

The Scientific Observer

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Exploring the Next Frontier in Food

The Future of Food: Five Key Considerations in Alternative Protein Food Production

The Ultimate Guide to Avoiding Predatory Conferences

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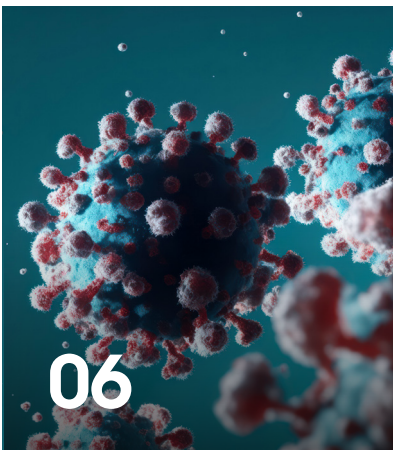
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EDITORS' NOTE

Dear readers,

Welcome to the 30th issue of *Technology Networks'* monthly magazine, *The Scientific Observer*.

If food is the way to your heart, there's no doubt that you'll gobble up this issue. Increasing awareness of sustainability issues, demand for nutritional, low-cost foods and technological advancements are just some of the drivers behind a profound shift in how we produce and consume food. The choices we make now regarding what and how we eat will have a ripple effect on future generations and the future of our planet – how do we make sure they are the right choices? In this issue, we're serving up fascinating articles that explore the latest innovations in agriculture, the intricate relationship between food and climate change and the ways in which science is contributing to the development of a more resilient and equitable food system.

The scientific community is not immune to issues of ethics and integrity, as Ruairi J Mackenzie recently discovered while investigating a “predatory” scientific conference. In an era of rapid information dissemination, the proliferation of predatory conferences poses a threat to the credibility of scientific research. Fear not – Ruairi has crafted the “ultimate guide” to avoiding predatory conferences, featured in this issue, to help you spot the red flags and avoid falling prey to this concerning form of scientific misconduct.

In Professor Michael S Kinch's latest op-ed for *Technology Networks*, he tackles one of the most pertinent issues of our time: vaccine mandates. “Is It Time To Discuss Vaccine Mandates?” provides a thoughtful discourse on the potential role and complexities of mandates in protecting public health against infectious diseases.

We hope you enjoy this issue of *The Scientific Observer*. [Subscribe](#) to make sure you never miss an issue.

The Technology Networks Editorial Team

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Have an idea for a story?

If you would like to contribute to *The Scientific Observer*, please feel free to [email](#) our friendly editorial team.

From the Newsroom



Could a Malaria Drug Treat Cancer One Day?

MOLLY CAMPBELL

While researching a cure for malaria, researchers discovered and characterized several bioactive compounds from the plant *Artemisia annua*. The Nobel Prize-winning effort saved millions of lives and might pave the way for novel cancer therapies. But there's a roadblock – scientists aren't clear on how the compounds work.

JOURNAL: *Natural Products.*



Journey Through the Genetic Evolution of Stone Age Europe

MOLLY CAMPBELL

An international team of scientists – led by researchers at Uppsala University – analyzed genome data from 56 specimens dating back to the Mesolithic, Neolithic and Eneolithic periods across Central and Eastern Europe.

JOURNAL: *Communications Biology.*



Circadian Clock Study Shows Why Jet Lag Wipes Us Out

RUAIRI J MACKENZIE

New research has modeled the interactions between our body's circadian clocks to investigate why jet lag leaves us so fatigued.

JOURNAL: *Chaos.*



21 Days in a Weightless Bed Can Affect the Body Like a Trip to Space

RUAIRI J MACKENZIE

A study suggests that some changes the body undergoes during a trip to space can also happen after a few weeks of weightlessness on Earth.

JOURNAL: *Science Advances*.



Weight Loss Drug Could Benefit Over 90 Million US Adults

SARAH WHELAN

A new study suggests that over 90 million US adults who are overweight or obese may benefit from the popular weight loss drug Wegovy™ (semaglutide).

JOURNAL: *Cardiovascular Drugs and Therapy*.



Humanized Kidneys Grown in Pig Embryos in World-First

SARAH WHELAN

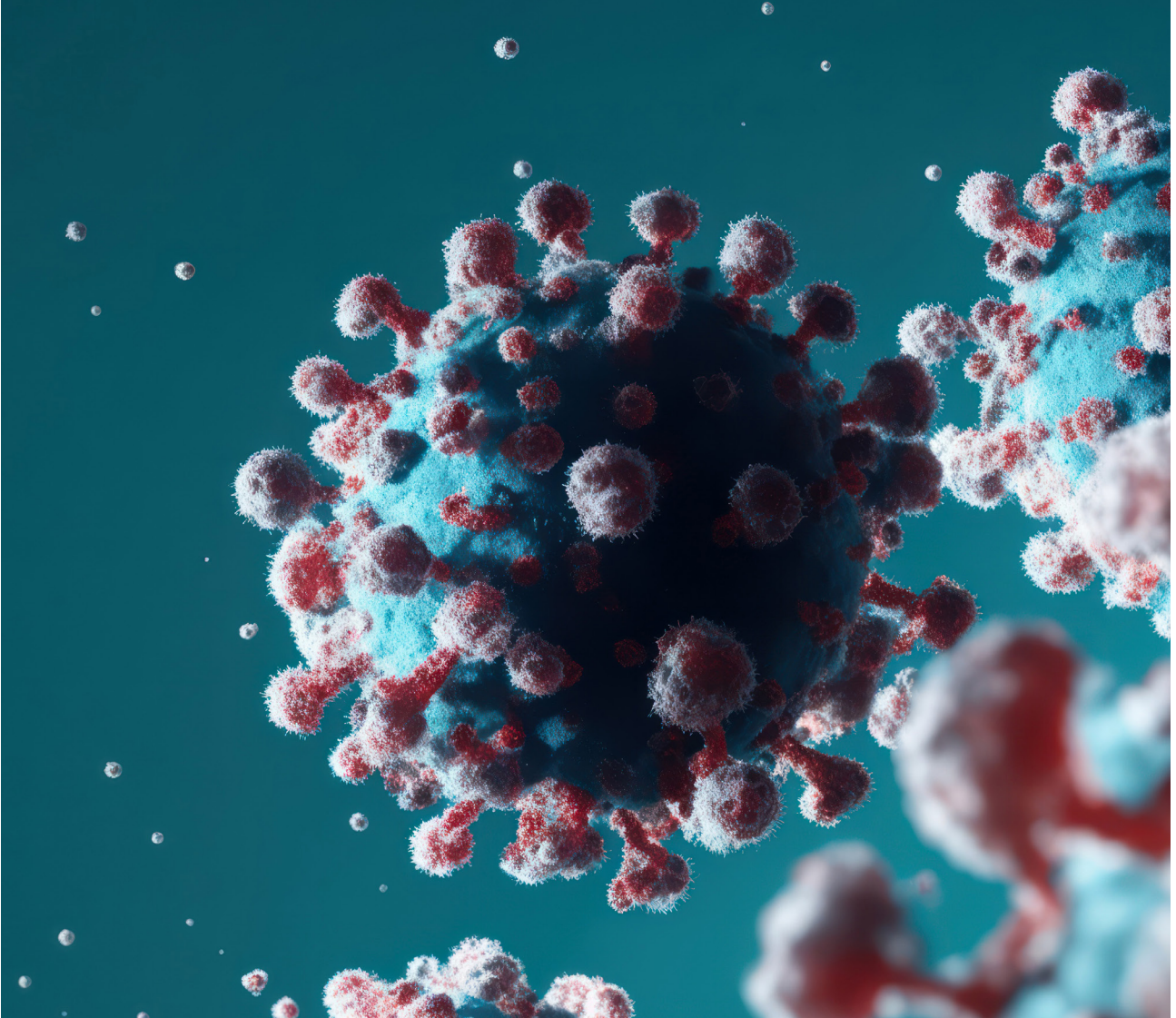
Researchers have grown early humanized kidneys in pig-human embryos at 28 days of gestation – the first time a solid humanized organ has been grown in another species, potentially influencing transplant medicine and our understanding of organ development.

