Discover the interconnectedness of human sustainability and Earth's ecosystems with One Health!

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- The One Health concept: human, animal and ecosystem health are linked.
- One Health can be used as a framework to examine complex subjects such as food security, emerging infectious diseases (e.g. vector-borne diseases), food safety and antimicrobial resistance, among others.

http://www.onehealthinitiative.com

http://www.onehealthcommission.org K-12 Education Resources

https://onehealthplatform.com/

Preparing Society to Create the World We Need through One Health Education

One Health Educational Resources

Curriculum guide - Lesson plans – Case studies - Links

https://www.onehealthcommission.org/en/resources__services/one_health_educational_resources/

How Does One Health Fit In with the Next Generation Science Standards (NGSS)?

One Health Issue	Interdependent Relationships in Ecosystems	Earth Systems/ Weather & Climate	Human Sustainability
Food Security	Crop & Livestock Production, Ecosystem Disruption (Deforestation, Waste Production, Pesticides)	Climate Change: Hotter, Drier Planet & More Severe Storms (Floods & Droughts)	Reduced Agricultural Output Leads to Hunger & Poor Health **HS-ESSE-4**
Emerging Infectious Diseases (e.g. Vector-borne)	Deforestation & Ecosystem Disruption for Agriculture & Development. Facilitate Vector (Insects) Spread.	Insects prefer warmer climates, likely to spread to higher elevations.	Higher Vector-borne Disease Rates in Humans & Domesticated Animals. **HS-ESS3-1 and HS-LS2-7**
Food Safety	Increased Human & Animal Waste Production Contaminates Food & Water; Adversely Impacts Ecosystems	Warmer temperatures increase rates of antimicrobial resistance in common pathogens (Nature Climate Change 2018; 8: 510-4)	High Microbial Burden in Environment Leads to Higher Disease Rates & Consumption of Antibiotics **HS-ETS1-1 and HS-LS2-7**

One Health Case Study #1: Human and Plant Health & Climate Change
Can Hummus Save Civilization?

https://www.hawaiimagazine.com/content/growing-chickpeas-hawaii

Food Security

One Health Issue	Interdependent Relationships in Ecosystems	Earth Systems/ Weather & Climate	Human Sustainability
Food Security (A fancy term for "preventing hunger")	Crop & Livestock Production, Ecosystem Disruption (Deforestation, Waste Production, Pesticides)	Climate Change: Hotter, Drier Planet & More Severe Storms (Floods & Droughts)	Reduced Agricultural Output Leads to Hunger & Poor Health **HS-ESSE-4**

HS-ESSE-4 Evaluate or refine a technological solution that reduces impacts of human activities on Natural Systems.

https://www.nextgenscience.org/topic-arrangement/hshuman-sustainability

Student Case Type: Debate

NGSS Standard

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Learning Objectives

- Students will be able to evaluate content from web sources to develop evidence-based arguments.
- Students will be able to evaluate alternative technological solutions to mitigate climate change.

http://sciencecases.lib.buffalo.edu/cs/collection/method.asp

Student Case Type: Debate

- Use a debate format involving a mock trial competition.
- Two teams of students prepare written briefs on both sides of the issue and prepare to argue either side.
- Before the trial, they flip a coin to determine which team debates which side of the argument.
- Students not involved in the arguments serve as jury and must prepare questions to ask the debaters. They evaluate the content and presentations of the two sides.
- Either a student or the teacher would serve as judge.

