

Initiative for Convergent-manufacturing of Agriculture and Food for Equity (I-CAFE)

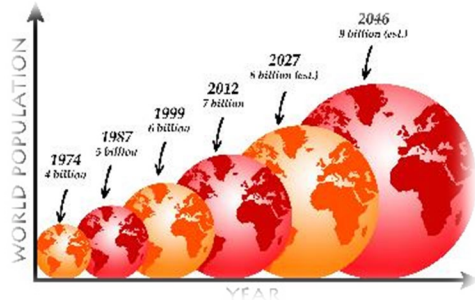
I-CAFE, a foundry for enabling nutrition and calorie equitable foods at the crossroads of traditional and future farms

Ajay P. Malshe, School of Mechanical Engineering (January 2022); amalshe@purdue.edu

(The opinions expressed in the presentation are solely of the speaker and are not intended to represent any official positions of Purdue University.)



Why?: Convergence of Tech-socio-economic-political drivers



Population



Supply chain



Bio-diversity



Life expectancy



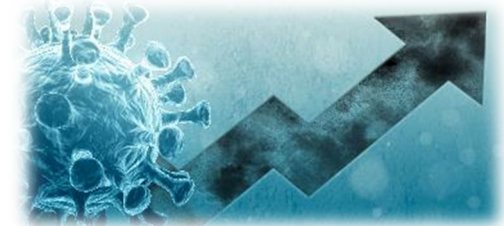
Climate



Inequity & Deserts



Taste-diversity



Pandemics



Traceability



Energy & Decarbonization



Trade War



Age of Mobility

Where?: Current Farms and Foods Trend



Global

COVID-19

Can Food Supply Chains Cope with COVID-19?



The complex global systems that bring food from fields to forks are overcoming many hurdles.

THE WALL STREET JOURNAL



The revival of U.S.-China trade relations is lifting American farmers who have struggled during a yearslong trade war. Pigs on a Michigan hog farm.

For U.S. Farmers, China Is Back and Bigger Than Ever

Record exports follow a painful trade war, but not just be reliant on China. "We can't just be reliant on China."

Photographs and video by [Name] for The Wall Street Journal

By 2050, 89% of the U.S. population and 68% of the world population is projected to live in urban areas. More than 300 urban areas in the U.S. have populations above 100,000; New York City, with 8.3 million inhabitants, is the largest. ... Between 2000 and 2010, urban land area in the U.S. increased by 15%.

<https://css.umich.edu/factsheets/u...>

U.S. Cities Factsheet | Center for Sustainability

TIME

SUBSCRIBE

BY ARYN BAKER

JANUARY 27, 2022 1:50 PM EST

China's Ministry of Agriculture and Rural Affairs has set the lab-grown meat industry abuzz with the release of its official five-year agricultural plan (pdf in Chinese) on Jan. 26. For the first time, China included cultivated meats and other "future foods" like plant-based eggs as part of its blueprint for food security going forward.

Grown from animal stem cells in a bioreactor and nourished on a nutrient broth, cultivated meats are a relatively new technology that promises to upend traditional animal agriculture by replacing slaughterhouses with laboratories. But while alternative meat companies have made immense strides in replicating the taste and texture of conventionally raised pork, beef, and chicken,

NIKKEI Asia



China is maintaining its food stockpiles at a "historically high level," says the head of grain reserves at the National Food and Strategic Reserves Administration. "There is no problem whatsoever about the supply of food."

DATAWATCH

China hoards over half the world's grain, pushing up global prices

Testy ties with U.S. and Australia could be prodding China to boost food reserves

SHIN WATANABE and AIKO MUNAKATA, Nikkei staff writers
DECEMBER 23, 2021 16:47 JST

The Beet.

Study: Plant-Based Diets Can Slash Greenhouse Gases by Up to 61 Percent

Maxwell Rabb
Published: January 16, 2022

The year 2021 was the worst for weather in our country's history, according to the National Oceanic and Atmospheric Administration (NOAA), with 20 climate-related deadly disasters – including wildfires, tornados, floods, hurricanes, and mudslides – leaving devastation that cost \$145 billion in property damages and a tragic loss of 688 lives in the US alone. This dire evidence of climate change has consumers wondering how we can possibly help fix things, or at least contribute to our own planet's long-term survival.

