Food System of the Future

The Applied Interface of Technology and Science to Population, Public Health, and Planting

Roger Clemens, DrPH, CFS, CNS, FIFT, FACN, FIAFST

Adjunct Professor, USC School of Pharmacy

clemens@usc.edu

Chief Scientific Officer, Horn

rclemens@ethorn.com

HORN

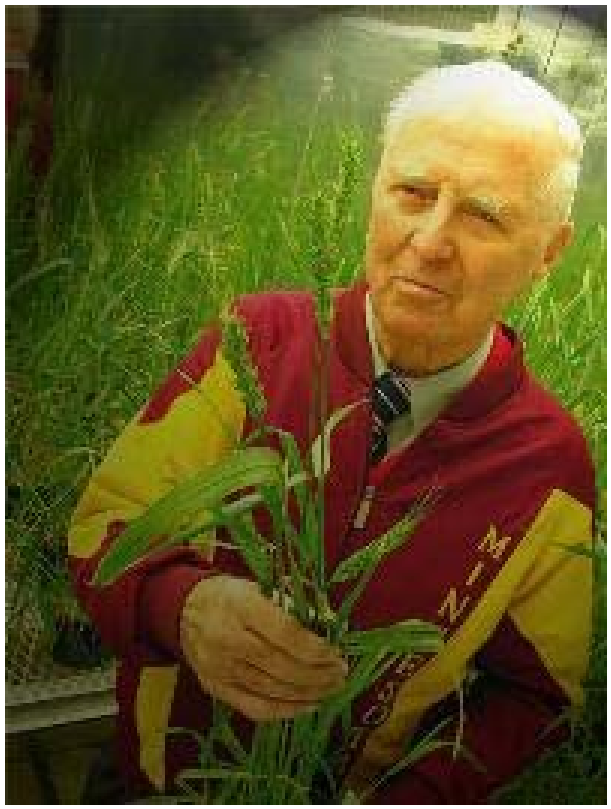
We orchestrate success.™

REGULATORYSCIENCE

UNIVERSITY OF SOUTHERN CALIFORNIA

USC Health Center Pharmacy

Dedication



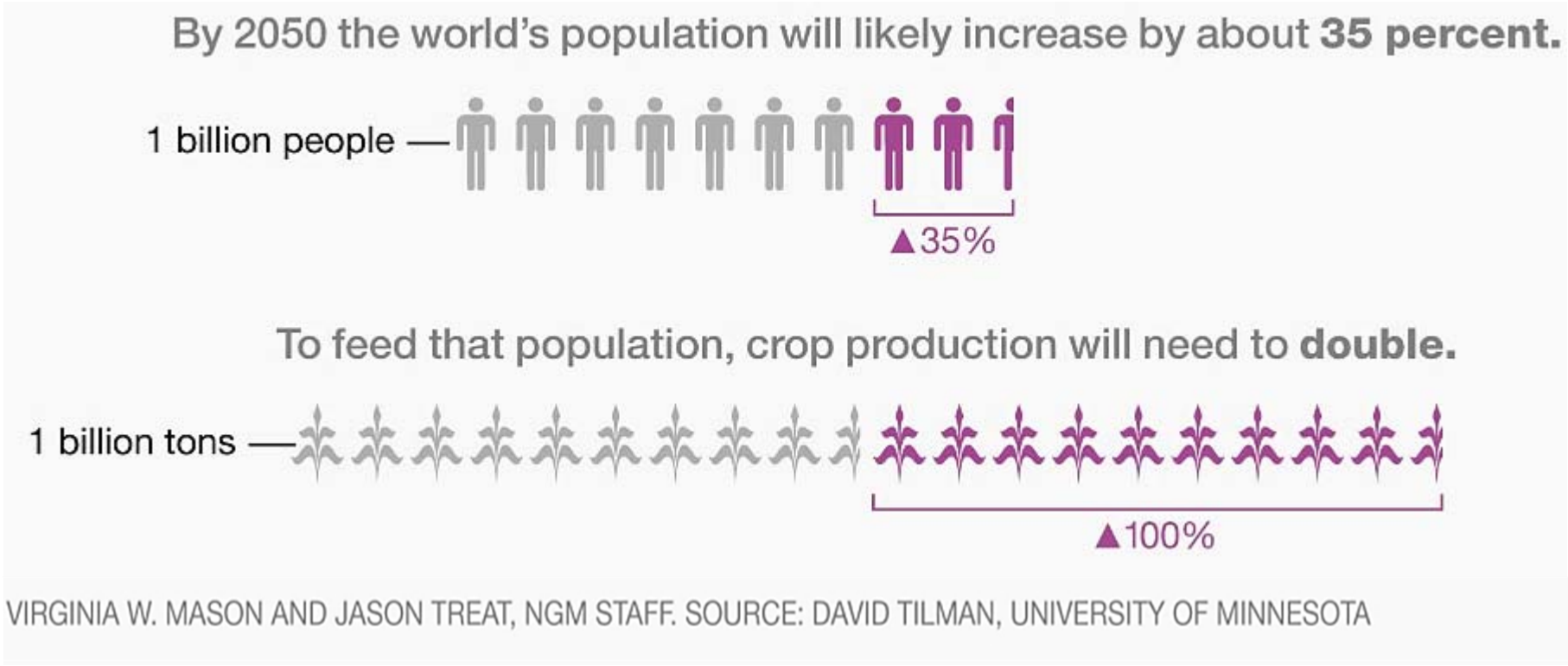
Norm Borlaug
March 25, 1914 – September 12, 2009

1. "There is no more essential commodity than food. Without food, people perish, social and political organizations disintegrate, and civilizations collapse."
2. "You can't eat potential." In other words, you haven't succeeded until you get new developments into the field and actually into people's bellies.
3. "It is easy to forget that science offers more than a body of knowledge and a process for adding new knowledge. It tells us not only what we know but **what we don't know**. It identifies areas of uncertainty and offers an estimate of how great and how critical that uncertainty is likely to be."