http://sciencecases.lib.buffalo.edu/cs/collection/method.asp

Agriculture is the foundation of civilization

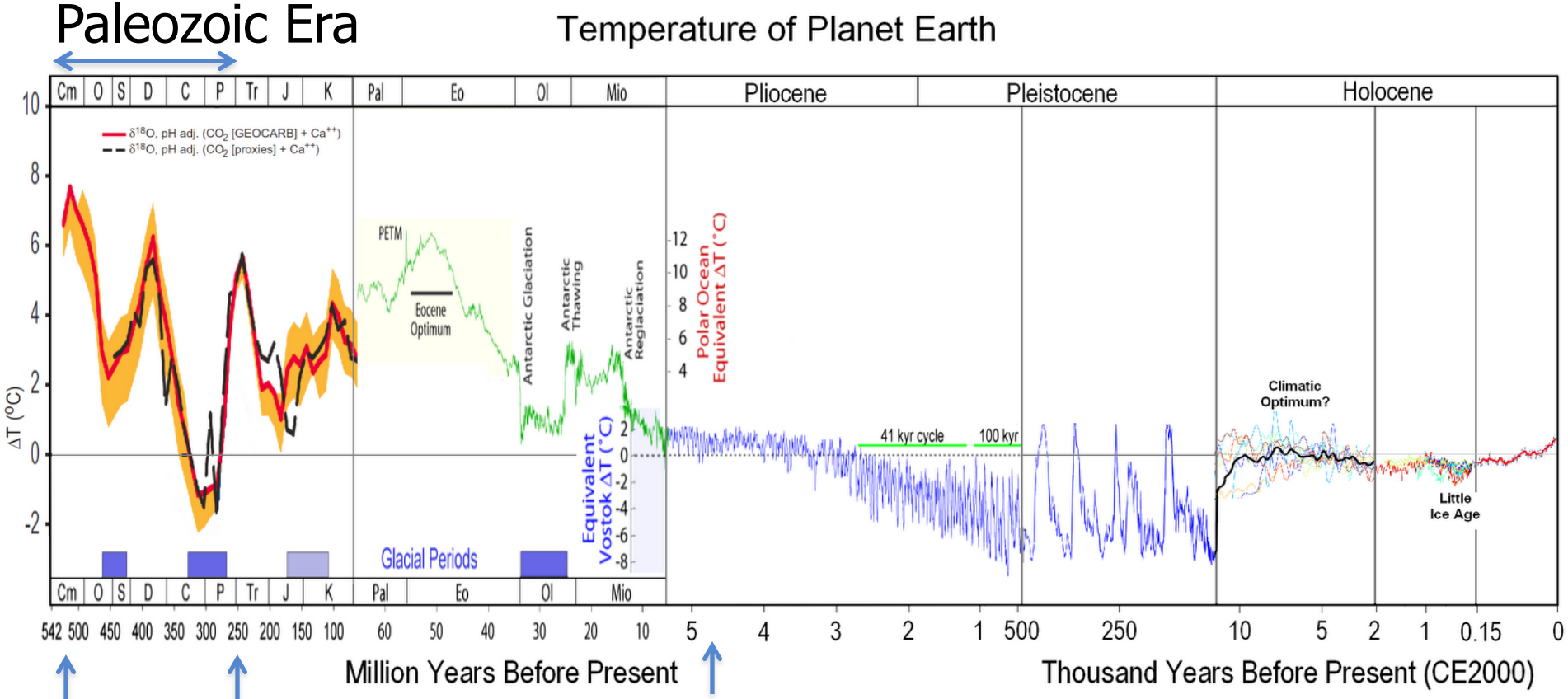
https://en.wikipedia.org/wiki/History_of_agriculture

Climate change threatens agriculture

https://arstechnica.com/science/2017/10/us-government-accountability-office-argues-for-acting-on-climate-change/
https://www.nytimes.com/2018/06/29/opinion/sunday/immigration-climate-change-trump.html

