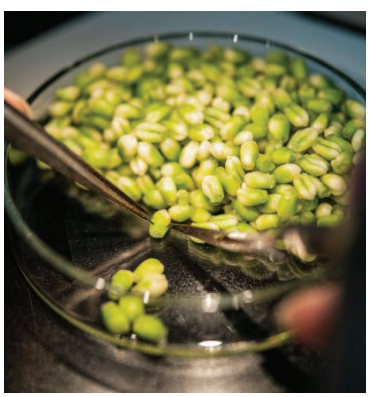
FEATURES

CHINA'S CRISPR REVOLUTION

By **Jon Cohen**; *Graphics by* **Nirja Desai**

FOR MANY PEOPLE, CRISPR plus China equals the biophysicist He Jiankui, who infamously used the genome editor last year to alter the DNA of two human embryos that would become twin girls. Before his announcement, He was little-known within the country's CRISPR community, which has grown rapidly and is now challenging—and by some measures surpassing—the United States in its use of the powerful tool (see graphics, p. 421).

A better representative of CRISPR in China is plant biologist Li Jiayang of the Institute of Genetics and Developmental Biology in Beijing. Li left the country in 1985 for his graduate education, as have many of China's best and brightest young scientists over the past few decades, and then returned home in 1995 to focus on manipulating plant DNA. Li, who recently ended a stint as head of the Chinese Academy of Agricultural Sciences, says he struggled for years to make pinpoint genome edits. CRISPR gave him a simple, fast way to do just that, turbocharging his efforts to modify rice. "Now, suddenly, the dreams come true," says Li, whose lab is humming at 9 p.m. on a Wednesday with two dozen members of his team running experiments.



A technician in Gao Caixia's lab selects immature wheat embryos for CRISPR editing.

The lights are burning late at CRISPR labs around the world. In 2012, the year researchers transformed a bacterial immune system into the fast and versatile tool for genome engineering, scientific publications mentioning CRISPR totaled 127. Since then there have been more than 14,000. Although the United States has had the most CRISPR publications—and continues to have the most cited papers—China is now a close second and is pouring money into CRISPR's uses.

With support from the Pulitzer Center, *Science* visited scientists in five Chinese cities who are harnessing CRISPR in a wide range of disciplines. China's biggest push is in agriculture (see p. 422) but researchers there are also applying the editor on a large scale in animals (see p. 426), with pig organs for human transplants the most provocative goal. And China is aggressively exploring genome editing in medicine, having launched far more clinical trials using CRISPR, mainly for cancer, than any country (*Science*, 6 October 2017, p. 20).

Although He's work lies far outside the mainstream, his actions haunt China (see p. 436). So does another, largely untold aspect of his rise and fall: the role that others, in China and abroad, played in the runup to his experiment. He shared his plans widely, and although several confidants tried to dissuade him, some were more encouraging (see p. 430).

Geneticist Wei Wensheng of Peking University in Beijing says the Chinese scientific culture has to look hard at how it creates researchers like He by overemphasizing firsts. "What I don't understand is why do you want to be named the first of something horrible or bad. What's the point?" Wei asks.