JOURNAL: *Cell Stem Cell*.



Want to learn more?

Check out the [Technology Networks](#) newsroom.



Is It Finally Time to Discuss Vaccine Mandates?

MICHAEL S. KINCH

The following article is an opinion piece written by Michael S. Kinch. The views and opinions expressed in this article are those of the author and do not necessarily reflect the official position of Technology Networks.

As a regional outbreak evolved into a global pandemic, I was one of many enlisted by the media to convey the objective realities of a deadly pandemic. Consistently cautioning against

false hopes for a “Hollywood ending,” my mantra was that nature tends to be rather more complex than a two-hour feature film. History teaches us that the discovery and distribution of a safe and effective vaccine might require years or even decades until a pandemic can be controlled. This assumes, of course, that the vaccine is administered to all.

Through a combination of luck and the exhaustive work of countless scientists, physicians and volunteers,

a life-saving vaccine was discovered and distributed in record time. It was the first of several vaccines – utilizing a variety of technologies and platforms – that are now authorized to protect against SARS-CoV-2. One national television anchor still teases me for cautioning against a presumption of a Hollywood ending.

The resulting vaccine has indeed been remarkably safe and efficacious. Overwhelming evidence confirms that

mRNA-based vaccines have proven safe and effective. Yet the deployment of the vaccine has been less ideal, encountering first hesitancy and then outright denial.

THE M-WORD

Any discussion of the M-word – mandates – has been taboo amidst a cacophony of politics, which unnecessarily enveloped the pandemic and the vaccine meant to end it. This failure, compounded by the prevalence of vaccine denial and disinformation, translates into the troubling statistic the full course of vaccination (the original series and two boosters) have been administered to only 17% and 15% of the populations of the United States and the European Union, respectively.

The sequel might prove as deadly as the original. Whereas the rates of death in the US had declined from 500 a day in January of this year to as many in a week, the EG.5 variant looks to be reversing this trend. According to the Centers for Disease Control and Prevention, death rates surged from 469 weekly deaths in mid-July to 722 a month later, a 54% increase accompanied by a 163% increase in hospitalizations.

While our current vaccines are effective, they are also transient, with protection lasting months, not years or decades. This cold reality means that we all must be boosted at least annually. New vaccines for COVID, like influenza, are likely to be introduced on at least an annual basis. Our fundamental understanding of pandemics and viral adaptation

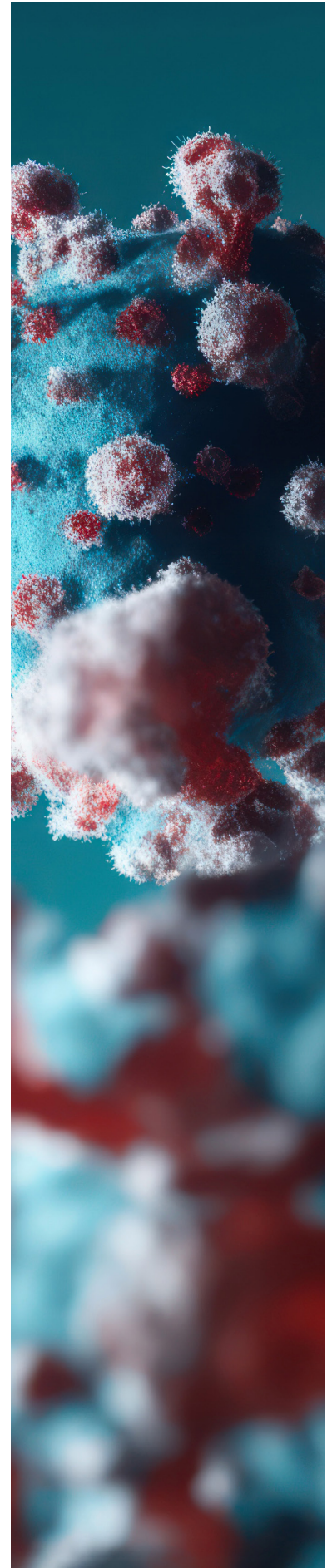
Our inability to mandate full vaccination, abetted by vaccine denial and misinformation, not only allowed the virus to circulate within our communities, but ensured it would adapt through countless variants that arisen over the past few years.