Agriculture and Food Self-Reliance and Assets for National Security

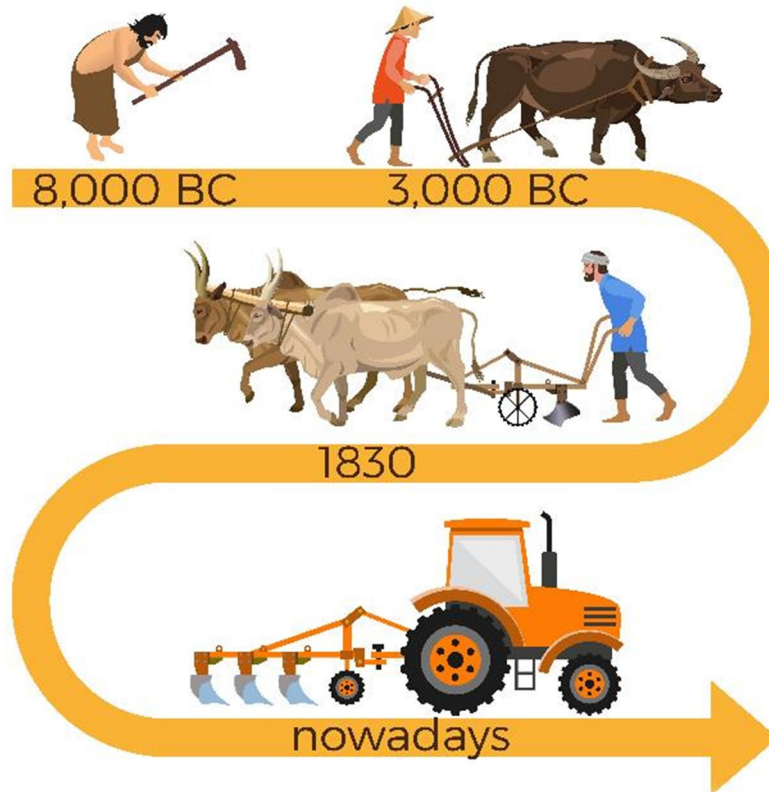


Agriculture and food revolutions *for* human health, equity, and competitiveness

Acceptability



History of agriculture



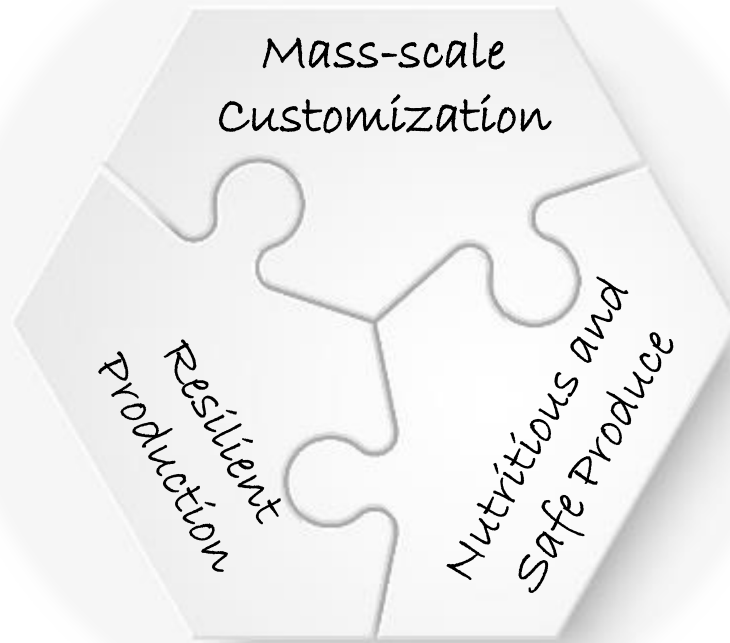
Availability

Demands, 4As:
Along with
Acceptability and
Availability,
Accessibility (gap)
and Affordability
(gap) to nutritious
food



How?: Approach, convergent-manufacturing for 4 “A”s

Delivery at point-of-need



E.g. Food and Farm-by-Design

E.g. Micro- (“small”) and distributed- Manufacturing

E.g. Nutrition and calorie equity

- Meet acceptability demand with nutrition, safety, taste and social participation.
- Meet availability demand with diverse materials sources, e.g. cellular ag, plant-based ag (e.g. soybean), insect-based protein, and more.
- Meet accessibility and affordability demands with digital, hybrid and distributed manufacturing *by, for* and *with* community participation.

