

Lecture 16: Industrial Food Production



Pascal Gagneux

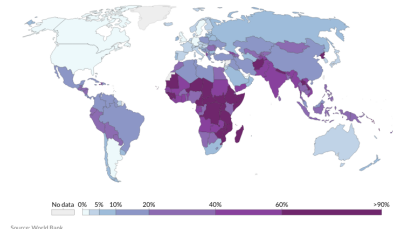
November 23, 2021

Pascal standing in a chicken Farm near Modesto owned by his Taiwanese-American friends, industrial chicken processing

The people producing our food: farmers and farm workers

Share of the labor force employed in agriculture, 2017

Share of persons of working age who were engaged in any activity to produce goods or provide services for pay or profit in the agriculture sector (agriculture, hunting, forestry and fishing).



A few generations ago, farming was the most common occupation for most humans!

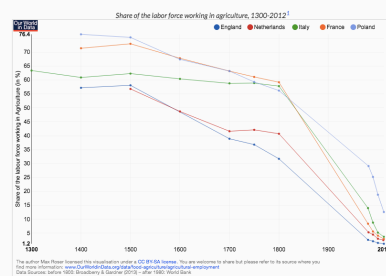
15 thousand years ago, before the neolithic, there were no farmers!

Practice question: What is the Neolithic?

The time period 10 to 4.5 thousand years ,the youngest stone age, also when humans started farming.

We are fed by fewer and fewer people

Employment in agriculture: 1300 to today



The number of farmers and farms workers keep going down, less than 2% of Americans today work growing food!

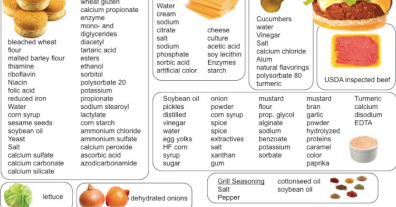
Practice question: What fraction of the population works on farms in the USA today?

Answer: 2% or less.

Global Supply Chain Complexity



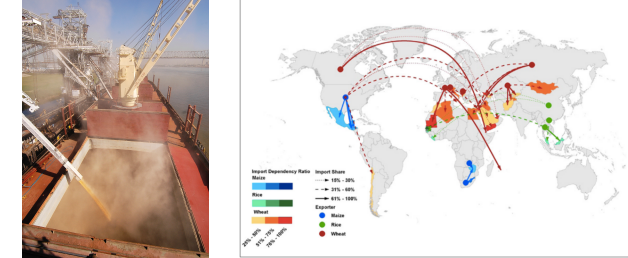
	soy flour baking soda vegetable oil	Milk milkfat		
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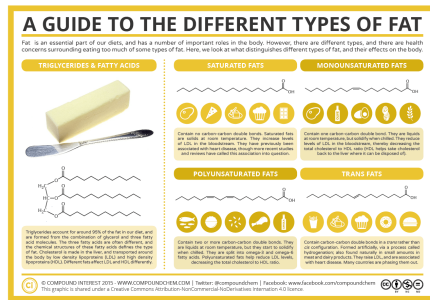
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Bren D'amours et al. Teleconnected food supply shocks *Environ. Res. Lett.* (2016)

Fats, Lipids



Chemical modification of unsaturated plant oils can yield saturated plant oils (**partially hydrogenated plant oil**). Such hydrogenated plant oil are ideal for long shelf life and originally thought to be healthy. The artificially produced fats however contain trans fatty acids, which are very rare in nature and turned out to be very unhealthy. Most industrially produced food is now switching to naturally saturated plant oils such as coconut and palm oil. These have no trans-fatty acids and allow food items to stay fresh for long periods time.

Trans Fatty acids: not a food!

Trans (Elaidic acid)	Cis (Oleic acid)	Saturated (Stearic acid)
Elaidic acid is the principal trans unsaturated fatty acid often found in partially hydrogenated vegetable oils. ^[41]	Oleic acid is a cis unsaturated fatty acid making up 55–80% of olive oil. ^[42]	Stearic acid is a saturated fatty acid found in animal fats and is the intended product in full hydrogenation. Stearic acid is neither cis nor trans because it has no carbon-carbon double bonds.

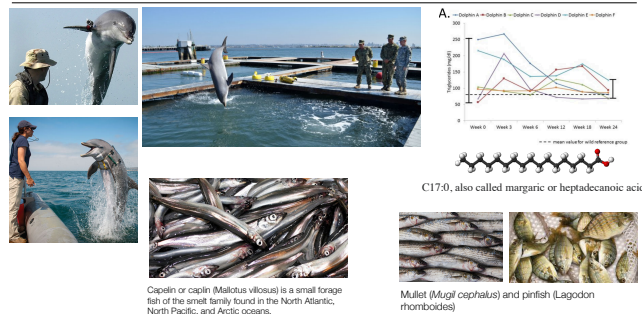
The FDA takes step to remove artificial trans fats in processed foods. U.S. Food and Drug Administration. June 15, 2016. Last accessed April 2, 2016. <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm451237.htm>

Practice question: what is the down side of unsaturated fats?

