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Alternative meats and alternative statistics: What do the data say?

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THE CONVERSATION

<https://theconversation.com/why-cows-are-getting-a-bad-rap-in-lab-grown-meat-debate-103716>

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Why cows are getting a bad rap in lab-grown meat debate


A battle royal is brewing over what to call animal cells grown in cell culture for food. Should it be in-vitro meat, cellular meat, cultured meat or fermented meat? What about animal-free meat, slaughter-free meat, artificial meat, synthetic meat, zombie meat, lab-grown meat, neo-meat or artificial muscle proteins?

Author: Alison Van Eenennaam, Cooperative Extension Specialist, Department of Animal Science, University of California, Davis

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"In vitro" or cultured "meats"

- What it is not
- An overview on the technology that is used to produce this product
- Who has invested
- Who is selling
- Who is buying it
- How it is currently regulated
- What impacts there are likely to be on the livestock industry because of it.




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What it is not

Vegan meat replacements

- 1. Isolation and functionalization**
 - Plant protein concentrates are extracted from plants
 - Proteins are hydrolyzed (broken down) to improve their functional traits
- 2. Formulation**
 - Binders, fats, and flavors are added to improve the sensory profile
 - Flavorings are added to at least meet the amount of nutrients in meat
- 3. Processing**
 - The mixture is shaped into final product via extruding, kneading, their cell processing, press forming, folding, leveling, or extrusion

e.g. Impossible Burger Beyond Burger



Sources: Good Food Institute, Impossible Foods, A1 Kearney analysis
<https://www.atearney.com/retail/article/?a/how-will-cultured-meat-and-meat-alternatives-disrupt-the-omnivorous-and-food-industry>

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Two distinct products

Vegan meat replacements


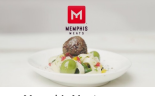
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"in-vitro" or "cultured" meat

- 1. Cell isolation**
 - An adult stem cell—called a satellite cell—is extracted from an animal
 - One cell is sufficient for the process and the animal can live on
- 2. Cell proliferation**
 - The cells are added to a bioreactor along with cell culture media, which causes the cells to proliferate
 - The result is exponential growth of the satellite cell
 - Cells are fed by a medium containing amino acids, salts, sugars, and signaling molecules
- 3. Tissue perfusion**
 - A change in culture conditions allows the cell to differentiate into muscle, fat and connective tissue
 - Cells are structured via 3D scaffolding materials to mimic fibers
 - Muscle fibers are combined with fat to meat

e.g. Memphis Meats New Age Meats JUST





Sources: Good Food Institute, Impossible Foods, A1 Kearney analysis
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Living cells in the bioreactor must be provided with nutrients in a suitable growth medium containing food-grade components that must be effective and efficient in supporting and promoting muscle cell growth

A typical growth medium contains

- synthetic amino acids,
- antibiotics
- fetal bovine serum,
- horse serum
- chicken embryo extract
- an energy source such as glucose




If cultured meat is to match or exceed the nutritional value of conventional meat products, nutrients found in meat not synthesized by muscle cells must be supplied as supplements in the culture medium.

- Essential amino acids
- Vitamin B₁₂
- Iron
- Micronutrients

Van Eenennaam 11/18/2018

In 2013, our Chief Scientific Officer Professor Mark Post unveiled the world's first slaughter-free hamburger to a packed press conference in London. It was the result of years of research at Maastricht University, and cost €250,000 to make. The effort was funded by Sergey Brin, the co-founder of Google.




Mark Post
Chief Scientific Officer

Mark Post
Chief Scientific Officer

Mark Post
Chief Scientific Officer

Van Eenennaam 11/18/2018



To date, there is no process for proliferating not just muscle cells but also fat cells, which are particularly relevant for taste. It is also not yet possible to produce larger pieces of meat such as steaks.

Van Eenennaam 11/18/2018

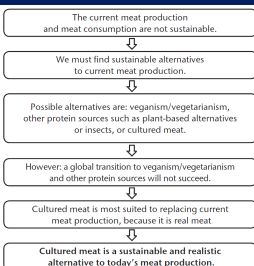
Self-propelling, self-cleaning, solar-driven, bioreactor



CH₄
BLUP

Van Eenennaam 11/18/2018

This is the underlying rationale for cultured meat



The current meat production and meat consumption are not sustainable.

