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The sensory-evaluation team in action at UK testing lab Reading Scientific Services Ltd.

RSSL

GASTRONOMY

Science you can taste

Food-industry scientists find diverse roles, from mediating public-health scares to perfecting meatless burgers.

BY DAVID PAYNE

In July 2016, a burger produced from fermented, genetically engineered yeast made its US restaurant debut. Its producers promised a taste, texture, nutritional value and sizzle similar to a meat patty.

Developed by Impossible Foods, a start-up founded in 2011 by biochemist and climate-change campaigner Patrick Brown, the burger's key ingredient is an iron-rich molecule called haem. Haem gives meat its flavour, but it can also be derived from plants: Impossible Foods found a way to extract it from soya-plant roots rather than ground beef.

The firm now has more than 300 employees and produces almost 500,000 kilograms of plant-based meat each month from its manufacturing site in Oakland, California.

The food industry is a complex and diverse sector, with companies ranging from start-ups to global multinationals. Its scientists include everyone from lab-based technicians who focus on foreign-body and microbiological-safety analysis to chemists, engineers, data analysts, social scientists and psychologists all working together on multidisciplinary research and development (R&D) teams.

In recent years, industry regulators have targeted certain strategies that some food companies use to market their products — advertising to children, and adding health claims and nutrition information on labels, for example — in response to public-health campaigns. As a result, some food scientists might face calls to explain the industry's role in tackling conditions such as obesity and type 2 diabetes.

Barbara Gallani, head of communication and engagement at the European Food Safety Authority in Parma, Italy, says that food science might not have the "glam factor" of, say, aviation or medical research, or the pace and pressures of academia, but "there's a lot of complex scientific work that goes on behind the scenes to produce everyday commodities".

In a 2016 TED talk, Brown, who left a "dream job" at Stanford University in California to start Impossible Foods, described his colleagues there as "brilliant, innovative, mission-driven scientists". Smita Shankar joined the company in 2013 as a protein chemist, and is now its director of research. Originally from India, Shankar completed a biochemistry PhD at Cornell University in Ithaca, New York, before moving to Hiten Madhani's yeast-genetics and molecular-biology lab at the University of California, San Francisco.

"At Cornell, I enjoyed teaching and doing good science in academia," she says. "But the San Francisco Bay Area exposed me to companies that were applying science to solve imminent problems, using microbial fermentation to make fuels, chemicals and other products."

Shankar leads a team of nine scientists and engineers who specialize in microbiology and industrial fermentation, collaborating closely with the group that extracts protein from the yeasts and adds them to the company's burger.

"Scaling up protein production from the lab to manufacturing is time consuming and expensive. Ultimately, the burger has to be delicious and affordable," she says.

A typical day for her team includes routine molecular biology and lab-based microbiology, alongside reading literature around yeast genetics. The researchers also hold a weekly group discussion to critically evaluate experimental design and discuss their data.

Other teams employ scientists who are trained in protein chemistry, polymers and textured materials, and flavour science. Their experiments aim to elucidate the properties of different animal-derived meats and determine how to recreate similar substances from plants.

Scientists at Impossible Foods are expected to have a PhD. "A PhD sets you up for working on hard problems. Also, you're not afraid of failing and trying new things," she says.

RISK COMMUNICATION

As with scientists in other sectors, food-industry researchers are often required to communicate complex science to the public, particularly in the event of a supply-chain ▶

problem, food-disease outbreak or chemical or microbiological contamination.

Helen Munday, chief scientist at the Food and Drink Federation, a UK industry body, spent much of June 2018 explaining the role of carbon dioxide in food production to the media, after routine maintenance closed several European fertilizer plants and so triggered a shortage of the gas in the United Kingdom — right during the World Cup football tournament, prompting fears of a beer shortage.

Carbon dioxide is used to carbonate drinks and deliver beer from pressurized kegs to the glass, to stun animals before slaughter and as a preservative in packaged products.

"If you cannot stun pigs and chickens, you cannot slaughter them. They can't just be left on farms. There's a highly sensitive supply chain," says Munday, whose career includes seven years of managing pet-food innovation at a plant owned by global food giant Mars in Los Angeles, California.

Ian Noble's first overseas post as a UK food scientist was to the central highlands of Sri Lanka, where he helped to create and launch new tea-powder manufacturing processes. His work involved developing an understanding of polyphenols, a category of chemical that occurs naturally in plants, and in the case of tea, provides its distinctive flavour, and using that knowledge to concentrate the leaves into an affordable powder with a consistent colour and taste and a shelf life of up to six months.

Noble's PhD at the University of Reading, UK, was in biochemical engineering and colloid science. In food, whipped cream is an example of a colloid, containing one substance stabilized as a separate phase inside another, a gas inside a liquid. Milk is another: an emulsion of fat globules suspended in a liquid. Noble enjoys the challenge of combining physical chemistry and biochemical engineering, and "working to scale up production from millilitres in the lab to thousands of litres in manufacturing".

"How do you replace salt and still taste great? How do you replace sugar and keep bulk?"

