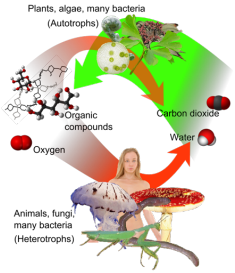
ANBI 141 Evolution of the Human Diet

Lecture 18: The Future of Food

Pascal Gagneux December 2, 2021

All food ultimately from plants!

autotroph
photosynthesis:
air plus water + light = food



heterotroph
digestion:
sugar, fat, protein +
air + water =
building blocks and energy

Animals as highly concentrated plants? Animals as outside-in plants that move about the landscape eating plants or other animals that eat plants?
Like animals, plants also use sugars and fats as energy sources for their metabolism, unlike animals, plants can make these themselves via photosynthesis from water CO2 and sunlight.

Life Processes plus human culture =

Cyclical use of carbon, oxygen, water and energy.

Plants use solar energy to synthesize organic matter, which together with trace elements form the basis of the food web.

Both plants and animal use energy to grow, feed and reproduce.

Human culture has come to massively complicate these basic relationships.

~ 200,000 years to reach 1billion people
~ 200 years to reach 7 billion!

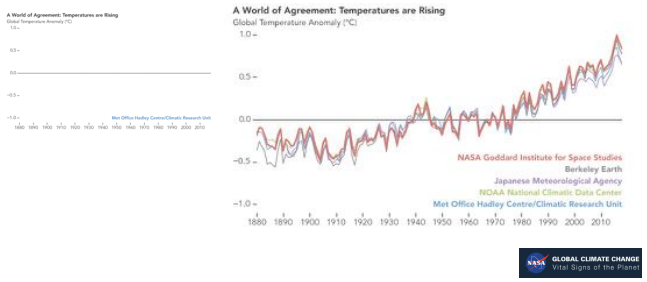
Practice question: How long did it take our human population to go from one billion to 7 billion?
~200 years.

The weather forecast

Hot, crowded, and increased chances of extreme weather events!

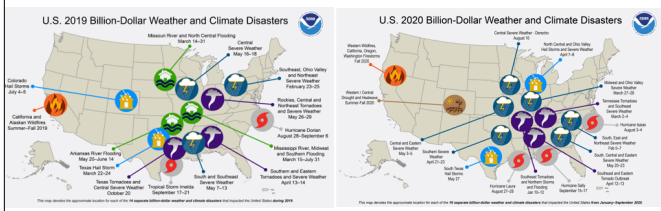
Imagine there are no people. Imagine a planet where the sea level is about five to 40 meters (16 to 131 feet) higher than normal. Imagine a planet that is hotter and wetter. Imagine, worldwide, it's roughly 3 to 4 degrees Celsius (5.4 to 7.2 degrees Fahrenheit) warmer than today. And the North and South poles are even warmer still – as much as 10 degrees Celsius (18 degrees Fahrenheit) hotter than today.
Welcome to the Pliocene. That was the Earth about three to five million years ago, very different to the Earth we inhabit now. But in at least one respect it was rather similar. This is the last time that carbon dioxide (CO2) levels were as high as they are today.
On May 9, 2013, CO2 levels in the air reached the level of 400 parts per million (ppm). This is the first time in human history that this milestone has been passed.

Temperatures Raising



Temperature data showing rapid warming in the past few decades, the latest data going up to 2018. According to NASA data, 2016 was the warmest year since 1880, continuing a long-term trend of rising global temperatures. The 10 warmest years in the 139-year record all have occurred since 2005, with the five warmest years being the five most recent years. Credit: NASA's Earth Observatory.

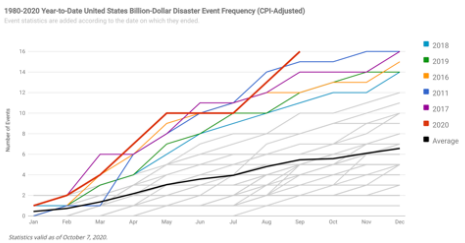
Number of Billion-Dollar Disasters



In 2019 (as of October 8), there have been 10 weather and climate disaster events with losses exceeding $1 billion each across the United States. These events included 3 flooding events, 5 severe storm events, and 2 tropical cyclone events. Overall, these events resulted in the deaths of 39 people and had significant economic effects on the areas impacted. The 1980–2018 annual average is 6.3 events (CPI-adjusted); the annual average for the most recent 5 years (2014–2018) is 12.6 events (CPI-adjusted).

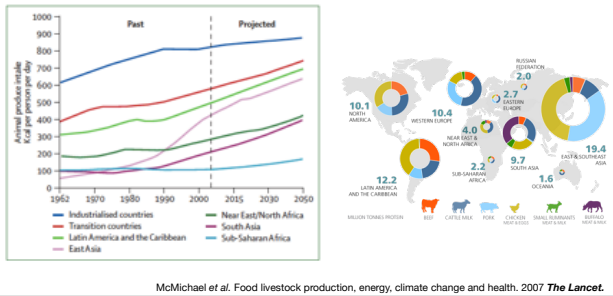
The first 9 months of 2020 ties the annual record of 16 events that occurred in 2011 and 2017. 2020 is the sixth consecutive year (2015-2020) in which 10 or more billion-dollar weather and climate disaster events have impacted the United States. Over the last 41 years (1980-2020), the years with 10 or more separate billion-dollar disaster events include 1998, 2008, 2011-2012, and 2015-2020.