We must find sustainable alternatives to current meat production.

Possible alternatives are: veganism/vegetarianism, other protein sources such as plant-based alternatives or insects, or cultured meat.

However, a global transition to veganism/vegetarianism and other protein sources will not succeed.

Cultured meat is most suited to replacing current meat production, because it is real meat

Cultured meat is a sustainable and realistic alternative to today's meat production.

Van Eenennaam 11/18/2018

According to a 2019 AT Kearney report:
"Novel vegan meat replacements and cultured meat have the potential to disrupt the meat industry"



Authors

- Dr. Carsten Gerhardt, Partner
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- Gerrit Suhlmann, Consultant
- Dave Donnan, Partner
- Dr. Hans-Jochen Kühhle, Consultant

By 2040
"only 40% of global meat consumption will still come from conventional meat sources"

<https://www.atearney.com/retail/article/7/so-how-will-cultured-meat-and-meat-alternatives-disrupt-the-conventional-and-food-industry>

Van Eenennaam 11/18/2018

According to a 2019 RethinkX report:

"The winners in food production are likely to be biotechnology and software companies – those that have a model where efficient product distribution is key – or those retailers and distributors able to adapt to and help shape the new supply chain."

THE FUTURE IS

Food Tech
 Steve Cook is a world-renowned thought leader, helping technology, education and the author of the Amazon #1 best-selling book *Food 2.0*. He is a frequent speaker at industry conferences and has been named one of the most influential people in the world by *Time* magazine. He is also a frequent speaker at industry conferences and has been named one of the most influential people in the world by *Time* magazine.

Food Policy
 James Altshuler is a leading expert in food policy. He is the Director of Public Policy at the Center for Food Safety and Food Policy at the University of California, Davis. He has been named one of the most influential people in the world by *Time* magazine.

EXECUTIVE LEADERSHIP
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RethinkX: Foodlands Agriculture Report.pdf (October 2019)

"Fermentation farms will be the new food farms". There will be job opportunities engineering, designing, building, & operating them.

Figure 12. U.S. Market Share of Cow vs. Modern Beef Products

By 2030 "70% of all beef consumed will come from modern production methods" (i.e. not cows)

RethinkX: Foodlands Agriculture Report.pdf (October 2019)

Animal Proteins & Beef versus Substitutes

Foodservice & Retail: Animal Proteins and Beef vs. Substitutes (billion pounds)

2018 Beef Substitutes:
 0.07 billion pounds = 70 million pounds = 280 million quarter pounds

Beef vs. Beef Substitutes:
 The remaining 13.93 billion pounds is beef. That is equivalent to 55,720,000 million quarter pounds; aka **fifty-five billion, seven hundred twenty million quarter pounds**

https://www.beefresearch.org/CMDocs/BeefResearch/MR_Presentations/NCBA_BIWFD_ConsumersInsightsNswOrleans_Final_012219-09_BeefResearchPostings.pdf

Carbon Footprint CO₂-eq, land use (m²), and energy use (MJ) per kg product for different products in a number of different studies.

*Qantiss is an independent company (<https://qantiss-intl.com>).

Product (Number of studies)	per kg product (not necessarily nutritionally equivalent)			Reference
	Carbon Footprint (CO ₂ -eq)	Land use (m ²)	Energy Use (MJ)	
Beef (15)	9-129	7-420		(Nijdam et al., 2012)
	30.5-33	92-113	78.6-92.6	Qantiss*
Mutton/lamb (4)	10-150	20-33		(Nijdam et al., 2012)
Pigs (8)	4-11	8-15		(Nijdam et al., 2012)
	9	16-18	16-19.6	Qantiss*
Poultry (4)	4.1-9	5-8		(Nijdam et al., 2012)
	2.3	9.5	26.6	Qantiss*
Eggs (1)	2.8	4.7		(Nijdam et al., 2012)
Impossible Burger	3.5	2.5		Qantiss*
Soybeans	2			Qantiss*
Pulses (2)	1-2	3-8		(Nijdam et al., 2012)
Cultured Meat	1.69 (19% protein)	0.2	26.64	(Tuomisto and Teixeira de Mattos, 2011)
	3.67 (19% protein)			(Tuomisto et al., 2014)
	7.5 (7% protein)	4		(Mattick et al., 2015)
	25 (7% protein)	4		(Mattick et al., 2015)
	4-25 (7-19% protein)	2-8	50-359	(Mattick, 2018)