He is now senior research, development and quality director at global snacks company Mondelēz International in Bournville, UK, the model village near Birmingham that was selected by the Cadbury family for its chocolate factory in 1879. Noble's fellow PhD colleagues include flavour chemists, toxicologists, microbiologists, computational modellers, mathematicians and theoretical physicists, who develop brands and products such as Oreos, Cadbury, Ritz and Toblerone.

Noble encourages food scientists to see themselves as commercial rather than academic researchers, whose understanding of science and technology as R&D professionals has earned them a place at the table where marketing and business decisions are made. "With food science, you are talking about fast-moving consumer goods and satisfying a marketplace demand for continuous new products," he says. "If I work on a product using a technological process that's already established in a factory, we can get it onto the shelf in a few months. Other sectors, including oil and gas technology, can take 25 years, so if you're working in those industries, you may have retired by the time it is introduced."

BRINGING HOME THE BREAD

Food-industry salaries vary widely across the world, with Germany topping the market.

Country	Median salary (US$)
Australia	91,603
Brazil	30,000
Canada	62,400
China	33,000
Germany	100,340
India	12,000
Mexico	31,000
New Zealand	82,800
United Kingdom	56,000

*Data included for countries with 10+ survey responses

SOURCE: M. E. KUHN & M. MALOCHLEB *EARNINGS GROW, WAGE GAP SHRINKS* (INSTITUTE OF FOOD TECHNOLOGISTS, 2018).

A developed nation's food sector typically contributes around 5–10% of its overall economy, says Noble. In the United Kingdom, the agri-food sector was worth £113.2 billion (US$114.3 billion) in 2017. A 2017 report by the Committee for Economic Development of The Conference Board, a US public-policy nonprofit in Arlington, Virginia, says that the sector accounts for 5% of total US gross domestic product and 10% of total US employment (see go.nature.com/2khdbmi).

The Institute of Food Technologists in Chicago, Illinois, is an international membership organization representing food-industry scientists. Its 2017 pay survey found that the median annual salary of US food-industry scientists is US$92,000, and that female scientists in their 20s were paid similarly to their male colleagues, at $60,000 (see go.nature.com/2syyirl).

Flavourists came out on top, earning a median salary of $123,500. At the other end of the range were microbiologists, earning $65,000 on average (see 'Bringing home the bread'). Overall, 22% of survey respondents were educated to PhD level.

Jacinta George, managing director at Reading Scientific Services Ltd (RSSL), Mondelēz's UK testing lab, highlights vegan diets and protein-enriched snacks as two emerging industry trends driven by growing consumer demand.

As director of ingredient research between 2012 and 2015, she and her team focused on reducing sodium, sugar and saturated fat in its products. "There are big technology challenges," says George. "How do you replace salt and still taste great? How do you replace sugar and keep bulk, and have the right texture and microbial safety?"

Tim Lang, a social scientist who established City University London's Centre for Food Policy in 1994, says that the wholefood movement of the 1960s and 1970s paved the way for the current vegan trend. A long-time critic of many industry practices, Lang highlights other past trends, such as the rise of processed foods in Western diets, the market dominance of multinationals with huge advertising budgets and increased meat consumption globally. China, for example, where meat was once a rare luxury, now consumes 28% of the world's meat.

Lang says that scientists considering a food-industry career should think carefully about which branch of the sector to join. "There are wholefood firms, vegan firms, animal-welfare-obsessed firms, and there are firms that are the complete reverse of those," he says. Lang also recommends horticulture as a field in which scientists can develop biotechnology to support subsistence farmers.

For the past two years, Mondelēz has been developing a version of its Cadbury Dairy Milk chocolate bar that has 30% less sugar than the original. The product is due to launch in the United Kingdom and Ireland next year.

Some health campaigners urge the industry to go further in a bid to tackle the global obesity crisis. According to World Health Organization figures, more than 1.9 billion adults of 18 years and older were overweight as of 2016, and more than 650 million adults were obese. How do food-industry scientists address such criticism?

Noble highlights two documents: a foresight report by the UK Government Office for Science on the obesogenic environment, first published in 2007 (see go.nature.com/2zvxhnb), and the 2014 McKinsey Global Institute report, *How The World Could Better Fight Obesity* (see go.nature.com/2dsqdta).

Both reports, he argues, make clear that the challenges are multifaceted and that reformulation of food products — such as reducing fat, sugar and salt content — is only one of them. Lifestyle also plays a part.

"We do need to change the quality and quantity, and for many people, the availability, of food," Noble says. "But it's going to take a while to change our biology to reflect the dramatic changes in our modern lifestyles.

"Also, we may be looking at the first or second generation of people in developed countries who don't know how to cook. Food technology is not on the UK school curriculum. In the United Kingdom, I think, we've broken our relationship with food," Noble says. "You can either sit outside and point the finger, or you can choose to help fix it from the inside." ■

David Payne *is chief Careers editor at* Nature.

CORRECTION

The Careers Feature 'Fathers in science' (*Nature* **563**, 725–727; 2018) gave the wrong name for Brian Cahill's wife. Her name is Lini, not Lina.