Benefits of Modern Food System

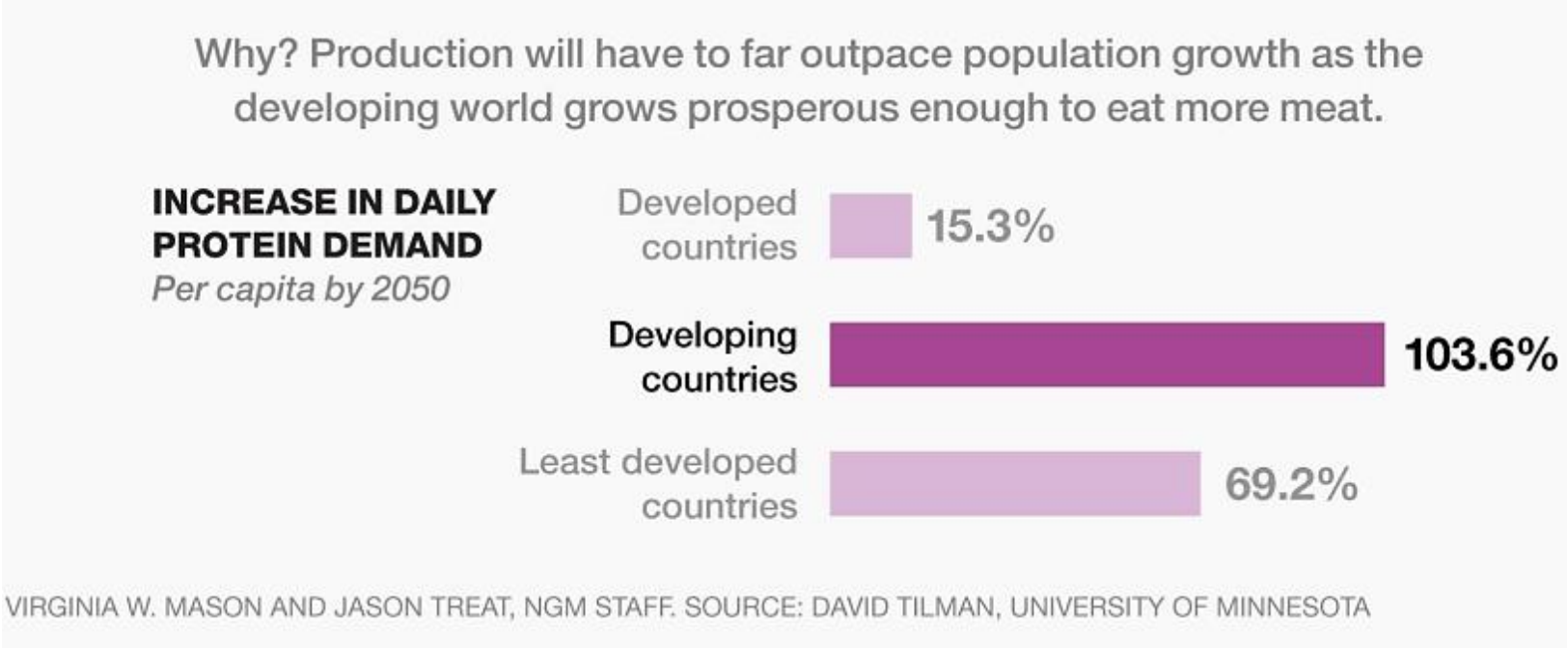
- Increased Food Availability
  - Decreased post-harvest losses → more food
  - Techniques: millings, grinding, canning, preserving, freezing and drying
- Safety and Freshness
  - Pasteurization (e.g., milk)
  - Packaging (reduces contamination)
  - Packaging atmospheres (e.g., MAP, CO_2)
- Convenience and Affordability
  - More food options → more affordability
- Variety and Choice
  - Expanded agriculture → improved nutrition (e.g., nutrient-dense)
- Improved Nutrition
  - Fortification and Enrichment (e.g., vitamin D, folic acid)
  - Reduced intolerances (e.g., gluten, lactose)

A World Demanding More



http://news.nationalgeographic.com/news/special-features/2014/04/140423-food-grown-london-underground-tunnels/

A World Demanding More



http://news.nationalgeographic.com/news/special-features/2014/04/140423-food-grown-london-underground-tunnels/

10 Projections for the Global Population in 2050

- The global population is getting older
- The world is graying faster than the U.S.
- Who will be among the oldest?
- Trading young for old
- Pressure on workers
- Population by 2050
- How big will the U.S. be?
- A population shift to Africa
- India replaces China as the world's most populous country
- Population losers

http://www.pewresearch.org/fact-tank/2014/02/03/10-projections-for-the-global-population-in-2050/
Posted February 3, 2014; Accessed March 27, 2014

Global Nutrition Challenge

Today, the global nutrition situation is a picture of extremes. Of fasting and feasting, of wasting, stunting, and obesity.

