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Feeding the 10 billion

The Mars Science Breakfast at the 65th Lindau Nobel Laureate Meeting saw a diverse panel discuss how to meet the nutritional needs of the world's future population.

The United Nations predicts that the global population will rise to between 8 billion and 11 billion by 2050, which means producing enough food to feed 1–4 billion extra people[1]. At the Mars Science Breakfast, Howard-Yana Shapiro told the audience of 130 scientists and Nobel laureates that 800 million people already suffer from chronic hunger, and that 161 million children under five years of age have stunted growth. "When we talk about feeding the world, we need to shift the dialogue to nutrition," he urged.

Much of the debate focused on sustainability, with panellists discussing how to reduce the impact of the agricultural system on the environment. "Nitrogen fertilizers are a problem," said Steven Chu, adding that his dream would be crops that can fix nitrogen biologically. The panel members agreed that using traditional breeding, and exploring the potential of emerging genetic technologies such as CRISPR, to create crop varieties that are perennial, more nutritious or better able to use soil nutrients could play a part in increasing food production without harming the planet.

Chu expressed concern that technological advances could be "locked up" in patents. Projects such as Mars' African Orphan Crops Consortium were praised for putting their intellectual property in the public domain, helping to increase the pace of progress and encouraging others to build on existing research. ■

CBS PHOTOGRAPHY

Nobel Media's chief scientific officer Adam Smith (left) moderated the discussion on how to feed the world's ever-increasing population with (left to right) Mars' chief agricultural officer Howard-Yana Shapiro, PhD student in food science and human nutrition Emma Beckett of the University of Newcastle, Australia, and physics Nobel laureate Steven Chu.

1. United Nations Department of Economic and Social Affairs, *Population Division World Population Prospects: The 2012 Revision* (2013).

Unlocking the potential of orphan crops

Sub-Saharan Africa is one of the regions worst affected by chronic hunger, nutrient deficiencies and stunted growth. Howard-Yana Shapiro, Mars, Incorporated's chief agricultural officer, talked at the 65th Lindau Nobel Laureate Meeting about one initiative set up to address this: the African Orphan Crops Consortium.

Indigenous plants such as African nightshade (*Solanum scabrum*) are staple crops for up to 250 million smallholder farmers in Africa, but they have been dubbed 'orphans' because they are largely ignored by agricultural researchers and seed companies, which focus on global commodities. However, the nutritional and environmental benefits of these orphan fruits and vegetables are attracting more and more attention both in Africa and beyond.

The African Orphan Crops Consortium is in the process of sequencing the genomes of 101 of these African orphan crops and is making the data free for anyone to access. It has also opened the African Plant Breeding Academy in Nairobi, Kenya, to train plant breeders from all over Africa to use a combination of traditional breeding methods and modern technology, such as marker-assisted selection, to develop new crop varieties that are more nutritious, more resilient and higher yielding. "We start with genomics, go to analysis, then to plant breeders, to the field, to seed companies, and to smallholder farms," said Shapiro. "And everything is 100% owned by the public." See *mars.com/aocc* for more ■

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Rural crops such as mung bean (*Vigna radiata*) and pigeon pea (*Cajanus cajan*) are considered orphans, but the essential vitamins and nutrients they contain might help to end malnutrition in Africa.

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Raising standards in global food safety

Dave Crean is vice-president for corporate research and development at Mars, Incorporated, where he has worked for 30 years. He has played a major role in driving food safety projects at Mars and is determined that food safety standards must be improved. Here he introduces his views on food safety and explains how Mars is tackling this issue.

Quality, as one of Mars' Five Principles, has been at the foundation of our business for generations, and rigorous practices and standards are essential to our procurement and production process. The trust that the company has built with our customers is vital to our success, and the safety of our consumers is our top priority.

As a food manufacturer within a global food supply chain, Mars believes it has a responsibility to help raise food safety standards on an international level. Our strategy is to carry out high-quality research, generating knowledge and expertise that can then help to improve

Dave Crean, vice-president for corporate research and development, Mars, Incorporated.

food safety management programmes, create robust supply chains, and enable food security. According to the Food and Agriculture Organization (FAO) of the United Nations, food security exists when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life[1]. We believe that access to safe and nutritious food for all can only be achieved by sharing food safety knowledge and expertise in a pre-competitive space across the entire industry. To that end, Mars has more than 60 partnerships and research collaborations with governments, universities, foundations, UN agencies, and organizations such as the UN World Food Programme, the World Bank, the Global Alliance for Improved Nutrition and others.

