NEWS IN FOCUS

PHONG PHAM/ALAMY

Creating a lab-grown version of this bacon cheeseburger is costly and difficult.

BIOTECHNOLOGY

Lab-grown meat gets rare funding boost

'Clean meat' firms have raised millions of dollars, but academic research lags behind.

BY ELIE DOLGIN

Private investment in lab-grown meat is soaring as companies chase the promise of boundless — and delicious — nuggets, steaks and burgers cultured *in vitro* rather than reared on the hoof. Clean-meat start-ups have raked in tens of millions of dollars in the past two years from billionaires including Bill Gates and Richard Branson, and the agriculture giants Cargill and Tyson.

But funding for academic research on lab-grown meat has lagged behind, and some researchers say that it is sorely needed. Despite the booming commercial interest in developing meat that is eco-friendly and ethically sound, critics argue that the industry lacks much of the scientific and engineering expertise needed to bring lab-grown meat to the masses. And advances made by commercial firms are often protected as trade secrets.

"There are lots of technical hurdles here to overcome," says Paul Mozdziak, a muscle biologist at North Carolina State University in Raleigh who studies lab-grown chicken and turkey. The challenges include developing better cell lines and nutrient media to feed those cells, along with scaffolding materials to help shape cultured cells into tissue, and bioreactor platforms for large-scale meat production.

Open-source research in the field got a boost on 6 February, when the Good Food Institute (GFI) — a think tank in Washington DC that promotes alternatives to conventional meat — announced the winners of its inaugural grant programme. The group ▶

will split US$3 million between 14 projects — 6 working to develop lab-grown meat and 8 focusing on plant-based proteins. Each team will receive up to $250,000 over two years.

"It does seem like the largest contribution that I can think of toward cellular agriculture research," says Kate Krueger, the research director of New Harvest, a non-profit organization in New York City that has contributed almost $1 million in the past decade to academics working on clean-meat research.

WHERE'S THE BEEF?

One area where the money could make a difference is in developing publicly available cell lines derived from the muscles of cows, pigs, fish and other food animals. Without such cells, researchers must either obtain tissues from slaughterhouses or run their experiments with mouse cells. The Norwegian Center for Stem Cell Research in Oslo plans to use a GFI grant to help build its Frozen Farmyard, a repository of agriculturally relevant cell lines.

Other researchers want to apply lessons learnt from decades of research in regenerative medicine. Amy Rowat, a biophysicist at the University of California, Los Angeles, who normally studies the biomechanics of cancer cells, is attempting to design scaffolds that can grow combinations of different types of cow cell to promote the marbling of fat in lab-grown steaks.

"It's still the same basic tissue-engineering principles," says Andrew Stout, a New Harvest fellow at Tufts University in Medford, Massachusetts. "But we need to start thinking about the design constraints from a food and sustainability perspective."

Clean-meat entrepreneurs, for their part, say they hope to see a larger contingent of scientists step into the field. The industry needs "innovative approaches to high-yield cell-based meat biomanufacturing", says Nicholas Genovese, chief scientific officer of Memphis Meats in Berkeley, California. "Academic research can play a significant and lasting role in accelerating the path to market."

The quest to culture meat in a dish dates back decades. In the 1990s, Dutch researcher and entrepreneur Willem van Eelen cobbled together research funding from private investors and produced the first clean-meat patent. He later convinced the Dutch government to award €2 million (US$2.3 million) to a consortium of scientists interested in taking the work further. This ultimately led Mark Post, a vascular biologist at Maastricht University in the Netherlands, to unveil the world's first lab-grown hamburger in 2013 — at a cost of €250,000.

"Academic research can play a significant and lasting role in accelerating the path to market."

But public financing for the project dried up as Dutch lawmakers prioritized research into cheaper plant-based protein sources, such as bean flours and pea protein, says Post, who has since founded the food-technology company Mosa Meat in Maastricht. And aside from a few pilot grants, such as one from NASA in the late 1990s to develop *in vitro* fish flesh, few government agencies have spent significant money on such research — in large part, experts say, because it is risky, complex and crosses disciplines.

In the United States, the National Institutes of Health funds most tissue-engineering research, but focuses on biomedical applications; the Department of Agriculture funds most food-science studies, but spends little on lab-grown meat. "This falls between the chairs," says Amit Gefen, a bioengineer at Tel Aviv University in Israel who is trying to grow chicken meat on scaffolds created by stripping apple flesh of its cells.

Funding opportunities are slowly beginning to sprout in some countries. The Israel Innovation Authority (IIA) funds the lab-grown-steak start-up Aleph Farms, whose work is based on the research of biomedical engineer Shulamit Levenberg at the Technion–Israel Institute of Technology in Haifa. Now, the IIA is putting up more than 100 million shekels ($27.7 million) over 8 years to create a food-tech incubator to help support many more such academic spin-offs.

Private investment in the clean-meat industry has already cut the cost of production. Post says that he can make a 140-gram burger for €500. Levenberg says that her company can culture a thin slice of steak for about $50.

And with prices expected to drop further, some scientists challenge the idea that foundational research in meat cultivation is lacking.

"We're now taking something that works with humans and works with mice and moving it into bovine cells," says Yaakov Nahmias, a biomedical engineer at the Hebrew University of Jerusalem in Israel and the chief executive of Future Meat Technologies, an Israeli start-up. "I'm not sure we're talking about basic science any more."

But, as with any first-generation product, there's room for improvement, says Ido Savir, chief executive of SuperMeat in Rehovot, Israel. The initial lab-grown meats will be more akin to that found in fast food than haute cuisine, he notes. That first batch will help to "set the ground for a new industry", but what's needed, Savir says, is to "actually create a new field of science here". ■

POLITICS

Ukraine's science revolution stumbles

On the fifth anniversary of a pro-European uprising, scientists say things are changing too slowly.

BY QUIRIN SCHIERMEIER

Ukraine's science system is in a precarious state, despite promised improvements in the wake of a revolution five years ago that aligned the country with the European Union. National science spending remains low, government funding is used inefficiently and low salaries discourage talented students from embarking on research careers in the country. "We've been promised change for years," says Nataliya Shulga, chief executive of the science-advocacy group Ukrainian Science Club in Kiev. "But what's happened so far is an imitation of change, rather than genuine reform."

The 'Euromaidan' revolution, also known as the Revolution of Dignity, was sparked by a wave of protests and civil unrest that, in February 2014, culminated in a change in leadership. It severed Ukraine's ties with Russia and prompted the election of a pro-European government, raising hopes among scientists that Western partnerships would form and steer them out of international isolation.

The initial aftermath was promising: the new government promised to revamp the obsolete, Soviet-style science system, and to boost research expenditure. In 2015, Ukraine started participating in EU research programmes as an associated country, earning the same rights as member states when applying for grants. And in early 2016, the parliament passed a law to strengthen science, technology and innovation.

But those early efforts haven't substantially improved things, say scientists. Government spending on science declined to a historic low of 0.16% of gross domestic product in 2016, and has not increased much since.

The little public money that there is goes largely to research institutes operated by the National Academy of Sciences of Ukraine (NASU) — the country's main basic-research organization — many of which are outdated. The academy will receive nearly 5 billion