What?: Message



Exploring new value space at the convergence of agriculture and technology to enable tasty and nutritious and calorie rich food accessible and affordable for all by mass-scale customization.

A cross-college thought leadership: Convergence of Cell Ag, Plant Ag, and Future Farms

Transformative Agriculture and Food Manufacturing for Equity

Cultivated Meat



Nutritious Food Equity



Nano and Micro Manufacturing

Design
Equity

Convergence

Industry 4.0

3-D Printing

Biomaterials

Materials

Big Data Analytics

Policies

Additive

SENSING

Protein

COMMUNITIES

FOOD

Robotics

Safety

Education

Businesses

Frugal engineering and social innovations

Surfaces & Interfaces

Cell Biology

AI

WORKFORCE

DEVELOPMENT

Nutrition

Farmers

Cyber Security

Sustainable raw materials



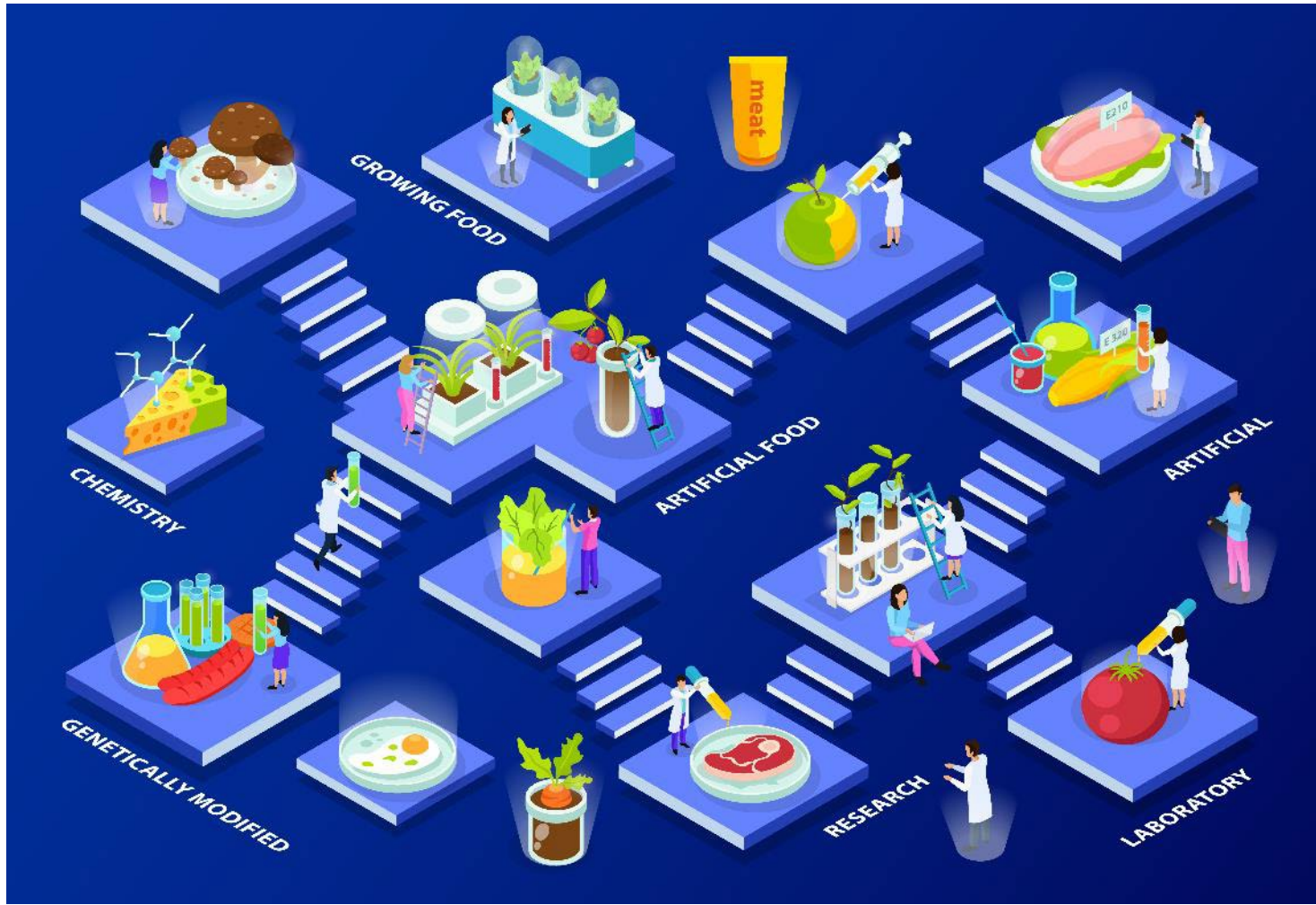
Plant-based Food



Future Farms

Farm and Food Foundry for Convergent Manufacturing

Anthropology, Economics, Education, Nutrition, Policy, Sociology, Sustainability



Highlights (*continuously updates*):

Few example of organizations in Indiana: Eli Lilly, Beck's Hybrids, Corteva Agriscience, AgriNovus Indiana, Indiana Soybean Alliance; Indiana Corn Alliance, Indiana Pork Farmers, Indiana University, Ivy Tech, Notre Dame University.

Few example heterogeneous materials: Proteins, cells and tissues, plants, and seeds.

Few example combinatorial processes: Bio-reactors, additive-transformative processes, integrated hybrid batch-continuous operations, intensified systems for rapid drying of particulates, digital agriculture, cultures and alternative protein; horizontal and vertical farming.

