

SFSS

The New Agricultural Research Revolution, Water, and the Future of Public Sector Research

Mark Giordano

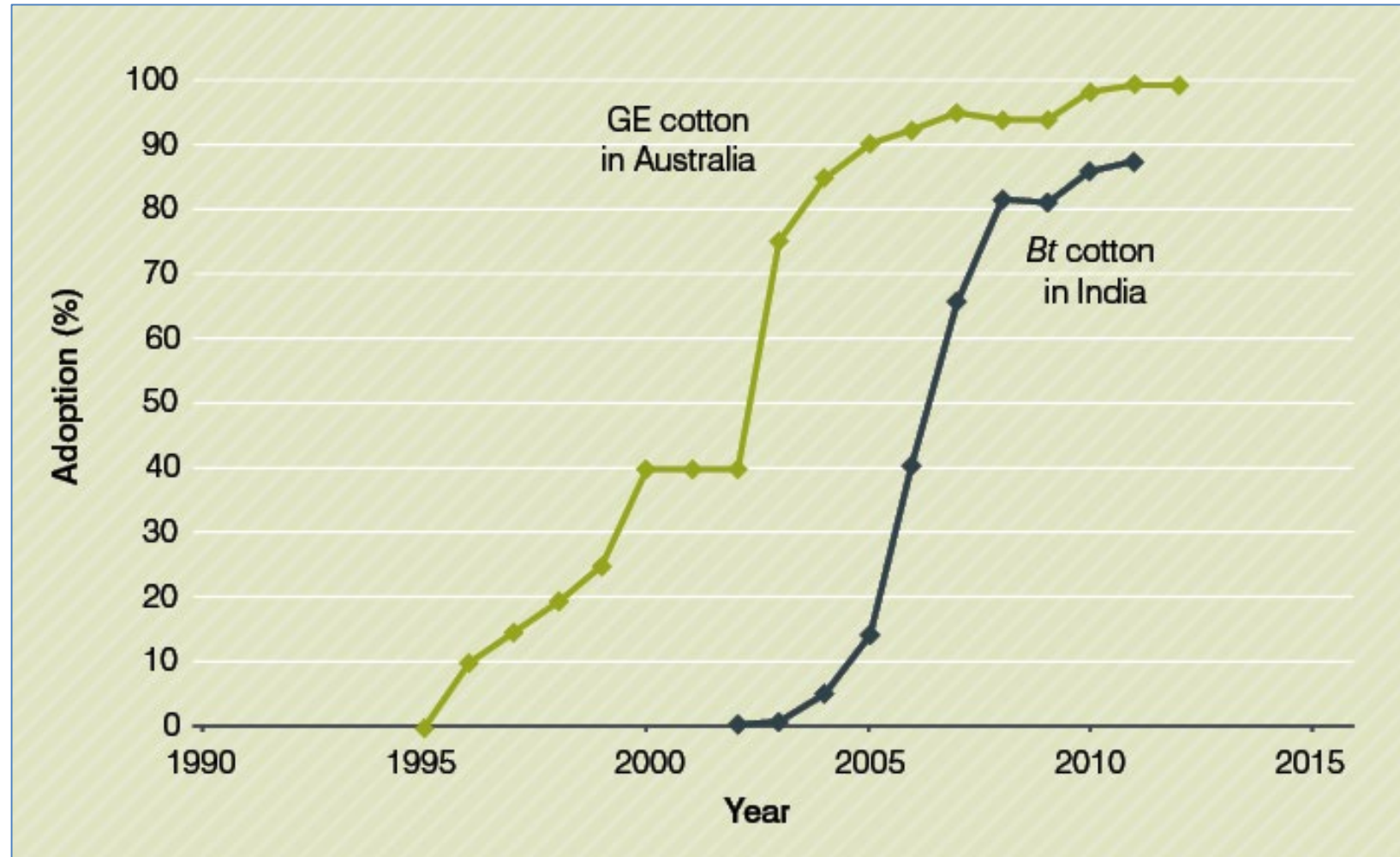
Five (unprecedented) Changes

1. Speed of technology change
2. Rate of cost reduction
3. Sources of investment
4. Growth in investment volume
5. Nature of the science, the scientists and implementers

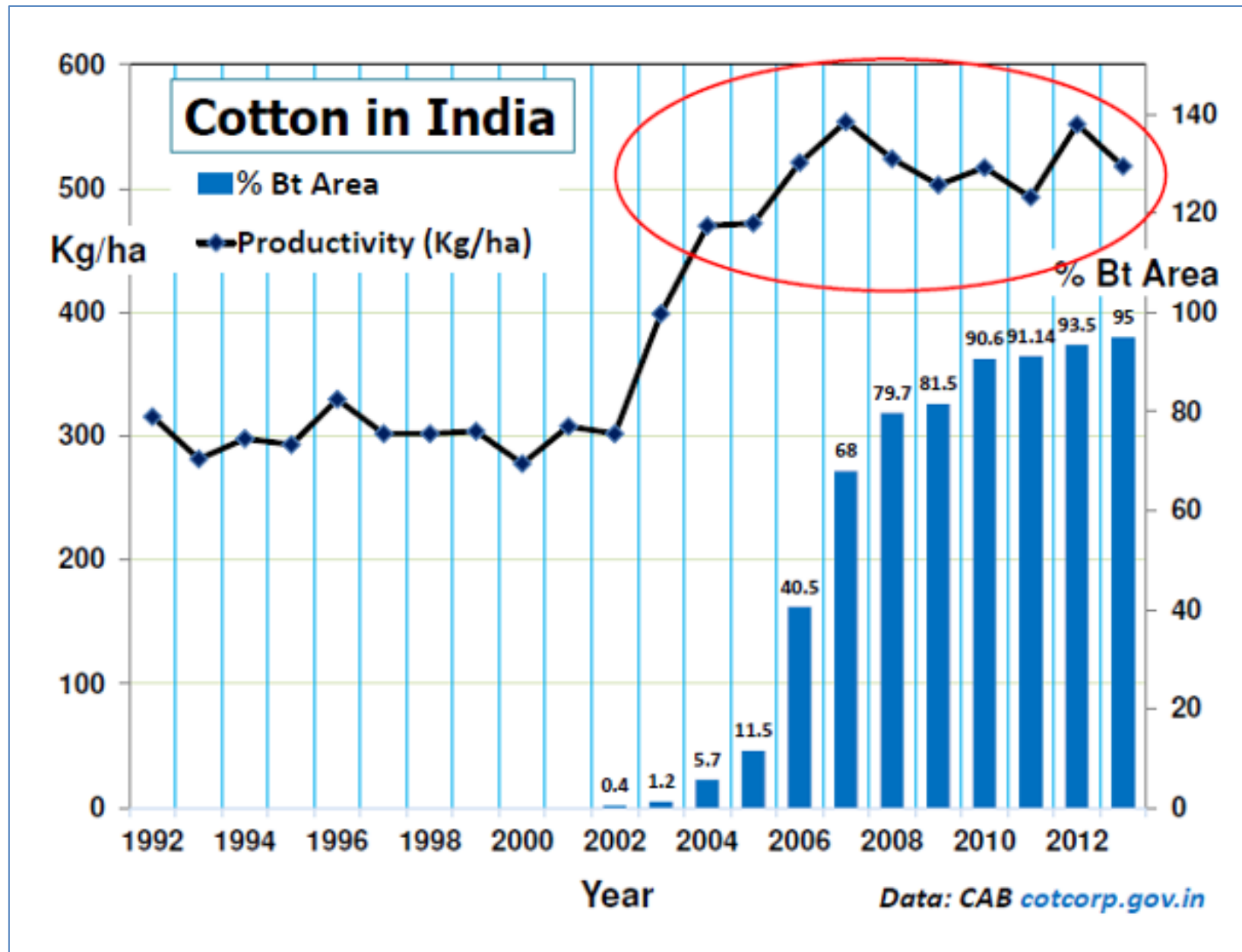
Five (unprecedented) Changes

1. **Speed of technology change**
2. **Rate of cost reduction**
3. Sources of investment
4. Growth in investment volume
5. Nature of the science, the scientists and implementers

