of applied human nutrition at Mount Saint Vincent University in Halifax, Nova Scotia. An increased risk of death due to this deficiency is not the only concern: some evidence suggests that having too little thiamine in early childhood

may cause lasting impairments in cognitive abilities.

Whitfield foresees a day when families in developing countries can get the thiamine they need through fortified foods, such as salt. She and her colleagues are already testing thiamine supplements in the region to establish how much thiamine a woman needs to consume in order to prevent beriberi in both herself and her infant.

The studies involving Whitfield, Fischer, and their colleagues reflect several initiatives underway that aim to use the latest developments in infant nutrition science to help families in developing nations nurture healthier babies. Prioritizing adequate nutrition for pregnant and lactating women and their babies is critical not only for women's health, but also for that of future generations and the productivity of these nations.

### **MULTIPLE MICRONUTRIENT DEFICIENCIES**

Many people in developing countries have deficiencies of multiple vitamins and minerals simply because they don't have enough food to eat or their diet lacks variety. Pregnant women are especially vulnerable because they require even more nutrients than usual. And it's not just their own health at stake; their children have an increased likelihood of stillbirth, premature birth, and a variety of birth defects, among other health problems. They also have an increased risk of death before age five and tend to perform more poorly than their peers in school.

It is difficult for a pregnant woman to consume all the nutrients she needs through diet alone. In fact, in most developed countries, pregnant women routinely take prenatal supplements containing multiple micronutrients (sometimes referred to as MMS). By contrast, in most developing countries, pregnant women usually receive a supplement containing only two: iron and folic acid (IFA) — the only two micronutrients that the World Health Organization (WHO) currently recommends that all pregnant women take.

"Women in low- and middle-income countries have many deficiencies that are not currently being addressed," said Robert Black, M.D., professor of international health at Johns Hopkins University in Baltimore, Maryland.





Robert Black, M.D.
 Professor of International Health,
 Johns Hopkins University

Clayton Ajello, Dr. P.H. Senior Technical Advisor, Vitamin Angels Alliance



Indeed, two recent systematic reviews of the scientific literature found evidence that multiple micronutrient supplements are better than supplements of iron and folic acid alone at reducing the risk of a child being born preterm, with low birth weight, or small for gestational age. And the supplements appear to be safe; they do not raise the risk of any adverse events.

"MMS does everything that IFA does, and more," said Clayton Ajello, Dr. P.H., senior technical advisor for Vitamin Angels Alliance, a nonprofit that provides MMS to mothers and children worldwide.

Because of these added benefits, both Ajello and Black advocate for developing countries with high rates of nutrient deficiencies to replace IFA supplements with MMS, especially in countries where such deficiencies are widespread among women of childbearing age. Progress is slow, in large part because current supplies are nowhere near what is needed to meet the needs of the estimated 206 million women who become pregnant in developing countries each year. However, supplies will increase as more and more countries adopt MMS, Ajello says.

### **IT TAKES A VILLAGE**

Minimizing nutrient deficiencies in pregnant and breastfeeding women is a key part of ensuring the development of healthy babies. Equally important are efforts to ensure that babies are breastfed optimally. The WHO recommends that all babies be breastfed within an hour of birth and continue exclusively for six months. After that, babies should start eating other foods but continue nursing until they are at least two years old.

Beyond simply providing a baby with its only source of nutrients for the first six months of life, breastmilk protects babies from infections and aids the development of their immune systems. Breastfed infants have lower rates of gastro-intestinal and respiratory infection and lower rates of death from infections overall as compared to non-breastfed infants.

Studies suggest that programs to promote breastfeeding may be an important way to reduce mortality in young children. "But establishing breastfeeding can be difficult for many women, especially if they don't have guidance and support," said Melissa Glassman, M.D., a pediatrician at New York Presbyterian Hospital and Columbia University Irving Medical Center, and the founder and medical director of the hospital's Newborn Clinic, which provides outpatient care to newborns with Medicaid insurance after they are discharged from the hospital. "It becomes more difficult to raise your baby if you don't know how to do it and you're not surrounded by a village that can help you."

New mothers often do not know what to expect when breastfeeding for the first time. For instance, many have trouble getting a newborn to latch onto the breast properly, causing pain and difficulty with feeding. And first-time mothers may not immediately recognize cues that their baby is hungry, resulting in too few feeding sessions and weight loss in the infant. What's more, breastfeeding can be physically exhausting: newborns typically feed at least eight times a day, and each feeding



Adequate intake of essential vitamins and minerals is critical for a healthy pregnancy. Unfortunately, many women in lowand middle-income countries (LMICs) struggle to meet the increased dietary demands for a healthy pregnancy through diet alone. Inadequate nutritional intake frequently leads to poor maternal health and adverse birth outcomes, such as: maternal mortality, preeclampsia, insufficient gestational weight gain, stunting, low birth weight (LBW), small for gestational age (SGA), and neonatal mortality. Currently, the World Health Organization (WHO) recommends iron-folic acid supplements (IFA) as the routine standard of care in antenatal care programs. However, strong evidence is now available demonstrating the superiority of multiple micronutrient supplements (MMS) over IFA. To help countries determine if they should transition from IFA to MMS in antenatal care, the New York Academy of Sciences assembled a task force. Charged with taking a closer look at MMS, the task force considered several factors, including benefits, risks, and cost-effectiveness. On June 25, 2019, the task force's findings were published in a special issue of Annals of the New York Academy of Sciences.