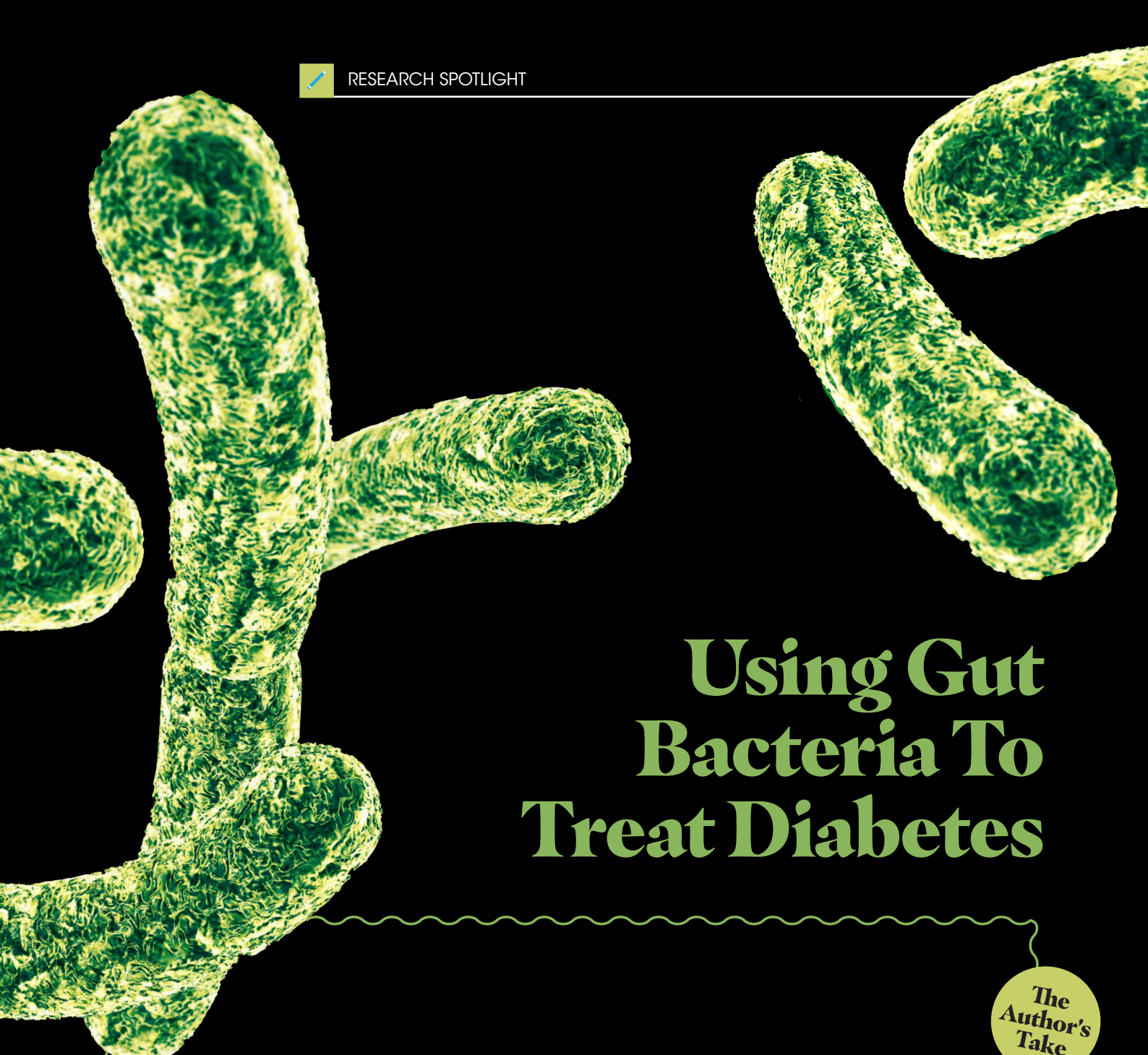
Nonetheless, the cinematic virtues afforded by vaccination allowed a shell-shocked and drained world to act like COVID was a problem of the past, with most seeking to forget the nightmares of deaths, lockdowns and disruption.

The only problem to our Hollywood ending is that we provided the virus with an opportunity for a sequel, ensuring more lives than a hockey-masked cinematic villain. Our inability to mandate full vaccination, abetted by vaccine denial and misinformation, not only allowed the virus to circulate within our communities, but ensured it would adapt through countless variants that have arisen over the past few years.

dictate that the need and frequency of vaccination are likely to persist for so long as there remain unvaccinated individuals. Despite the recognition, disinformation and vaccine denial ensures COVID continuation.

As summer ebbs and parents anticipate the new school year, the last thing we want to confront is the prospect of new waves of disease and chaos. Nonetheless, it is incumbent upon us to recognize COVID is far from over. The only way we can end this drama is to mandate that all individuals not merely are vaccinated but remain up to date with boosters. Until or unless this occurs, we will continue to be derailed for years and perhaps generations to come. ●





Using Gut Bacteria To Treat Diabetes

The Author's Take

Suhanee Mitragotri

Type 2 diabetes currently affects about 462 million individuals worldwide. A multi-institutional study led by Dr. Tadashi Takeuchi at Stanford University and published in Nature, demonstrates the specific role that various species within the gut microbiota play in carbohydrate metabolism, suggesting the potential for insulin-sensitive (IS) gut bacteria to combat insulin resistance (IR) and serve as a treatment for individuals with Type 2 diabetes.

TARGETING INSULIN RESISTANCE

IR, which is when cells are unable to respond to insulin and extract glucose from the blood, is one of the key factors responsible for the development of Type 2 diabetes. Previous studies have indicated that many species in the gut microbiota are involved in carbohydrate metabolism, which can contribute to insulin resistance when unregulated. However, Takeuchi et al. wanted to improve understanding of the roles of specific species within the gut microbiota, because, while there are IR-associated bacteria in the gut, there are also understudied IS-associated bacteria that could play a role in combating insulin resistance.

Fecal metabolomics could be used to study IR pathogenesis

IDENTIFICATION OF GUT BACTERIA ASSOCIATED WITH INSULIN RESISTANCE AND INSULIN SENSITIVITY

The researchers combined unbiased fecal metabolomics with metagenomics, host metabolomics and transcriptomics data to determine the role of the microbiome in insulin resistance. They recruited 306 individuals (71% male) without diabetes, between the ages of 20 to 75 years. They were assessed for insulin resistance, which was defined as a homeostatic model assessment of IR (HOMA-IR) of at least 2.5. They analyzed metabolites in 22 human fecal IS- and IR-associated bacteria to understand which carbohydrates were consumed by each type of bacteria. They also looked for the presence of associations between fecal metabolites and metabolic syndrome (MetS), an IR-related pathology, and used two mass spectrometry (MS)-based

analytical platforms to conduct untargeted metabolomics analysis. After these various tests were conducted on human-derived samples, Takeuchi et al. administered seven IS-associated bacterial strains in mice to assess their role in potentially combating IR.

The key findings from this study were that:

- Fecal metabolomics could be used to study IR pathogenesis, as many features of fecal metabolomic data were more efficient at predicting IR compared to 16S rRNA sequencing and metagenomics
- Fecal carbohydrates are increased in IR, as monosaccharides were increased in the feces of individuals with IR and MetS
- When administered to mice, *Alistipes indistinctus* (*A. indistinctus*) was able to reduce diet-induced obesity and IR, through ameliorating ectopic triglyceride accumulation in the liver and glucose intolerance

A. INDISTINCTUS AS A TREATMENT FOR INSULIN RESISTANCE

Although carbohydrate metabolism has been implicated in obesity and prediabetes before, the actual biological link has not been thoroughly studied, and Takeuchi et al.'s findings suggest that fecal metabolomics may be an efficient way to study IR pathogenesis, compared to other methods such as 16S rRNA sequencing and metagenomics. Through using metabolomics, they were able to identify fecal metabolites involved in IR. They found that excessive monosaccharides can further ectopic lipid accumulation and activate immune cells, leading to a host inflammatory response and increased IR. However, the team found that *A. indistinctus* administration in mice was able to improve lipid accumulation and alleviate IR, thereby suggesting the role that IS-associated bacteria could play in treating IR.