Pest resistance by adding gene from bacteria



**Implicit
increase in
water
productivity
from higher
yield for same
water**

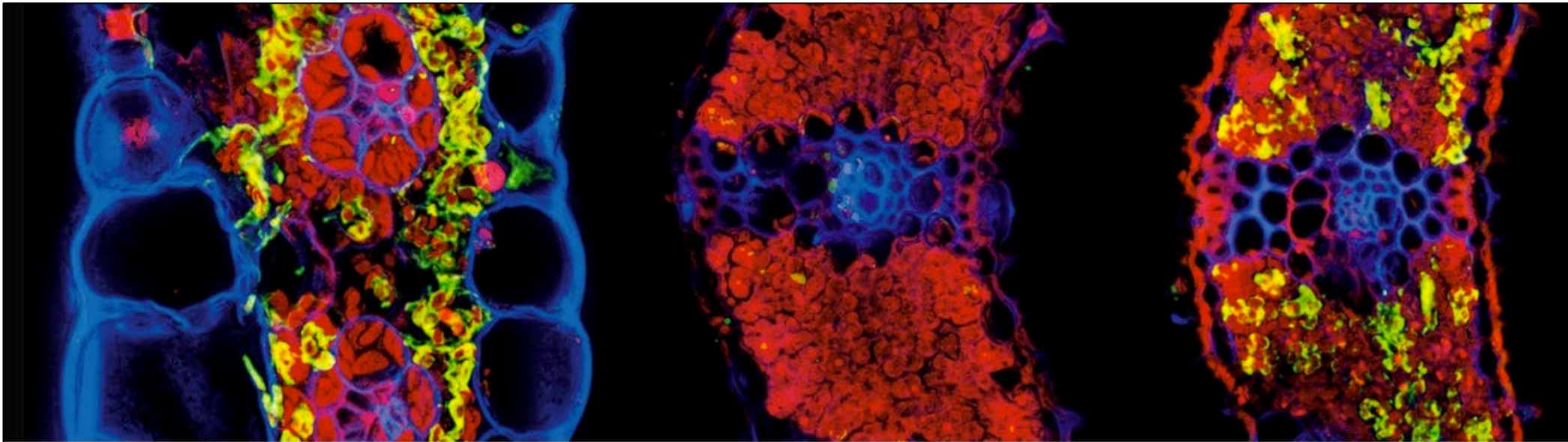


Possibility now to fundamentally change transpiration requirements

Corn with green
photosynthesis proteins

Rice without

Rice with



Can rice be made to photosynthesize as efficiently as corn? If so, yields could rise 50 percent. In a magnified cross section of a corn leaf (left), photosynthesis proteins are stained fluorescent green. Ordinary rice (middle) makes none of the proteins—but rice that has been genetically manipulated by IRRI scientists (right) makes some. WILLIAM PAUL QUICK, IRRI

Deeper root systems



Increasing glaucousness



Quick closing stomates



Better early growth



**Other
water
specific
GMO
efforts**

Summary of potential mechanisms for biotech to impact agricultural water use

1. Implicit water implications of any yield improving biotech
2. Reduced runoff from less tillage means less sediment and more groundwater recharge/soil moisture
3. Fundamentally transform transpiration and/or more yield per unit of water transpired
4. Make crops better adapted to water stresses like drought, flood and salt



[Science](#). Author manuscript; available in PMC 2018 Dec 7.

PMCID: PMC6286148

Published in final edited form as:

HHMIMSID: HHMIMS995853

[Science](#). 2012 Aug 17; 337(6096): 816–821.

PMID: [22745249](#)

Published online 2012 Jun 28. doi: [10.1126/science.1225829](#)

A programmable dual RNA-guided DNA endonuclease in adaptive bacterial immunity

[Martin Jinek](#),^{#1,2} [Krzysztof Chylinski](#),^{#3,4} [Ines Fonfara](#),⁴ [Michael Hauer](#),^{2,5} [Jennifer A. Doudna](#),^{1,2,6,7,*} and [Emmanuelle Charpentier](#)^{4,*}



Super-muscly pigs created by small genetic tweak

Researchers hope the genetically engineered animals will speed past regulators.

David Cyranoski

30 June 2015

PDF Rights & Permissions



Xi-jun Yin

These meaty pigs could become the first genetically engineered animals to be approved for human consumption.



DEFENSE ADVANCED
RESEARCH PROJECTS AGENCY

[ABOUT US](#) / [OUR RESEARCH](#) / [NEWS](#)

[Defense Advanced Research Projects Agency](#) > [Program Information](#)

Insect Allies

Dr. Blake Bextine

The Insect Allies program is pursuing scalable, readily deployable, and generalizable countermeasures against potential natural and engineered threats to the food supply with the goals of preserving the U.S. crop system. National security can be quickly jeopardized by naturally occurring threats to the crop system, including pathogens, drought, flooding, and frost, but especially by threats introduced by state or non-state actors. Insect Allies seeks to mitigate the impact of these incursions by applying targeted therapies to mature plants with effects that are expressed at relevant timescales—namely, within a single growing season. Such an unprecedented capability would provide an urgently needed alternative to pesticides, selective breeding, slash-and-burn clearing, and quarantine, which are often ineffective against rapidly emerging threats and are not suited to securing mature plants.

Maize	ZFNs	ZmIPK1	HR	Herbicide tolerant and phytate reduced maize	[14]
Maize	ZFNs	ZmTLP	HR	Trait stacking	[15]
Rice	ZFNs	OsQQR	HR	Trait stacking	[16]
Rice	TALENs	OsSWEET14	NHEJ	Bacterial blight resistance	[18]
Wheat	TALENs	TaMLO	NHEJ	Powdery mildew resistance	[19]
Maize	TALENs	ZmGL2	NHEJ	Reduced epicuticular wax in leaves	[20]
Sugarcane	TALENs	COMT	NHEJ	Improved cell wall composition	[21]
Sugarcane	TALENs	COMT	NHEJ	Improved saccharification efficiency	[22]
Soybean	TALENs	FAD2-1A, FAD2-1B	NHEJ	High oleic acid contents	[23]
Soybean	TALENs	FAD2-1A, FAD2-1B, FAD3A	NHEJ	High oleic, low linoleic contents	[24]
Potato	TALENs	Vlnv	NHEJ	Minimizing reducing sugars	[25]
Rice	TALENs	OsBADH2	NHEJ	Fragrant rice	[26]
Maize	TALENs	ZmMTL	NHEJ	Induction of haploid plants	[27]
<i>Brassica oleracea</i>	TALENs	FRIGIDA	NHEJ	Flowering earlier	[28]
Tomato	TALENs	ANT1	HR	Purple tomatoes with high anthocyanin	[29]
Rice	CRISPR/Cas9	LAZY1	NHEJ	Tiller-spreading	[39]
Rice	CRISPR/Cas9	Gn1a, GS3, DEP1	NHEJ	Enhanced grain number, larger grain size and dense erect panicles	[40]
Wheat	CRISPR/Cas9	GW2	NHEJ	Increased grain weight and protein content	[41]
<i>Camelina sativa</i>	CRISPR/Cas9	FAD2	NHEJ	Decreased polyunsaturated fatty acids	[42]
Rice	CRISPR/Cas9	SBEIIb	NHEJ	High amylose content	[43]