There is a dramatic difference between the results of the cultured meat studies

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Tuomisto, H. L. and M. J. Teixeira de Mattos. 2011. Environmental Impacts of Cultured Meat Production. *Environmental Science & Technology* 45(14):6117-6123.

Acknowledgments: We thank ... Björn Lindh (New Harvest), Jason Matheny (Johns Hopkins University, New Harvest), and Prof. Mark J. Post (University of Maastricht) for commenting on the article. The project was funded by New Harvest (a nonprofit dedicated to cultured meat production).

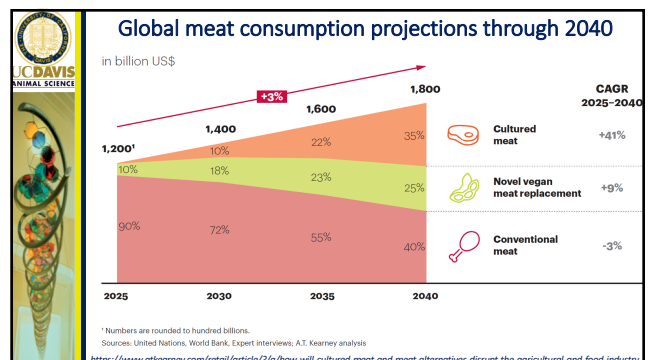
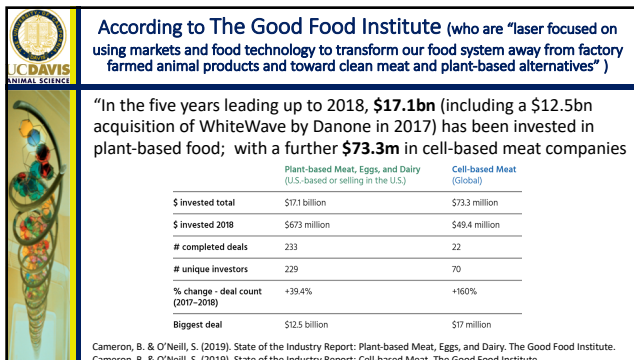
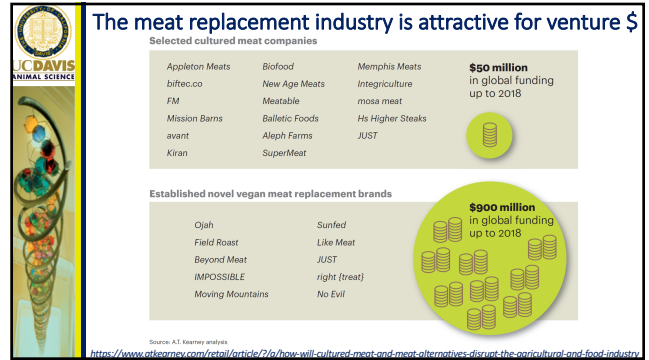
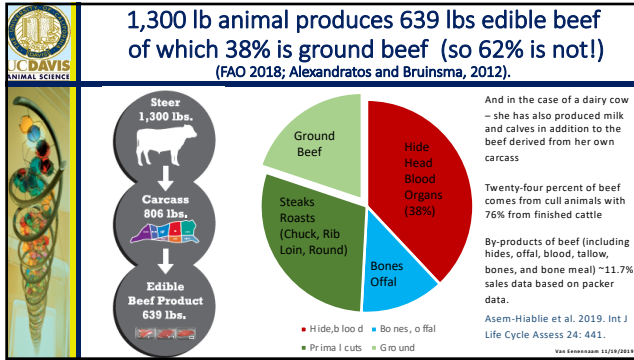
Mattick, C. S. 2018. Cellular agriculture: The coming revolution in food production. *Bulletin of the Atomic Scientists* 74:32-35.