Extreme weather events



2019 is the fifth consecutive year (2015-2019) in which 10 or more billion-dollar weather and climate disaster events have impacted the United States. Over the last 40 years (1980-2019), the years with 10 or more separate billion-dollar disaster events include 1998, 2008, 2011-2012, and 2015-2019.

Trends in consumption of livestock products per person

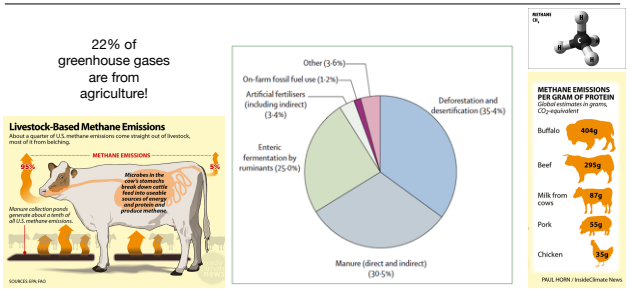


McMichael *et al.* Food livestock production, energy, climate change and health. 2007 ***The Lancet.***

Trends in consumption of livestock products per person (milk, eggs, and dairy products, excluding butter).
The projected trends assume no policy-induced change from present consumption. Note the rapid recent increase in east Asia, dominated by China, where per-head meat consumption would reach European levels by mid-century. Cultural, agricultural, and political factors will determine how the composition of animal products intake actually changes in the future. For example, in the near east and in north Africa, higher intake of milk, eggs, and poultry are likely, whereas greater consumption of beef and poultry is expected to dominate the increase in Latin America. Reproduced from FAO,42 with permission.

Regional production. Regional total production and their profile by commodity are shown. Meat production in protein basis was calculated by using data on dressing percentages, carcass to bone-free meat and average bone-free meat protein content. Milk from all species was converted into fat and protein corrected milk. Eggs production is also expressed in protein terms.

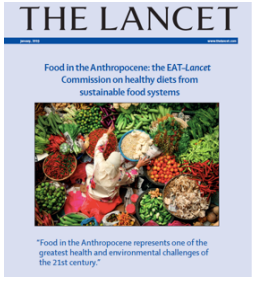
Green House Gas emission from livestock



McMichael *et al.* Food livestock production, energy, climate change and health. 2007 ***The Lancet.***

Proportion of greenhouse-gas emissions from different parts of livestock production
Adapted from FAO.42
Practice question: What proportion of green house gases comes from agriculture?
Answer: >20%.

Food for the Anthropocene: the EAT-*Lancet* Commission



Willett W. *et al.* 2019 Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems ***The Lancet***

Healthy reference diet, with possible ranges, for an intake of 2500 kcal/day

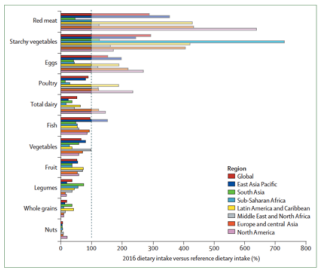
	Macronutrient intake (possible range), g/day	Caloric intake, kcal/day
Whole grains*		
Rice, wheat, corn, and other†	232 (total gains 0–60% of energy)	811
Tubers or starchy vegetables		
Potatoes and cassava	50 (0–100)	39
Vegetables		
All vegetables	300 (200–600)	..
Dark green vegetables	100	23
Red and orange vegetables	100	30
Other vegetables	100	25
Fruits		
All fruit	200 (100–300)	126
Dairy foods		
Whole milk or derivative equivalents (eg, cheese)	250 (0–500)	153

	Macronutrient intake (possible range), g/day	Caloric intake, kcal/day
Protein sources‡		
Beef and lamb	7 (0–14)	15
Pork	7 (0–14)	15
Chicken and other poultry	29 (0–58)	62
Eggs	13 (0–25)	19
Fish§	28 (0–100)	40
Legumes		
Dry beans, lentils, and peas*	50 (0–100)	172
Soy foods	25 (0–50)	112
Peanuts	25 (0–75)	142
Tree nuts	25	149
Added fats		
Palm oil	6·8 (0–6·8)	60
Unsaturated oils¶	40 (20–80)	354
Dairy fats (included in milk)	0	0
Lard or tallow‖	5 (0–5)	36
Added sugars		
All sweeteners	31 (0–31)	120

Willett W. *et al.* 2019 Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems ***The Lancet***

For an individual, an optimal energy intake to maintain a healthy weight will depend on body size and level of physical activity. Processing of foods such as partial hydrogenation of oils, refining of grains, and addition of salt and preservatives can substantially affect health but is not addressed in this table.
*Wheat, rice, dry beans, and lentils are dry, raw.
†Mix and amount of grains can vary to maintain isocaloric intake.
‡Beef and lamb are exchangeable with pork and vice versa. Chicken and other poultry is exchangeable with eggs, fish, or plant protein sources. Legumes, peanuts, tree nuts, seeds, and soy are interchangeable.
§Seafood consist of fish and shellfish (eg, mussels and shrimps) and originate from both capture and from farming. Although seafood is a highly diverse group that contains both animals and plants, the focus of this report is solely on animals. ¶Unsaturated oils are 20% each of olive, soybean, rapeseed, sunflower, and peanut oil. ||Some lard or tallow are optional in instances when pigs or cattle are consumed.