<i>Camelina sativa</i>	CRISPR/Cas9	FAD2	NHEJ	Decreased polyunsaturated fatty acids	[42]
Rice	CRISPR/Cas9	SBEIIb	NHEJ	High amylose content	[43]
Maize	CRISPR/Cas9	Wx1	NHEJ	High amylopectin content	[44]
Potato	CRISPR/Cas9	Wx1	NHEJ	High amylopectin content	[45]
Wheat	CRISPR/Cas9	EDR1	NHEJ	Powdery mildew resistance	[46]
Rice	CRISPR/Cas9	OsERF922	NHEJ	Enhanced rice blast resistance	[47]
Rice	CRISPR/Cas9	OsSWEET13	NHEJ	Bacterial blight resistance	[48]
Tomato	CRISPR/Cas9	SlMLO1	NHEJ	Powdery mildew resistance	[49]
Tomato	CRISPR/Cas9	SlJAZ2	NHEJ	Bacterial speck resistance	[50]
Grapefruit	CRISPR/Cas9	CsLOB1 promoter	NHEJ	Alleviated citrus canker	[51]
Orange	CRISPR/Cas9	CsLOB1 promoter	NHEJ	Citrus canker resistance	[52]
Grapefruit	CRISPR/Cas9	CsLOB1	NHEJ	Citrus canker resistance	[53]
Cucumber	CRISPR/Cas9	eIF4E	NHEJ	Virus resistance	[54]
Mushroom	CRISPR/Cas9	PPO	NHEJ	Anti-browning phenotype	[55]
Tomato	CRISPR/Cas9	SP5G	NHEJ	Earlier harvest time	[56]
Tomato	CRISPR/Cas9	SlAGL6	NHEJ	Parthenocarp	[57]
Maize	CRISPR/Cas9	TMS5	NHEJ	Thermosensitive male-sterile	[58]
Rice	CRISPR/Cas9	OsMATL	NHEJ	Induction of haploid plants	[59]
Tomato	CRISPR/Cas9	SP, SP5G, CLV3, WUS, GGP1	NHEJ	Tomato domestication	[60]
Rice	CRISPR/Cas9	ALS	HR	Herbicide resistance	[61]
Rice	CRISPR/Cas9	ALS	HR	Herbicide resistance	[62]
Rice	CRISPR/Cas9	EPSPS	NHEJ	Herbicide resistance	[63]

Rice	CRISPR/Cas9	EPSPS	NHEJ	Herbicide resistance	[63]
Rice	CRISPR/Cas9	ALS	HR	Herbicide resistance	[64]
Soybean	CRISPR/Cas9	ALS	HR	Herbicide resistance	[65]
Maize	CRISPR/Cas9	ALS	HR	Herbicide resistance	[66]
Potato	CRISPR/Cas9	ALS	HR	Herbicide resistance	[67]
Flax	CRISPR/Cas9	EPSPS	HR	Herbicide resistance	[68]
Cassava	CRISPR/Cas9	EPSPS	HR	Herbicide resistance	[69]
Maize	CRISPR/Cas9	ARGOS8	HR	Drought stress tolerance	[70]

Applications and potential of genome editing in crop improvement

Yi Zhang, Karen Massel, Ian D. Godwin and Caixia Gao

Genome Biology 2018 19:210

<https://doi.org/10.1186/s13059-018-1586-y> | © The Author(s). 2018

Published: 30 November 2018

Nov 23, 2015 to Feb 8, 2016

Technology Review

Biomedicine

With This Genetic Engineering Technology, There's No Turning Back

Designers of a "selfish" gene able to spread among mosquitoes say it could wipe out malaria, but the scientific community is at odds over whether or not we should do it.

by Antonio Regalado November 23, 2015

MIT Technology Review

Biomedicine

We Have the Technology to Destroy All Zika Mosquitoes

Fear of the Zika virus could generate support for gene drives, a radical technology able to make species go extinct.

by Antonio Regalado February 8, 2016

MIT Technology Review

Biomedicine

Top U.S. Intelligence Official Calls Gene Editing a WMD Threat

Easy to use. Hard to control. The intelligence community now sees CRISPR as a threat to national safety.

by Antonio Regalado February 9, 2016

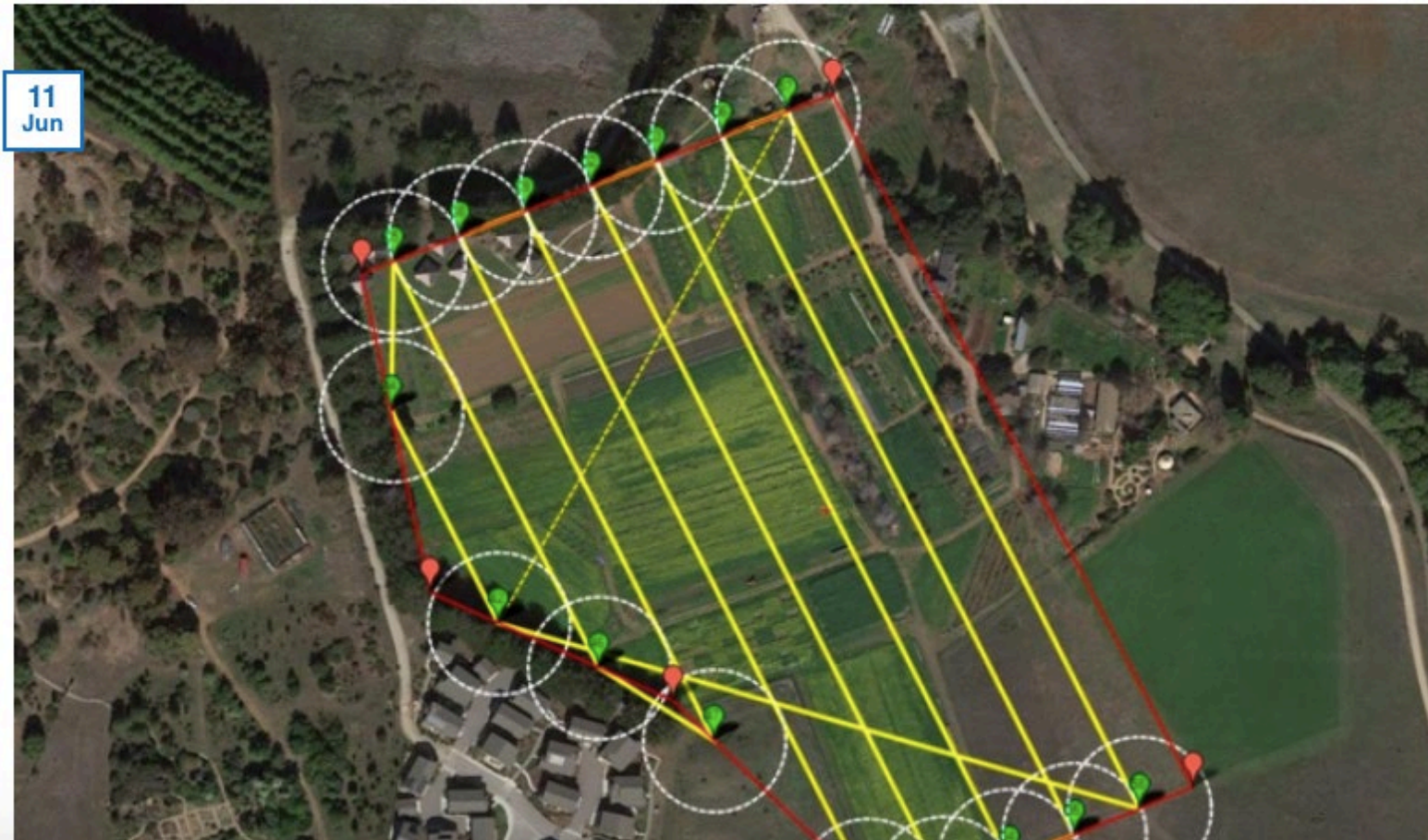
In China, Gene-Edited Babies Are the Latest in a String of Ethical Dilemmas