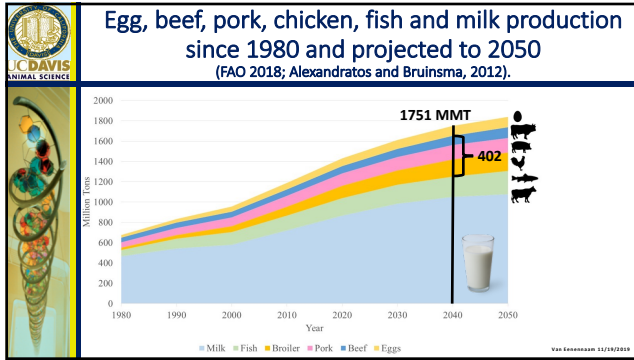
Acknowledgments: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. Carolyn S. Mattick is a science and technology policy fellow with the American Association for the Advancement of Science (AAAS).

Industrial Energy Use and Global Warming Potential

The functional unit (FU) of these analyses is kg of product

Mattick et al. 2015. Anticipatory Life Cycle Analysis of In Vitro Biomass Cultivation for Cultured Meat Production in the United States. *Environ Sci Technol* 49:11941-11949.





If by 2040 cultured meat will be 35% and vegan meat replacements will be 25% of global meat production then

So doing the simple math, and assuming that only the 402 MMT of land-based meat production is replaced with "quarter pounders" of the alternative source that would be $[(.25 \times 402 \text{ MMT}) \times (1,000,000,000/0.1133981)] =$

886,258,235,367 plant-based quarter pounders
(Eight hundred and eighty-six billion, two hundred and fifty-eight million, two hundred and thirty-five thousand, three hundred and sixty-seven)

and for the cultured meat the calculation is $(.35 \times 402 \text{ MMT}) \times (1,000,000,000/0.1133981) =$

1,240,761,529,514 cultured meat quarter pounders
(One trillion, two hundred forty billion, seven hundred and sixty-one million, five hundred and twenty-nine thousand, five hundred and fourteen)

by 2040 (~ 20 years)

Listing of companies formed to produce cellular animal-based products, and their location.

Company	Total Capital Raised	Location	Product
Alphaz Farms	??	Israel	Meat (beef)
Applied Meats	??	Canada	Meat (beef)
Augen	??	China	Meat (beef or porcine)
Baltic Foods	??	USA	Meat (beef or porcine)
Blue Nubi	\$4.5 million	USA	Food (beef)
Bluebird	??	Canada	Meat
BioFood Systems	??	Israel	Meat?
BioFuel Food	??	USA	Meat (beef)
Caldera Foods	\$1.8 million	Spain	Chicken (beef)
Cellular Foods	\$1.8 million	USA	Chicken (beef)
Cellular Meat Technologies	\$14 million by 2020 (venture)	Israel	Chicken (beef, pork)
Higher Steaks	??	United Kingdom	Beef
Incubate	??	Australia	Meat (beef or porcine)
InspiraMeat	\$2.7 million	Japan	Meat (beef or porcine)
JUST	\$230 million	USA	Meat (beef, pork, veal)
Kura Meats	\$2.5 million	USA	Meat
Meatable	\$2.5 million	Netherlands	Meat (general meat)
Memphis Meats	\$10.1 million + 22.55 from Tyson Ventures	USA	Meat (general meat)
Mission Farms	\$1.5 million	USA	Meat (general meat)
Modern Meats	??	USA	Meat
Mosa Meats	\$4.4 million	Netherlands	Meat
Meat Innovations	\$11.2 million	USA	Beef, pork, veal proteins
New Age Steaks	\$10 million	USA	Beef
Onco Culture	??	USA	Chicken
Perfect Day (Dana-He)	\$50.7 million	USA	Ice cream (beef protein)
SealSource	??	Canada	Meat
Shik Meats	??	Singapore	Meat
Supra Meat	\$4.2 million	Israel	Chicken
UPON	??	USA	Meat (general meat)
Wild Earth	\$4.5 million	Australia	Meat (beef for pet food)
Wild Type	\$1.5 million	USA	Meat (beef or porcine)

Jerusalem Post Hi tech news 10/10/2019
ISRAELI START-UP TO BUILD WORLD'S FIRST LAB-GROWN MEAT PRODUCTION FACILITY

Jerusalem biotechnology company **Future Meat Technologies** has announced it will establish the world's "first cultured meat pilot production facility," producing GMO-free meat cultivated directly from animal cells on a commercial scale.