Continued investment in enhancing food safety processes and finding better solutions is imperative. That's why our Consortium for Sequencing the Food Supply Chain, a platform founded together with IBM, and the opening of the Mars Global Food Safety Center in China are so important. If we are to transform the approach to food safety, improve the global supply chain and provide access to safe and nutritious food, then such collaborative solutions are vital. ■

1. FAO *Rome Declaration on World Food Security and World Food Summit Plan of Action*. World Food Summit 13–17 November 1996.

Building collaboration on global food safety

Despite great advances made in the technology of food production, food-borne diseases still remain a significant threat. According to the World Health Organization, contaminated food and drinking water kill an estimated 2 million people annually[1]. Even in the world's richest countries, the problem still persists — every year, 1 in 6 Americans suffers from a foodborne illness[2], costing the US economy an estimated US$51 billion to $77 billion[3]. In the Huairou district of Beijing in China, Mars has established a global research and training centre where researchers and industry can collaborate to tackle these food safety challenges.

The purpose of the centre is to expand global knowledge in critical areas of food safety management through research and training. The centre is equipped with advanced facilities and is establishing a global network with academic institutions, research laboratories and universities to facilitate its three main objectives:

- ***Knowledge capture:*** scanning the horizon to identify potential global food safety threats;
- ***Knowledge generation:*** analysing existing and new food safety threats and developing new methods to tackle them;
- ***Knowledge sharing:*** building capability through food safety education and training, and opening up world-class laboratory and technical facilities to all food safety stakeholders.

The centre is also to be a source of inspirational opportunities for young researchers and science graduates, attracting those who are keen to contribute to the research. ■

The Global Food Safety Center opened on 24 September in China to enable collaborations between government, industry and academia, and to advance the global understanding of food safety.

1. World Health Organization *Fact sheet no. 399: Food safety.* www.who.int/campaigns/world-health-day/2015/fact-sheet.pdf?ua=1 (2015).
2. Centers for Disease Control and Prevention *Estimates of Foodborne Illness in the United States.* www.cdc.gov/foodborneburden/index.html (2011).
3. Scharff, R. L. Economic burden from health losses due to foodborne illness in the United States. *J. Food Protect.* 75, 123–131 (2012).

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Sequencing the food supply chain

As it works to generate and share food safety knowledge and practices, the Global Food Safety Center may enable the creation of technologies that completely change the way we approach food safety. One of its programmes, the Consortium for Sequencing the Food Supply Chain, led by computational giant IBM and co-founded by Mars, is using cutting-edge genomics technology and managing massive amounts of data to understand what microbial communities look like at each step of the food supply chain, and what this could mean for food safety management.

Even with industry's best practices, today's testing methods are inherently limited in their ability to detect risks. The Hazard Analysis and Critical Control Point (HACCP) approach introduced in the 1970s is a systematic method of examining every point of a production process to understand what hazards exist and how they could be controlled, and this is currently the best available system for managing food safety. But HACCP relies on the experience of the practitioner, and does not incorporate numerical risk-assessment methods. Factories can continually carry out microbiological testing to monitor samples, but an absence of pathogens and contaminants in the tests does not always tell the whole story.