The Diet Gap



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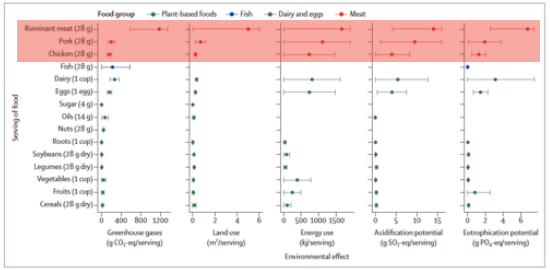
Diet gap between dietary patterns in 2016 and reference diet intakes of food Data on 2016 intakes are from the Global Burden of Disease database. The dotted line represents intakes in reference diet (table 1).

Practice question: What is the diet gap?

Answer: The gap between what people eat and what they should eat under a balanced, healthy, and sustainable diet.

Environmental effects per serving of food produced



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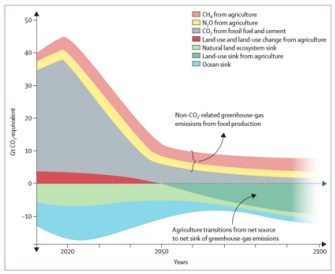
Environmental effects per serving of food produced. Bars are mean (SD).5,216 Some results are missing for fish due to lack of data for some impact categories (eg, land use stemming from plant-based feeds in aquaculture). This was, however, accounted for in the global food systems modeling framework used in Section 3. CO2=carbon dioxide. Eq=equivalent. PO4=phosphate. SO2=sulphur dioxide.

Global Emissions Projections



to keep global warming to well below 2°C, aiming for 1·5°C

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Projections of global emissions to keep global warming to well below 2°C, aiming for 1·5°C
Data are from Intergovernmental Panel on Climate Change fifth assessment report (RCP2.6 data for nitrous oxide and methane) and Rockstr.m and colleagues (for fossil-fuel emissions, land use, land-use change, and forestry, and biosphere carbon sinks).

Key messages of the EAT-*Lancet* Commission

1 **Unhealthy and unsustainably produced food poses a global risk to people and the planet.** More than 820 million people have insufficient food and many more consume an unhealthy diet that contributes to premature death and morbidity. Moreover, global food production is the largest pressure caused by humans on Earth, threatening local ecosystems and the stability of the Earth system.

2 **Current dietary trends, combined with projected population growth to about 10 billion by 2050, will exacerbate risks to people and planet**. The global burden of non-communicable diseases is predicted to worsen and the effects of food production on greenhouse-gas emissions, nitrogen and phosphorus pollution, biodiversity loss, and water and land use will reduce the stability of the Earth system.

3 **Transformation to healthy diets from sustainable food systems is necessary** to achieve the UN Sustainable Development Goals and the Paris Agreement, and scientific targets for healthy diets and sustainable food production are needed to guide a Great Food Transformation.

4 **Healthy diets** have an appropriate caloric intake and consist of a diversity of plant-based foods, low amounts of animal source foods, unsaturated rather than saturated fats, and small amounts of refined grains, highly processed foods, and added sugars.

5 **Transformation to healthy diets by 2050 will require substantial dietary shifts,** including a greater than 50% reduction in global consumption of unhealthy foods, such as red meat and sugar, and a greater than 100% increase in consumption of healthy foods, such as nuts, fruits, vegetables, and legumes. However, the changes needed differ greatly by region.

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Key messages of the EAT-*Lancet* Commission cont'd

6 **Dietary changes from current diets to healthy diets are likely to substantially benefit human health**, averting about 10.8–11.6 million deaths per year, a reduction of 19.0–23.6%.

7 **With food production causing major global environmental risks, sustainable food production needs to operate within the safe operating space for food systems at all scales on Earth.** Therefore, sustainable food production for about 10 billion people should use no additional land, safeguard existing biodiversity, reduce consumptive water use and manage water responsibly, substantially reduce nitrogen and phosphorus pollution, produce zero carbon dioxide emissions, and cause no further increase in methane and nitrous oxide emissions.

8 **Transformation to sustainable food production by 2050** will require at least a 75% reduction of yield gaps, global redistribution of nitrogen and phosphorus fertiliser use, recycling of phosphorus, radical improvements in efficiency of fertiliser and water use, rapid implementation of agricultural mitigation options to reduce greenhouse-gas emissions, adoption of land management practices that shift agriculture from a carbon source to sink, and a fundamental shift in production priorities.

9 T**he scientific targets for healthy diets from sustainable food systems are intertwined with all UN Sustainable Development Goals**. For example, achieving these targets will depend on providing high-quality primary health care that integrates family planning and education on healthy diets. These targets and the Sustainable Development Goals on freshwater, climate, land, oceans, and biodiversity will be achieved through strong commitment to global partnerships and actions.