In order to improve understanding of how to treat patients with IR, it is important to understand the interactions that occur between the gut microbiome, the immune system and nutrients that are fed to the body on a daily basis. By utilizing metabolomics, Takeuchi et al. were better able to understand the role that fecal carbohydrates play in the development of IR. Additionally, they realized the role that gut bacteria could hold in reducing IR, which suggests the potential for probiotics to be a therapy for patients with Type 2 diabetes.

Further experimentation is required to understand the mechanisms of *A. indistinctus* absorption and the specific ways in which it affects host metabolism, such as further examining how they suppress carbohydrate metabolism. Additionally, it would be important to assess how insulin signaling occurs in not only the liver, but also peripheral tissues, such as skeletal tissue and adipose tissue, to improve understanding of the whole-body impact of therapeutics that could potentially treat IR.

THE NEED FOR LONGITUDINAL STUDIES

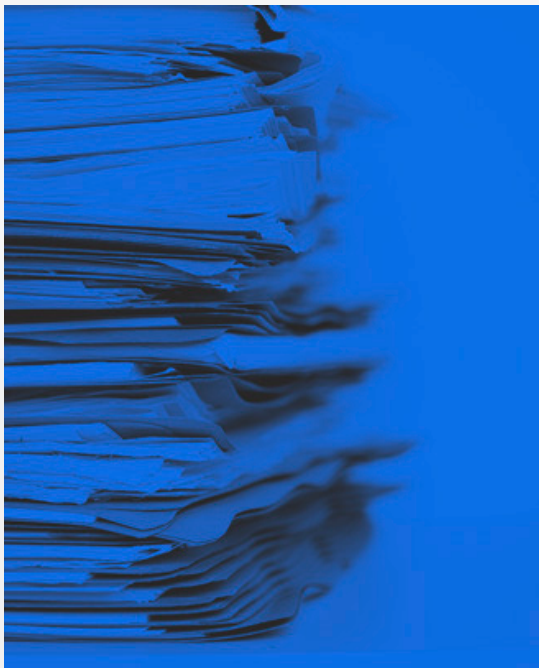
This study shows promise in better understanding the role that microbial metabolism plays in the development and course of insulin resistance in patients with Type 2 diabetes. Not only does it reveal new ways to study insulin resistance, but it also demonstrates the potential that IS-associated probiotics could have in treating people with diabetes. However, the next step is to conduct a longitudinal study in order to determine the role of microbial metabolism in patients with diabetes in the long-term and thereby inform scientists on the development of long-lasting therapies to combat insulin resistance. ●

Reference

1. Takeuchi T, Kubota T, Nakanishi Y, et al. Gut microbial carbohydrate metabolism contributes to insulin resistance [published online ahead of print, 2023 Aug 30]. *Nature*. 2023. doi:10.1038/s41586-023-06466-x

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**Find Out
More**



The Ultimate Guide to Avoiding Predatory Conferences

RUAIRI J MACKENZIE

If you work in science, be it as a student, postdoc or seasoned professor, you've probably received an email from a predatory conference provider. The message comes in many forms, often arriving many times a week, but will read something like the following:

Dear Valued Professor [whether you are a professor or not is irrelevant],

Please be joining us for the next instalment of our top quality scientific program at the 423rd International Conference on Varied Research Activities and Information Sharing, to be held in the finest venues [read:

budget motel] that your country has to offer.

For just the low, low price of [this will not be a low price] we can offer you a poster, speaker, plenary, conference organizing committee position, where you can share your amazing research and add to your well endowad [sic] CV.

Sign up now!!

Best,

Shakira Baratheon, Customer Service Rep, Incredible Science Conferences LLP.

Now, as much as we would all like to enhance our standing in our individual research fields, the truth is that Shakira cannot help you with this goal. Predatory conferences are the ramshackle, distant cousin of your regular scientific event, a Fyre Festival of science (without the involvement of Ja Rule). While many readers might assume that, should you accept her offer and send money for a booking fee, Shakira would simply take the cash and run, I can assure you that these events *do* actually take place. I should know – I attended one.

The standard of these events is, however, likely to be rather pitiful. Would-be attendees should expect missing plenary speakers, multiple fields of research smashed together in a Frankenstein program and an absence of the important academic rigor that fuels the conferences that scientists know and love. The companies organizing these events are motivated by profit above all else. When tickets are sold at hundreds of dollars a pop, with logistics either outsourced to bemused academic organizing committees or poorly paid administrators, there are huge margins to be realized in the predatory conference field.

The problem is that it is getting harder to separate fake conferences from real ones.

For every few shoddy, eyebrow-raising emails from Shakira and colleagues, there will now likely be one or two slick emails, pumped out by a ChatGPT-assisted administrator, that look a lot more believable. Searching online is futile as well. A cursory Google search for “Biology Conferences” turns up at least two results that link to predatory conference companies in high-ranking positions on the first page.

Given this deluge of dodgy science, I have created a guide to spotting and avoiding predatory conferences, which, should you follow it, will help you avoid getting hoodwinked, scammed, swindled, stung, defrauded or bunkoed by predatory conferences. These events are always updating their tactics, however, so please [reach out](#) if you have any questions about predatory conferences.

THE BASICS

Have you got a passion for “science”? Or webpage design? The first tip I have for you is also the most straightforward. Whether you are studying an unprompted email or a conference webpage, look for shoddy writing quality or outlandish layouts. As an example here, I will use the predatory conference provider, Conference Se-

ries. As a rule – see **the gray areas of predatory science** below – it is hard to definitively call any particular conference provider entirely predatory, but I feel comfortable doing so with Conference Series. It is owned by OMICS International, a company that was [slapped](#) with a still-unpaid \$50 million fine by the US Federal Trade Commission for their “deceptive” practices.

In terms of red flags, the [Conference Series](#) site has it all: eye-watering fonts, weird capitalization, spelling errors and brutal UX design which makes you feel unwell just from scrolling. Please take this nausea as an indicator of quality and click away from these sites.

WE NEED TO TALK

The second tip I have for you is also straightforward but should be at the forefront of your decision-making when it comes to choosing a conference. Ask yourself, “Do I know anyone who has attended one of these conferences before?” and “Is this a conference I have been recommended by my institution, university, or lab leadership?” If the answer to either of

these questions is “no”, please talk to your colleagues and get their read on the event. The dominant conferences in your field are probably in that position because they have proved time and time again that they can deliver a valuable experience for attendees. Do you really need to set out on an uncharted course by attending a new conference no one has ever heard of?