The company plans to establish the facility south of Tel Aviv and begin operations next year. The expansion of research and development efforts come after the start-up secured **\$14 million** in a Series A funding round.

Future Meat Technologies EVP R&D Dr. Maria Shimon, founder and chief scientist Prof. Yoav Nahmias, and CEO Rom Kshuk. (photo credit: DUDI MOSKOVITZ)

<https://www.jpost.com/Israel-Start-up-to-build-worlds-first-lab-grown-meat-production-facility-604184>

Jerusalem Post Hi tech news 10/10/2019
ISRAELI START-UP TO BUILD WORLD'S FIRST LAB-GROWN MEAT PRODUCTION FACILITY

The company says its laboratory-based manufacturing model results in 99% less land use and 80% fewer greenhouse emissions than traditionally produced meat. The company plans to introduce hybrid products into the market, combining plant proteins for texture with cultured fats to create the aroma and flavor of meat.

While existing costs are \$150 per pound of chicken and \$200 per pound of beef, it aims to market its hybrid products at a "competitive cost level" from its pilot production facility by 2021.

This picture from the article had no caption...is it lab-grown meat or chicken?
<https://www.jpost.com/Israel-Start-up-to-build-worlds-first-lab-grown-meat-production-facility-604184>

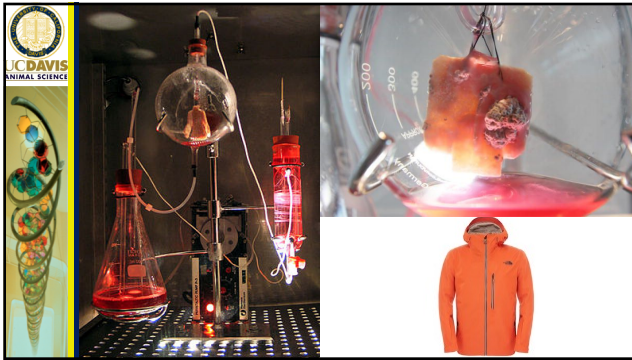
Jerusalem Post Hi tech news 10/10/2019
ISRAELI START-UP TO BUILD WORLD'S FIRST LAB-GROWN MEAT PRODUCTION FACILITY

The company's manufacturing process, during which fibroblast cells double in mass every 24 hours, enables the production of cell-grown chicken, lamb and beef within only two weeks.

The funding was led by Chicago-based venture capital firm S2G Ventures, a leading backer of successful meat substitute developer Beyond Meat, and Swiss venture capital firm Emerald Technology Ventures. They were joined by investors Henry Soesanto, the CEO of Philippine-based food manufacturer Monde Nissin; UK-based venture capital firm Manta Ray Ventures; and Chinese food and agriculture technology venture capitalist firm Bits x Bites.

"With this investment, we're thrilled to bring cultured meat from the lab to the factory floor and begin working with our industrial partners to bring our product to market," said Future Meat Technologies CEO Rom Kshuk.

<https://www.jpost.com/Israel-Start-up-to-build-worlds-first-lab-grown-meat-production-facility-604184>



Who's Buying?

Nobody yet.
However there is still money to be made (at least for the vegan burgers)

- **Beyond Meat** had its initial public offering May 2019, shares have ↑ ~ 8 fold in value
- July 29th, it had a secondary offering of 3.25 million shares only three months after its IPO.
- It was reported that shareholders plan to sell 3 million shares, while 250,000 shares will be offered by the company itself.
- Based on value of \$222.13 per share, the offering could raise \$721.9 million for Beyond.
- **Beyond CEO Ethan Brown** planned to sell 39,130 shares, which could net him **\$8.7 million**
- **CFO Mark Nelson** planned to sell 55,530 shares, potentially earning him **\$12.3 million**
- **Impossible Foods** has been valued a \$2 billion

Lucas, A. 2019. Beyond Meat posts mixed quarterly results, announces secondary share offering; stock dives. <https://www.cnbc.com/2019/07/29/beyond-meat-earnings-q2-2019.html>.