Dr Margaret Chan
WHO Director-General

At one end, undernutrition, and more specifically, deficiencies in essential nutrients, are the underlying cause of an estimated 3.5 million deaths each year, largely in young children and pregnant women.

At the other end, we have a global epidemic of obesity, increasingly starting in childhood. We have millions of people at increased risk of developing diet-related chronic diseases, like heart disease, cancer and diabetes.

Keynote address at the Pacific Health Summit, 2008

Immediacy

- Sustainability
- Resource management (land, water, energy)
- Cultivars compatible with climate dynamics
- Biodiversity
- Supply chain (e.g., grains, fish → price stability)
- Globalization of food supply
- R&D investment → New technology and innovation
- Political tension → unstable food supply
- Food security policy
- Poverty → Inadequate food → Decline physical and mental development
- Rural development → ↓ hunger

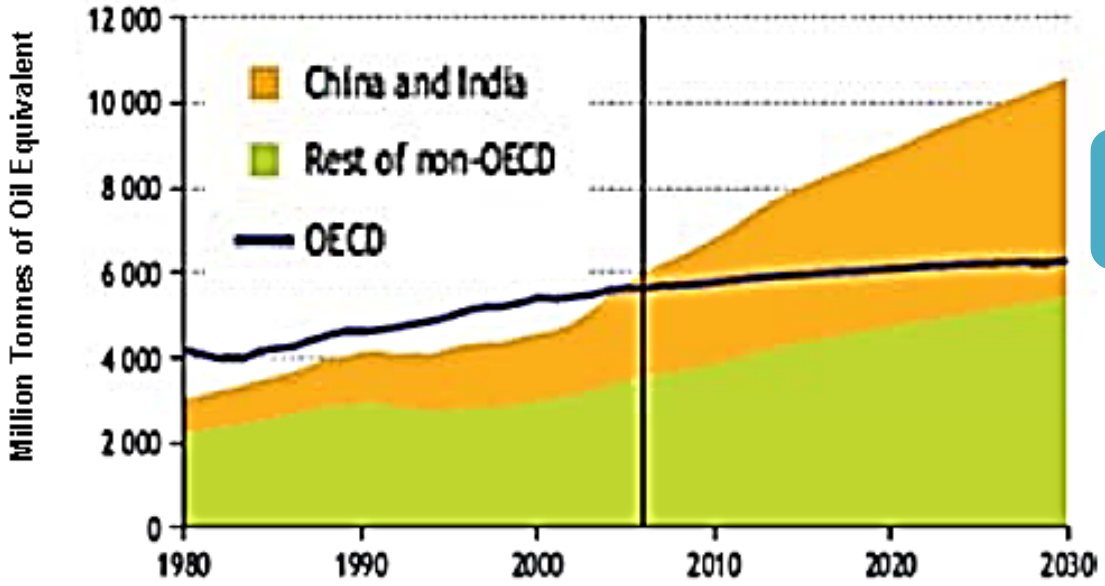
Food Security
A G20 PRIORITY

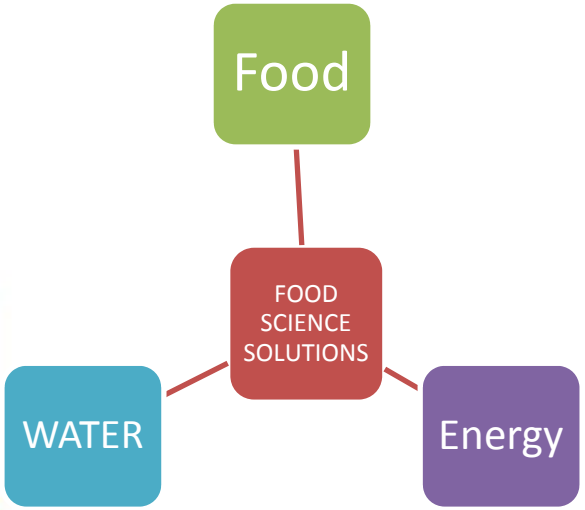
- Increase investment → 50% agricultural productivity by 2030
- Improve nutrition → nutritious, safe and affordable food
- Ensure sustainable practices (water, land, energy) → food security

http://www.iatp.org/files/Mexican%20G20-Food%20Security%20Discussion%20Paper.pdf
Accessed April 1, 2014