Full eBriefing by Saima Ahmed: nyas.org/ebriefings/2019/improving-birth-outcomes-with-multiple-micronutrient-supplementation/

session can last as long as an hour. If women don't know to expect these feeding patterns, they often assume that they're not making enough milk and their baby is going hungry. All of these factors may prompt women to give up on breastfeeding too soon.

"There's nothing worse than a woman wanting to breastfeed, then developing problems with breastfeeding that she doesn't know how to fix, and not having the support she needs to address these problems," said Glassman, who provides breastfeeding support to women from a wide range of socioeconomic backgrounds — from those with commercial insurance who visit her at a ColumbiaDoctors practice — to the almost exclusively immigrant population with public insurance who visit the Newborn Clinic. "If we can get women comfortable and on the right foot early with breastfeeding, that will get moms on the path for long-term successful breastfeeding and all the associated health benefits for both mom and baby."

# New York Academy of Sciences **Talent Showcase**

Meet the rising stars of science who are receiving recognition for their ground-breaking research.

Earlier this year, the 2020 Blavatnik Awards for Young Scientists announced the honorees of the 2020 Blavatnik Awards for Young Scientists in Israel and in the United Kingdom. The Blavatnik Awards for Young Scientists are the largest unrestricted cash prizes available to scientists under the age of 42. For more information visit: blavatnikawards.org.

### 2020 Blavatnik Awards Laureates in Israel

### **PHYSICAL SCIENCES & ENGINEERING LAUREATE**

Dr. Guy Rothblum, Associate Professor, Department of Computer Science and Applied Mathematics, Weizmann Institute of Science

In our modern-day information age of cloud computing, "Big Data", AI, and machine learning, new issues have emerged related to the privacy and security of personal data. Guy Rothblum, Ph.D., develops theories to address these emerging issues



and the societal concerns they raise. His work has not only advanced our understanding of the fundamental limitations of cloud computing systems and machine learning methods, but has also influenced the development of new algorithms and protocols in these fields. For example, he developed a theory to efficiently verify the correctness of computations performed in the cloud which has influenced the ongoing development of verification protocols. He has also developed a state-of-the-art algorithm that prevents leakage of personal, sensitive information from analysis of big data sets, such as medical records or census data.

### **LIFE SCIENCES LAUREATE**

Dr. Igor Ulitsky, Senior Scientist, Department of Biological Regulation, Weizmann Institute of Science

Igor Ulitsky, Ph.D., is working in uncharted areas of the human genome, studying how a type of genetic information produced there — long noncoding RNA (IncRNA) — works to influence human health and disease. Understanding how, when, and where In-



cRNAs are active in our bodies has major implications for the development of novel regenerative medicines and disease treatments. IncRNAs are unique in that — unlike canonical RNA molecules — they do not contain information for making proteins. Instead, their main function is to control gene expression. Ulitsky conquers the substantial challenges of understanding how IncRNAs function in cells and organisms by combining novel experimental and computational methods. In this way, he has creatively unlocked the potential for using IncRNAs as both therapeutic agents and targets that can pave the way for the treatment of diseases such as cancer, brain injury, and epilepsy.

#### **CHEMISTRY LAUREATE**

Dr. Emmanuel Levy, Senior Scientist, Department of Structural Biology, Weizmann Institute of Science

Life processes involve an intricate choreography between tens of millions of protein building blocks that form the infrastructure of a cell. Recent technological advances have revealed the catalogues of proteins present in



various cells and organisms. However, understanding how these protein building-blocks assemble and work together is an extraordinarily complex task due to the huge number of potential interactions. Emmanuel Levy, Ph.D., has revealed protein hot-spots on the surfaces of proteins, where mutations frequently trigger new assemblages. His findings suggest that these assemblages emerge frequently during evolution, in both health and disease. Additionally, Levy has developed a range of computational and biochemical methodologies to study proteins and their interactions, thereby generating key ideas and tools for grasping the molecular infrastructure of living cells.

# 2020 Blavatnik Awards Honorees in the U.K.

### **PHYSICAL SCIENCES & ENGINEERING LAUREATE**

Professor Claudia de Rham, Professor of Theoretical Physics, Imperial College London

Claudia de Rham, Ph.D., has completed a decades-old quest to construct a rigorous and viable theory of massive gravity — a theory of physics that modifies Einstein's theory of General Relativity to explain the nature of gravity. de Rham's



innovative solutions provide a potential explanation for why the universe is expanding faster and faster, and also has profound implications for the answers to other important questions in physics, such as the search for new types of particles in the universe.

### PHYSICAL SCIENCES & ENGINEERING FINALISTS

Professor Ian Chapman, Chief Executive Officer, U.K. Atomic Energy Authority

Ian Chapman, Ph.D., is an international leader in developing renewable energy from nuclear fusion, the same mechanism that powers the Sun and other stars. By designing the device at the center of the world's largest fusion project, his work is speeding up prog-



ress towards one day delivering practical and reliable fusion energy to the world. He also leads the U.K.'s new national fusion energy project, as CEO of the U.K. Atomic Energy Authority.