Answer; they spoil (go rancid) faster.

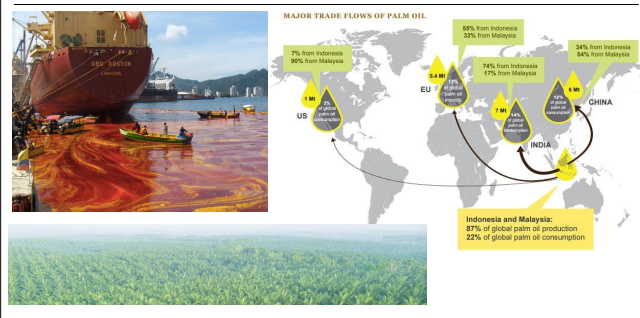
Trans fats are very rare in nature and only occur in minor amounts in animal products and some fruit.

Good started fats: Margarinic acid



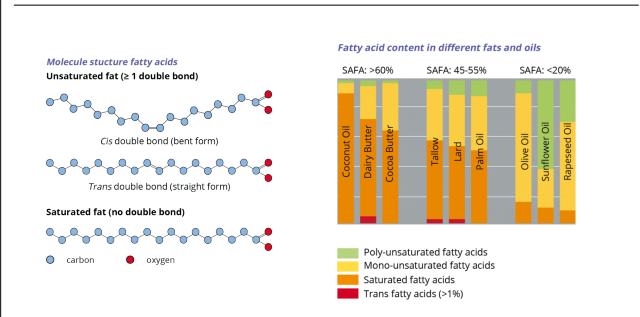
Feeding intervention in captive dolphins in San Diego: saturated fatty acids found in mullet and pinfish reduced serum triglycerides and cured military dolphins from metabolic syndrome!

Global palm oil



Palm oil is highly saturated and works well for processed food that requires long shelf life. It is replacing the artificially partially hydrogenated plant oils (trans fatty acids). originally from West Africa, oil palms grow well in other tropical areas and are planted in huge plantations in South East Asia and South America.

Oil composition



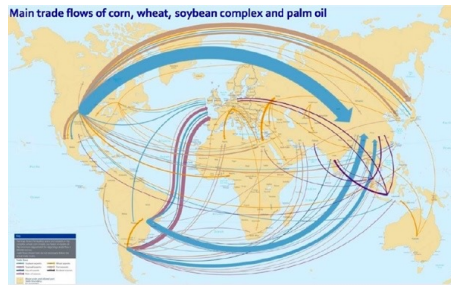
The term saturated fatty acid is often written in shorthand as SAFA. In a saturated fatty acid the carbon atoms are connected with only single bonds, which enables the fatty acids to pack closely together. Oils and fats which are rich in saturated fatty acids will have a higher melting point and a denser structure and thus will be more solid at room temperature.

Unsaturated fatty acids can be either mono-unsaturated (MUFA) or poly-unsaturated (PUFA). Unsaturated fatty acids contain one or more double bonds in their hydrocarbon chain. The double bond introduces a kink in the hydrocarbon chain, which makes it more difficult for the fatty acids to pack tightly. Oils which are rich in mono- or poly-unsaturated fatty acids are therefore often liquid at room temperature, like cooking oils.



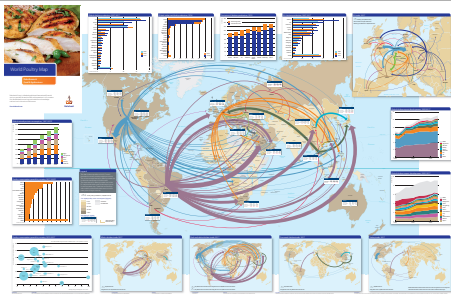
making chili crisp (lajiao you, 辣椒油)

The global flow of staple foods!



grain, beans and oil are moved globally

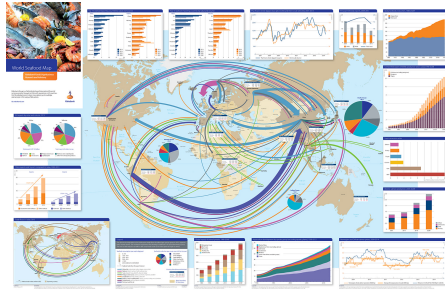
Global Chicken Trade



Chickens, chicks, and chicken meat are also moved globally.

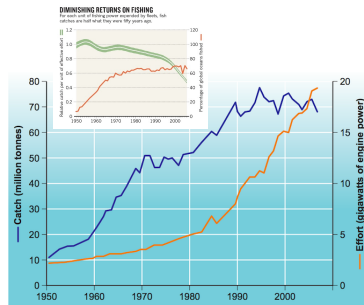
This can be a great concern for certain diseases such as Newcastle virus (a chicken disease) and Influenza A virus (a bird virus that can infect humans!).