World Primary Energy Demands

Figure 2: World primary energy demand by region



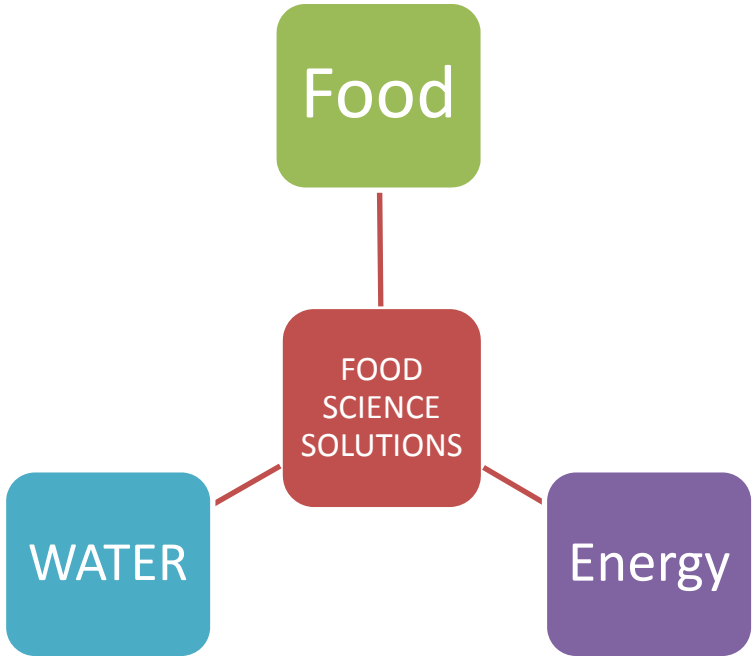


Energy demand in non-OECD is now greater than the OECD, predominantly in China and India (IEA 2008)

OECD: Organisation for Economic Co-operation and Development

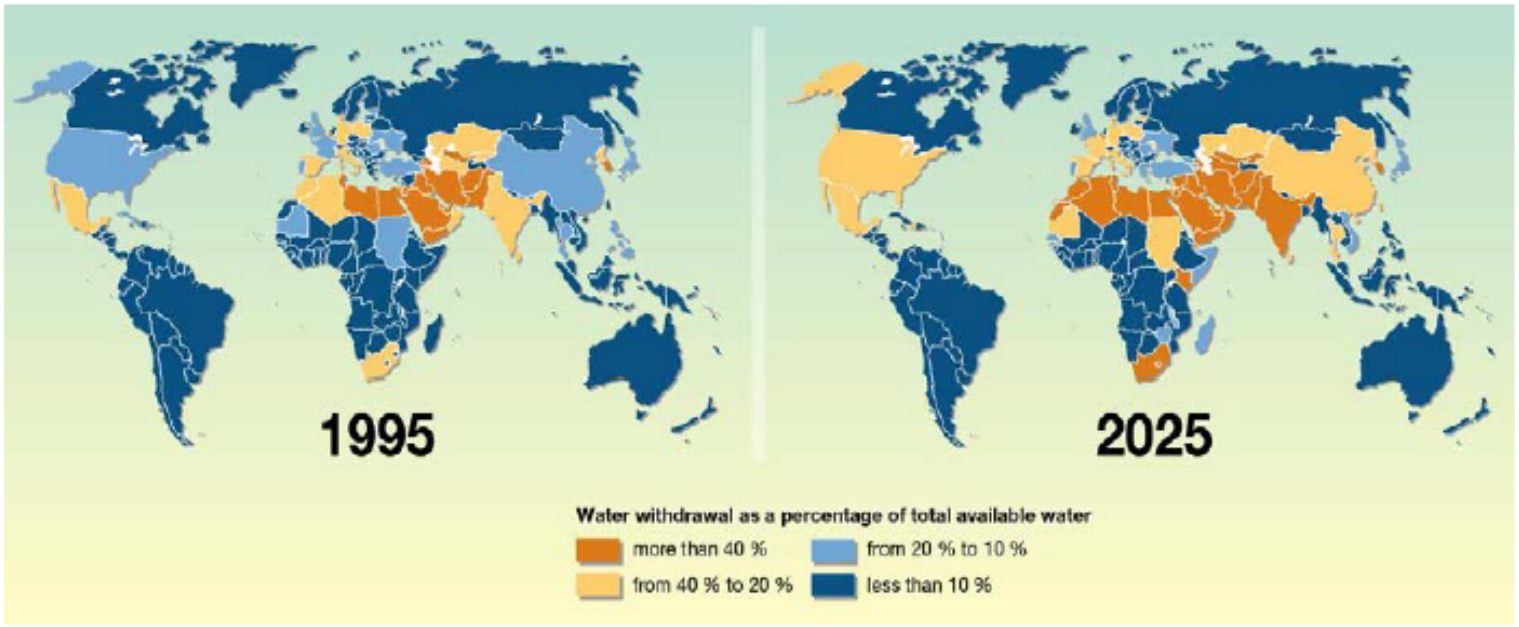
Water Scarcity

- 96% of water is salt water….68% of fresh water is glacier or polar ice
- Leaves < 0.01% available for consumption
- Irrigation consumes 70% of world's fresh water used
- 1 Kg of beef consumes 22,000 litres of water
- 175m Indians consume grain produced from water supplies that will soon run dry
- 2/3 of people could be water stressed by 2025
- 261 river basins are shared by more than one country



