US Food and Drug Administration (see *Nature* **497,** 17–18; 2013).

Kim and his colleagues are part of a growing band of researchers who hope that gene editing, which can be used to disable — or knock out — a single gene, will avoid this. Reports of gene-editing applications in agriculture include the creation of hornless cattle. (Horns make the animals difficult to handle and are currently burned off in a painful procedure.) Researchers have also engineered pigs that are immune to African swine fever virus.

Key to creating the double-muscled pigs is a mutation in the myostatin gene (*MSTN*). *MSTN* inhibits the growth of muscle cells, keeping muscle size in check. But in some cattle, dogs and humans, *MSTN* is disrupted and the muscle cells proliferate, creating an abnormal bulk of muscle fibres.

To introduce this mutation in pigs, Kim used a gene-editing technology called a TALEN, which consists of a DNA-cutting enzyme attached to a DNA-binding protein. The protein guides the cutting enzyme to a specific gene inside cells, in this case in *MSTN*, which it then cuts. The cell's natural repair system stitches the DNA back together, but some base pairs are often deleted or added in the process, rendering the gene dysfunctional.

The team edited pig fetal cells. After selecting one edited cell in which TALEN had knocked out both copies of the *MSTN* gene, Kim's collaborator Xi-jun Yin, an animal-cloning researcher at Yanbian University in Yanji, China, transferred it to an egg cell, and created 32 cloned piglets.

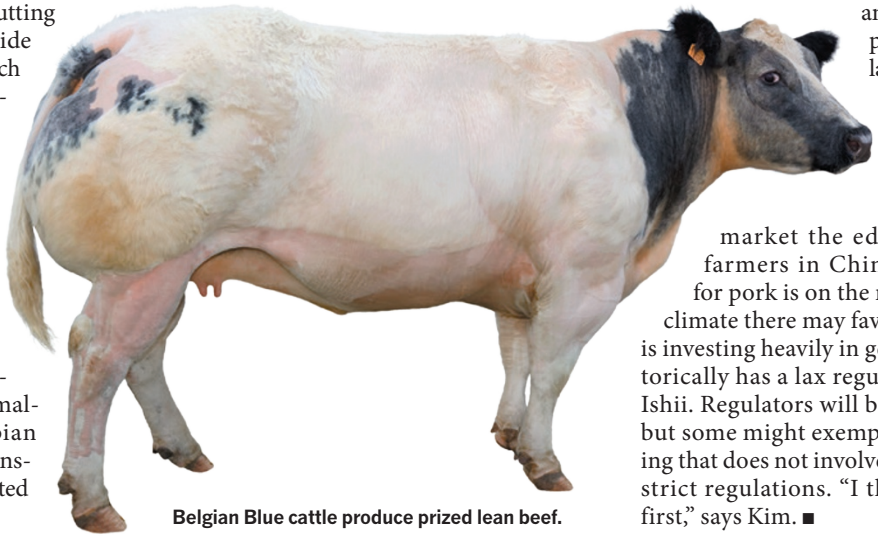
Kim and his team have not yet published their results. However, photographs of the pigs "show the typical phenotype" of double-muscled animals, says Heiner Niemann, a pioneer in the use of gene-editing tools in pigs who is at the Friedrich Loeffler Institute in Neustadt, Germany. In particular, he notes, they have the pronounced rear muscles that are typical of such animals.

Yin says that preliminary investigations, show that the pigs provide many of the double-muscled cow's benefits — such as leaner meat and a higher yield of meat per animal. However, they also share some of its problems. Birthing difficulties result from the piglets' large size, for instance. And only 13 of the 32 lived to 8 months old. Of these, two are still alive, says Yin, and only one is considered healthy.

Rather than trying to create meat from such pigs, Kim and Yin plan to use them to supply sperm that would be sold to farmers for breeding with normal pigs. The resulting offspring, with one disrupted *MSTN* gene and one normal one, would be healthier, albeit less muscly, they say; the team is now doing the same experiment with another, newer gene-editing technology called CRISPR/Cas9. Last September, researchers reported using a different method of gene editing to develop new breeds of double-muscled cows and double-muscled sheep (C. Proudfoot *et al. Transg. Res.* **24,** 147–153; 2015).

Because gene editing is a relatively new phenomenon, countries have only just started to consider how to regulate it in agricultural plants and animals. There are some signs that government agencies will view it more leniently than they do conventional forms of genetic modification: regulators in the United States and Germany have already declared that a few gene-edited crops fall outside of their purview because no new DNA has been incorporated into the genome. But Tetsuya Ishii, who studies international biotechnology regulation at the Hokkaido University in Sapporo, Japan, and who has done an international comparison on GM regulations, says that gene editing will raise increasing alarm as it progresses in animals.