Dr. Amaury Triaud, Lecturer and Birmingham Fellow, University of Birmingham

We have all wondered if life exists in the universe beyond our solar system. Amaury Triaud, Ph.D., is an astrophysicist searching for exoplanets — planets orbiting stars other than the Sun — and has made major contributions to the discovery of a plane-



tary system known as TRAPPIST-1. Of all the planetary systems discovered beyond our own, this has the most promising physical conditions to support life as we know it. In addition, he has pioneered the study of exoplanets that surround two stars instead of one, revealing profound new clues for understanding the formation and evolution of planets.

### **LIFE SCIENCES LAUREATE**

Professor Timothy Behrens, Deputy Director, Centre for Functional MRI of the Brain and Professor of Computational Neurosciene, University of Oxford and Honorary Lecturer, Wellcome Centre for Imaging Neuroscience, University College London

Timothy Behrens, D.Phil., seeks to solve a fundamental mystery of the brain: how do the electrical signals in our brain control our behavior? To do this, he builds computer models and measures brain signals in humans and animals. His research reveals



basic knowledge about the human brain and has translational implications for how doctors are guided while performing brain surgery, how computer scientists design artificial intelligence systems, and how we research mental and cognitive disorders.

### LIFE SCIENCES FINALISTS

Professor Eleanor Stride, Statutory Professor of Biomaterials, University of Oxford

How can you guide drugs and other therapeutics to reach specific parts of the human body? Eleanor Stride, Ph.D., develops synthetic microbubbles that act as tiny vehicles to carry specific compounds throughout the body. Her innovative technology aims to revolutionize



the treatment of cancer — microbubble delivery of cancer drugs

- has the potential to eliminate common side effects of cancer treatment, including hair loss, nausea, and a weakened immune system. By delivering drugs just where they are needed, it is possible to attack tumors without harming healthy cells.

Professor Edze Rients Westra, Professor of Microbiology and NERC Independent Research Fellow, University of Exeter

Edze Westra, Ph.D., studies how bacteria protect themselves from viral attacks information we can use to develop alternatives to conventional antibiotics. By investigating the bacterial immune system, CRISPR-Cas, Westra has laid the necessary



groundwork for the development of strategies to circumvent antibiotic resistance, aiding in the development of novel antibiotics and next generation bacteria-enabled therapeutics.

### **CHEMISTRY LAUREATE**

Dr. Kirsty Penkman, Reader in Analytical Chemistry, University of York

Kirsty Penkman, Ph.D., leads a research program that has made tremendous advances in our ability to accurately date ancient fossils. A variety of methods currently exist for dating ancient objects, but beyond approximately 50,000 years, dating is



very challenging. By carefully refining a technique called amino acid racemization, Penkman has extended this upper limit and successfully dated fossils more than 3 million years old, opening up a time window to help scientists better understand human evolution and climate change.

### **CHEMISTRY FINALISTS**

Professor Matthew Fuchter, Professor of Chemistry, Imperial College London

Matthew Fuchter, Ph.D., leads a multifaceted research group that uses a detailed understanding of molecular structural design to invent novel molecules and materials. His research has shown the potential to significantly alter the properties of carbon-



based electronics, such as organic light-emitting diodes (OLEDs), as well as define novel therapeutic approaches for the treatment of diseases ranging from malaria to cancer.

Professor Stephen Goldup, Professor of Chemistry and Royal Society Wolfson Fellow, University of Southampton

Stephen Goldup, Ph.D., is a synthetic chemist who has developed elegant methods for the construction of "mechanically interlocked molecules." These are molecules that consist of two or more smaller molecules threaded through one another, rather than joined together



by chemical bonds. This arrangement makes interlocked molecules very flexible and creates cavities that can be exploited in novel applications, such as to create new catalysts or novel materials.

# When Two Leaders Come Together,

# A Partnership Is Born

By Melanie Brickman Borchard, Ph.D., M.Sc., NYAS Staff

► **Glenda Greenwald**President and Founder,

Aspen Brain Institute



The New York Academy of Sciences and Aspen Brain Institute celebrate a decade of collaboration.

Bringing together some of the world's greatest thinkers is no small accomplishment. But a decade ago, a seemingly chance meeting in Aspen led to a partnership that would bring some of the world's leading figures from science, politics and entertainment to landmark events in the field of neuroscience, early childhood development and STEM education. Such innovators as Edward Boyden (MIT), George Church (Harvard), Christof Koch (Allen Institute for Brain Science), Philip Low (NeuroVigil), Helen Mayberg (Emory University), Andrew Schwartz (University of Pittsburgh), Nora Volkow (NIH) as well as former Secretary of State Hillary Rodham Clinton, former Congressman Patrick Kennedy, First Lady of New York City Chirlane McCray, and iconic film star Goldie Hawn, Founder, The Goldie Hawn Foundation, have all been guest speakers at programs developed by the New York Academy of Sciences and the Aspen Brain Institute.

The partnership began when President Emeritus of the New York Academy of Sciences, Mr. Ellis Rubinstein, attended a dinner hosted by Aspen Brain Institute Founder and President, Glenda Greenwald at her Aspen home in the spring of 2009. They quickly discovered their mutual passion for bringing scientific knowledge to the wider community, so when Mrs. Greenwald asked President Rubinstein if he would like to partner on a global brain research conference, he promptly said yes and a partnership was born. Since that meeting the New York Academy of Sciences and Aspen Brain Institute have brought together the most innovative, important and inspiring individuals together to discuss topics on the cutting edge of science.