Time of Complex Life on Earth

Paleozoic Era



Early hominids

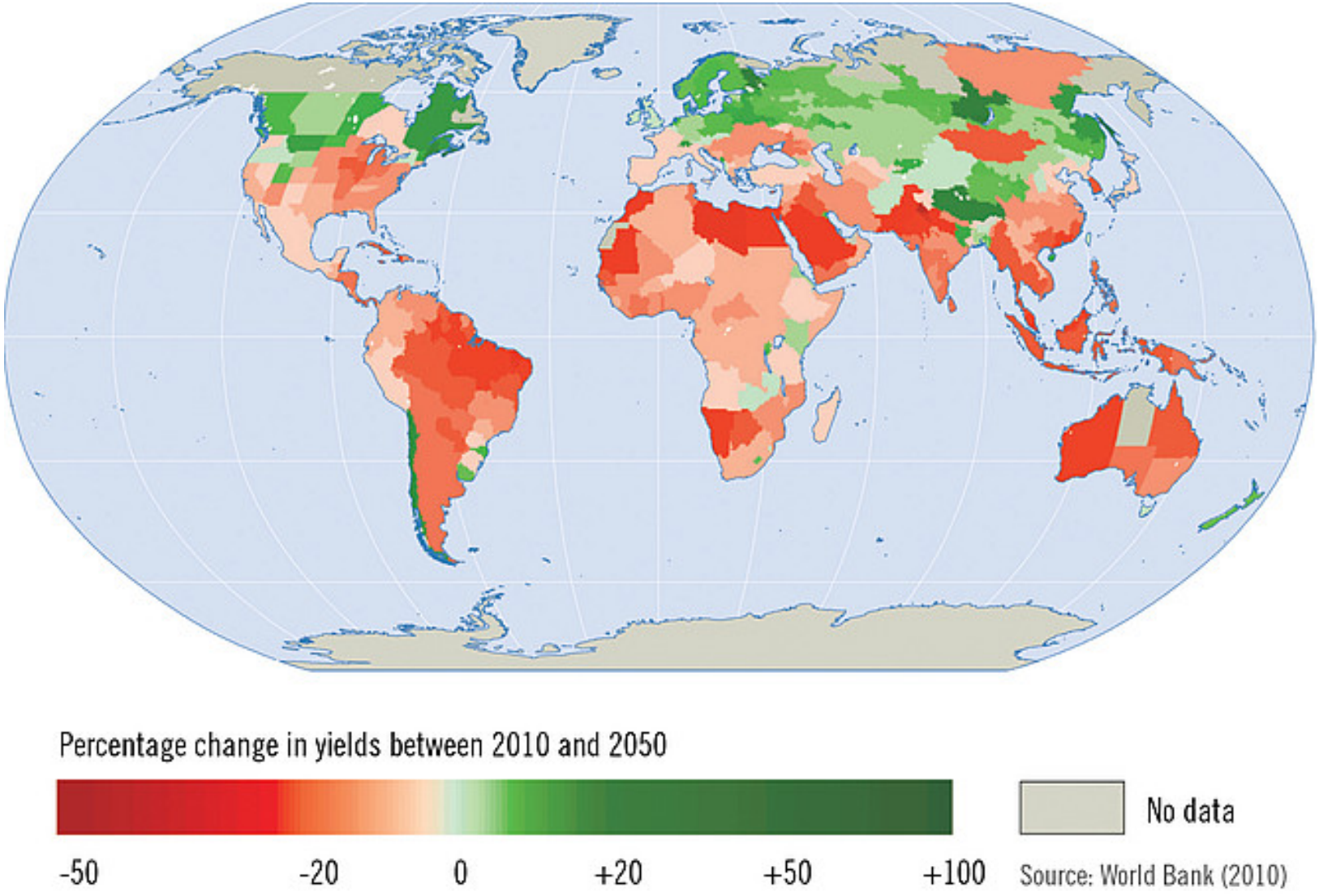
Permian-Triassic Extinction

Cambrian Explosion: Thriving life in seas but barren land

Earth is 4.5 Billion Years Old

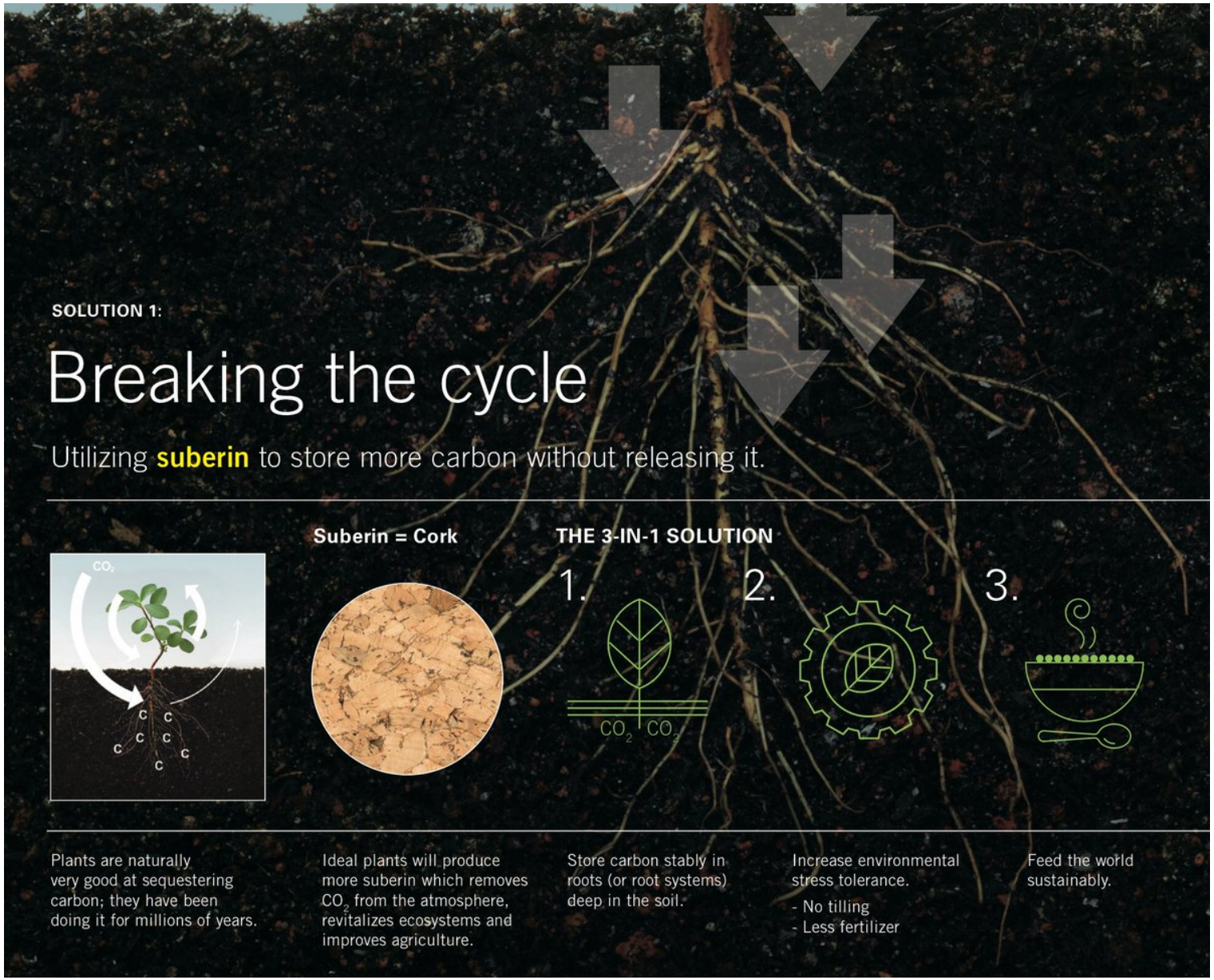
https://commons.wikimedia.org/wiki/File:All_palaeotemps.png
http://gergs.net/2015/06/updating-the-geological-temperature-plot/all_palaeotemps/

Estimated agricultural yields in 2050 due to climate change effects,
assuming current agricultural practices, crop varieties, and a 3 degree warmer planet.



https://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1255547194560/WDR2010_BG_Note_Mueller.pdf
http://www.wri.org/sites/default/files/wri13_report_4c_wrr_online.pdf
https://openknowledge.worldbank.org/handle/10986/4387

Dr. Joanne Chory, Plant Geneticist, Salk Institute, La Jolla, California



Dr. Chory is developing a "super" chickpea plant that could sequester 20X more CO2 than perennial grasses and store CO2 for hundreds, possibly thousands, of years. She is doing this through cross-breeding plants.

Domesticating plants through selective cross breeding is a slow form of genetic modification