Global Seafood Trade



Seafood: fish, shrimp, crabs, sea urchin etc are all traded globally.

Wild Fisheries



The world's fishing fleets are putting in greater and greater effort for diminishing returns.

Practice question: What do the trends of fishing effort and catch in the last 50 years tell us?

Answer: Massive increase in effort did not result in increased catch : unsustainable!

Fish Farming

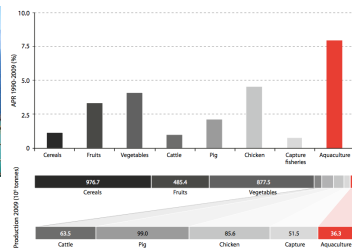


Fig. 1. Comparison of growth of aquaculture and main food commodities/groups. Based on refs. 1 and 2). Growth expressed as annual percentage for the period 1960-2009 and production for 2009. Data on meat from animals obtained from Tacson and Mearns (3) and FAO/FAO/FAO (2). Similar sources (1, 2) for data on production of cereals, fruits, and vegetables.

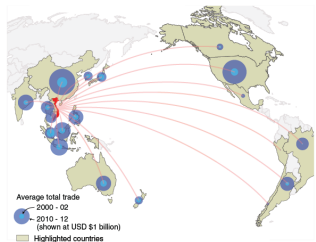
Farmed fish is a rapidly growing sector of the fishing economy.

Practice question: What are the advantages and disadvantages of fish farms?

They produce fish without depleting wild fish stocks. They can spread disease to wild fish due to the high density of fish.

Case example: Vietnamese food trade

Growth of Vietnamese agricultural trade in the Asia-Pacific region

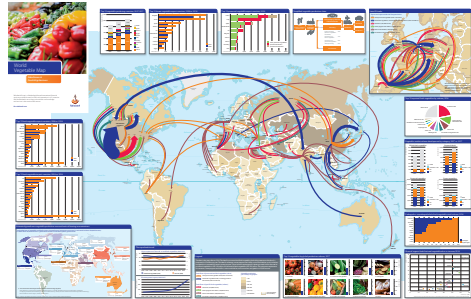


Source: USDA, Economic Research Service using data from United Nations, Comtrade.



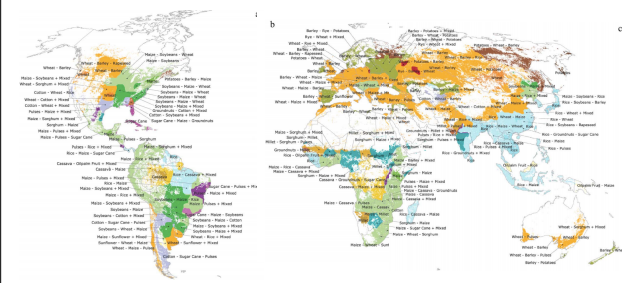
Massive recent growth of exports from Vietnam to the rest of the world.

Case example: World Vegetable



Vegetables travel less than meat or fish. Major international movements from Mexico to US and from China to Japan and S Korea.

Geography of food crops

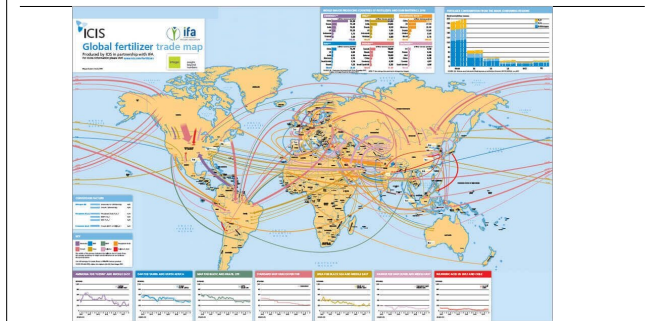


Local climate dictates which staple crops are grown where.

Practice question: Why is wheat not grown in Indonesia?

Wheat does not grow well in tropical climates.

Global fertilizer trade

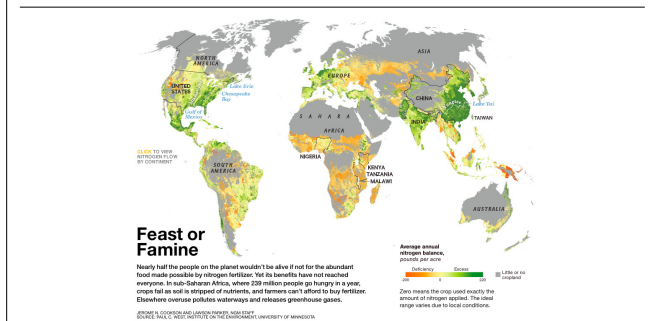


Fertilizers are trade globally as well. Phosphate is mined but nitrates are mostly made industrial by fixation of Nitrogen from air (Haber-Bosch method).