He Jiankui, who claimed to have created the world's first genetically edited babies, at a conference in Hong Kong this week. Other scientists have sharply denounced his work. Kin Cheung/Associated Press

Best Drones For Agriculture 2019: The Ultimate Buyer's Guide

POSTED ON JUNE 11, 2019 BY ANDREW NIXON



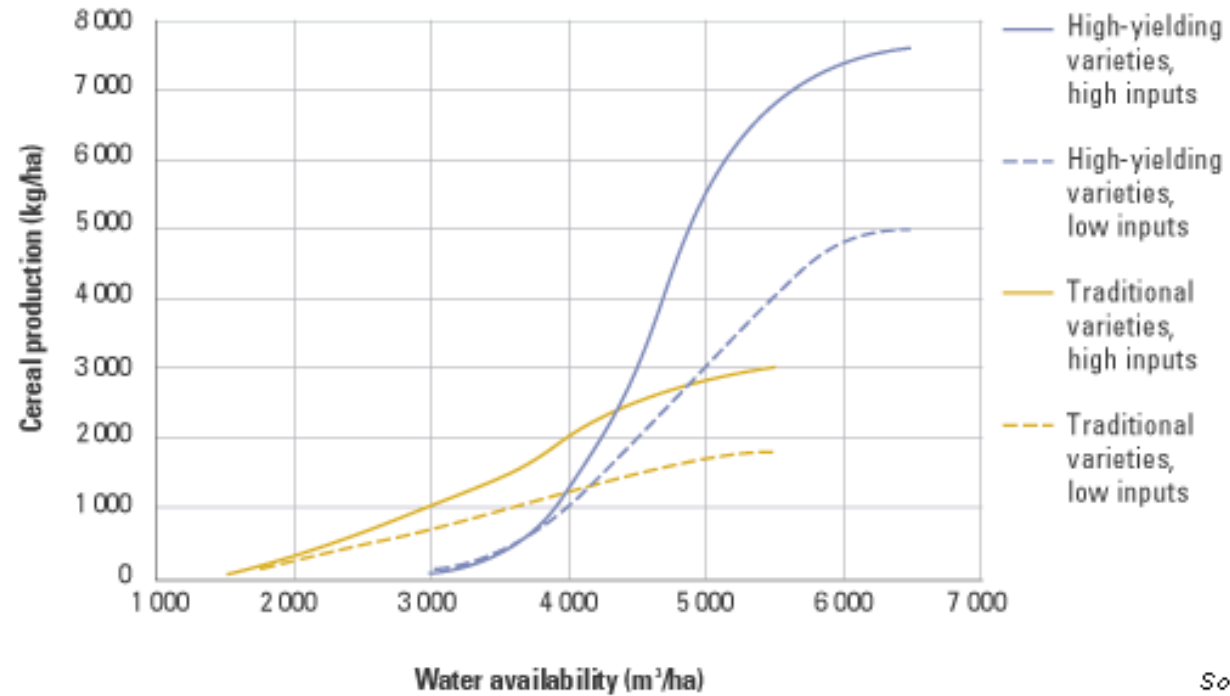
VEGAN IMPOSSIBLE BURGER HEADS TO AFRICA TO SOLVE THE
WORLD'S 'BIGGEST ENVIRONMENTAL ISSUE'



New tech and lower research costs should make it possible to target farmers, regions and crops missed by the GR and GMOs.

But if this possibility is not realized, those farmers may be made worse off by negative price effects.

Figure 3 Typical response to water for cereal crops



The graph shows the yield response of crops to water availability. High yielding varieties produce more than rainfed varieties only when provided with adequate amount of water.

Source: Smith et al., 2001.

[Products ▾](#)[Services ▾](#)[Applications ▾](#)[Brands ▾](#)[Resources ▾](#)[Contact Us](#)[About Us ▾](#)[Home](#) | [Gene Editing](#) | [CRISPR-Cas9](#) | [CRISPR Controls](#) | [Edit-R tracrRNA](#)

Edit-R tracrRNA

Chemically synthesized trans-activating CRISPR RNA required for use with synthetic crRNA for fast and easy gene editing.



The synthetic crRNA:tracrRNA approach to CRISPR-Cas9 includes transfection-ready RNA components and enables fast assessment of multiple target sites per gene, for multiple genes.

Edit-R CRISPR-Cas9 Synthetic tracrRNA

Catalog #
U-002005-05

Unit Size
5 nmol

Price
\$99.00

[Add To Cart](#)**Questions?**[Chat with an expert >>](#)

Related Products

- [Edit-R Predesigned crRNA](#)
- [Edit-R Synthetic Positive crRNA Controls](#)
- [Edit-R Synthetic crRNA Non-targeting Controls](#)
- [Edit-R crRNA Library](#)

Recently Viewed

- [Edit-R tracrRNA](#)



Find a Biohacking Makerspace Near You



DIY BIO

Five (unprecedented) Changes


1. Speed of technology change
2. Rate of cost reduction
3. **Sources of investment**
4. Growth in investment volume
5. Nature of the science, the scientists and implementers



A FOOD REVOLUTION HAS BEGUN S2G IS INVESTING IN IT

S2G Ventures (Seed 2 Growth) is a multi-stage food and agriculture venture fund investing in entrepreneurs whose products and services meet the shifting demands for healthy and sustainable food.

WE INVEST FROM “SOIL TO SHELF”



We help build next-generation food and agriculture technology companies.

The food and agriculture sector is undergoing unprecedented change, driven by demographics, globalization, sustainability pressures, new energy sources and concerns about food safety and security.

Taranjeet Singh of AgNext is disrupting the agribusiness industry by using sensing solutions and big data to embed intelligence across growing, procurement, and processing



2ND ANNUAL GOOD FOOD CONFERENCE TICKETS ARE ON SALE! SAVE WITH [EARLYBIRD PRICING](#) UNTIL JUNE 30



MANAGED BY  Unovis
Partners

[PHILOSOPHY](#)

[PORTFOLIO](#)

[TEAM](#)

[PRESS](#)

[CONTACT](#)

A full-page background image of a landscape at sunset or sunrise. The sky is a mix of orange, yellow, and light blue with wispy clouds. In the foreground, there is a green field. On the left, some trees are visible, and on the right, the branches of a tree with green leaves hang down from the top edge.