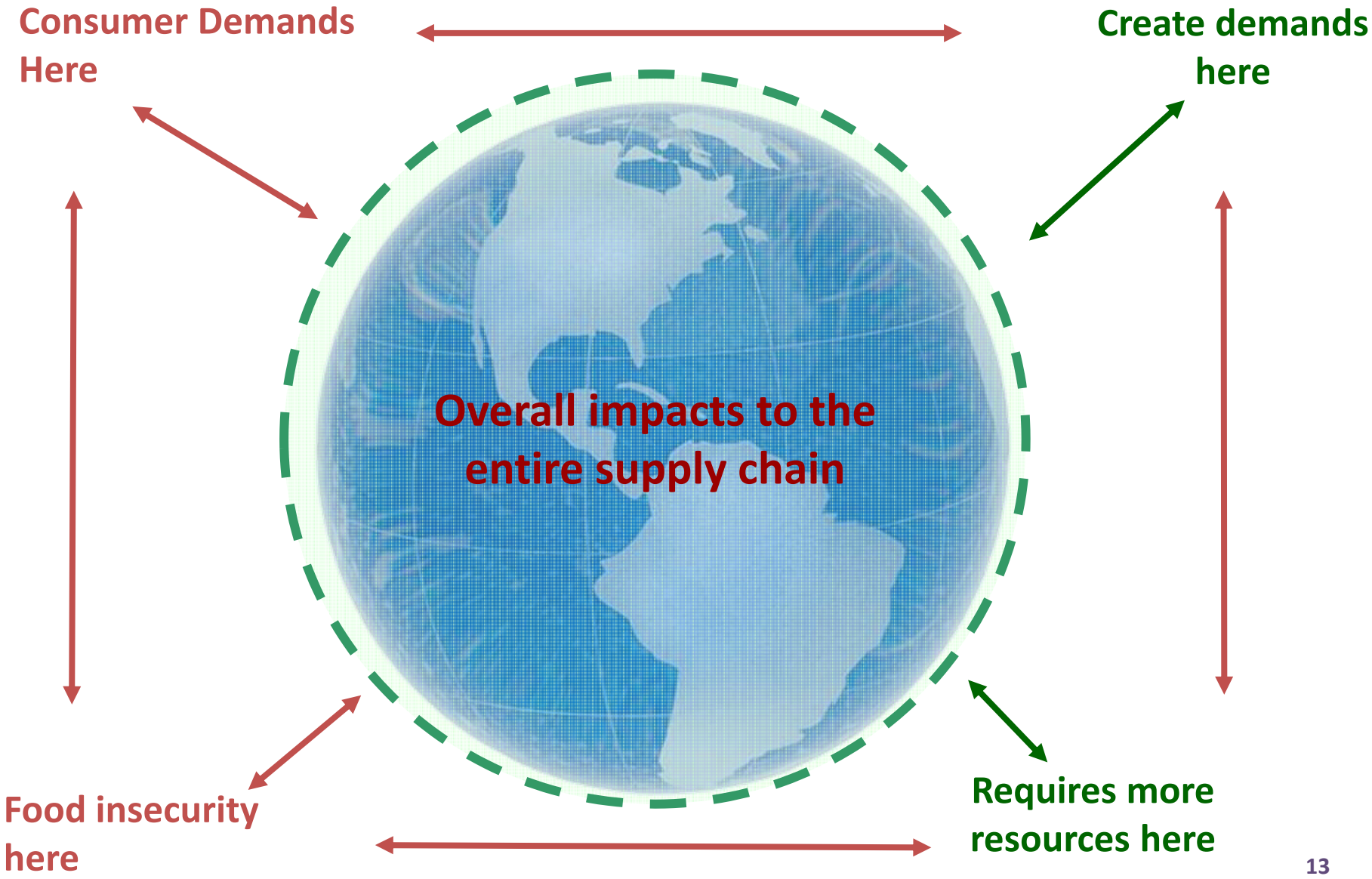
Predicted Water Scarcity and Stress

Figure 3: Predicted water scarcity and stress in 2025

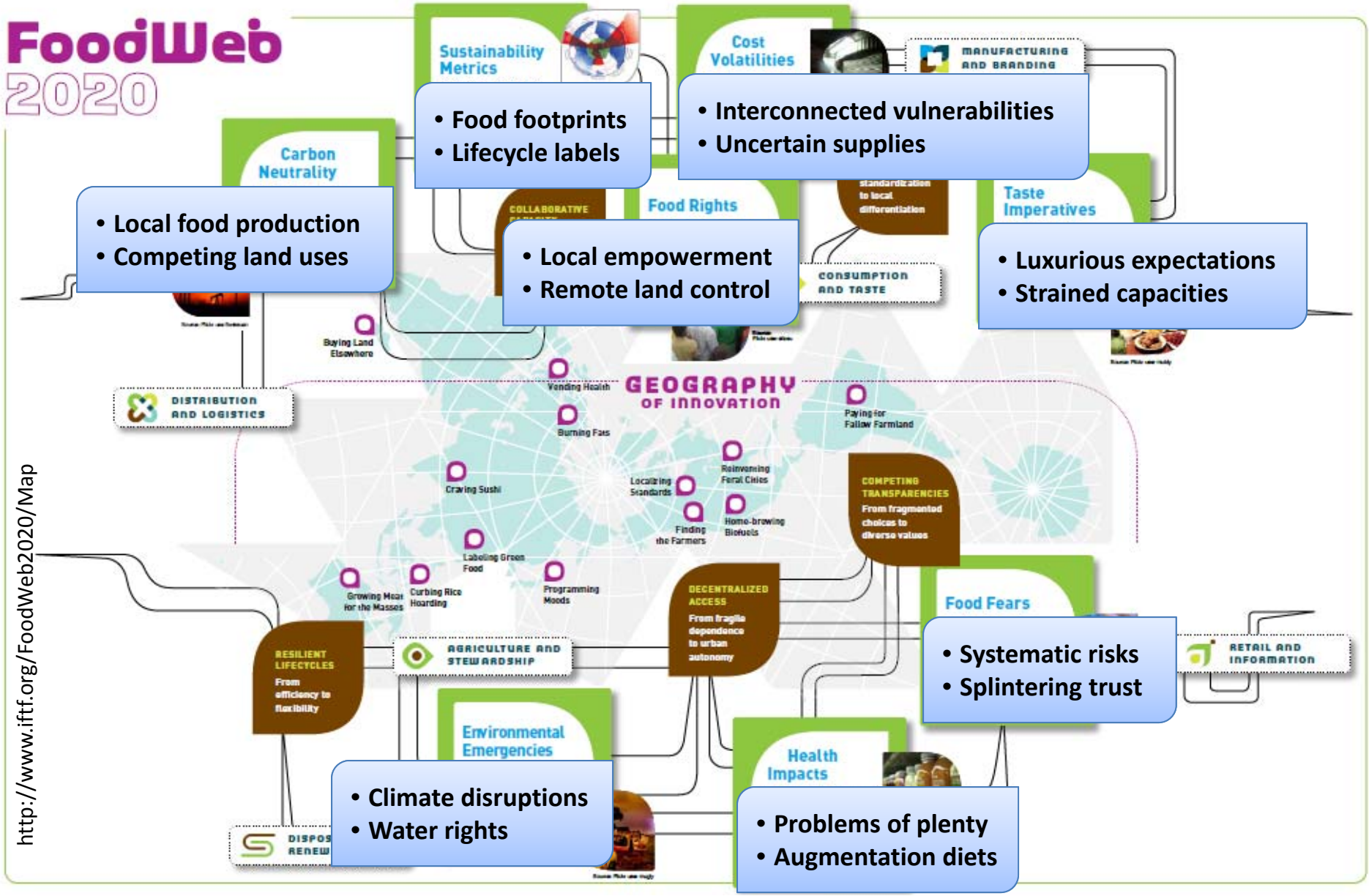


Water withdrawal is defined as the loss of water for some use by humans. (UNEP 2008)

Convergence in the Supply Chain

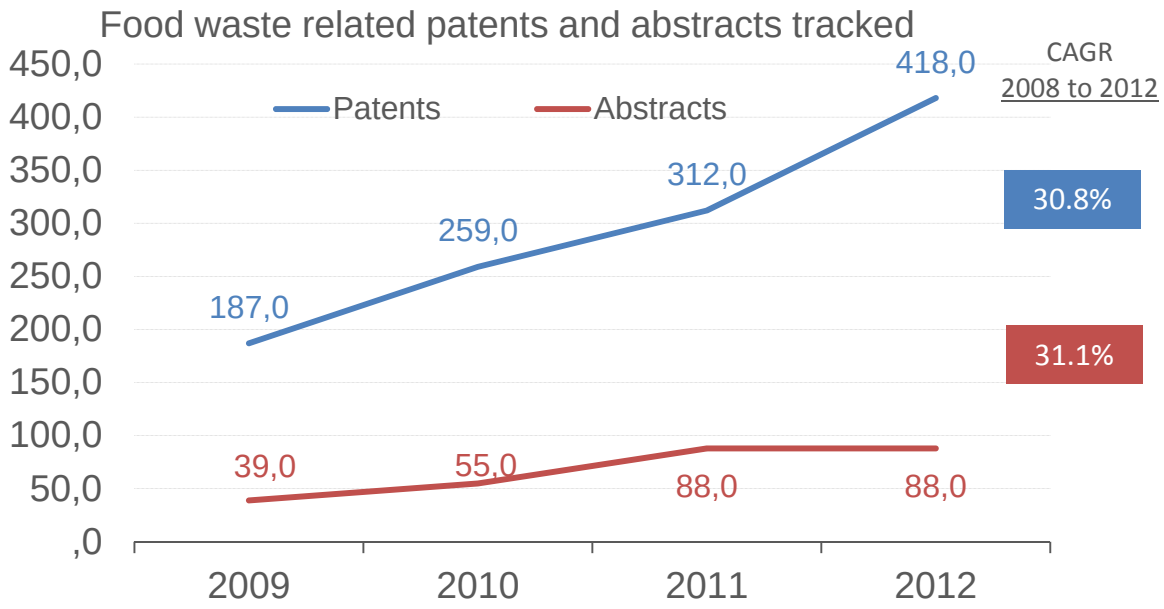


Eight Primary Disruptions & Future of Global Food Supply



Trend 1: Waste not want not

- The development of secondary markets for the reuse of food and by-product recycling with energy recovery will become the norm.
- Transit and packaging innovation will come to the fore to keep food fresher for longer, along with smaller pack availability.
- Waste “footprints” could become the next environmental measure for both big and small companies.



Patent and scientific article publications tracked with “food waste” and “food loss” has increased significantly in the last years.

INNOVA MARKET INSIGHTS

Trend 2- You can Trust Us...
How transparancy is displayed to gain trust

Traceability

Full traceability of ingredients.

Hongkong: Babynat Organic Apple & Blueberry Puree for Babies

No antibiotics

Pork raised without antibiotics.