Practice question: What is the limiting factor for producing nitrogen fertilizer?

The energy required for the fixation of N_2 from air (fuel for heat and pressure).

Fertilizer over- or underuse



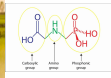
Fertilizer are overused in many places and still in very short supply in others (poorer places).

Herbicides and Pesticides: Glyphosate and Kepone

Round Up (Glyphosate) and Kepone (Chlordecone)

Kepone (Chlordecone)

now banned by Stockholm Convention

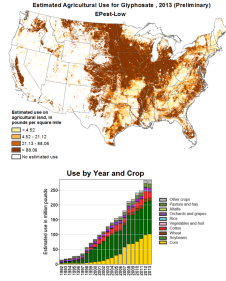
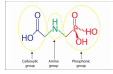


The EPA, during a routine review of its glyphosate registration, said earlier this year glyphosate does not cause cancer, but the International Agency for Research on Cancer in 2015 classified glyphosate as “probably carcinogenic to humans.”

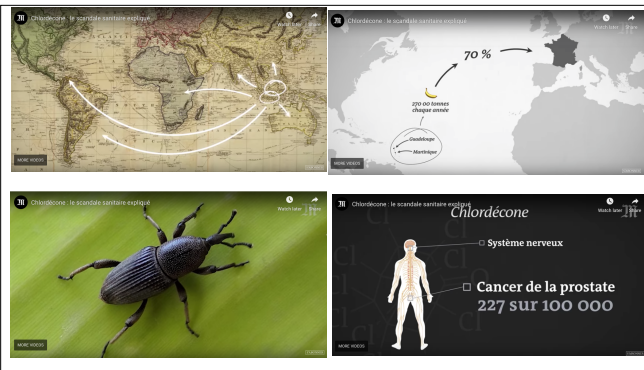
Glyphosate is globally the most used herbicide. It is used to control weeds.

Older pesticides such as DDT and Kepone are massively more toxic as these are halogenated hydrocarbons with carcinogenic and hormone disrupting properties. These pesticides also accumulate in the soil and in food chains. They are now banned.

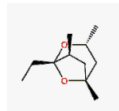
Round Up (Glycophosate)



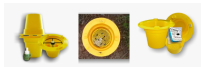
Older pesticides such as DDT and Kepone are massively more toxic as these are halogenated hydrocarbons with carcinogenic and hormone disrupting properties. These pesticides also accumulate in the soil and in food chains. They are now banned.



Martinique and Guadeloupe have high levels of Kepone pollution and the highest level of prostate cancer in the world. It took over 13 years for the James River in the US to recover from Kepone pollution!



Insect pheromones used to trap pests.



BBW-pitfall-sordilure

S.A. Palm Weevil arriving in San Diego!



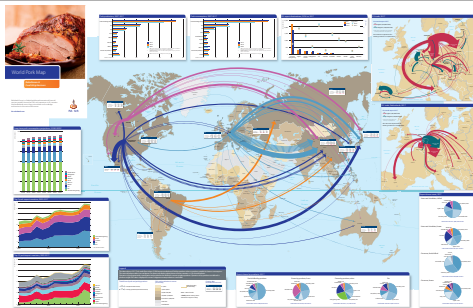
Entomologist Mark Hoddle shows a specimen of the South American Palm Weevil, a beetle that has the potential to cause millions of dollars in damage to the region's palm and date industry, that he caught in a trap in the Sweetwater Preserve in San Diego County. (John Gibbins / San Diego Union-Tribune)

Global Beef Trade



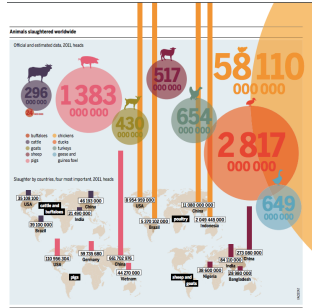
Refrigerated containers allow shipment of beef and other meats across continents. Australia, South America and North America are the major producers and exporters.
Practice question: Which three regions of the world are the major beef producers and exporters?
Answer: North America, South America and Australia.

Pork



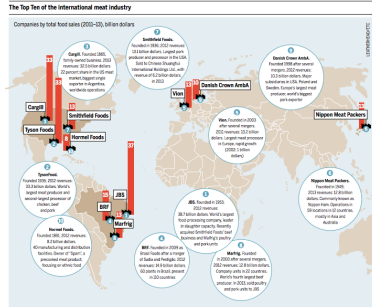
Pork is also moved around the world. Pork production is less costly than beef.