Funding the future of food



#SOILHEALTH #MICROBIOME #BIOTECH

Invest with us in the **bold and exceptional founders** transforming our food and agriculture system

Some venture funds in traditional ventures

Tyson Ventures

Monsanto Growth Ventures

Danone Manifesto Ventures

Syngenta Ventures

Mars Ventures

Rabobank Food and Ag Fund

The background of the page is a complex aerial mosaic of agricultural fields. The fields are represented by various shades of green, yellow, and brown, with some areas containing circular patterns, possibly representing irrigation systems or crop types. The overall effect is a dense, textured representation of farmland.

WE INVEST IN COMPANIES
THAT ARE TRANSFORMING
THE SAFETY, SECURITY AND
SUSTAINABILITY OF GLOBAL
FOOD

BIG IDEA VENTURES

Cohort Close Date: August 1
APPLY NOW

Apply to BIV: Food Accelerator

[Apply](#)

Investing in Entrepreneurs to Deliver Big Ideas



We help ambitious founders transform food and agriculture

Since 2006, we've provided growth capital to partner with the best and boldest companies that are helping feed the world sustainably. [Learn more about us.](#)



FIVE SEASONS
VENTURES

HOME

INVESTMENT THEMES

TEAM

PORTFOLIO

CONTACT

in

tw

We back Food Tech Entrepreneurs

for a healthier, more sustainable
and efficient food system

[Learn how we work >](#)

Scroll down

v

Some accelerators investing in food/ag

Ycombinator

SOSV

Hatch

TechStars

Food-X

China AgriFood Startup Funding Breakdown 2017

\$1.8bn

INVESTMENT

177

DEALS

\$741m

INVESTMENT
WITH BAT
INVOLVEMENT

79%

SINGLE DEAL
INVESTORS

\$330m

LARGEST
DEAL

Upstream

Ag Biotech, Farm Management SW, Farm Robotics & Equipment, Bioenergy & Biomaterials, Novel Farming, Agribusiness Marketplaces, Midstream, Innovative Food

\$106m

INVESTMENT

\$30.3m

LARGEST DEAL

28

DEALS

Undisclosed

INVESTMENT WITH
BAT INVOLVEMENT
BY VAULE

Downstream

In-store Restaurant & Retail, Online Restaurants, eGrocery, Restaurant Marketplaces, Home & Cooking

\$1.7bn

INVESTMENT

\$330m

LARGEST DEAL

149

DEALS

\$741m

INVESTMENT WITH
BAT INVOLVEMENT
BY VALUE

*BAT refers to China's three largest internet companies Alibaba, Tencent and Baidu

Most Active Venture Funds

- The most prolific was ZhenFund, China's largest seed fund set up by two founders of China's educational group New Oriental School, with 11 agrifood investments, mostly in In-Store Retail & Restaurant Tech.
- Bits x Bites was the only food tech-focused fund in China backing eight projects covering indoor farming, blockchain for food supply chain, insect protein, and other food tech sectors.
- Big VCs with diversified portfolios such as Matrix Partners China, IDG and Tiantu Capital were active in mid-to-later stages. In 2017, they chose startups in In-Store Retail & Restaurant Tech, Premium Branded Foods and Restaurants, and eGrocery.



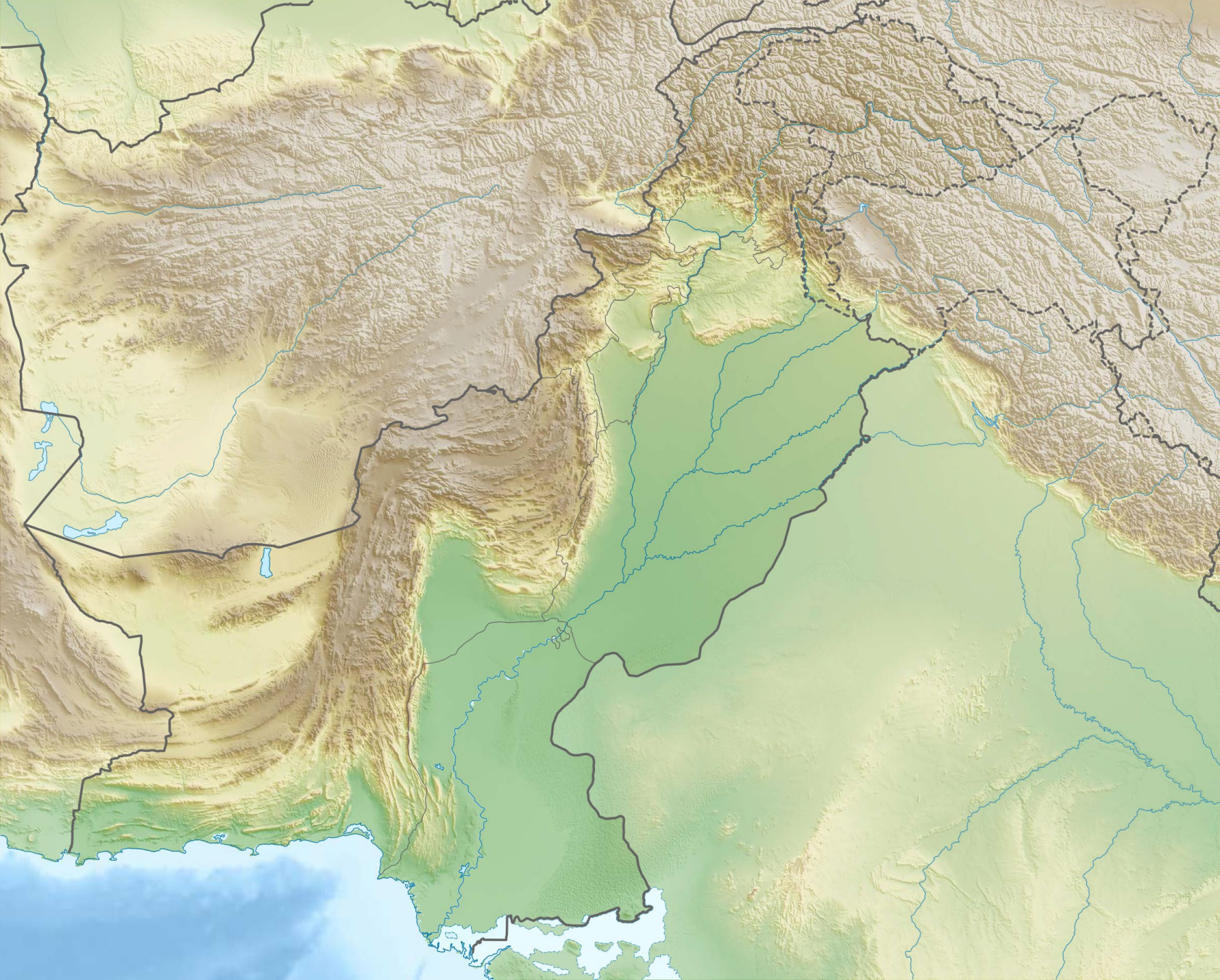
AGFUNDER

Number of Deals

Projects invested by BAT's controlled subsidiaries or venture arms are counted as BAT's projects