10 **Achieving healthy diets from sustainable food systems for everyone will require substantial shifts towards healthy dietary patterns, large reductions in food losses and waste, and major improvements in food production practices.** This universal goal for all humans is within reach but will require adoption of scientific targets by all sectors to stimulate a range of actions from individuals and organisations working in all sectors and at all scales.

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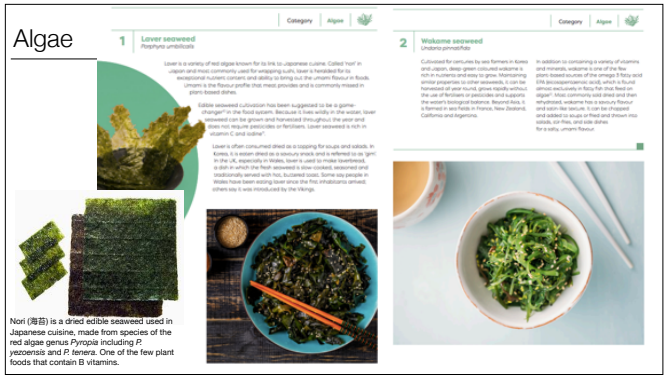
Unlikely allies?

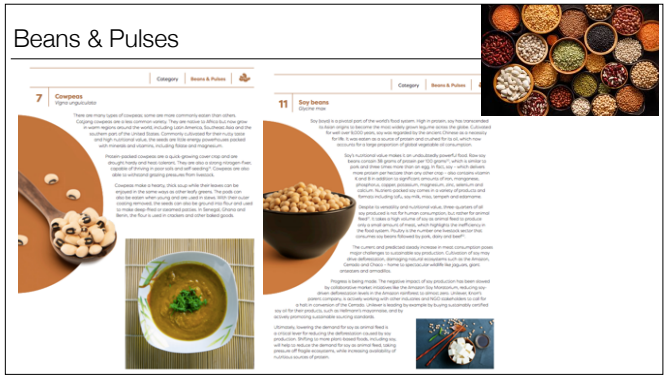
Knorr owned by Nestlé and the Worldwide Fund for Nature have formed an alliance to explore future crops.

Algae

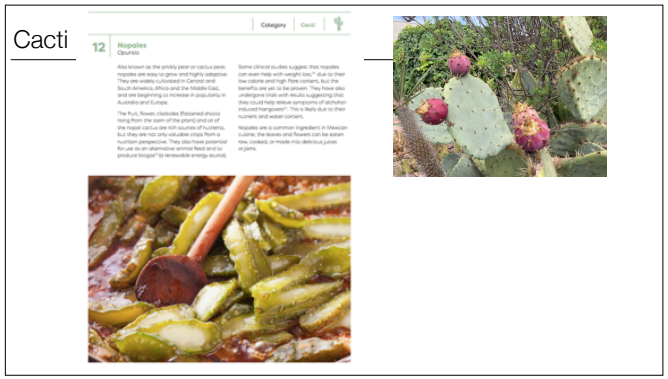


Nori (海苔) is a dried edible seaweed used in Japanese cuisine, made from species of the red algae genus *Pyropia* including *P. yezoensis* and *P. tenera*. One of the few plant foods that contain B vitamins.

Beans & Pulses



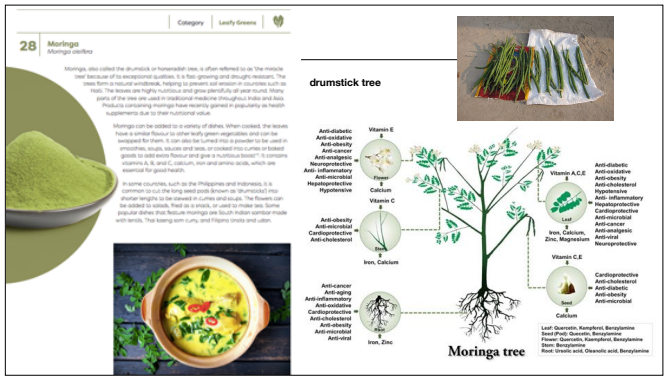
Cacti



Because plants are non-mobile, they have evolved numerous chemical adaptations for protection against predators and diseases—sweet rewards to animals who disperse their seeds (eg, fruits and berries) or providing their offspring with large energy stores for germination and growth (eg, seeds and nuts). These adaptions are the source of the diverse nutritional values of plant foods. Consuming a diversity of fresh fruits and vegetables, whole grains, seeds, and nuts is an important part of a healthy diet, benefiting from this evolutionary history and resultant diversity. However, of more than 14 000 edible plant species, only 150–200 are used by humans withonly three (rice, maize, and wheat) contributing 60% of the calories consumed by humans. Many underused plant species have excellent nutritional profiles, as well as traits of interest for adapting food production to climate change (ie, quinoa, millet, sorghum, or teff for grains, or zapote (fruit tree) , chaya (tree spinach), or chenopodes (spinach family including amaranth) for fruits and legumes). These qualities are especially important considering the increasing risk that climate change will pose on crop yields and the nutritional content of foods. However, food system simplification drives loss of these plant species and varieties, reducing options that support healthy diets from sustainable food

systems.