Meat Atlas



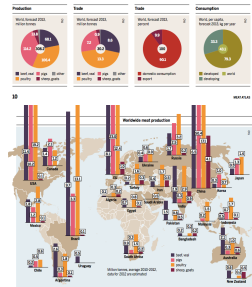
A graphic representation of number of farm animals consumed across the world.
Chicken far outnumber all the other animals.
Practice question: Which continent consumes most pigs?
East Asia.

Meat Atlas



The meat industry like all other food industries is mostly controlled by few large international companies.

Meat Production, Trade and Consumption



Very uneven consumption of global meat: most of it by the richer, “developed” world.

Coffee and Tea



Illegal drugs: ~400 to 600 billion
or 2% of global trade!

Comparative size of global markets in 2015 :
Cars: 4000 billion \$
Crude Oil: 788 billion \$
Meat: 714 billion \$
Beef: 300 billion \$
Soda (carbonated drinks) 340 billion\$
Fertilizer: 150 billion \$
Sea food: 120 billion \$
Aluminium: 106 billion \$
Palm Oil: 65 billion \$
Soybeans 57 billion \$
Pesticide & Herbicide 53 billion \$
Tea: 50 billion \$
Coffee: 23 billion \$
Wheat 29 billion \$
Heparin 16 billion \$
Collagen 6 billion \$, Fetal Calf Serum 1 billion \$

Coffee has sometimes been said to be the second biggest traded commodity after crude oil. NOT True!

This short list compares the value of some global food and non-food items.

Roundup (glyphosate), the most used herbicide is worth 5 billion.

Practice question: Which traded item is the whole meat trade similar to?

Crude Oil/petroleum.

Which traded items have a higher global market: beef or illegal drugs?

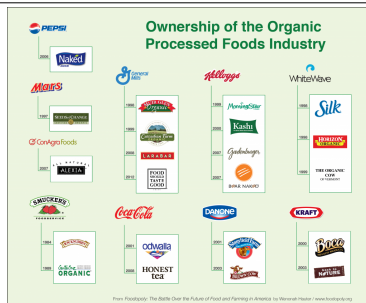
Illegal drugs.

Globalized Food Business



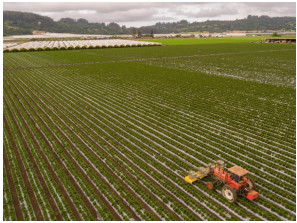
A handful of very large multinational corporation control a huge fraction of the food market, and with it countless brands.

Organic Food Giants



The same companies also own much of the organic processed foods market!

Organic Food Giants



Driscoll's, Watsonville, CA

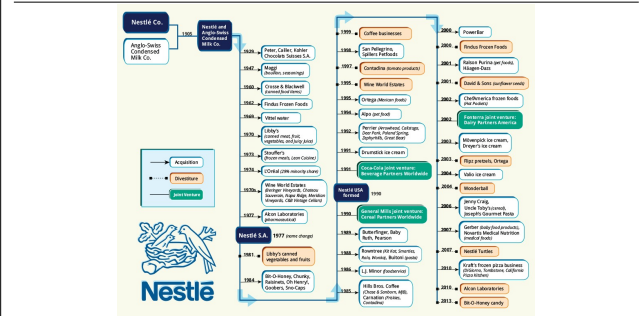


Earth Bound Farms, Hollister, CA

A tractor passes over organically grown strawberries with an attachment that vacuums unwanted insects at Driscoll's near Watsonville, California. The technology, piloted by the company in the 1980s, is used by both conventional and organic growers. Driscoll's produces about 20 percent of the U.S. strawberry market; independent growers raise Driscoll seedlings, hire workers to harvest them, and deliver packaged fruit to a warehouse, where they are inspected and prepared for shipment.

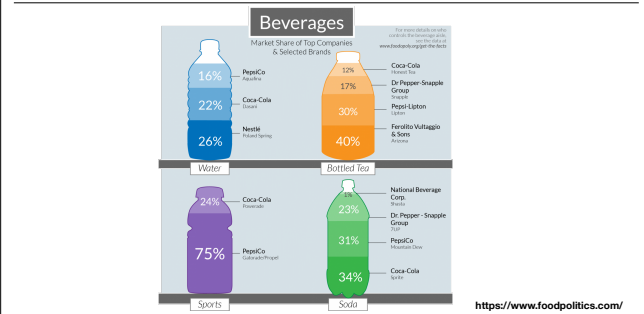
Organically grown green oak leaf lettuce is harvested for Earthbound Farms near Hollister, California. The process begins before dawn and concludes by midday to keep the greens as fresh as possible. The harvester, preceded by workers on foot who scan for debris, cuts the lettuce within an inch of the ground with a bandsaw-like blade. The greens are air blown to remove soil or other contaminants before being put on a refrigerated truck. The machine can harvest 10,000 pounds per hour with a crew of 12, a process that used to take an entire day with a crew of 40. The resulting baby salads are packaged in space age multilayered plastic bags that can keep them fresh for many days!