Ethan Brown
President & CEO of Beyond Meat

Pat Brown
Founder & CEO of Impossible Foods

LA-based vegan

Impossible Foods has 12 current team members, including Founder & CEO Patrick Brown

Ethan Brown President & CEO of Beyond Meat	Patrick Brown Founder & CEO SFO Bay Area	David Lee Chief Operating Officer & Chief Financial Officer
LA-based vegan	Mattie Casiro CO-Founder	Nick Heals Chief Strategy Officer
Dan Okami Head of Engineering	Jack Kossmann Head of Human Resources	Chris Davis R&D Director
Stephanie Lind SVP Global Sales	Chuck Math	Geray Shah
Mark Nelson	Danish Ajami	Neri L. Wittmann

How is it currently regulated?

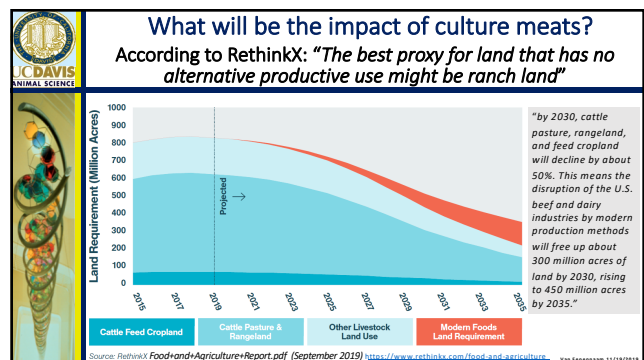
- FDA oversees cell collection, cell banks, and cell growth and differentiation
- Transition from FDA to USDA occurs during cell harvest stage
- USDA will then oversee the production and labeling of food products derived from the cells of livestock and poultry
- FDA also has a legal standard for what can be called "ice cream"
- Officially, ice cream must contain no less than 10% milk fat
- As **Perfect Day** ice cream products have none; they contain coconut oil and sunflower oil instead, to remain animal-free, and must therefore be labeled as a "frozen dairy dessert"