DEEPER DIVES

The advice above should prove handy for avoiding the most obvious scam conferences. But the reality is that most people who end up attending these events likely don’t have a support network they can consult. Here, I will dig deeper into the smaller clues that give away potentially predatory providers that you can investigate solo.

QUALITY OVER QUANTITY

If you have ever attended a decent scientific conference, you may have noticed that they seem rather a pain to put on. There’s a huge amount of planning that goes into making sure even smaller events run well. If the

THE GRAY AREAS OF PREDATORY SCIENCE

You might be wondering why we don’t simply provide a list of websites to avoid in this guide.

There are two key reasons.

1. Stamping out predatory providers can become a game of whack-a-scram. Every time you mark out a provider as dodgy, the company behind the conferences will likely switch to a new domain or name and continue as before.
2. Predatory or not? University of Colorado librarian Jeffrey Beall attempted to make a [list](#) of predatory journal companies back in 2008. But Beall was eventually forced to take the list down, having received both legal threats from predators and rebukes from legitimate providers that had failed some of his stringent quality tests, such as the open-access journal provider *Frontiers*.

provider you are consulting is organizing, say, 25 conferences in a single month, all around the globe, on every different conceivable topic, you can make one of two assumptions. Either that said provider has the logistical acumen of Hannibal's chief elephant mountaineer and a bank balance to make Bernard Arnault look like a medieval peasant, or that the conferences this provider arranges are individually going to be rather poor. Examine the volume of events being put on by the provider and weigh up for yourself how likely it is that they can happen at an acceptable standard.

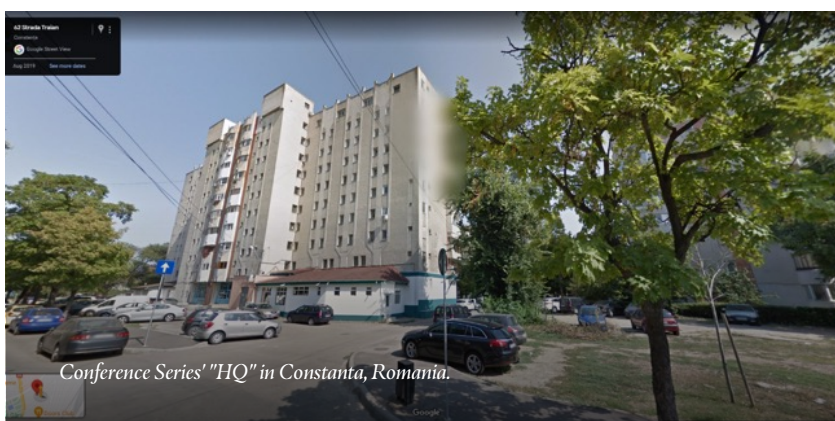
LEARNED SOCIETY OR UNLEARNED ANARCHY?

Time for a bit of amateur sleuthing. Many respectable conferences, such as this brain reporter's favorite, the Society for Neuroscience's Annual Meeting, are organized by a learned society that is made up of researchers in the field. It shouldn't take much fumbling about on the provider's website to turn up some basic contact information. Do the provider's details match what you'd expect from the organization? Take legitimate conference non-profit Gordon Research Conferences. These folks are very much not predators and put on a host of interdisciplinary events each year. A quick search shows that they are based at 512 Liberty Lane in South Kingstown, Rhode Island. A hop on Google Maps Street View shows us that there is indeed a rather large building with the Gordon Research Conferences logo on the side.

A similar hunt for Conference Series' European HQ shows a residential street in the town of Constanta in eastern Romania. They appear to be based out of a housing block. With all due respect to Constanta, is this likely to be the epicenter of the academic monolith that Conference Series claims to be?



Gordon Research Conferences' "HQ" in Rhode Island.



Conference Series' "HQ" in Constanta, Romania.

WHO'S SPEAKING?

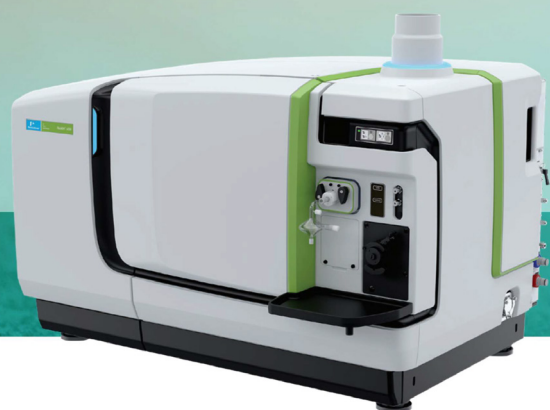
The speaker lineup is a huge draw at the best academic events. Hearing from and chatting with the brightest minds in your field can be a thrill. But if your conference lineup looks like a random administrator has scraped headshots from academic websites from across the globe and pasted them in haphazardly, you might want to take a pause. Look closely at the speakers listed – do their headshots look warped? Do they represent a span of disciplines that bears little resemblance to the topics under discussion? Do searches of their profiles online turn up blanks? Probably a predator. Be warned, however, that this is not a golden rule, as some conferences will pay a lone plenary speaker an exorbitant fee to turn up, speak and lend some legitimacy to proceedings. Look carefully through the whole speaker list. Some of them

might be listed at institutions that no longer exist. Some of the speakers may no longer exist themselves; predatory conferences are not above including dead speakers in their lineups.

SUMMARY

Even if you feel that your sleuthing skills are up to the challenge these conferences pose, I would still urge caution. These organizations are always changing their strategies, and I intend to update this guide as I am made aware of new approaches and tactics. If I can leave you with one final maxim, it's this: academic science is a ruthless and competitive business; if someone offers you a cushy speaker slot out of the blue, or an oddly specific conference invite arrives in your inbox, think twice before accepting the offer. ●

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Exploring the Next Frontier in Food

KERRY TAYLOR-SMITH





Climate change and a growing global population are putting our planet under immense pressure. Our current food systems, the activities related to producing and consuming food and their economic, health and environmental effects are pushing us toward the planetary boundaries.

“Our food system is at a pivotal moment; there is enormous potential for innovation to unlock more healthy, accessible and sustainable diets for all, but we are simultaneously facing huge global challenges,” says Richard Zaltzman, chief impact officer at EIT Food, a pan-European organization working to build an innovative, inclusive and resilient food system. “The decisions we make now, from across policy and investment to lifestyle and behavior, will have a significant impact on our future food system.”

The food industry is already a major contributor to climate change, with emissions from worldwide agriculture and livestock activity reaching 2.3 billion tons of carbon dioxide equivalent (Gt CO₂e) in 2018, and unless something changes, emissions could increase by 15 to 20% by 2050.