Kim hopes to market the edited pig sperm to farmers in China, where demand for pork is on the rise. The regulatory climate there may favour his plan. China is investing heavily in gene editing and historically has a lax regulatory system, says Ishii. Regulators will be cautious, he says, but some might exempt genetic engineering that does not involve gene transfer from strict regulations. "I think China will go first," says Kim. ■



CLAUDIUS THIRIET/PHOTONONSTOP/CORBIS

**Belgian Blue cattle produce prized lean beef.**

FUNDING

# How an Oregon cancer institute raised a billion dollars

*Gains from two-year fund-raising frenzy will aid the early detection of tumours.*

**BY HEIDI LEDFORD**

Cancer researcher Brian Druker had no idea that a fund-raising gala would change his life. On 20 September 2013, armed with a speech that his wife had written for him, he waited patiently to be introduced by Philip Knight, the billionaire co-founder of sportswear brand Nike.

Knight was a friend and benefactor; a few years earlier, he and his wife Penny had donated US$100 million to the cancer centre that Druker directs at Oregon Health & Science University (OHSU) in Portland. But nothing had prepared Druker for what happened next. "Penny and I will donate $500 million to OHSU, if it is matched in pledges within two years in a fund-raising campaign," Knight said, drawing gasps of surprise from the audience. "If the campaign raises $499 million, we are relieved of our pledge," he added. Druker turned in shock to his wife. "What do I do now?," he asked.

So began a frantic two-year scramble at the

OHSU FOUNDATION

OHSU Knight Cancer Institute to boost its fund-raising — about $10 million in a good year — to $250 million annually. On 25 June, OHSU announced that it had reached its target in 22 months. It is the largest amount a US institution has ever raised to win a challenge grant, according to the Indiana University Lilly School of Philanthropy in Indianapolis.

"Publicly we were always very confident, because if you aren't, people aren't going to donate," Druker says. "But when we first got started, we thought, 'How are we going to do this?'"

Billion-dollar campaigns are still relatively rare, says Bruce Flessner, a fund-raising consultant at Bentz Whaley Flessner in Minneapolis, Minnesota. And when universities do set out to raise that much, he notes, they typically take about seven years and dedicate the proceeds to all corners of the institution. The Knight Cancer Challenge aimed to fund a single institute at a university that is far from the clusters of wealth found in New York City or Silicon Valley.

"Portland is a great city, but it's not minting billionaires at a fast rate," says Flessner. "If there is a wealthy person in Oregon who hasn't been asked to make a gift to that cancer programme, I would be shocked."

## LOCAL APPEAL

But OHSU does have Druker, a renowned physician and researcher who made his name by laying the groundwork for the revolutionary leukaemia drug Gleevec (imatinib). The drug was approved by US regulators in 2001, and turned chronic myeloid leukaemia (CML) — once a death sentence for 70% of people diagnosed with it — into a long-term, manageable disease for 90% of patients.

Druker's star power and Knight's showmanship in designing and announcing the challenge galvanized the grass-roots fund-raisers. The campaign received more than 10,000 donations, given from 5 countries and every US state. Three-quarters of the money came from sources in Oregon. The largest single donation was $100 million from Gert Boyle, chair of the Oregon-based company Columbia Sportswear. Boyle's late sister, a molecular biologist, died of brain cancer and was a scientific mentor to Druker when he was an undergraduate at the University of California, San Diego.


**Brian Druker spearheaded a campaign that raised US$500 million in under 2 years.**

The campaign decided early on to approach Oregon's state legislature for $200 million to construct two buildings for the cancer institute. OHSU pitched the expanded cancer centre to legislators as a way to create jobs for the state while fighting a disease that is the number-one killer of Oregonians. When the state senate approved the measure by a vote of 28–2 in March 2014, Druker began to believe that Knight's challenge could be met.

***"If there is a wealthy person in Oregon who hasn't been asked to make a gift, I would be shocked."***

But two months later, the campaign hit a public-relations snag when its advertising — designed to be catchy and blunt — suggested that Druker's work on Gleevec had "cured" CML. The pitches angered some people with CML, who must take expensive drugs for the rest of their lives while enduring side effects and the fear that their cancer will become resistant to treatment. Patients said that calling Gleevec a cure would slow the search for better therapies. Druker issued an apology and OHSU toned down the adverts to read: "That's one cancer down. Now we're going after other cancers as aggressively as they come after us."

With the money now in hand, it is time for Druker, OHSU and the cancer centre to deliver on that promise. Druker aims to rapidly hire up to 30 principal investigators, and to provide researchers with a funding cushion intended to free them from the burden of constantly applying for grants. But the investigators will also be expected to meet research milestones. "We want to make progress as quickly as we can," he says.

The institute will focus on detecting cancers early in their development, when treatments generally have a better chance of success. Druker also wants the institute to take advantage of emerging technologies to develop better tests that would reduce false diagnoses.

He is eager to turn his full attention to the science, but already feels nostalgic about the past two years. "It's been busy," he says. "But it's been quite a ride." ■

KIYOSHI TAKAHASE SEGUNDO/ALAMY

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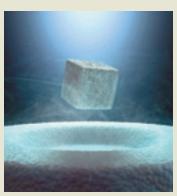

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