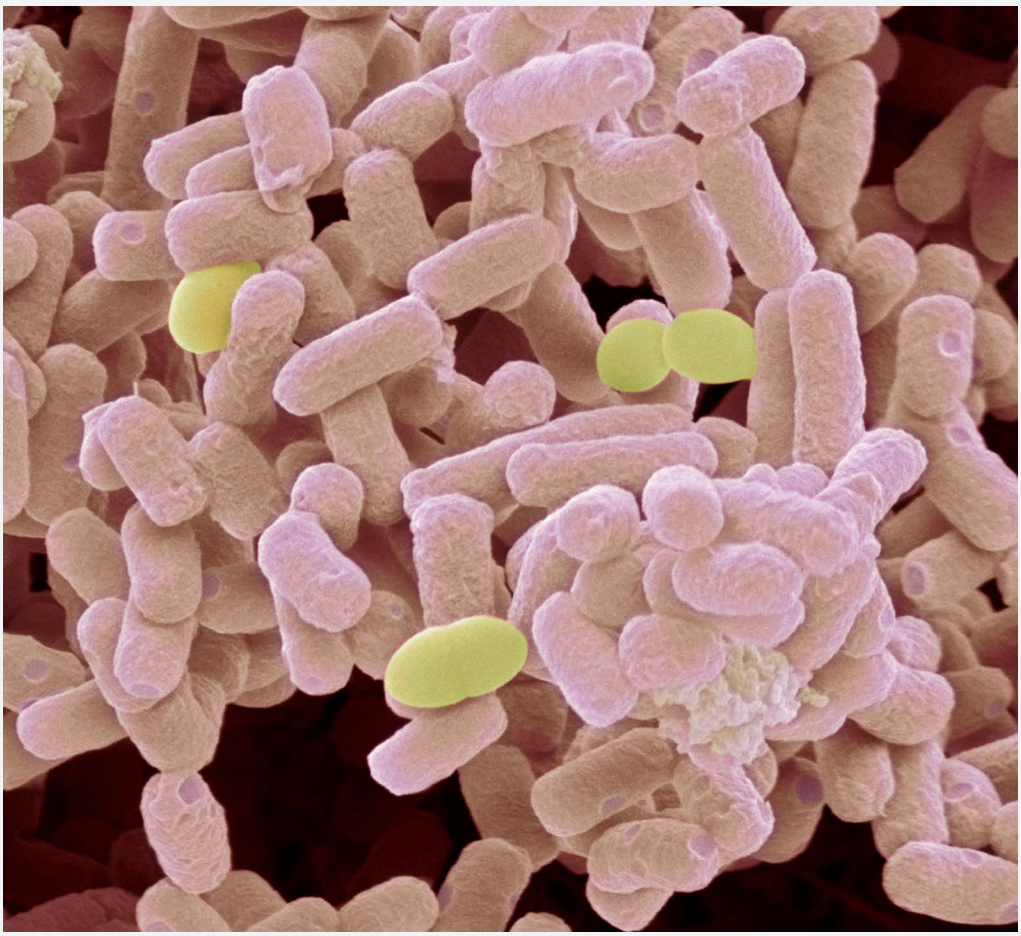
We would need to take 300 samples from every single delivery or batch to have a 95% probability that no more than 1% is contaminated. But this 1% would still represent a high risk level for high-volume manufacturers, and 300 samples is an unrealistic level of operational testing. The situation is even worse if we consider that these statistics assume an underlying random distribution of organisms throughout a given product, but we know that bacterial contamination typically doesn't behave this way — bacterial distributions tend to be clumped. What's more, current testing methods for pathogens can test for only one organism at a time, so critical information is easy to miss. When we look at current approaches to food safety, we feel that we are lacking some important tools.

This is why IBM and Mars have teamed up and are enlisting additional partners into the Consortium for Sequencing the Food Supply Chain, to develop a predictive system that seeks to find the root causes of food contamination. The process involves the isolation and sequencing of RNA and DNA from food samples, and linking these data with sample metadata. The goal is to establish baselines for microbial communities — an index of normal microbe communities that will act as a global benchmark for food health and safety stakeholders worldwide. Tracking data over time may enable researchers to detect irregularities in microbial constellations as a result of toxin or heavy-metal contamination, to identify environmental changes that could increase the risk of pathogen contamination, and to trace the source of pathogenic organisms in the food chain.

This research will start by collecting information from raw materials and factory environments to build up its library of information. Once these bacterial profiles are established, it will move on to each step of the food supply chain, and may even offer applications for farmers. As potentially the largest ever metagenomics study, using terabytes of genomic information, the consortium has the potential and momentum to significantly reduce risk and fundamentally change the food safety process.

Jeff Welser, vice-president and lab director of IBM Research, has said of the programme: "Genome sequencing serves as a new kind of microscope — one that uses data to peer deeply into our natural environment to uncover insights that were previously unknowable." ■

Dave Crean is vice-president for corporate research and development, Mars, Incorporated, 6885 Elm Street, McLean, Virginia 22101-3810, USA.



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The Consortium for Sequencing the Food Supply Chain is harvesting and sequencing DNA and RNA samples to establish what normal microbial communities look like along the entire food supply chain.