Grains



Moringa tree

Practice question: What is the Moringa tree?

Answer: Drumstick tree, a fast growing and drought resistant subtropical tree from the Indian subcontinent that produces many edible pots: leaves, seeds, and flowers.

sprouts

Practice question: What is the nutritional advantage of eating sprouted seeds?
The young sprouting plants contain new vitamins and proteins not present in the dormant seed..

Future Foods

Bugs

One future food that's sure to take some getting used to will be insects, like crickets, grasshoppers and mealworms. You can already buy pasta and food bars made with cricket flour to add some extra protein into meals, our you can eat the crickets whole. 100-gram servings of crickets and grasshoppers amount to around 13 and 21 grams of protein, respectively. Others are exploring mealworms and black soldier flies as a source of dietary fat.
The debate continues over how much more environmentally-friendly bugs are than meat—a study from last year found that crickets fed low-quality diets didn't grow nearly as large as those fed higher-quality diets akin to what farmers feed livestock. The black soldier fly did not suffer this same issue, and produced protein more efficiently.
Insects supposedly taste pretty good when prepared properly, reports the New York Times. But broader acceptance will probably require overcoming our cultural taboos. Around two billion people already snack on arthropods, so why not join them?

Golden bananas

Provitamin A

Just last year, researchers from Australia showcased a banana with high levels of provitamin A, an important nutrient not normally present in the fruit. To create this fruit, the researchers snipped out genes from a specific type of Papua New Guinean banana that's naturally high in provitamin A, then inserted them into the common banana variety.

Food for the aging population

Nursing homes in Germany serve 3D-printed smoothfood

Biozoon prints out gourmet-looking food for seniors who need to eat purified meals. ZMorph and Choc Edge can print out chocolate in whatever forms the user wants. In 2013, NASA's food printer has printed a proof–of–concept thin pizza that baked in 70 seconds after printing. And the end product is not always pizza, but anything they can model through the software.

The future is cultured, not slaughtered Cow-free milk?

Ryan Pandya and Perumal Gandhi of Perfect Day, a company that is developing synthetic milk

Cellular agriculture, so far mostly small biotech start ups

A team in San Francisco is working on vegan cheese that contains protein identical to milk protein but doesn't come from animals. They transform yeast cells into miniature milk–protein factories. It isn't a cheese substitute, but real cheese that has no animal origin. Their process is more environmentally sustainable than standard cheese–making. The startup Muufri hopes to design yeast cultures that can produce milk proteins. This retains the taste and nutritional value of real milk. It could be accessible to many people worldwide less expensively than dairy milk. Dairy production is responsible for about 3% of global greenhouse gas emissions every year. Muufri argues that making an entire cow to make just the milk is inefficient. They can control what the milk actually contains, and while their milk cannot provide the same quality that Mother Nature does, it can come close.

Lab Grown Meat

the first lab grown burger essentially cost $325,000

Agricluture is only possible if seeds are preserved for future planting!!

Lab-grown meat saves land and water. Meat is a hot topic in global discussions about the environmental impact of food, largely because of the resources required to raise livestock. For instance, it takes around 441 gallons of water to produce one pound of beef, and the same amount of meat produces the equivalent of 22.3 pounds of carbon dioxide emissions, contributing to climate change at an alarming rate. A few years ago, food scientists in the Netherlands got to work on a controversial solution: lab-grown meat, also known as “in vitro meat.”
Cultured muscle grown from actual cow stem cells is laced together in layers in a round mold to become what advocates are touting as an ethical beef burger. The process is complicated and extremely expensive (the first burger essentially cost $325,000), but it results in a fat-free burger that testers report “tastes reasonably good,” while virtually eliminating the environmental problems of traditional livestock rearing.