Example key platform issues (horizontals): Energy, sustainability, digital smartness and Industry 4.0, robotics, IoT, drones and sensor network, microelectronics and sensor and actuator chips and systems, cybersecurity, logistics and supply chain, equity and equality, technology policy and diplomacy.



Themes & Teams: Future Food and Farms

- Genetics, cells and tissues
 - **Deng, Meng; Kim, Brad; Kuang, Shihuan; Rainey, Katherine Martin; Sealy, Michael P.**
- Manufacturing, Nutrition and Safety
 - **Bapat, Salil; Butzke, Christian E; Campbell, Wayne W; Deng, Meng; Kim, Brad; Kuang, Shihuan; Mattes, Richard D; Mishra, Dharmendra K; Liceaga, Andrea; Mosier, Nathan S; Nemali, Krishna; Sealy, Michael P; Simsek, Senay; Sotelo, Luz**
- Testing, Data Analytics and I 4.0
 - **Ardekani, Arzoo; Buckmaster, Dennis; Sutherland, John W; Tuinstra, Mitchell R; Yih, Yuehwern**



Group picture of faculty attendees from of the Future Foods and Farms meeting (Monday, 12/13/2021)

- Purdue Leaderships and Admin Support
 - **Bogan, Bill; Bond, Sally J; Chen, Wayne; Engle, Bernie; Farmus, Cristina D; Huetteman, Carl A; Shade, Steven A**

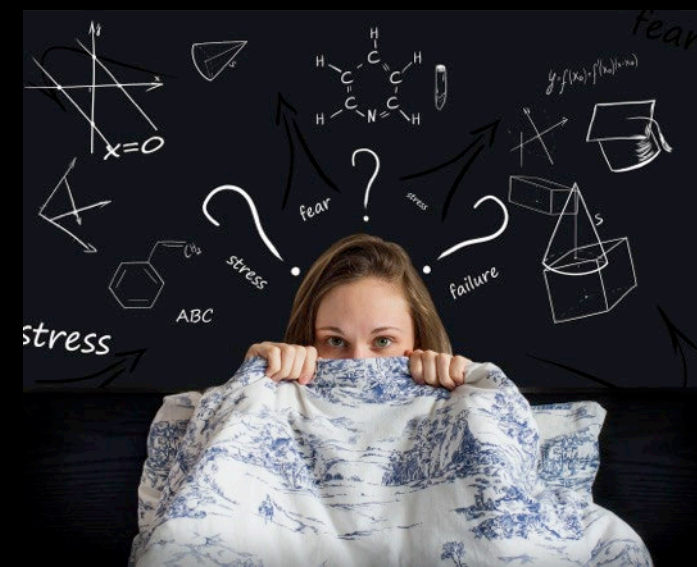
- Commerce, Supply Chain, Jobs
 - **Butzke, Christian E; Iyer, Ananth V; Groll, Eckhard A; Joyce, Brad; Lusk, Jayson L; Sutherland, John W; Thomas, Arthur William; Yih, Yuehwern; Zehrung, Craig Allen; Ziviani, Davide**
- Equity, Communities, Education
 - **Connaughton, Stacey L; Giri, Nandhini; Katar, Bhagyashree; Pfeiffer, Linda J; Prokopy, Linda S; Yih, Yuehwern; Sotelo, Luz**
- Ecosystem and Sustainability
 - **Ciez, Rebecca Elaine; Flachs, Andrew T; Krishna, Ashima; Singh, Shweta; Sutherland, John W; Yih, Yuehwern**