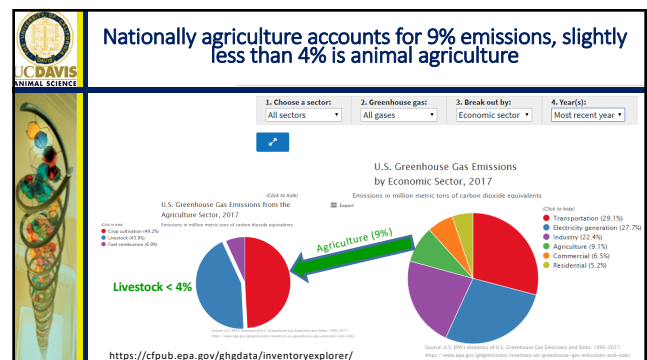
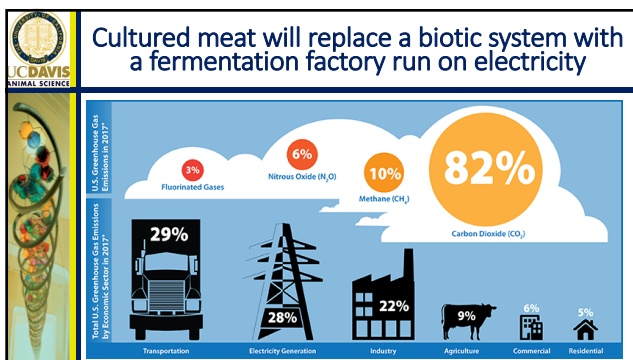
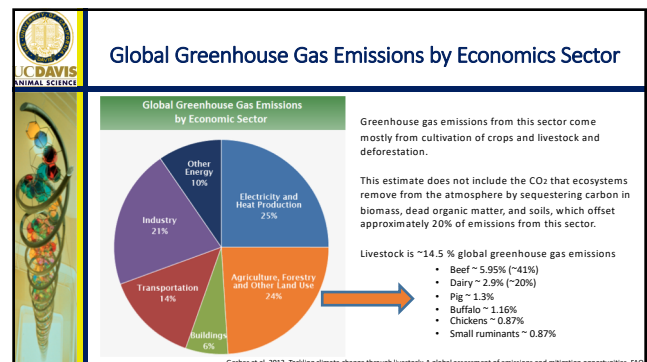
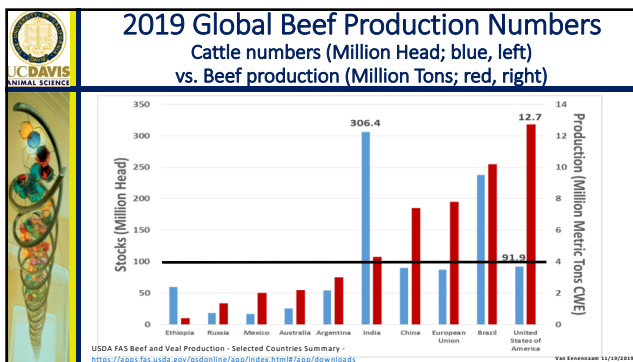
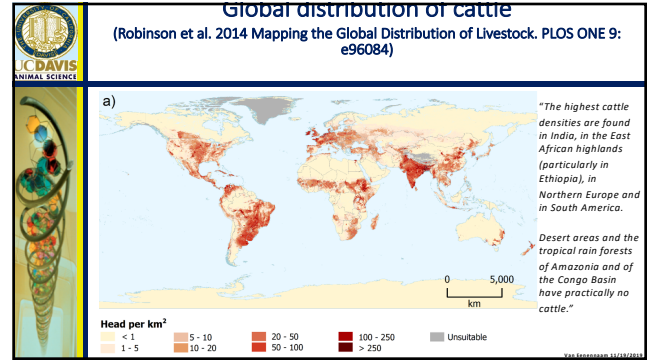
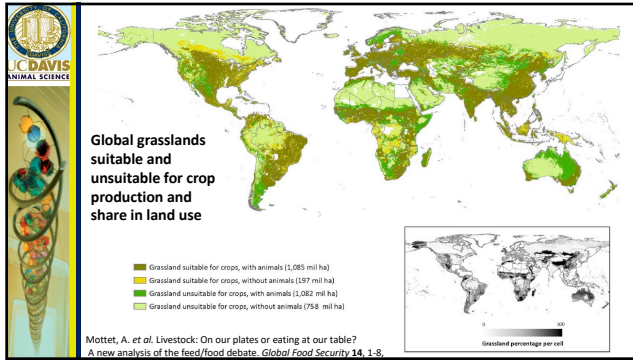
FDA. 2018. Statement from USDA Secretary Perdue and FDA Commissioner Gottlieb on the regulation of cell-cultured food products from cell lines of livestock and poultry. <https://www.fda.gov/news-events/press-announcements/statement-usda-secretary-perdue-and-fda-commissioner-gottlieb-regulation-cell-cultured-food-products>