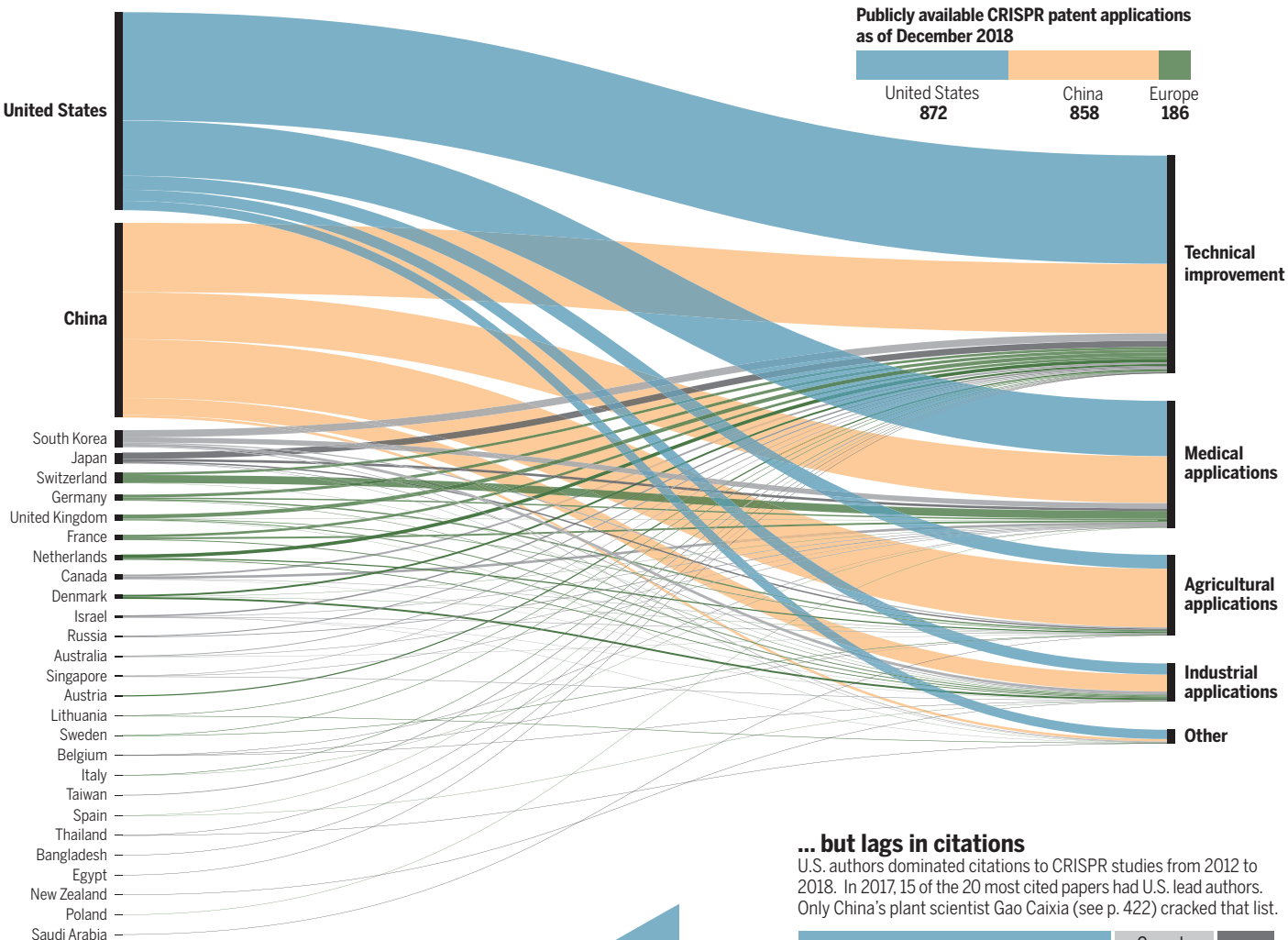
Yang Hui of the Institute of Neuroscience in Shanghai, one of the most successful young CRISPR researchers in the country, hopes China can move past He and up its game. Yes, Chinese researchers publish many CRISPR studies, he says, but "very few" do respected work that breaks new ground. "Our generation should publish more innovative papers," Yang says.

But Yang stresses that he has seen the quality increase "very fast" over the past 2 years or so. As China plants its flag at this scientific frontier, overseas sojourns like Li's and his own may soon be the exception. "Now, many good students will choose to stay here because of the good opportunities," Yang says. "And we have many good students working hard."