"The seeds were planted between the Aspen Brain Institute (ABI) and the New York Academy of Sciences at that dinner," said Glenda Greenwald, "and the partnership is still very much blossoming and bearing fruit."

In the years that followed, the two organizations developed scores of scientific symposia, public programs, podcasts, and e-Briefing multimedia reports that highlighted the most important advancements in science. "Thanks to Glenda Greenwald's personal participation as well as the generous support of the Aspen Brain Institute, we jointly convened a number of significant conferences that engaged some of the greatest innovators in science today," said Ellis Rubinstein.

These joint symposia have focused on such notable topics as:

• Cracking the Neural Code: Exploring how the activity of

- individual neurons and neuronal circuits gives rise to higher order cognition and behavior, with talks on areas like mapping neural networks;
- Accelerating Translational Neurotechnology: Exploring innovative scientific, clinical, and organizational models for advancing the translation of neuroscience research into technologies for neurological and psychiatric disease;
- Shaping the Developing Brain: Exploring the latest discoveries from cognitive neuroscience and experimental psychology regarding typical and atypical development of human learning and memory, emotion, and social behavior in early life; and
- The Enhanced Human Risks and Opportunities: Exploring existing and emerging enhancement technologies, with a focus on gene editing and artificial intelligence as examples of technologies with broad capabilities and ethical concerns.

"These conferences and public programs were not only scientifically outstanding, but also often awe-inspiring," Rubinstein commented. "For me, the most moving moment was in the Bionic Skeletons and Beyond program. Watching Amanda Boxtel — a long-time paraplegic — walk across the stage thanks to a wearable bionic exoskeleton, was truly remarkable."

In 2017 the ABI began supporting the Academy's Global STEM Alliance (GSA), a coalition of more than 250 organizations united in their commitment to increase the number and diversity of students in the STEM pipeline. For two years, the ABI sponsored a Social Impact Challenge for young, high-achieving STEM students from around the world. "I fell in love with the GSA concept of a global, online peer network of high school students collaborating on solving world problems," said Greenwald. "The global aspect, the STEM aspect, and the brilliant innovation of the kids were all phenomenal."

"In working with the New York Academy of Sciences, I have appreciated their wide open vision — the ability of the organization to stay topical and timely so that we could highlight the most current and exciting research, as well as bring in the highest level scientists at our conferences," said Greenwald. Both organizations anticipate that their decade-long partnership will extend well into the future, with many more years of progressive and collaborative programs to come.

More information may be found at nyas.org and AspenBrainInstitute.org. ◀

# **Investing in Teachers**

### **Yields Smart Returns for Students**

Contributed by Ravi Kumar S., President, Infosys Ltd. and Chairperson, Infosys Foundation USA

Over the past few years, there has been growing acknowledgment that it is important to make computer science a core component of K-12 education. And how could there not be? With 500,000 jobs currently available in the computing sector and projections that these jobs will grow at twice the rate of others, there is no ignoring that computer science is not just the future of work, but very much the present.

K-12 education should be setting our children up for postsecondary success, but multiple studies show that if students are not meaningfully exposed to STEM subjects by middle school, especially girls, they will never take an interest in them later on. How to do we ensure that our children study these subjects early and continue them into their careers?

The answer is training teachers. Too often we bypass these critical members of our workforce, but that is a mistake. The average teacher will reach thousands of students throughout their career so their potential for impact in the classroom is huge. Developing a strong future workforce starts with learning computer science at a young age, and that means training and retaining confident teachers.

Here are five ways to make computer science professional development effective for teachers:

- 1. Offer multi-day trainings through multiple channels:

  Computer science can be challenging and intimidating. In order to get teachers more comfortable and familiar with the material, professional development should be sustained for multiple days rather than a one-day meeting or a single intervention seminar so they gain the confidence and competence to stand in front of their classes and teach the subject. Additionally, in-person trainings should be supplemented by online resources and coursework so teachers can continue to develop their skills and increase their facility with these concepts. The Every Student Succeeds Act (ESSA) outlines specific requirements for professional development and underscores the importance of sustained Professional Development (PD).
- 2. Create a community: Creating a community is key when it comes to teaching computer science, especially for teachers who are new to the subject. Successful PD should foster peer networks through online forums that encourage teachers to connect with one another, ask questions and share best practices so that success is shared across schools and states, and pain points can be worked through collaboratively.

- 3. Keep it collaborative and hands-on: Computer science is collaborative, so learning how to teach it should be as well. Beyond the hard-technical skills that are gained from the subject, students and teachers alike will benefit from a wide array of soft-skills creativity, critical thinking, problem solving and collaboration. And these skills are necessary for all disciplines, so the applications are much wider than just the computing space. Furthermore, group learning helps to strengthen the community that teachers will walk away with once the PD is over.
- **4. Offer variety:** Just like math, science or history, computer science covers a multitude of skills and subject areas, so there is no one-size-fits-all course when it comes to PD. In order to successfully integrate computer science principles across grade-levels and skill-levels, there needs to be a diverse offering so every teacher can find something that is relevant to their grade, ability and comfort-level.
- 5. Make it classroom relevant and contextual: PD should go beyond abstract theories and concepts, and the content should be relevant for the context in which it will be used. This means teachers should receive tools, such as lesson plans, teaching guides and other resources to support classroom instruction, and the materials should be adaptable to real-life scenarios and common core subjects so all students can take interest in what they are learning. Underinvesting in the PD of teachers hinders the growth of our students. But if we ensure that teachers have the confidence and tools they need to bring the principles of computer science into the classroom, it will reverberate through to their students and help to light a spark in all students and build a healthy pipeline of tech talent for the future.