Fake burger

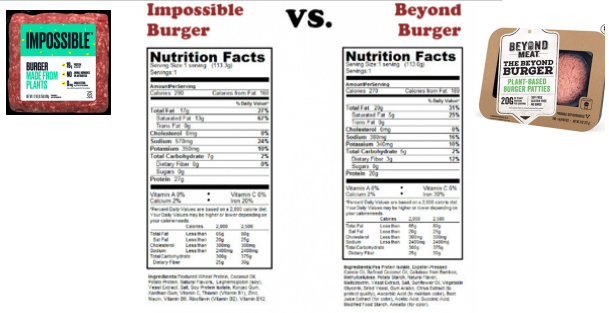
Top five ingredients: Water, soy protein concentrate, coconut oil, sunflower oil and natural flavors.
Calories: A four-ounce serving, which is a pretty skimpy burger, clocks in at 240 calories. That’s in the range of a beef burger, depending on the fat content. This is the 2.0 version of Impossible, the formula rejiggered largely to reduce saturated fat; the original had 290 calories. This is the patty alone — bun, condiments and accoutrements are additional calories.
Cholesterol: Impossible contains no cholesterol. To compare, a regular beef patty contains about 80 milligrams, a quarter of your daily cholesterol limit.
Fat: 14 grams, including eight grams of saturated fat, which is generally considered less healthy than unsaturated fat. This is comparable to a beef burger, mostly due to the coconut oil. This year, Impossible replaced a portion of the coconut oil, which has the highest saturated fat content among plant-based oils, with sunflower oil, which is an unsaturated fat. The oils give the patty a plush mouthfeel and make it sizzle on the griddle.
Sodium: The Impossible has 370 mg of added salt, which is 16 percent of your daily recommended amount — so fairly high. A beef burger does have a small amount of naturally occurring sodium (three ounces of cooked lean beef contains about 55 mg of sodium), but a beef burger’s total sodium depends on how much it is seasoned.
Protein: The plant-based burger has 19 grams, or 31 percent of the daily recommended amount, which is about the same as a regular four-ounce beef burger.
Heme: This is the most controversial ingredient. It adds to the flavor and color of the burger and makes it “bleed” like a beef burger. Heme, or soy leghemoglobin, is found most abundantly in animal flesh and is the catalyst for hundreds of chemical reactions that occur while a burger is cooking. Unlike the heme found in beef, the heme in the Impossible Burger is made by taking the DNA from the roots of soy plants, inserting it into genetically engineered yeast and then fermenting that yeast (much the way Belgian beer is made). Soy contains estrogen-like compounds called isoflavones that some findings say can promote the growth of some cancer cells, impair female fertility and mess with men’s hormones.
The rest: Impossible Burger beats beef in many vitamin and mineral categories such as folate, B12, thiamin (2,350 percent of daily recommended?!) and iron, and the product is fortified to include nutrients a vegan or vegetarian might not otherwise get. It contains less than one gram of added sugar and three grams of fiber per serving (largely in the form of methyl cellulose, a plant-based

bulk-forming binder). Animal meat contains no fiber.

Fake Meat Wars

The plant-based market is still in its infancy. While the total market value has surged to $4.5 billion, that's a fraction of U.S. cattle production alone, which accounted for $67.1 billion in cash receipts in 2018. While Impossible doesn't disclose its financials, the company has raised $750 million since its founding in 2011, much of that spent in research and development.

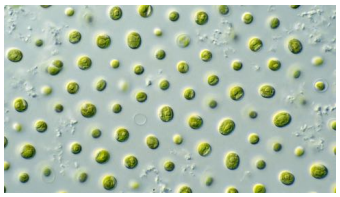
Fake burgers



Fake seafood

New Wave Foods, is looking to create synthetic shrimp out of red algae.

Microalgae



Microalgae, like other plants, feed off carbon dioxide in the atmosphere. A 2013 study from the awesomely-titled Algal Research journal found that these tiny green critters produce a slew of proteins, fats, and carbohydrates that make for a good source of nutrients in food products. A more recent study found that some species of algae contained lots of omega 3 fatty acids, as well as other fatty acids that could promote good heart health. You might know someone who's already eaten algae. Soylent included algal flour in their meal replacement beverages. The algae was subsequently blamed for a slew of gastrointestinal problems in consumers, so Soylent took the questionable ingredient out. Bloomberg reports that products by TerraVia, Soylent's algae provider, have made people sick as well. But this probably won't be the end of algae, since TerraVia denies their flour as the culprit and Soylent's newest products still contain algae-based oil.

Vertical farming (urban) for local produce

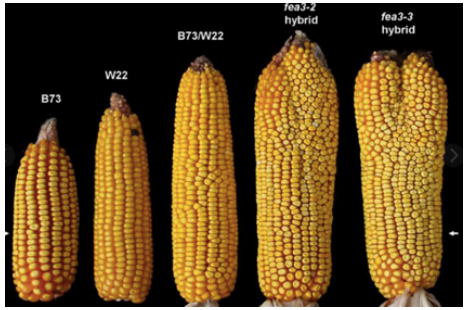
Vertical indoor farms create local produce
As climate change spurs fits of droughts and flooding in different areas of the planet, agriculture has become a much more tenuous industry. Perhaps the most exciting alternative is the rise of indoor farming, which brings hydroponic warehouses to urban centers and brings higher food production per square foot, as well as reduced costs and environmental impacts related to transportation. Japanese plant physiologist Shigeharu Shimamura, CEO of Mirai Co., partnered with GE Japan to build the world's largest indoor farm in Miyagi Prefecture in eastern Japan. The former Sony factory now houses high-tech hydroponics equipment that allows workers to harvest thousands of heads of lettuce each day.

local urban pumpkin and squash

robot farm labor

What are the costs to people looking for jobs?

More productive crops

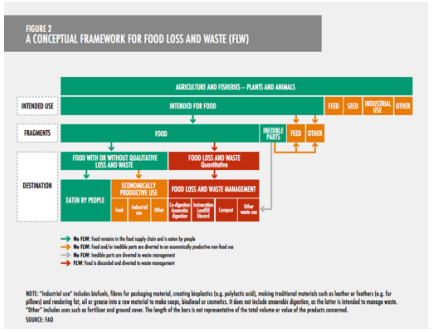


Addressing world hunger seems like a natural aim for food production technology, and some biologists think mutant corn might be the answer. Scientists found a way to exploit a natural genetic mutation and then cross-breed mutated corn with traditional corn crops to produce larger ears of corn, without changing any other aspects of the corn itself.
The result is an increase in crop yield of up to 50 percent -- a staggering figure for regions where agriculture is struggling to keep up with food demand, often with limited acreage. Although the breakthrough hasn't been tested outside the lab, scientists are already looking into ways to harness similar genetic mutations in other staple crops -- such as wheat and rice -- that could lead to increases in crop output.