To mitigate the negative impacts of increased production and ensure future food supplies, the food industry must establish a sustainable food system from farm to fork, protect resources and use them efficiently and effectively. As consumers, our relationship with food – how we grow, produce and eat it, must change in response to increased demand and warming conditions. But how can this be achieved?

SMART FARMING

The United Nations expects the global population to rise to 9.7 billion within the next 30 years. As food production increases to keep up, more land will be needed for livestock and crops, generating increased greenhouse gas emissions. Feeding a growing population in a changing climate, with limited land and finite resources, is a difficult task. The additional space needed

for farming will compete with that required for housing needs, and just as housing developers are building up, farmers will have to consider farming upwards to make the most of the space available.

Vertical farming involves growing crops like tomatoes, mushrooms and strawberries in stacked layers, typically in factory-style situations, often without soil and sunlight.

Such farms utilize low-value land that might not otherwise be used for food production, and have even been adopted outside of Earth's atmosphere. Additionally, 1 acre of vertical farm is capable of producing the equivalent of between 10 to 20 acres of conventional farming. Because the method is highly controlled, crops that are less vulnerable to the climate, pests and pathogens can be grown all year round, regardless of the season.

To ensure future food security, farmers must also ensure their crops are robust enough to survive under changing conditions. Biotechnological solutions – those using biological

systems, living organisms or parts of them to develop different products – could be key.

Precision breeding, or gene editing, allows plant and animal breeders to precisely modify DNA by removing or altering genes at a specific location to create an organism with desirable genetic traits, such as resistance to pests or disease, essentially expediting the natural selection process. It's different from genetic modification, a more controversial technique, which introduces specific genes – often from another species – to the plant or animal's genome.

The technique has shown promise for breeding cacao trees with enhanced resistance to disease; developing barley, rice and tomatoes with increased disease resistance and breeding a type of tomato plant with shortened stems that grows faster and requires less space, making it suitable for vertical farming. Scientists have also edited hen DNA so that only female eggs develop when blue light is shone on their fertilized eggs. Bull calves have been genetically edited to produce

Feeding a growing population in a changing climate, with limited land and finite resources, is a difficult task.





more male offspring, meaning that the same amount of beef can be produced using fewer cattle.

RISE OF THE ROBOT FARMERS

Agriculture produces 23.7 million tons of food per day, and methods have changed considerably since our ancestors first farmed the land. Mechanization of automated manual labor with machines like tractors and combine harvesters has made industrial farming on large scales possible. A second revolution, which implements agricultural technology and introduces innovative and sustainable practices, can further improve the efficiency and yield of crops and reshape our food systems for the better.

And it starts with seeds; the human eye currently evaluates seedlings, but robots equipped with machine vision and artificial intelligence (AI) could be taught to recognize desirable traits to aid plant breeding, speeding up or even ending the laborious process of sorting seedlings.

“Agriculture is a rapidly growing area for machine learning applications, and we can expect to see more aspects of our food production supported by AI, robotics and automation in the coming years,” says Zaltzman.

Robotic farmers equipped with AI, GPS and machine learning can help farmers care for plants at an individual

level. They are employed at all stages of the farming process, from autonomously mapping the land to planting seeds, predicting soil moisture, nutrients and soil carbon, weeding and herbicide distribution and pest and disease detection. Such technology ensures only those plants needing attention receive it, helping to conserve resources and resulting in environmental and financial savings.

Drones can perform similar tasks, including automating the inspection of fields for pest or weed outbreaks, gathering data and measuring the soil humidity, and delivering livestock vaccines to remote areas.

Robots also have a role to play after harvesting to monitor the health of the produce. Engineers have developed a

robotic device that “swims” through grain stores using a patented technology and helps to ensure the quality of the stocks and prevent food waste.

And it’s not just on the land; new technologies are trickling into aquaculture too. Farming of aquatic animals and plants could meet up to two-thirds of global seafood consumption by 2030, but it’s inefficient and often results in overexploitation of resources, impacting the environment and aquatic biodiversity. Many fish species are caught as bycatch due to indiscriminate fishing methods. New devices that “tune” fishing nets by emitting light that can attract or repel different species of fish, are helping to support sustainable fishing.

WASTE NOT...

A quarter of food produced for human consumption goes uneaten, with EIT Food estimating that 88 million tons are wasted in Europe alone. It’s time to “reboot the system”, the organization says, in favor of a circular economy that uses resources efficiently to reduce food lost throughout the farming and sorting processes, and beyond.

“We are seeing a growing shift across the supply chain to embed circular principles,” says Zaltzman. Smart technology, including camera, weighing scales and waste bins are



being integrated into the food service industry. The approach will “help companies to make more informed choices about food purchasing, to reduce waste,” Zaltzman adds.

thrown away by consumers tied to such dates. Extending the shelf life of perishable products could reduce retail waste by 50%, and 63% in the home.

Roughly 60% of the food wasted in the UK is edible, thrown away by consumers tied to such dates.

During sorting, foods like fruit and vegetables are often discarded because they are considered of sub-standard quality, the wrong shape or color, for example. Sensor-based sorting machines can detect and eject unwanted products from manufacturing and processing lines and redirect them, thus reducing food waste. “Where it’s impossible to reduce waste, entrepreneurs are also looking at innovative ways to give by-products a new life, Zaltzman says. Fruit pits, for example, can be rescued and converted into useful products such as spreads, oils and milk alternatives.

Best before and sell-by dates were introduced in the 1970s as a means of determining the freshness of our foods, often with little scientific basis or uniformity. Roughly 60% of the food wasted in the UK is edible,

Researchers are working on various means of determining the freshness of our food in real-time, including cellulose-paper-based gas sensors that sense water-based gases like ammonia from spoiled meat and fish, food packaging containing low-cost pH sensors that can tell when foods like fish, fruits, milk and honey have spoiled and colorimetric sensors that detect ethylene, a gas given off when fruit ripens.

OUR EVER-CHANGING DIET AND ALTERNATIVE PROTEIN SOURCES

As consumers, we also have a role to play. We are more aware than ever that our choices, including what we eat and how we shop, have an impact on the environment and sustainability.

Thanks to our ability to import produce from around the world, we have lost touch with the seasonality of foods. Instead of expecting foods to be available all year round, we should consider eating seasonal produce and look at labels to see how far our food has traveled from farm to fork. “With a global pandemic, climate change and international conflict exposing the fragility of our food system in recent years, we are finding consumers increasingly acknowledging the value of local, seasonal produce,” says Zaltzman. “More effort is needed to embed sustainability throughout our supply chains, from supporting and incentivizing farmers to adopt regenerative farming practices, right through to making sustainable food choices more transparent, affordable and accessible for consumers.”