# The Case for Mentoring as a **Pathway to Promote** Student Interest in STEM

...the U.S. needs to

raise its investment in

science, technology,

engineering and math

(STEM) to remain

globally competitive.

By Adrienne Umali, NYAS Staff

Regardless of the field you're in, it is likely that if you looked back at your career path, you could identify at least one person who has helped guide you to where you are today. Whether this person was a teacher, family member, coach, or supervisor, mentorship has always been an incredibly important part of not only exposing individuals to new ideas and opportunities, but in encouraging them to their full potential.

When the 2018 Program for International Student Assessment (PISA) scores in math and science showed the United States ranked 13th, behind several Asian and European nations, it was once again demonstrated that the U.S. needs to raise its investment in science, technology, engineering and math (STEM) to remain globally compet-

itive. These fields are core to almost every industry, but a 2017 poll found that only 38 percent of middle and high school teachers see their students as being "naturally interested" in STEM.

Most students rarely have the opportunity to meet a working scientist, so developing programs that expose students to science professionals is proving to be a critical way to cultivate

a love of STEM in the next generation. It's what brought Emily Bohonos, a middle school science teacher in Brooklyn, N.Y., to join the New York Academy of Science's Scientistin-Residence (SiR) program.

SiR brings together scientists and NYC middle and high school teachers for a year-long collaboration that aims to jump-start student interest in STEM through real-world projects and the opportunity to "humanize" a scientist.

Bohonos along with her partner Kathrin Schilling, Ph.D., an associate research scientist of Geochemistry from Columbia University, have spent the last few months creating a project focused on something that most students already have an interest in: food. Building off of Schillings' expertise — she has degrees in geology, soil science and microbiology — the two are challenging students to research diet variations around the world and create experiments that explore the effects of different conditions on plant growth. Their project pushes students to practice thinking critically, creatively, and globally.

Schilling loves sharing her passion for science with students and is thrilled when she sees them thinking outside of the box. The benefits of programs like this, however, are not

limited to added content expertise — they also provide tangible examples of people who have found success in STEM.

In fact, Schilling notes that many of the questions she gets are far removed from her area of expertise. With the title of "Dr.", the students see her as an expert in all science-related fields, a factor she recognizes may be one of the reasons that science can seem inaccessible to some students. "It feels like you have to be a genius in every field [to be a scientist] and we are definitely not." Schilling admits that she herself wasn't a great student until she was able to start specializing in her post-secondary education.

To this end, Bohonos creates time during each lesson to allow students to interact one-on-one with their Resident Scientist and get to know her on a personal level. In this way,

students can hopefully begin to see STEM as a career path not just limited to those who have already been labeled as "smart". Fostering this type of environment is particularly critical at schools like Bohonos', where students of color make up almost 90 percent of the student body, a group which still remains significantly underrepresented in the number of individuals receiving undergraduate STEM degrees.

Mentoring takes time and it comes with its own challenges, but despite this, Schilling remains optimistic about her role in fostering a positive outlook regarding STEM. "Even if I can change the mind of just a few [students] it's more than before the program."



# Building an Effective Network to **Achieve Your Career Goals**

By Srikant Iyer, Ph.D., NYAS Staff

No one knows who first coined the popular saying "It's not what you know that counts so much as who you know ..." although there is some evidence it was first used in 1914 in *The Electrical Worker*, a publication of the International Brotherhood of Electrical Workers union. Origins aside, there is a good deal of truth behind these words, and most career guidance experts will agree that the most effective way to advance one's career is by leveraging a network of contacts.

Networking helps cultivate relationships that pave the path for our future. However, many STEM professionals just starting out find the idea of networking daunting. Thoughts like "I don't feel comfortable asking for help", "I don't want to bother people", "My research is very niche and I can't dumb it down" become self-imposed barriers towards shaping one's career journey and often prevent individuals from exploring new career opportunities and connecting to potential colleagues.

### MAKE IT EASY FOR PEOPLE TO REMEMBER YOU

Networking is defined as the exchange of information and ideas among people with a common profession or special interest, usually in an informal social setting. Shruti Sharma, Program Manager at Stony Brook University moved from India to the U.S. for her Ph.D. "In the U.S. the culture of being a self-promoter felt foreign to me," she said. "I was raised in a culture where one's work is supposed to speak for itself." She identified networks like Science Alliance Leadership Training (SALT) where she found the safe space to navigate the cultural differences. "I realized that for my work to speak, I needed to communicate my skills and achievements to build a community of allies and advocates," adds Sharma. This helped her leverage both the individualistic and community-based cultures to her advantage.

Satish Rajaram (SALT Alum), Engineer and Scientist at TRI Austin, says, "It is important to articulate your story for your personality to show, and to separate yourself from others with similar backgrounds." As a Graduate Writing Consultant and mentor to undergraduate students, Rajaram recommends the value of being specific about one's experience — it provides context to conversations and makes you more marketable — an important trait when applying for a job.