Canada: Schneiders Country Naturals Maple Syrup Countryside Pork Sausage

Origin of the beef

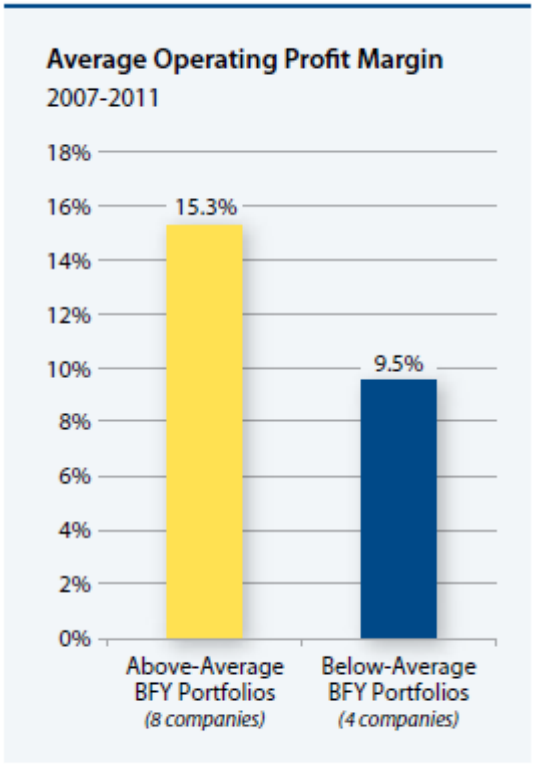
Beef origin: France

France: Letal Du Boucher 10 Haches Au Boeuf: 10 Beef Burgers

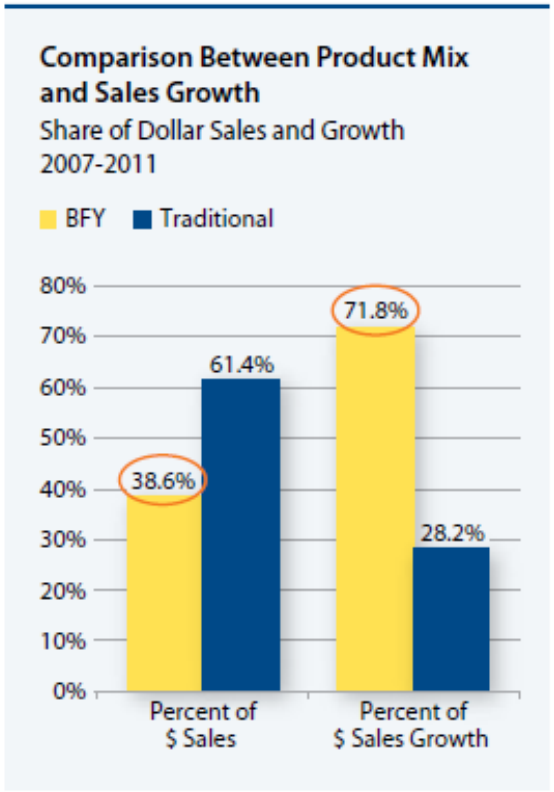
INNOVA MARKET INSIGHTS

Trend 3- Healthy Fast Food...
Consumer Demands "Better for You" (BFY) Food

- Companies that have a higher percentage of product sales in the BFY category perform better financially



Source: Nielsen Data and Company Annual Reports.
(Excludes beverage companies due to higher margin structure.)



Source: Nielsen Food, Drug and Mass Merchandiser sales tracking.

Source: Hudson Institute, **Better-For-You Foods: *It's Just Good Business, Oct 2011***
Innova Market Insights Presentation at Wellness13 Conference