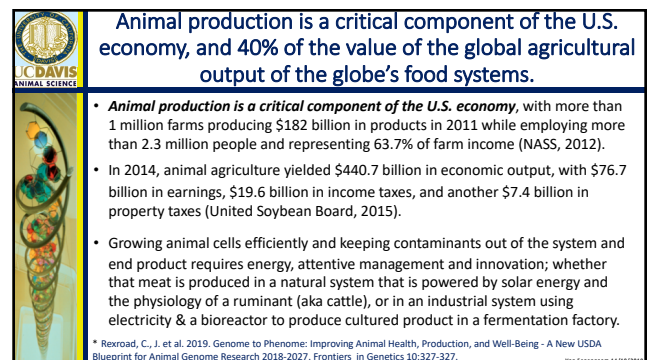
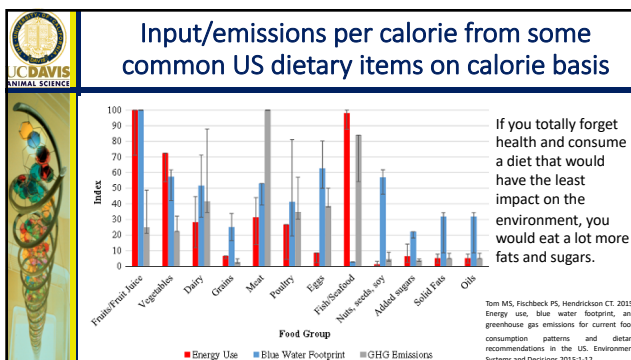
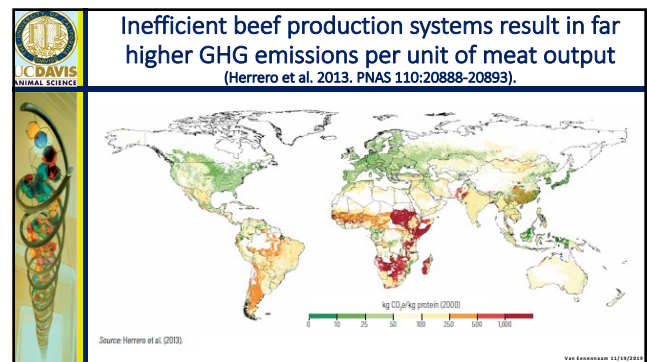
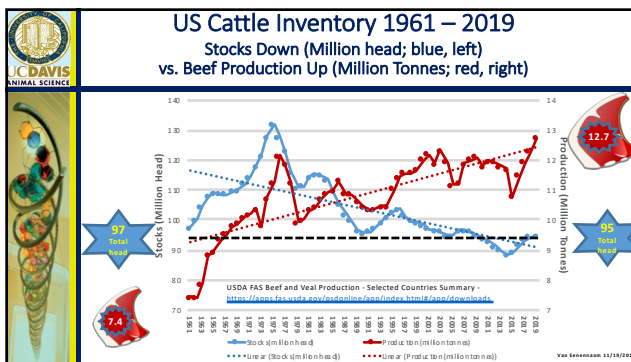
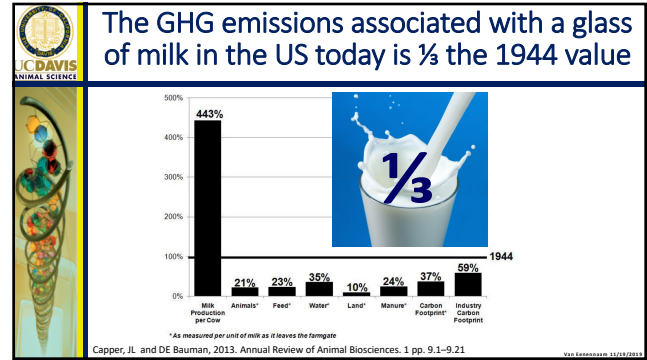
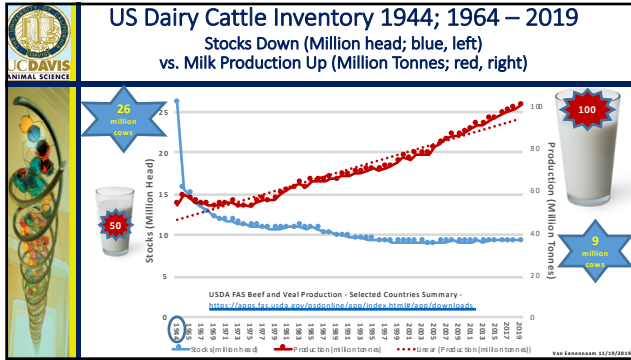
Perfect Day cofounders (Berkeley –based) Ryan Pandya and Perumal Gandhi

Cellular agriculture start-up Perfect Day – which is creating "vegan" dairy proteins without cows – raised \$24.7 million in a Series A funding round.


February 27, 2018 <https://www.foodnavigator-usa.com/Article/2018/02/27/Perfect-Day-raises-24.7m-in-Series-A-round-to-commercialize-animal-free-dairy-ingredients>







Thanks for inviting me!



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My laboratory receives public funding support from the National Institute of Food and Agriculture and the Biotechnology Risk Assessment Grant (BRAG) program, U.S. Department of Agriculture, under award numbers 2015-67015-23316, 2015-33522-24106, 2017-33522-27097, and 2018-67030-28360.



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