Swiss Food Giant (~ 10 billion \$ in net profit)



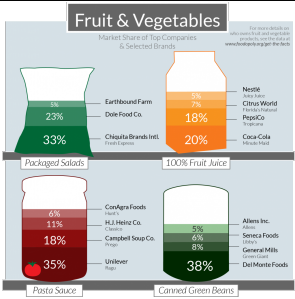
Long series of acquisitions by Nestle Corporation

Beverages



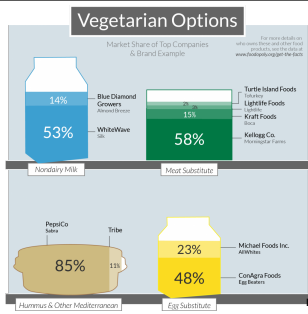
Impressive graphics from Marion Nestle's website "Foodpolitics" (not related to the "Nestlé" Company!) Forbes magazine listed Nestle as number 2 of "The world's 7 most powerful foodies."

Title



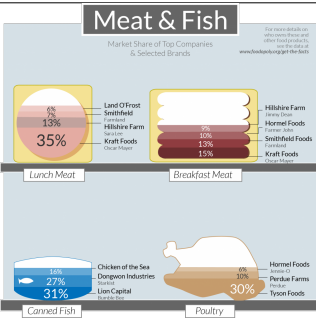
<https://www.foodpolitics.com/>

Title



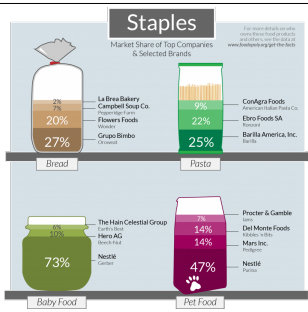
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Meat and Fish



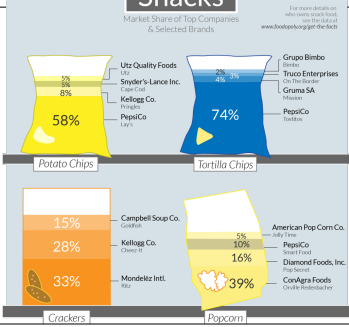
<https://www.foodpolitics.com/>

Staples



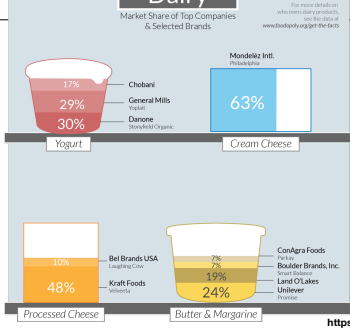
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Snacks



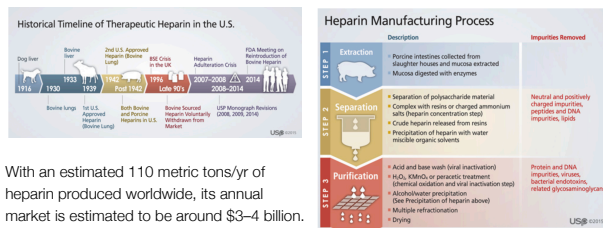
<https://www.foodpolitics.com/>

Dairy



<https://www.foodpolitics.com/>

From Farm to Pharma: Heparin



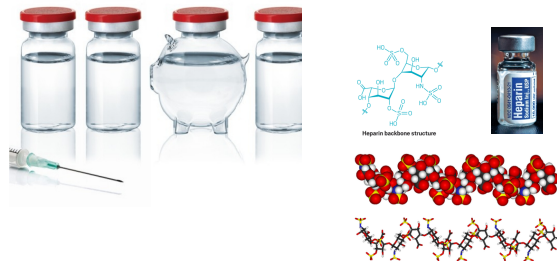
With an estimated 110 metric tons/yr of heparin produced worldwide, its annual market is estimated to be around \$3–4 billion.

Figure 2: Heparin manufacturing process.

Heparin, a sulfated polysaccharide (technically a polysaccharide with two repeating sugar units, sulfated glucosamine and sulfated Iduronic acid) is a potent anticoagulant without which modern medicine would not be possible.

With an estimated 110 metric tons/yr of heparin produced worldwide, its annual market is estimated to be around \$3–4 billion.

From Farm to Pharma: heparin from pig guts



The most common drug used by humans globally comes from pig intestines....

Practice question: What is heparin?

A drug made from the mucosa (slimy inner lining) of pig intestines (or cow lung) that consists of sulfated polysaccharides. It is the most used drug and is used to prevent blood clotting.