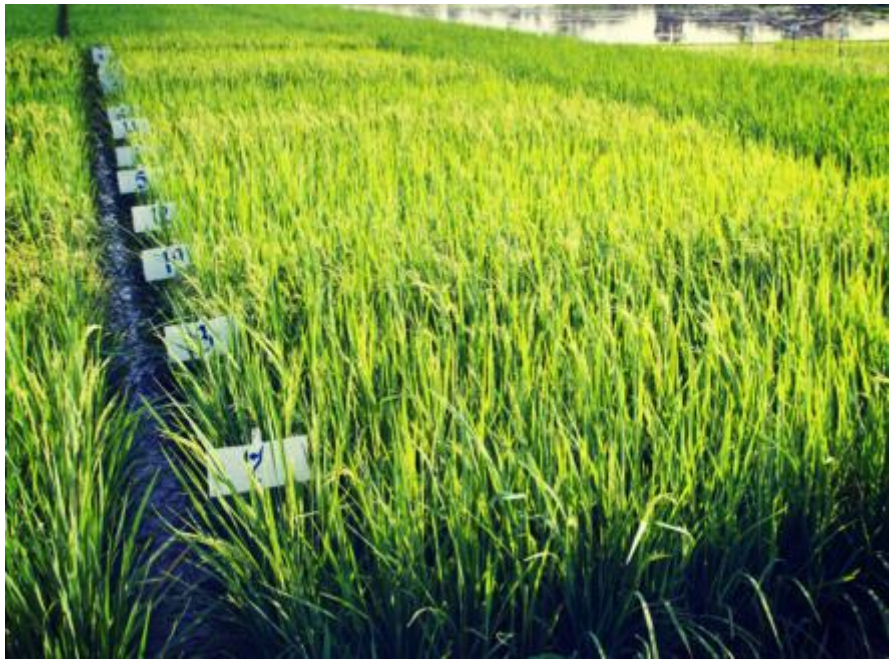
INNOVA MARKET INSIGHTS

World Without Food Science

World Without Food Science

https://www.youtube.com/watch?v=yhuaXO2A3Tk

Sowing Seeds For More Abundant Rice Crops



- Pam Ronald, PhD (UCDavis) and her team isolated and characterized the **Xa21** gene, which confers resistance to a common rice pathogen.
- They identified a gene called **Sub1** that helps rice plants resist flooding, which ruins 4 million tons of rice every year in Bangladesh and India.

- Marker-assisted breeding is a combination of traditional genetics and molecular biology. Scientists use molecular markers to find genes that are associated with a desired trait, such as flood resistance, and then introduce that trait into new strains through selective breeding.

Farming For Nutrition

- Geneticist M.S. Swaminathan, heralded as the father of India's Green Revolution and recipient of the first World Food Prize (1987), says it's time for the next step: greater agricultural productivity without ecological damage.
- Biofortification is the future; This is a process through which crops are bred to increase their nutritional value.

- In India, hunger presents in three forms:
  - inadequate food consumption or undernutrition
  - protein hunger (with half of the population vegetarian, unable to afford pulses; unwilling to purchase/consume eggs and dairy products)
  - micronutrient deficiencies (e.g., vitamin A, vitamin B12, iron, zinc and other nutrients)
- Future farmers will grow seeds that address the specific nutrition deficiencies of a population in an attempt to combat malnutrition and hunger.

Women Hold Key To Hunger Solutions

- “The single most important development [for combating hunger], if it was implemented worldwide, could be to educate girls.”
- “Even the immediate task of distributing food in developing countries can be more effective when women are taken into account.”

Catherine Bertini
2003 World Food Prize Laureate

The Brave New World of Meat Alternatives

- Current meat production is inefficient and environmentally unfriendly (water, land, feed)
- Ultimately consumers will be able to choose from a “meat case” meat at the supermarket

- Mark Post and a team of 20 researchers is on a two-year quest to create a better lab-grown manmade meat hamburger, an effort that is being funded by Sergey Brin, co-founder of Google.

Isha Datar
Executive Director,
New Harvest

Underground Farming
A New Way to Cultivate the Earth

- The world is running out of land.
- The world needs to uncover new places to produce food.
- Underground farming to container farms to rooftop gardens are being explored among the newest and most efficient ways to produce food for billions of people around the world.

One hundred feet below London, old World War II bomb shelters have been turned into a sustainable farm.
Daniel Stone,
National Geographic, April 2014

Food Science Research Designed to Boost Shelf Stability to Infinity and Beyond

- Food research for NASA's planned Mars mission in the 2030s is focused on extending shelf life for foods from 18 months to five years and developing systems to grow vegetables under low gravity so astronauts could supplement their rations and add vitamins and other nutrients to their meals on Mars.
- Two of the newest processes being studied
  - Pressure assisted thermal sterilization (PATS), where food is preheated to a specific temperature and then processed at high pressure.
  - Microwave assisted thermal sterilization (MATS), which can dramatically shorten the time needed to process in-package foods.

Michele Perchonok, PhD
NASA's Human Research Program Science Management Office, Houston, TX

3-D Food Printing Reaches for the Stars

- Theorized that cartridges of food ingredients could be inserted into a printer, similar to those used to produce ink-on-paper documents.
- A device would print out food ingredients layer by layer onto a heated printer bed that would cook the ingredients.
- 3-D devices could be used to print a variety of foods for space voyagers by mixing po
oil and fl
- NASA aw
t phase of the project.

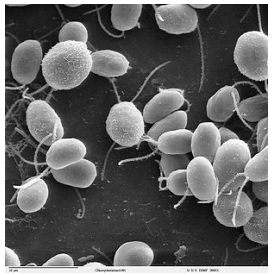
Anjan Contractor
Mechanical Engineer
Systems & Materials Research Corp,
Austin, TX

"… If we can store the [3-D printer] powdered food ingredients for a very long time, then why not utilize that for refugee camps where the food supply is a big issue?" —Anjan Contractor

Algae-based Vaccines

- Global: Infections → 25% of mortality
- Developing Countries: Most without vaccines
- Production: Costly (considerable R&D + regulatory hurdles)
- Administration: Inconsistent
- Green algae: *Chlamydomonas reinhardtii*
  - Genetically stable
  - Single chloroplast
  - Antigen production (e.g., malaria; reduce transmission [target surface proteins])
  - Reduced cost, administration ease, process (lyophilization) stable, storage stable

C. reinhardtii



a female
Anopheles mosquito

Plasmodium falciparum

Specht & Mayfield, Frontiers Microbiol 2014;5 (doi:10.3389/fmicb.2014.00060

Food Scientists Reflect on The Future

Future of Food Science

Today and in the future, the food system must be flexible and resilient, consumer driven, and sustainable, and it must secure the environment and natural resources and assure the health and wellness of an increasing number of consumers.

Floros et al., Comp Rev Food Sci Food Safety 2010