Our choice of diet – vegetarian, vegan, pescatarian or meat-based – also has an impact, and there are justifications for which is best not only for our health but the health of the planet. “How we eat has a huge impact on our planetary boundaries, and we know farming animals in particular disproportionately contributes to these severe and escalating impacts,” explains Nicola Harris, communications director of Plant Based Treaty, a landmark grassroots campaign that aims to reduce greenhouse gas emissions from animal agriculture. “Farming animals is a leading cause of Amazon deforestation, land-use change, species extinction, water pollution, methane emissions and ocean dead zones. To ensure a safe



and livable planet, we need to use our resources wisely to prevent crossing dangerous tipping points.”

We are increasingly seeing a shift towards plant-based diets which is essential if we want to live safely within our planetary boundaries, Harris says: “A plant-based food system would deliver huge cuts to methane emissions, of which a third come from animal farming globally. Global methane cuts of around 45% this decade could prevent a 0.3°C temperature rise by 2045.”

A recent analysis of the diets of 55,000 vegans, vegetarians, fish-eaters and meat-eaters found vegan diets had just 30% of the environmental impact of a high-meat diet, and per unit of food consumed, meat and dairy had between 3 and 100 times the environmental impact of plant-based foods.

“If existing healthy eating and environmental behavior guidelines were updated to promote the benefits of eating plant-based food, we could prevent 45,000 deaths annually and save the NHS £1.2 billion,” Harris adds.

The study suggests that even small changes, like eating less meat or opting for meat alternatives, could have a profound impact. Low meat diets have a much lower impact on the environment compared to high meat diets, with a reduction of 70% across most

environmental measures, leading the authors to say: “You don’t have to go full vegan or even vegetarian to make a big difference.”

But reducing meat consumption can also reduce the amount of protein in the diet. Proteins are essential for a number of bodily functions, including in their roles as hormones and enzymes, and therefore need to be supplemented in a low-protein diet. What alternative sources are there?

There are a range of products such as tofu, tempeh, seitan, pulses, algae, seeds, nuts and insects, the aim of which is to mimic the physical and organoleptic properties of our meat staples, using technology to provide similar texture and flavor. Plant-based proteins, like soy, peas, lentils, lupine, chickpeas, rapeseed, canola and rapeseed are considered healthier and more sustainable than meat, and have a lower environmental impact. Due to their presence on supermarket shelves, they are already familiar to consumers and generally well accepted.

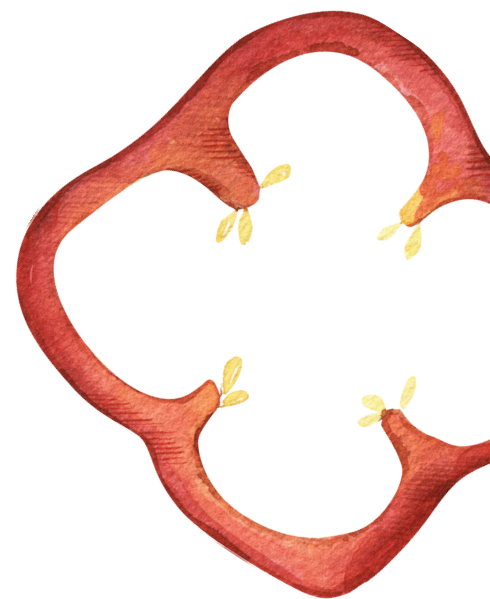
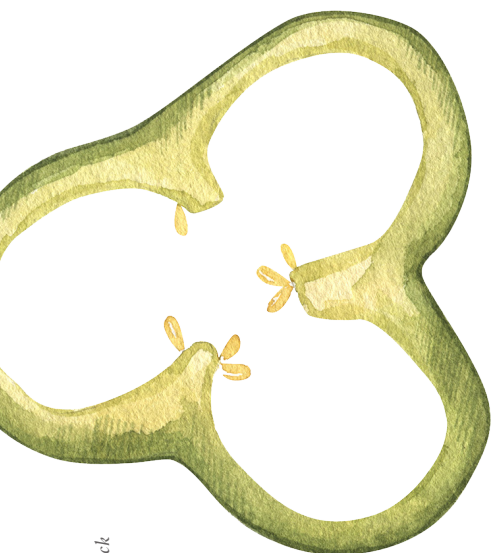
Lab-grown meat is produced by growing in animal cell cultures, resulting in a product that resembles traditional meat in texture and appearance. Despite it being more efficient to produce, requiring lower resources per unit of meat, consumers are concerned about its safety because it is artificial.

Likewise, insects are rich in proteins and essential amino acids and readily available, but our negative perception often affects our ability to view them as a suitable meat alternative.

MAKING DIETARY CHOICES THAT ALIGN WITH VALUES

Farmers and the food industry are already making strides in the right direction to ensure future food security, by adapting current farming practices or adopting new ones designed to decrease waste, cut greenhouse gas emissions or ensure agricultural land is used as sustainably as possible. There is still much more to be done, and consumers are guiding farmers and industry with their purchasing behavior, opting for sustainability and environmentally friendly options, over inefficiency and wastefulness.

“How consumer behavior will change in the future depends largely on the steps we take right now,” says Zaltzman. “With so many entrepreneurs developing exciting solutions across the supply chain, from sustainable agriculture inputs to circular packaging solutions, we need to find ways to communicate clearly and transparently about the increased choices available to consumers and empower them to make dietary choices that align with their values.” ●



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The Future of Food: Five Key Considerations in Alternative Protein Food Production

SOPHIE PROSOLEK

As the world's population continues to grow, so too does the strain on its resources including our food supply. Traditional agriculture methods for the production of protein-rich foods typically center around the farming of livestock such as cattle, sheep, goats, pigs and poultry. However, despite its continued practice, animal husbandry is now accepted to be responsible for significant environmental concerns.^{1,2,3}

Alternative sources of protein-rich food such as insects, plant-based prod-

ucts and lab-grown or cultured meats now garner significant interest from food manufacturers across the world. However, despite their early promise, alternative protein foods face a largely uncertain future. As food manufacturers continue to navigate new and uncertain markets, several analytical techniques lie at the forefront of future food development.

Here, we explore five key considerations in the development and testing of alternative protein foods, highlighting some of the common analytical

techniques used to evaluate their sensory, nutritional and economic viability.