Five (unprecedented) Changes

1. Speed of technology change
2. Rate of cost reduction
3. Sources of investment
- 4. Growth in investment volume**
5. Nature of the science, the scientists and implementers



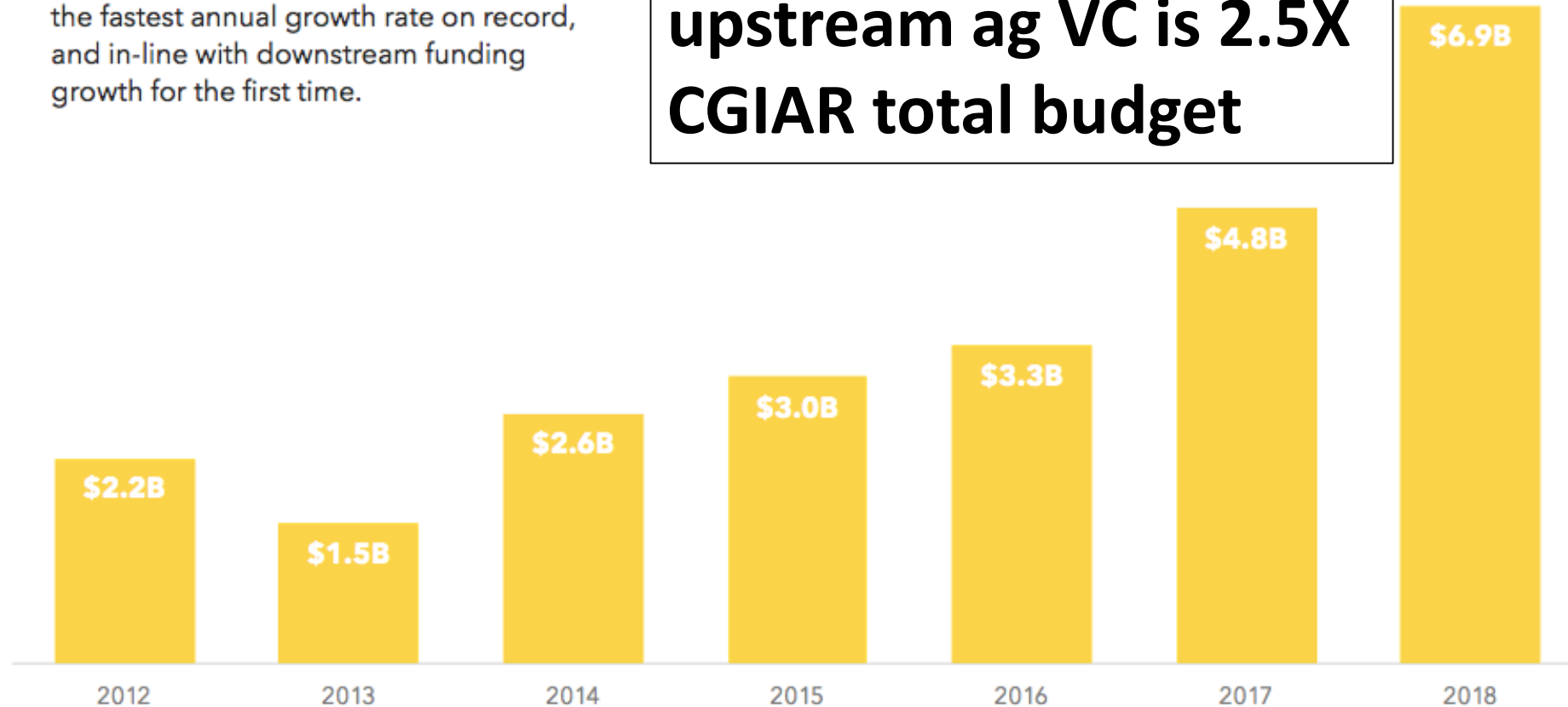
**Pakistan's
GNP 2017=
\$305 Billion**

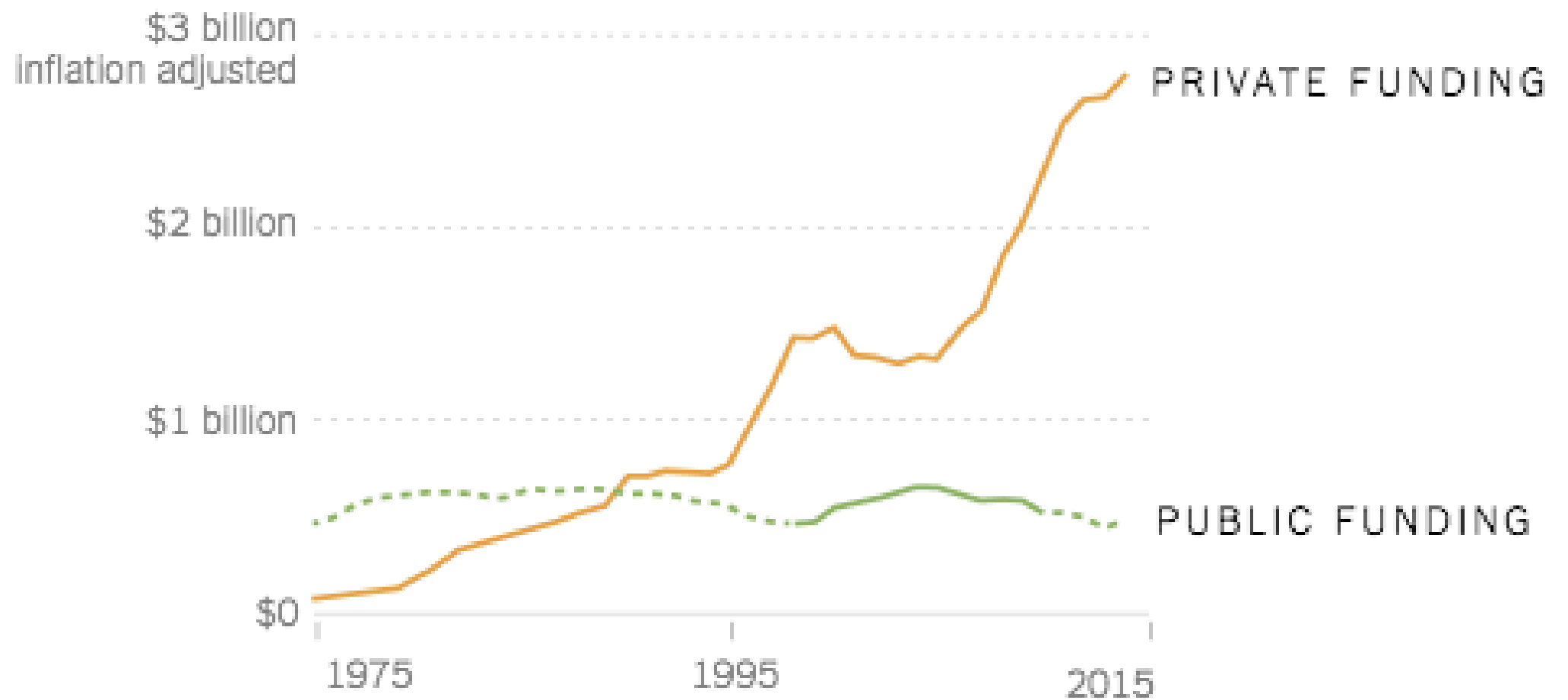
**India's GNP
growth 2016-
2017=
\$323 Billion**

Annual Financings | 2012-2018

Investment to startups operating closer to the farmer grew over 44% year-over-year, the fastest annual growth rate on record, and in-line with downstream funding growth for the first time.