From Farm to Pharma: Heparin

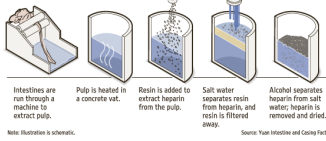


Heparin manufacturers can only buy pig intestines from government-inspected slaughterhouses. Their first step (shown here) is separating the mucosa, or inner lining, from the rest of the intestine. After mucosa are collected, crude heparin is extracted by a process involving enzymatic decomposition (shown here), elution, alcohol precipitation, heating, drying, and grinding. After the 2007–08 scandal (during which adulterated heparin killed 80 patients in the US), heparin producers were required to add several quality control steps. A polymerase chain reaction test (shown here) verifies that heparin is from porcine sources. Crude heparin is further processed into different drug active ingredients such as heparin sodium and tinzaparin. Shown here is an Enoray active pharmaceutical ingredients plant.

Heparin: no modern medicine without it!

The Birth of a Medicine

Heparin, a type of sugar that can help prevent blood clots, has its origins in slaughterhouses and sausage-casing factories in China. How the process unfolds at the Yuan Intestine and Casing Factory in Yantai, China:



Medical Uses of Heparin:

- Acute coronary syndrome
- Atrial fibrillation
- Deep vein thrombosis
- Pulmonary embolism
- Cardiopulmonary bypass heart surgery
- Hemofiltration
- Indwelling catheters
- Vacutainers capillary tubes
- Blood oxygenators
- Purification of viral vectors

List of medical uses of heparin.

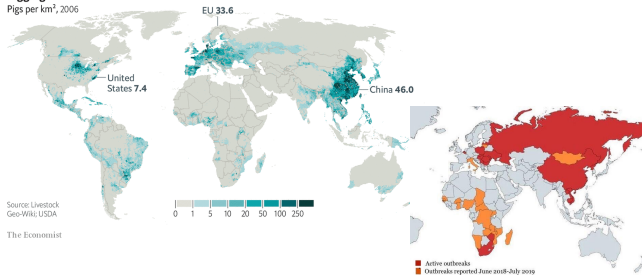
What is the role of Heparin in modern medicine?

Answer: Modern medicine would not be possible without it!

Sick Swine: African Swine Fever

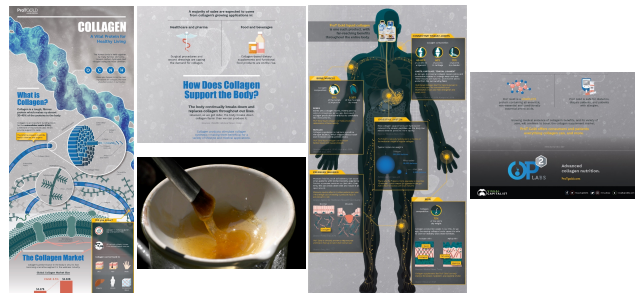
Pigging out

Pigs per km², 2006



IN THE CHINESE zodiac, 2019 was the year of the pig. But at the moment hogs have little to celebrate. African swine fever, a highly contagious virus, has spread to every province in China. The country is the world's biggest pork producer, and home to half the pigs on the planet. In the last year it has reported 149 outbreaks. Some 1.2m pigs have been culled, according to official statistics. Unofficial reports suggest far bigger losses. Rabobank, a Dutch bank, reckons that by year-end, as many as 200m pigs could be lost to disease or slaughter, leading to a 30% drop in pork production. Although African swine fever is not harmful to humans, it kills up to 90% of pigs. Infected animals stop eating, haemorrhage and die, often within a week. There is no vaccine or cure. Before 2007 the disease had been eliminated from most of the world, with the exception of Africa. It reemerged in Georgia in early 2007 and spread to Russia, Ukraine, Belarus and Lithuania.

Collagen



Collagen (the word means origin of glue) is rendered connective tissue from a variety of animals. It is used in cooking e.g. jello and other thickened foods (mostly beef collagen). cooking animal extracellular matrix/connective tissue is how string glue (such as wood glue) is originally made.

Practice question: What is the origin of the word collagen?

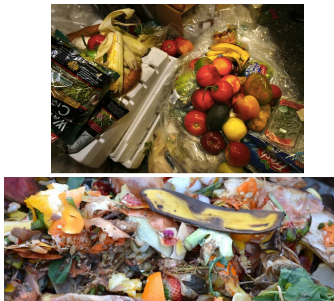
Answer: Where glue comes from.

Donkey to medicine “ejiao” 阿膠 (colla corii asini)



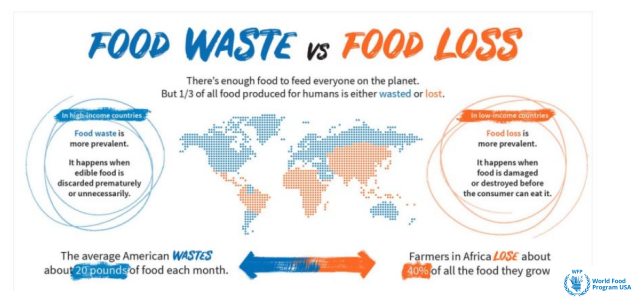
Donkey skin collagen is a traditional Chinese food and medicine. Hundreds of donkey skins drying in the sun as part of the production process of ejiao. Global demand is estimated between 4 to 10 million skins per year. The rapidly growing demand is a threat to the donkey populations of Africa and Asia!