NUTRITION, HEALTH AND DIGESTIBILITY

Healthy adults require a balanced diet of macro and micronutrients for body tissue maintenance and repair.^{4,5} While daily intake requirements for a healthy adult may vary (depending on several factors such as age, sex, body weight and physical activity level) the United States Department

of Agriculture (USDA) suggests a recommended dietary allowance (RDA) of 0.8 g of protein per kilogram of body weight.^{6,7} While it is possible to meet daily intake requirements from plant protein sources, some experts argue that protein adequacy may be difficult to achieve on some plant-based diets.⁸

Protein content and type has become a focus for food manufacturers catering to the needs of plant-based diets. Protein sources vary in their molecular structure, and hence have different digestibility, bioavailability and nutritional profiles.⁴ Methods for determining the digestibility of dietary protein typically center around the digestible indispensable amino acid score (DIAAS) as a measure of *in vivo* metabolism.² DIAAS scores are calculated by estimating the mass of each digestible amino acid in 1 g of dietary protein obtained from ileal samples.¹⁰ The results are compared to a known reference to assess the degree of protein breakdown. Amino acids are typically measured using high-performance liquid chromatography-mass spectrometry (HPLC-MS) methods.¹¹ HPLC-MS can validate the presence of essential and non-essential amino acids, therefore also indicating the completeness of protein-rich foods.

DIAAS % = 100 x [(mg of digestible dietary indispensable amino acid in 1 g of the dietary protein) / (mg of the same dietary indispensable amino acid in 1 g of the reference protein)].

In dietary terms, “completeness” refers to the nutritional content of a food. Complete foods contain all nutrients required for optimal health, including each of the nine essential amino acids (EAAs).¹² Many plant proteins are low in levels of the EAA lysine and hence, cannot be considered nutritionally

complete.^{15,14} Food manufacturers address this issue by combining multiple protein sources; thus, helping to meet dietary protein requirements using only plant-based sources.^{15,16,17}

TASTE, TEXTURE AND AROMA

The success of alternative protein food products is largely determined by consumer acceptance.¹⁸ In fact, acceptance studies report that consumers are more satisfied by products that accurately replicate the taste, texture and aroma of animal-derived meat.^{18,19,20}

Sensory assessments can help manufacturers in evaluating consumer preferences. Such studies typically involve a hedonic analysis in the form of a sensory evaluation questionnaire alongside instrumental measurements that produce more quantitative results.^{20,21} During a hedonic analysis, volunteers typically report upon the aroma, texture, taste and mouthfeel of a product.²⁰ As sensory parameters can be subjective, it's important that manufacturers use trained evaluators and standardized analytical methods alongside supporting instrumental data. Gas chromatography-mass spectrometry

(GC-MS) methods can support scientists in defining the exact flavor and aroma compounds that drive consumer acceptance.²² Hence, GC-MS methods can guide food producers to develop plant-based products that accurately replicate the desirable and familiar sensory characteristics of

meat. GC-MS has been used to create plant-based protein-rich alternatives to meats such as pork, chicken and beef.^{22,23,24}

Additionally, understanding a product's water retention and biomechanical properties can help manufacturers expedite the development of new ingredient formulations and attain desirable textures. Rheological and viscosity analyses can provide information about the fluid flow and internal resistance of a novel food substance. Using technologies such as rheometers and viscometers, scientists can directly measure the mechanical properties of novel protein foods. Hence, such analyses can provide insights into how animal-derived dairy proteins could be replaced.²⁵

FOOD SAFETY AND COMPLIANCE

While alternative protein foods must certainly meet consumers' sensory expectations and nutritional needs, they must also meet robust safety standards.²⁶ As the variety of alternative protein foods becomes increasingly diverse, so too do the potential risks that surround novel products' safety.

Insects – consumed either as finely ground meal or as whole foods – are a staple protein source in many countries around the world.²⁷ However, microbiological safety concerns remain a barrier to the mass production of insect-based foods across the Western world.^{28,29} The insect gut microbiome is home to a variety of bacterial species and therefore represents a potential source of human pathogen contamination. While most insect-dwelling commensals cannot infect humans, an explosion in their popularity has sparked significant analytical interest in the microbiological analysis of insect-based foods.³⁰

Researchers now use a variety of genomic techniques to profile insect-based foods and their accompanying microbiomes. DNA barcoding – a method of species identification that relies on “reading” short frag-

ments of genomic material – can now be used to recognize insect species in raw and processed insect-based foods.^{30,31} Correct species identification allows researchers and manufacturers to ensure safety standards, ruling out potential toxicity, allergens and contamination.

SUSTAINABILITY AND FUTUREPROOFING

Alongside increasing environmental awareness, new opportunities have been identified to assess the sustainability of alternative protein foods.³² Insect proteins are largely considered to be one of the most sustainable protein sources for large-scale production; this is largely due to their high nutrient density and relatively small requirement for land and resources.³³ New reporting frameworks have been recently developed to assess the climate, biodiversity and nutritional impacts of insect protein foods. The framework combines environmental, social and governance data to highlight and monitor the benefits of different production methods for the purpose of ongoing sustainability.

While many measures of sustainability incorporate factors such as land and water usage into their analysis, algal proteins – which can be cultivated at sea – are also expected to contribute to the futureproofing of our food supply.^{34,35} While algae are yet to be fully domesticated as a protein-rich crop, their high digestible macronutrient content and potential

for large-scale aquaculture offer great promise in the future of novel food production.

COST AND AFFORDABILITY

Manufacturing costs and product affordability are also important considerations in the production of alternative protein foods. If products are too expensive at the point of purchase, they will fail to offer a sustainable solution on the global market.³⁶

Lab-grown or cultured meat offers a high degree of engineering potential, both for health benefits and consumer preferences.³⁷ However, current challenges surround the high costs of large-scale production.³⁸ To produce lab-grown meat, animal muscle cells are grown outside the body using a process called tissue culture.³⁹ During tissue culture, cells are maintained in a nutrient-rich solution known as “media.” While each cell type has its own media requirements, all media formulations contain a range of essential nutrients that support tissue growth and cell metabolism.

Spent media analysis can help support the affordability of cultured meat products by providing information about the metabolic needs of cultured cells. It can help manufacturers optimize the composition of their growing media and hence reduce expenditure on unnecessary supplement costs.^{38,39,40} Spent media analyses are conducted by a combination of standard techniques such as HPLC and inductively coupled plasma-mass

spectrometry (ICP-MS). HPLC methods detect a range of biological molecules and nutritional compounds, meanwhile, ICP-MS methods support the detection of trace elements. If cells appear not to utilize the fullest availability of nutrients in their media, manufacturers can reduce their concentration, therefore minimizing production costs.

The success of alternative protein food products is largely determined by consumer acceptance.

CONCLUSION

The development and production of high-protein novel foods requires careful consideration with respect to their taste, nutritional and sustainability profiles as well as regulatory compliance. Hence, these factors must be balanced to ensure that the products are both acceptable to consumers and safe for sustained consumption. Various analytical techniques ranging from sensory analyses to chromatography methods can be employed to ensure that products are safe, satiating and sustainable. However, challenges remain in navigating the uncertain markets of novel alternative protein foods. ●





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