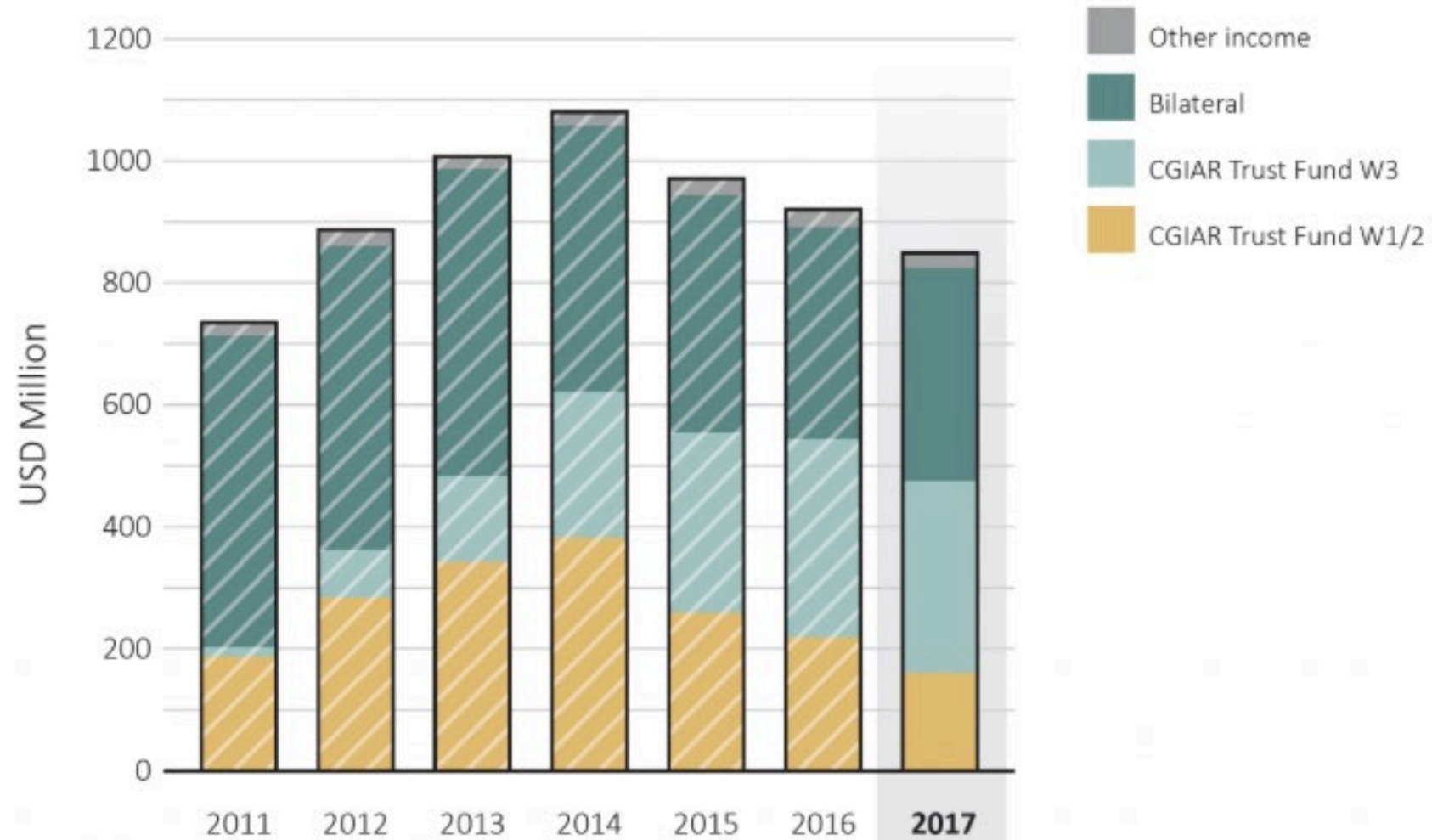
2017-18 GROWTH in
upstream ag VC is 2.5X
CGIAR total budget





Note: Dotted line is extrapolated. Source: USDA

Figure 3. CGIAR revenue by funding channel in 2017, compared to the CRP Portfolio 2011-16



SHARE



84



1



165



The pharmaceutical industry is fueling an increase in basic research investment by companies.

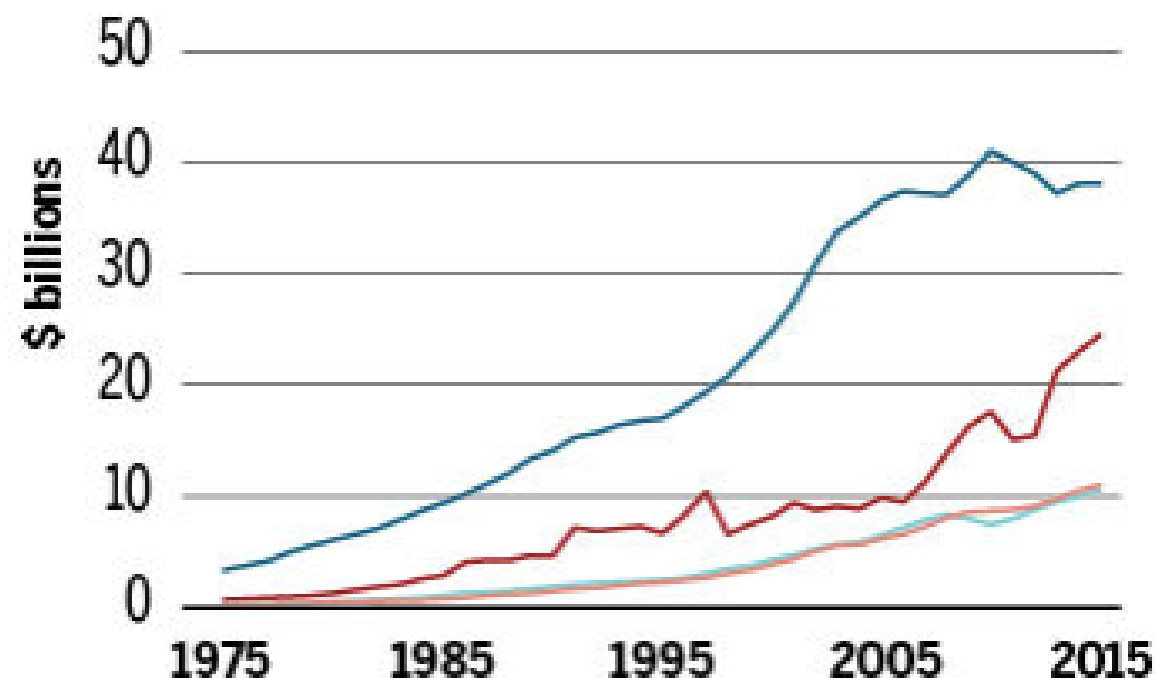
OJO Images Ltd/Alamy Stock Photo

Data check: U.S. government share of basic research funding falls below 50%

A basic shift

Federal agencies provided less than half of U.S. basic science funding in 2015, a result of stagnant budgets and rising investment by industry, universities, and philanthropies.