One third of globally produced food is trashed!

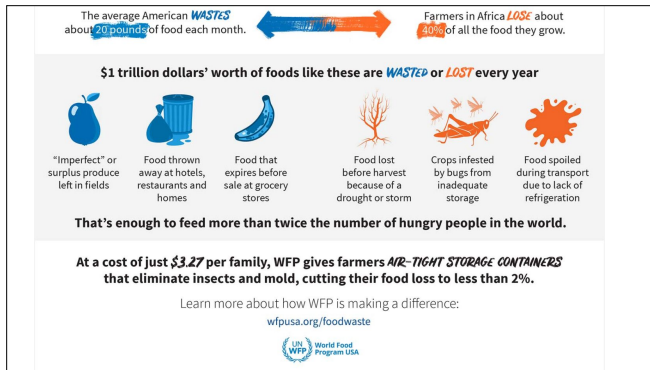


Edible food dumped by vendors in a New York market. There is a demand for ‘blemish-free produce’ in the industry. Much of the food that we all throw away could feed many people and animals.
There is now reason for it to be hauled to some landfill.....at the very least we ought to ferment it to make natural gas!

US food waste



Both **waste**: too much food purchased and food **loss**, food going bad due to pest or molds or bacterial spoilage mean that we are losing a lot of the food produced.



Better storage among farmers with very little means and less waste among us with too many means would go a long way to feeding the world.

Mining Urban food waste



Many cities have initiatives to reduce food waste and to use food waste. New York is among them.

Practice question: How can you generate energy from urban food waste?

Answer: Composting and generation of methane.

Mature compost can be used to fertilize local gardens.

Miramar municipal compost



City plant waste to perfect soil in about two months!

Municipalities from all over the world have visited this facility.

A school compost with some celebrations of the critters found in compost.



Growing crops with elementary school kids in Pacific Beach using compost from the Miramar landfill and “urbanite” concrete fragments from construction sites.

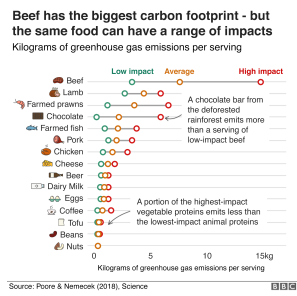
Miramar compost for PB Elementary School garden



Teaching kids where food comes from is key.

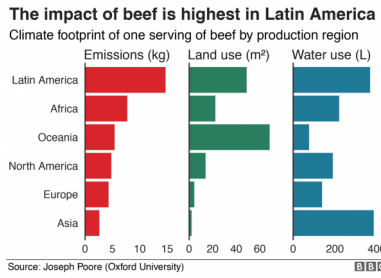


Carbon foot print of different foods

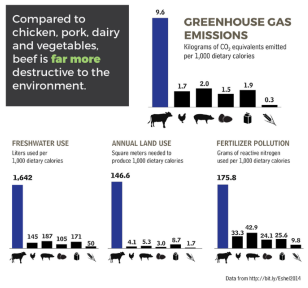


Our foods have very different carbon footprints.

Beef impact on land use and water



Hold the beef!



Beef is tasty and prestigious food, it also comes with a huge environmental impact. Maybe we should eat more like we eat lobster.

Farmers with a Beef



Food production and farming often generates huge conflicts. in 2019 German framers descended on the capital Berlin to protest new regulation on fertilizer use....for many farmers the risk of pollution of waterways is not worth educing their profit from larger harvests made possible by excess fertilizer!

Farmers protest in India (successfully)



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Summary

Fewer people produce more and more of our food.

Few giant transitional corporations sell us our food.

Our food is globally produced, traded and manufactured.

Long shelf life demands special ingredients: palm oil and preservatives and packaging.

Fishing harvest is not keeping up with fishing effort, fish farms may help but have their own problems.

Fertilizer is over used in many places and in short supply in many other places (new regulation meet protests by farmers and industry!).

Pesticides can be dangerous and bioaccumulate. They have become less toxic, but many unknowns about their safety remain.

Biocontrol, using pheromone traps, natural predators etc is a relatively new option, GMO can help reduce pesticide use but has low public acceptance globally.

Meat is costly, but especially beef is costly, (consider eating beef like you eat lobster)

Coffee, chocolate and tea (and tobacco) are important farming products (so are illegal drugs, with a market values similar to global beef!).

Large food companies also control most of the "organic" food market.

Animal byproducts like heparin, collagen and fetal calf serum (for biomedical research) are important products.

We have to stop throwing 1/3 of our food in the trash!

We should be mining urban waste, turning food waste into soil (compost).

The global production systems can spread disease very rapidly and endanger food production.