Investing in food equity for Human and Humanity: A Call to Action

Impact: Food-integrated Equity

Every nutritious food and manufacturing farm matters, when at least one human goes hungry!



Drivers for Selection of this Theme

Differentiation

Subject Matter Expertise

Indiana, mid-west and US centric for advancing value
and value chain for economy

More than \$1T in real impact

The theme is aligned with national and the White House Priorities

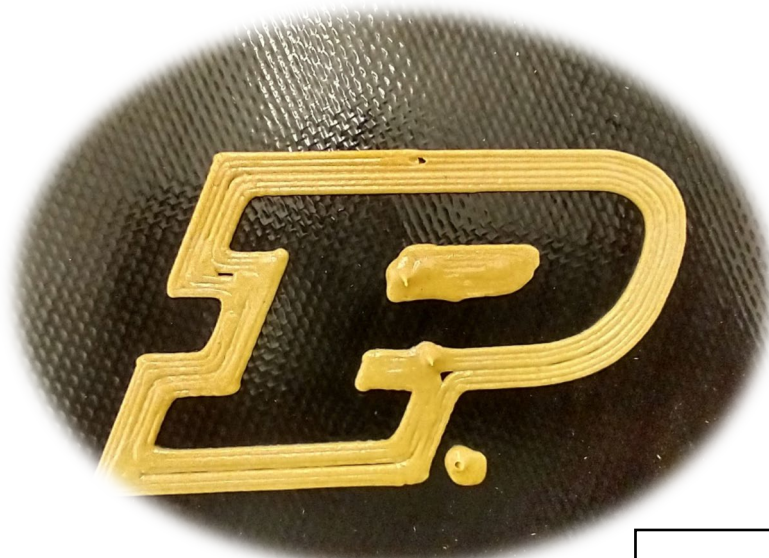
Climate justice

Equity for all

Jobs in communities

Manufacturing in US

Thank you

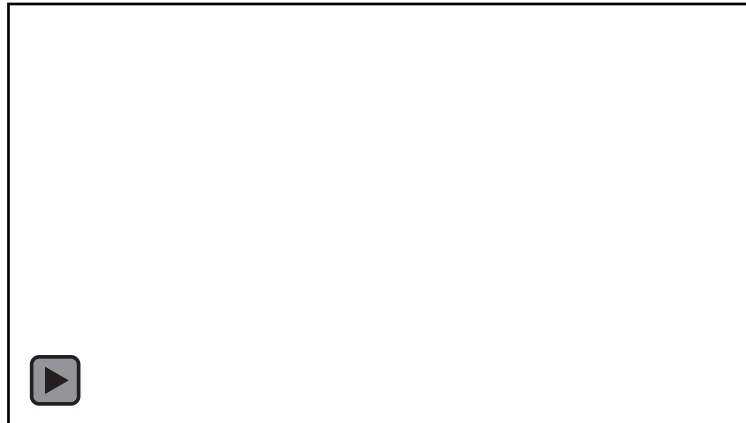


3D printing of food



Micro Farms

Education



Cell Ag



Smart and Sustainable Manufacturing Systems

Salil Bapat,¹ Vishvesh Koranne,¹ Neha Shakelly,² Aihua Huang,²
Michael P. Sealy,¹ John W. Sutherland,² Kamlakar P. Rajurkar,¹ and
Ajay P. Malshe²

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Cellular Agriculture: An Outlook
on Smart and Resilient Food
Agriculture Manufacturing

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