Truly biodegradable packaging made from seaweed

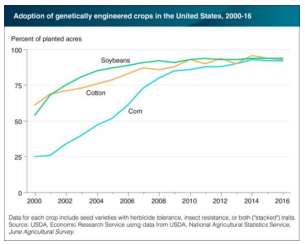
When it comes to the environmental impacts of food, plastic bottles and packaging rank pretty high. They're cheap from a financial perspective, but they are difficult and expensive to recycle (a process that also consumes a lot of water), and huge amounts of plastic waste escape the waste management process entirely and pose a danger to wildlife. Icelandic product designer Ari Jónsson created an alternative to single-use plastic bottles using agar, a jelly-like, edible substance derived from algae. Agar is used in cooking applications as a gelatin substitute, but it can also be mixed with water and poured into molds to create durable food containers, including water bottles, that are truly biodegradable.

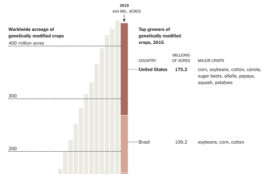
Edible Gardens everywhere?



Loss of food at every step…resulting in a 30% waste of all the food produced on the planet.
Practice question: what fraction of total food produced globally is wasted?
~30%.

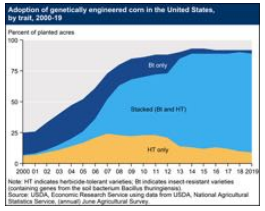
GMO crops

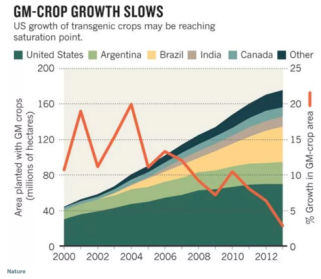




More than 93 percent of the corn and soy planted in the United States is genetically modified in some way. Most of that ends up as animal feed, ethanol, or corn syrup — and corn syrup gets into lots of foods. Cotton, sugar beets, and canola are also common genetically modified crops. Roughly 60 to 70 percent of processed foods in grocery stores contain at least some genetically modified ingredients.
Animals are a slightly different story. There are currently no genetically modified animals that have been approved for use as food in the United States, although there's a type of GM salmon that's currently awaiting regulatory approval from the Food and Drug Administration. Companies have also used genetic engineering to create certain enzymes and hormones for cheese and milk production.

GMO crops





GMO are mostly designed to be herbicide resistant and to contain the natural pesticide Bt toxin. Around the world, the vast majority of GM crops are grown in just five countries: the United States, Argentina, Brazil, Canada, and India. In 2013, more than 12 percent of global farmland (175 million hectares) was given over to GM crops, although growth appears to be slowing:

Documentary

interesting documentary on the GMO food debate. The Filmmakers have ben accused of making blatant propaganda for GMO giant Monsanto, now owned by Bayer. Worth watching for many reasons.

Summary

Humans are actively shaping multiple Earth Systems: **the Anthropocene.**

If we are to feed over **10 billion people** on our small planet we have to make radical changes.

Produce food differently and **redistribute** the food we produce.

Closing **the diet gap** globally.

Focus on novel ways to **produce crops sustainably.**

Food production should **minimize green house gases**, **land use**, **acidification** and **eutrophication** of waterways.

Farming has to become a carbon sink.

Changing global diets could **improve human health** for rich and poor.

GMO is here, but requires **regulation** and oversight.

Plant-based fake meat and seafood likely are part of the solution.

Many **novel crops** offer parts of the solution.

Solutions will require **global cooperation** and participation by the over **50% of humans who now live in urban centers**.

Solutions will require BIG cultural & societal changes on a global scale!

Your minds are needed!! Whether your interests are in public health, social justice, bioengineering, agricultural technology, biotech, politics, international relations, public service, health advocacy, we, as in **WE** the global human population need your brilliant new ideas and initiatives to address the many urgent problems related to feeding the world.

Summary

The human diet is the result of **million-year long interaction of biology and culture**.

Social and natural sciences take very different but complementary approaches to our diet.

We are **the only animal that cooks**, how long we have been doing so is not known.

Cooked food appears to have **changed our genes**.

The last groups without farming (hunter-gatherers/foragers) allow **crucial insights into original human diets!**

Human niche construction is heavily applied to food production, preparation, trade and regulation.