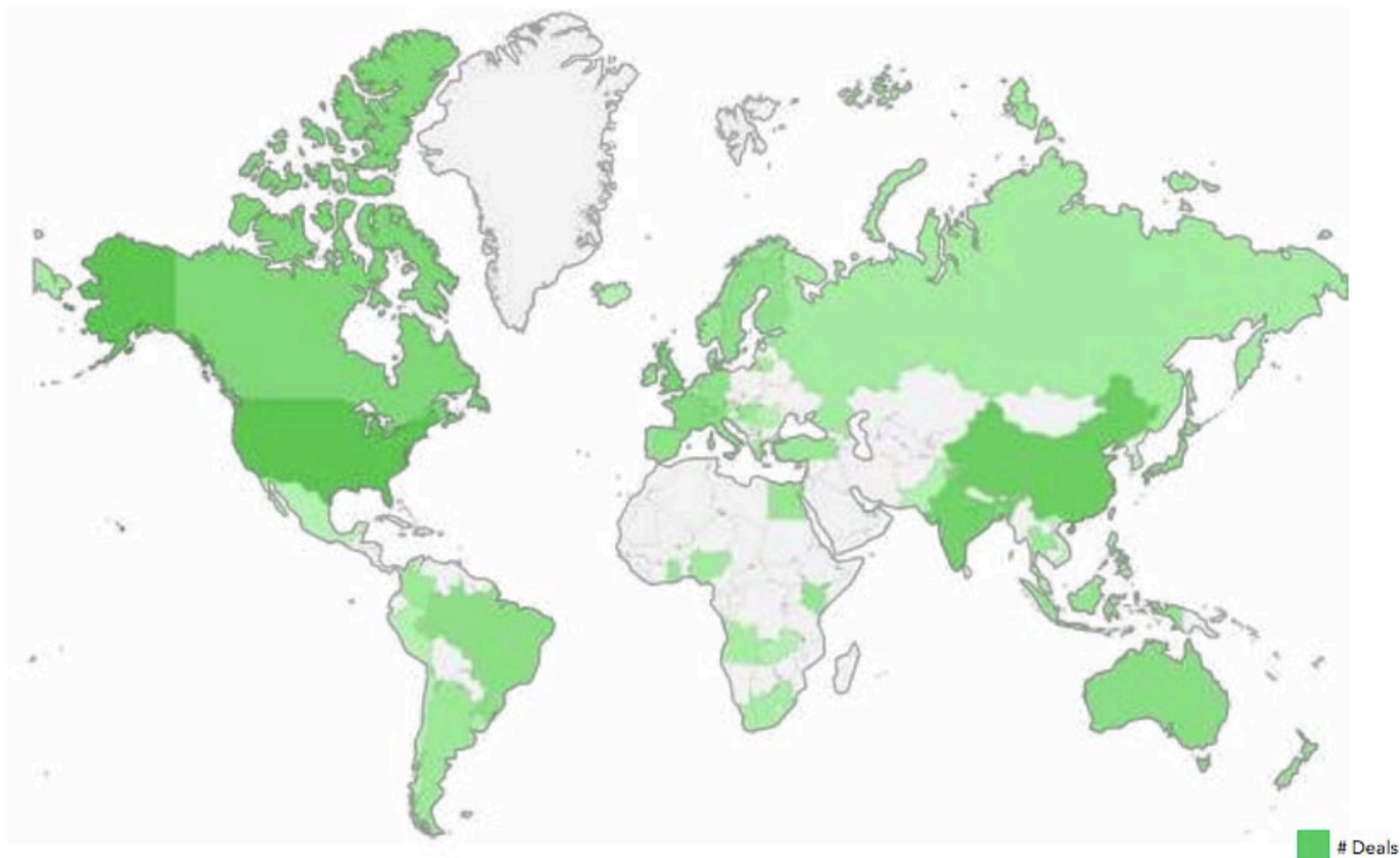
■ Federal ■ Corporate ■ University ■ Philanthropy



Graphic: D. Malakoff/Science

Data: National Science Foundation

Global Investment World Map



Five (unprecedented) Changes

1. Speed of technology change
2. Rate of cost reduction
3. Sources of investment
4. Growth in investment volume
- 5. Nature of the science, the scientists and implementers**



Data Analytics

[Data Analyst](#)
[Data Engineer](#)
[Data Scientist - Deep Learning](#)
[Operations Lead, Data Analytics](#)
[Senior Software Engineer, Backend \(Data Analytics\)](#)
[Software Engineering Manager, Backend \(Data Analytics\)](#)
[Sr. Engineering Manager, Data Analytics](#)


Design

[Principal UX Designer](#)
[UX Researcher](#)


Engineering

[Engineering Director, Data Infrastructure](#)
[Enterprise Data Architect](#)
[Head of Application and Platform Engineering](#)
[Lead Web Engineer](#)
[Master Data Management Lead \(MDM\)](#)
[Senior Technical Program Manager](#)
[Senior Technical Program Manager, Capabilities](#)
[Software Engineer, Backend \(Multiple levels\)](#)
[Software Engineering Manager, Data Translation](#)
[Sr. Software Engineer, Cloud Engineering](#)
[Sr. Staff Software Engineer, Backend \(Multiple levels\)](#)
[Sr. Staff Software Engineer, Cloud Engineering](#)
[Staff Software Engineer, Backend \(Remote Sensing / Raster Pipelines\)](#)


Science

[Atmospheric Scientist](#)
[3 Locations](#)
[Data Scientist - Machine Learning](#)
[2 Locations](#)
[Data Scientist - Soy Crop](#)
[2 Locations](#)
[Data Scientist - Spatial Statistics](#)
[2 Locations](#)
[Data Scientist- Cereals/Other Crops](#)
[2 Locations](#)
[Designed Field Research Scientist](#)
[St. Louis, Missouri](#)
[Scientific Analytics Technical Project Manager](#)
[St. Louis, Missouri](#)
[Scientific Software Engineer](#)
[2 Locations](#)
[Senior Data Scientist - Machine Learning](#)
[2 Locations](#)


Security

[Product Security Manager](#)
[2 Locations](#)
[Check on an application you've submitted.](#)

Hello! From a few of us.

Want a better feel for the office environment? Look no further. The proof's in our people.
They run the gamut from conventional to quirky. They also run on coffee.



Seattle and San Francisco, not Pullman and Davis



Millennials 'Make Farming Sexy' in Africa, Where Tilling the Soil Once Meant Shame



WWOOF

Live and Learn On Organic Farms TM

GET STARTED...



Welcome to WWOOF

WWOOF organisations connect people who want to live and learn on organic farms and smallholdings with people who want to share their lifestyles, teach new skills and welcome volunteer help. There are places in Africa, Americas, Asia, Europe, Middle East and Oceania.

WWOOF hosts offer food, accommodation and opportunities to stay and learn about organic/biological growing and farming.

WWOOF Volunteers give hands on help and have an interest in learning about organic farming and gaining skills in sustainable

- **The Good** -rapidly changing technology and rapidly falling costs will make it possible to target the water problems of neglected farmers.
- **The Bad** -The changing nature of investment suggests that the neglected may well be neglected again-with greater negative impacts, since markets are now more integrated.
- **The (potentially) Ugly**-It is not clear that the public sector research community will adapt quickly enough to the changing environment to impact its direction.

- **Recognize and acknowledge the changes**
- **Think like Pakistan**
- **At a minimum:**
 - New engagement strategies to deliver the equity messages we have already learned
 - Rethink the public sector/CGIAR niche
 - New and different partnerships