PHOTO: STEFEN CHOW

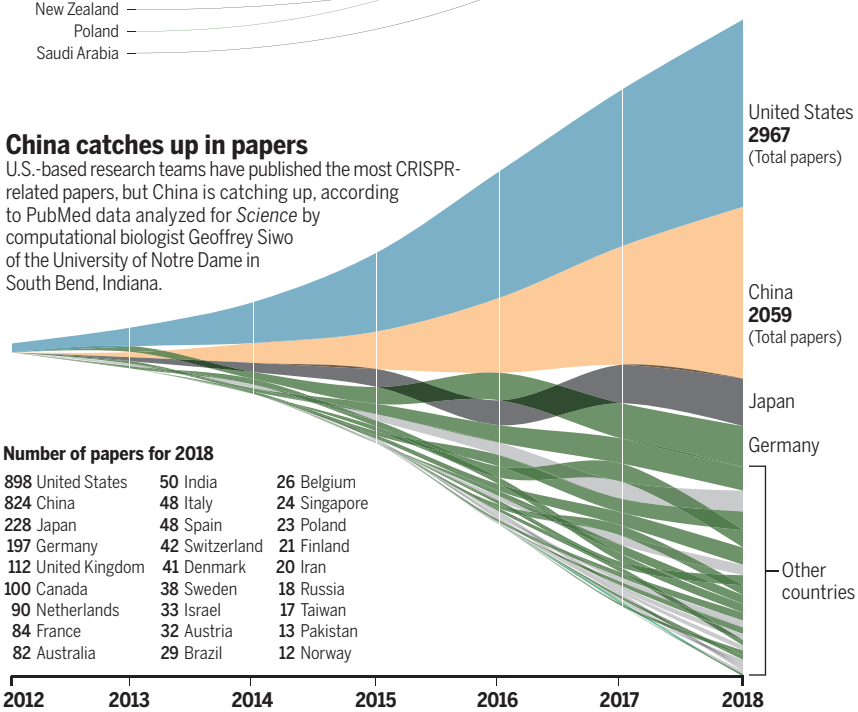
Invention inventory

In a recent analysis of more than 2000 patent applications for distinct inventions that involved CRISPR, the United States barely edged out China. Applications from China have climbed rapidly in recent years, and the country dominates in the agricultural and industrial realms.



China catches up in papers

U.S.-based research teams have published the most CRISPR-related papers, but China is catching up, according to PubMed data analyzed for *Science* by computational biologist Geoffrey Siwo of the University of Notre Dame in South Bend, Indiana.

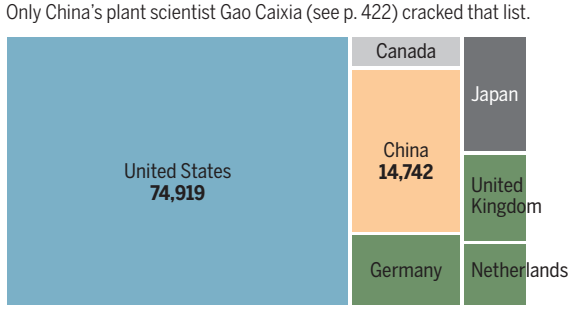


Number of papers for 2018

898 United States	50 India	26 Belgium
824 China	48 Italy	24 Singapore
228 Japan	48 Spain	23 Poland
197 Germany	42 Switzerland	21 Finland
112 United Kingdom	41 Denmark	20 Iran
100 Canada	38 Sweden	18 Russia
90 Netherlands	33 Israel	17 Taiwan
84 France	32 Austria	13 Pakistan
82 Australia	29 Brazil	12 Norway

... but lags in citations

U.S. authors dominated citations to CRISPR studies from 2012 to 2018. In 2017, 15 of the 20 most cited papers had U.S. lead authors. Only China's plant scientist Gao Caixia (see p. 422) cracked that list.



Planting a flag

Among 52 CRISPR publications on improving traits in agricultural crops, published between 2014 and 2017, China accounted for 42% of them.

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