### **SUCCESS TAKES TIME AND EFFORT**

Effective networking requires strategic preparation and being mindful of leveraging assertive ways to succeed when building relationships. Arthee Jahangir, Assistant Director,

Postdoctoral Affairs at New York University School of Medicine, believed that by being a consistent high performer the merit based system would reward her, and her gender would not be a hindrance. But despite being a lead entrepreneur, Jahangir, like many women in science, experienced systemic barriers of being overlooked in favor of her male colleagues at networking events and pitches. She says, "I started to become [aware of] unconscious bias and micro-aggression that permeated the bubble I lived in, and learned strategies to counteract it by controlling my own narrative."

Getting others to talk about their own career path facilitates conversations and builds relationships. Monika Buczek (SALT Alum), Business Development Manager and Scientific Project Leader at Champions Oncology Inc., used the "identify common ground approach" to connect with, and cold contact, individuals on LinkedIn. In her informational conversations Monika would ask such questions as: "If you could change anything about your path what would you change?" and "What would you tell yourself at the beginning of your journey?" to cultivate relationships.

Networking is a skill that needs to be practiced. Regardless if you are an introvert or an extrovert, practicing talking to your immediate circle, e.g. friends, colleagues, supervisors and even vendors, is a first step to building your network.

Join professional associations and attend conferences to build a portfolio of people you'd like to meet. Cultivate your narrative to feel confident about approaching people. Email leaders in your field you admire and request a meeting. You may not always get a positive response, but it's a "no" if you don't ask!



# **Academy eBriefings**

By Lauren Savage, NYAS Staff

eBriefings are online multimedia reports documenting recent Academy events. Additional reports may be found on the Academy website at: nyas.org/ebriefing.



# PROTEIN FOLDING IN HUMAN HEALTH: 2019 DR. PAUL JANSSEN AWARD SYMPOSIUM

Mammalian cells can make up to 20,000 different proteins, responsible for a wide range of cellular functions, including structure, catalysis, transport, and signaling. Proteins are synthesized as linear chains, but to carry out their myriad roles, they must then fold into complex three-dimensional configurations. Franz-Ulrich Hartl, M.D., of the Max Planck Institute of Biochemistry and Arthur Horwich, M.D., of Yale School of Medicine and Howard Hughes Medical Institute, are working to better understand the molecular machinery that drives protein folding, and the implications when a protein misfolds. They discovered a new class of proteins, part of the chaperone family, responsible for protein folding. Chaperones bind to peptide chains as they are being transcribed to prevent them from aggregating and to give them an isolated space, shielded from the hubbub of the crowded cytoplasm, in which to fold properly. Misfolded proteins are associated with aging and diseases including Alzheimer's disease, Parkinson's disease, Huntington's disease, and prion disease.

On October 4, 2019, prominent scientists gathered at the New York Academy of Sciences to grant the 2019 Dr. Paul Janssen Award to Hartl and Horwich for their groundbreaking insights into chaperone-mediated protein folding.

### **Symposium Highlights**

- While studying mitochondrial protein import, Horwich and Hartl hypothesized that the process may not be spontaneous but dependent on cellular machinery. They discovered a new class of proteins responsible for protein folding.
- Hsp60, its bacterial homolog GroEL, and its eukaryotic homolog TRiC have a double ring structure that forms a chamber in which a peptide substrate can fold into its proper shape.
- The unfolded protein response of the endoplasmic reticulum responds to the presence of misfolded proteins, which accrue with age. The response itself declines with age.
- Hsp70 is a diverse family of monomeric chaperones that

- binds to polypeptide chains as they're being translated or when they misfold from mutation or stress and prevents them from collapsing into aggregates.
- Clinically relevant receptors that have been difficult to treat require specific chaperones that may provide more easily druggable targets for neurological and psychiatric disorders.

### Full eBriefing by Diana Gitig:

nyas.org/ebriefings/2019/protein-folding-in-human-health-2019-dr-paul-janssen-award-symposium/

# SOLVING MALNUTRITION THROUGH FOOD SYSTEMS AND NUTRITION PROGRAMS

Malnutrition, in all its forms, is a global challenge. As a key modifiable risk factor for chronic and infectious diseases, it has far-reaching health, economic, and social consequences. On September 13, 2018, the New York Academy of Sciences hosted a discussion of two contrasting, yet not mutually exclusive, strategies to meet the global population's nutritional needs. Barbara Burlingame, Ph.D., of Massey University, New Zealand, and Kathryn Dewey, Ph.D., of the University of California Davis, presented their views on food systems and nutrition programs.

### **Highlights:**

- According to Dewey, filling nutrient gaps with supplementation, fortification, bio-fortification, and fortified products may be an appropriate complement to improve food systems as a whole.
- Burlingame argued that food systems can adequately support healthy diets for the population through sustainable diets and food biodiversity already present in the ecosystem.
- Both Dewey and Burlingame agree on the importance of finding mutually agreeable strategies and exploring areas of complementarity using multisectoral involvement.

### Full eBriefing by Saima Ahmed:

nyas.org/ebriefings/2019/solving-malnutrition-through-food-systems-and-nutrition-programs/

### THE FUTURE OF COMPLEX MEDICINES: **DEVELOPMENT AND REGULATION**

Advances in biomedical research, biotechnology, and nanotechnology are yielding innovative medicines that can change the course of a disease in ways never before possible. These life-saving new medicines — biologic compounds such as gene therapies and recombinant proteins, as well as non-biological complex drugs such as liposomes and iron-carbohydrate complexes — are so diverse, and often difficult to characterize, that regulatory agencies around the world have struggled to figure out what kinds of data should be submitted to approve them.