Technologies allow for enough food to feed over 10 billion humans (and their pets), **but only if redeployed in fairer ways.**

Our food supply relies on **artificial fertilizer and ways to control pests and weeds.**

The long history of use of **fire is taking a large toll on our health and that of the planet.**

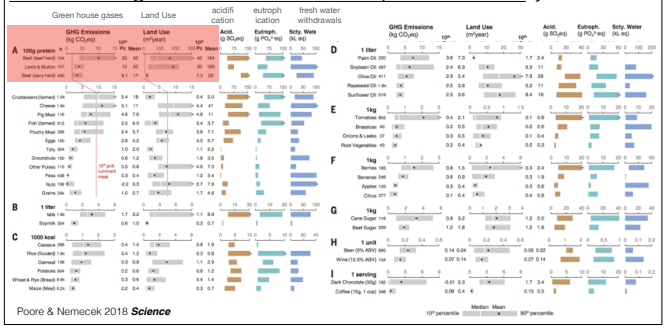
Water use, just like food use will have to be equalized across regions.

Cities will have to be redesigned for increased physical mobility of humans, local production of food and social equality.

Trade is a defining feature of our species, it creates many opportunities but is also the mechanism for creating inequality.

Solutions will require a BIG cultural changes on a global scale!

Estimated global environmental impact of 40 major foods



Poore & Nemecek 2018 ***Science***

Estimated global variation in GHG emissions, land use, terrestrial acidification, eutrophication, and scarcity-weighted freshwater withdrawals, within and between 40 major foods.
(A) Protein-rich products. Grains are also shown here given that they contribute 41% of global protein intake, despite lower protein content.
(B) (B) Milks.
(C) Starch-rich products.
(D) Oils.
(E) Vegetables.
(F) Fruits.
(G) Sugars.
(H) Alcoholic beverages (1 unit = 10 ml of alcohol; ABV, alcohol by volume).
(I) Stimulants. n = farm or regional inventories. Pc and pctl., percentile; scty., scarcity.

Feasibility of reference diet

Although the reference diet, which is based on health considerations, is consistent with many traditional eating patterns, for some individuals or populations this diet might seem extreme or not feasible.

However, from a global perspective the features of this diet, which could include strict vegetarian diets and consumption of modest amounts of animal source foods, have well established traditions in various regions. The best studied example is the Mediterranean diet, similar to the diet of Crete in the mid-20th century. **This diet was low in red meat (average intake of red meat and poultry combined was 35 g/day and largely plant-based, but high in total fat intake (about 40% of energy) consumed mainly as olive oil. Greeks had one of the longest life expectancies at the time.**

Many other traditional diets, such as those in Indonesia, Mexico, India, China, and West Africa, also include little red meat, which might be consumed only on special occasions or as minor ingredients of mixed dishes. Some of these cultures have also consumed few or no dairy foods, often corresponding with lactose intolerance and lower rates of bone fracture than have countries with high dairy consumption.High consumption of nuts is traditional in some West African populations (ie, about 100 g/day in Niger) and large amounts of soy foods are consumed in many Asian populations (ie, 46 g/day in Taiwan). Legume consumption has traditionally been high in many cultures, such as Mexico, India, and Rwanda.

Thus, ample precedent exists for the ranges of food intakes represented by the reference diet, and the culinary experiences of different regions provide many opportunities to learn new ways of preparing diets that are healthy and enjoyable.

Willett W. *et al.* 2019 Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems ***The Lancet***

Animal source foods in sub-Saharan Africa

People in sub-Saharan Africa are some of the **most nutritionally insecure** on the planet. About 220 million people have inadequate nutrition.

Despite micronutrient supplementation programs, the **burden of multiple micronutrient deficiencies, as well as anaemia and stunting, remains high.** Although several countries have substantially reduced the proportion of people who are starving and whose growth is stunted (ie, Rwanda 44% to 24.5%; Uganda 38.3% to 29%; Ghana 46% absolute decline; Tanzania 50% to 34%; Malawi 53% to 37%), declines in children who are stunted in Africa have been marginal—from 38% in 1990 to 34% in 2008.

Of the 36 countries with the highest burden of stunting among children younger than 2 years, 21 (58%) are in Africa, and **40% or more children in most of those countries are stunted.** This undernutrition is sometimes associated with low consumption of animal source and other protein rich foods.

Because carbohydrate intake is high in many parts of sub-Saharan Africa, **promotion of animal source foods for children,** including livestock products, can improve dietary quality, micronutrient intake, nutrient status, and overall health.

In observational studies, **high intake of animal source foods has been associated with improved growth,** micronutrient status, cognitive performance, and motor development, and increased activity in children.

However, per-capita consumption of animal source foods in sub-Saharan Africa has decreased in the past few decades and remains low at about 164 kcal/capita per day (Zambia), compared with 995 kcal/capita per day in the USA.

Based on projections by the Food and Agricultural Organization, availability of animal source protein across sub-Saharan Africa will only be 13 g/person per day in 2050, which is less than half of the world average of animal source protein availability in 2011 and less than the recommended quantity in our healthy reference diet (table 1).

Because many regions, such as sub-Saharan Africa, still face severe burdens of undernutrition and malnutrition, and growing children often do not obtain adequate quantities of nutrients from plant source foods alone, the role of animal source foods should be examined carefully.

Achieving healthy diets from sustainable food systems for everyone on the planet is possible; however, to accomplish this goal, local and regional realities need to be carefully considered.

Willett W. *et al.* 2019 Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems ***The Lancet***

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