To advance research and build consensus, it is necessary to engage together key stakeholders from academia, regulatory bodies, industry, and drug manufacturing. On May 13, 2019, the New York Academy of Sciences, the Nanotechnology Characterization Laboratory, and the Non Biological Complex Drugs Working Group hosted a conference to stimulate this discussion. A follow-up to a 2016 convening on the same topic, this event featured presentations on best scientific approaches for the development and regulation of complex medicines, current challenges in the assessment of equivalence, and methods to improve timely patient access for new medicines.

### **Symposium Highlights:**

- There is no standard definition of what constitutes a complex medicine — it could be a product containing a complex active ingredient or formulation, or even a simple medicine enabled to access a complex environment in the body.
- Regulatory agencies around the world are still in the process of developing the framework for approving complex medicines. That process is especially problematic for follow-on medicines, and it will have to evolve as increasingly different types of complex medicines emerge.
- Real-world data generated when people use the healthcare system can boost regulatory efficiency for complex medicines.
- The approval of biosimilars would significantly decrease healthcare costs and make the most powerful medicines more accessible.
- As complex medicines drive up the cost of healthcare, governments and regulators will also have to confront inequality in access to medicines.

### Full eBriefing by Alla Katsnelson:

nyas.org/ebriefings/2019/the-future-of-complex-medicines-development-andregulation/

### THE NEW TRANSFORMERS: INNOVATORS IN REGENERATIVE MEDICINE

The human body regenerates itself constantly, replacing old, worn-out cells with a continuous supply of new ones in almost all tissues. The secret to this perpetual renewal is a small but persistent supply of stem cells, which multiply to replace themselves and also generate progeny that can differentiate into more specialized cell types. For decades, scientists have tried to isolate and modify stem cells to treat disease, but in recent years the field has accelerated dramatically.

A major breakthrough came in the early 21st century, when

researchers in Japan figured out how to reverse the differentiation process, allowing them to derive induced pluripotent stem (iPS) cells from fully differentiated cells. Since then, iPS cells have become a cornerstone of regenerative medicine. Researchers can isolate cells from a patient, produce iPS cells, genetically modify them to repair any defects, then induce the cells to form the tissue the patient needs regenerated.

On April 26, 2019, the New York Academy of Sciences and Takeda Pharmaceuticals hosted the Frontiers in Regenerative Medicine Symposium to celebrate 2019 Innovators in Science Award winners and highlight the work of researchers pioneering techniques in regenerative medicine. Presentations and an interactive panel session covered exciting basic research findings and impressive clinical successes, revealing the immense potential of this rapidly developing field.

### **Symposium Highlights:**

- New cell lines should reduce the time and cost of developing stem cell-derived therapies.
- The body's microbiome primes stem cells to respond to infections.
- iPS cell-derived therapies have already treated a deadly genetic skin disease and age-related macular degeneration.
- Polyvinyl alcohol is a superior substitute for albumin in stem cell culture media.
- A newly isolated type of stem cell reveals the stepwise process driving early embryo organization.

### Full eBriefing by Alan Dove:

nyas.org/ebriefings/2019/the-new-transformers-innovators-in-regenerative-medicine/

### WHY STEM PROFESSIONALS ARE VALUABLE **ACROSS INDUSTRIES**

According to the Pew Research Center, employment in science, technology, math and engineering (STEM) occupations has grown 79% since 1990. But STEM expertise is vital to many industries, some of which you'd never associate with those skills. As companies large and small work to find and retain top talent who can identify emerging trends to propel their businesses forward, they are actively investing in professionals with STEM skills.

In a new webinar series, A Recruiter's Perspective, the Academy's Science Alliance talks to companies about how and why they're recruiting talented STEM professionals. On September 26, 2019, PepsiCo, the first partner in the series, shared their creative approach to recruiting top talent in data science and research and development. Learn more from the leading global food and beverage company in this summary.

### **Webinar Highlights**

- A STEM-proficient workforce helps PepsiCo identify emerging scientific trends and advance innovative efforts.
- Their educational programs encourage employees to sharpen their skills and develop new ones across disciplines.
- Applicants should convey their hard and soft skills to PepsiCo recruiters, as communication, flexibility, and intellectual curiosity are critical.

### Full eBriefing by Lauren Savage:

nyas.org/ebriefings/2019/why-stem-professionals-are-valuable-across-industries/



# **Annals Highlights**

Annals of the New York Academy of Sciences is the premier publication of the Academy offering original research articles and commissioned review articles.

nyas.org/news-and-publications/Annals

# Setting research priorities for multiple micronutrient supplementation in pregnancy

Important throughout the life cycle, adequate nutrition is particularly important during pregnancy to support both maternal health and fetal development. Many micronutrients have critical roles during this life stage (especially vitamins A,  $B_{6'}$ ,  $B_{9'}$ ,  $B_{12'}$ , C, D, and E and minerals iron, zinc, iodine, copper, and selenium), for which the recommended intakes may increase by up to 50% to accommodate the higher maternal, placental, and fetal demands.

The increased nutritional demands of pregnancy, in combination with the preexisting nutritional deficiencies among some undernourished (and/or the even higher nutritional demands for adolescent) pregnant women, may put their health, and that of their offspring, at risk.

Maternal micronutrient malnutrition is associated with low birth weight (<2500 grams), preterm birth (<37 weeks), being born small-for-gestational-age, and perinatal and maternal mortality, among other pregnancy-related adverse outcomes. Prenatal multiple micronutrient supplementation provides a good solution for supplying essential nutrients.

To clarify research needs for successfully implementing multiple micronutrient supplementation, the New York Academy of Sciences, acting on behalf of the recently assembled Multiple Micronutrient Supplementation Technical Advisory Group (MMS-TAG), conducted a research prioritization exercise using the Child Health and Nutrition Research Initiative methodology—a systematic and transparent method for setting priorities in health research using a rationale, conceptual framework, application guidelines, and strategies to address the needs of various stakeholders.

The Ann NY Acad Sci paper by Gomes et al. summarizes the research prioritization exercise. The MMS-TAG, a group of international specialists, ranked the most urgent gaps in knowledge, focusing particularly on aspects that would improve the delivery and effectiveness of MMS in low- and

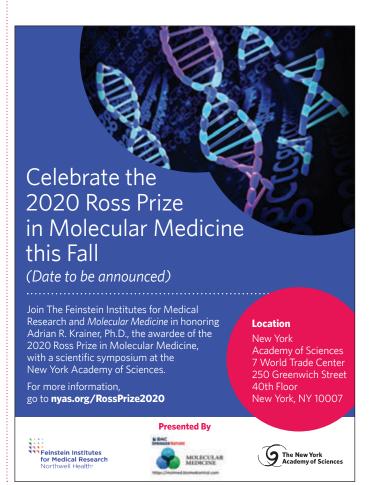
middle-income country populations.

The paper describes the process of prioritizing 35 non-redundant research questions that should be considered and addressed if the positive potential of multiple micronutrient supplementation is to be fully realized in low- and middle-income countries.

Given the simple nature and relatively low cost of the process, this research prioritization exercise could be repeated periodically as new information becomes available.

Setting research priorities on multiple micronutrient supplementation in pregnancy

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# Gut microbiome and its role in obesity and insulin resistance

The microbes living in the human gut—the gut microbiota play an important role in metabolism and function together as an "organ" that consists of trillions of bacteria and other biological agents, weighs ~1.5 kilograms, and contains at least 150 times more genes than human cells.

Residing in the distal colon, the gut microbiota comprises bacteria, viruses, phages, yeast, and fungi that have evolved a symbiotic relationship with humans, even though they outnumber human cells by a factor of ten.

A recent article by Clare J. Lee, Cynthia L. Sears, and Nisa Maruthur, published in the Ann NY Acad Sci reviews series The Year in Diabetes and Obesity, provides information on the gut microbiome and possible mechanisms through which it contributes to human obesity and insulin resistance.

The advent of high-throughput DNA sequencing technologies has substantially boosted scientists' abilities to study complex microbial communities. These new tools now enable study of the gut microbiota in depth, a goal that was only recently out of reach owing to high cost and inability to culture most of the gut microbiota organisms in the laboratory.

In 2012, the Human Microbiome Project Consortium reported that the dominant microbial phyla in the human gut include Bacteroidetes, Firmicutes, and Proteobacteria. And as computational analytical approaches have advanced since, identification of specific bacterial species and strains associated with diseases have been possible.

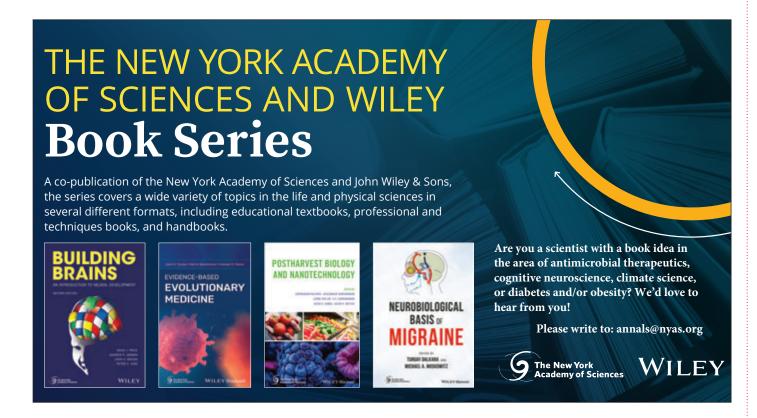
The authors cover many areas of human physiology and diet that influence obesity and insulin resistance, including that the gut microbiota likely affect metabolism and obesity through several metabolic pathways—energy extraction, gut barrier integrity, production of metabolites affecting satiety and insulin resistance, and metabolism of bile acids and subsequent changes in metabolic signaling.

They conclude that additional human studies are required to distinguish the contribution of the gut microbiome from effects of diet, medications, and environment, and how gut dysbiosis (microbial imbalance or maladaptation) causes obesity and when it can potentially be reversed to treat obesity.

Studying the gut microbiome presents a promising window through which significant advances can be made in understanding human physiology. And it may open the door to developing new microbiota-based therapies to prevent and treat diseases such as obesity and insulin resistance.

Gut microbiome and its role in obesity and insulin resistance Ann. N.Y. Acad. Sci. 1462: 37-52.

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