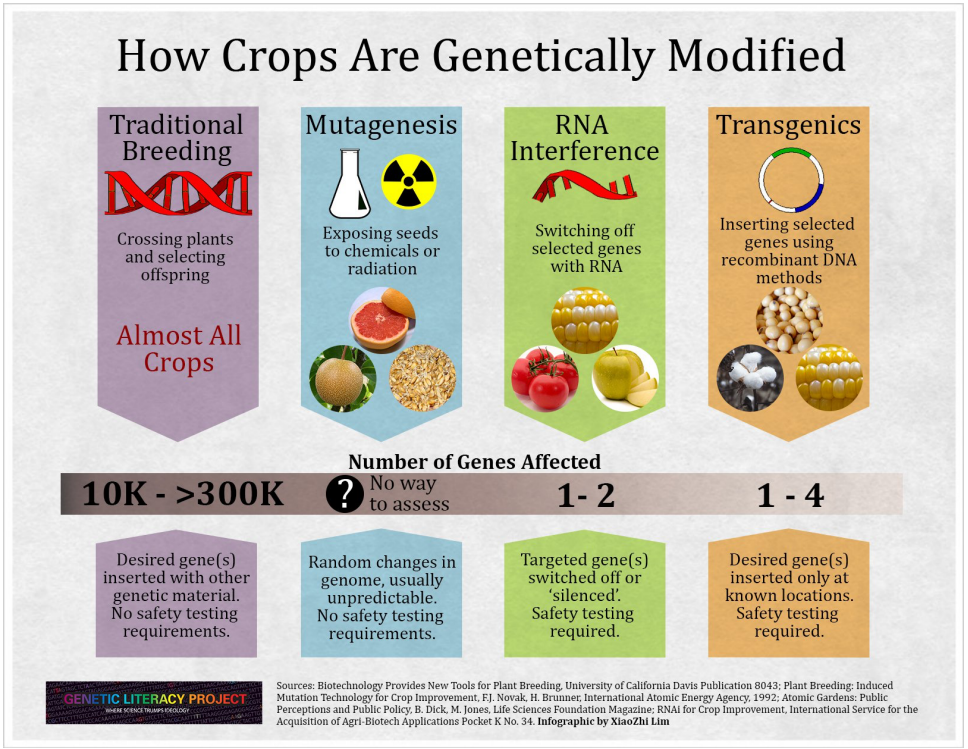
Teosinte vs Maize

Teosinte was a wild Mexican grass domesticated about 9,000 years ago. Probably took hundreds of years.

https://www.nytimes.com/2010/05/25/science/25creature.html

Genetically Modified Organisms (GMOs)

Golden Rice with Vitamin A



Have generated considerable political opposition…

https://geneticliteracyproject.org/2018/02/13/golden-rice-gmo-crop-greenpeace-hates-and-humanitarians-love/
https://geneticliteracyproject.org/2014/04/22/glp-infographic-how-crops-are-modified-are-gmos-more-dangerous/
https://www.npr.org/sections/thesalt/2015/06/24/413755699/genetically-modified-salmon-coming-to-a-river-near-you

Challenges with Dr. Chory's Plan

- Dr. Chory estimates that her cross-breeding efforts to develop the "super" chickpea plant will take around 10 years.
- Meanwhile the planet continues to warm with rising sea levels, worsening droughts, and dying coral reefs.

https://thebulletin.org/2018/06/a-plant-that-could-save-civilization-if-we-let-it/

Debate Case Questions

- Should we wait 10 years to develop “super” CO2 fixing plants through cross breeding or should we use CRISPR technology to develop them faster?
- What is CRISPR technology? How does it differ from cross breeding?
- Problem with CRISPR: plants would be labeled as “GMO” potentially generating political opposition.
- Why are people opposed to GMO crops?
- We would need about 5% of world’s cropland (about the size of Egypt) to plant the modified plants to sequester the CO2 needed to slow climate change.
- How would farmers be convinced to use part of their land for this plant?

One Health Case Study #2: Human, Animal, and Ecosystem Health
Why are Lyme Disease Rates So High In Some States?

Tick on a human

Ticks on a dog

http://www.momjunction.com/articles/lyme-disease-in-toddlers_00362985/#gref
http://aetapet.com/lyme-disease-dogs/

Emerging Diseases (e.g. Vector-borne)

One Health Issue	Interdependent Relationships in Ecosystems	Earth Systems/ Weather & Climate	Human Sustainability
Emerging Diseases (e.g. Vector-borne)	Deforestation & Ecosystem Disruption for Agriculture & Development. Spread of Vectors (Arthropods/ Insects).	Insects prefer warmer climates, likely to spread to higher elevations.	Higher Vector-borne Disease Rates in Humans & Domesticated Animals. **HS-ESS3-1 and HS-LS2-7**

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

https://www.nextgenscience.org/topic-arrangement/hshuman-sustainability
https://www.nextgenscience.org/dci-arrangement/hs-ls2-ecosystems-interactions-energy-and-dynamics

Student Case Type: Interrupted

NGSS Standard

HS-LS2-7: Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Learning Objectives

- Students will be able to use data to understand the relationship between biodiversity, habitat size, and disease risk.
- Students will be able to apply information about the ecology of Lyme disease to design strategies to reduce human disease risk

Modified from Stein and Pardini. The Dilution Effect: How Biodiversity Can Affect Human Health
http://sciencecases.lib.buffalo.edu/cs/files/dilution_effect.pdf

Student Case Type: Interrupted

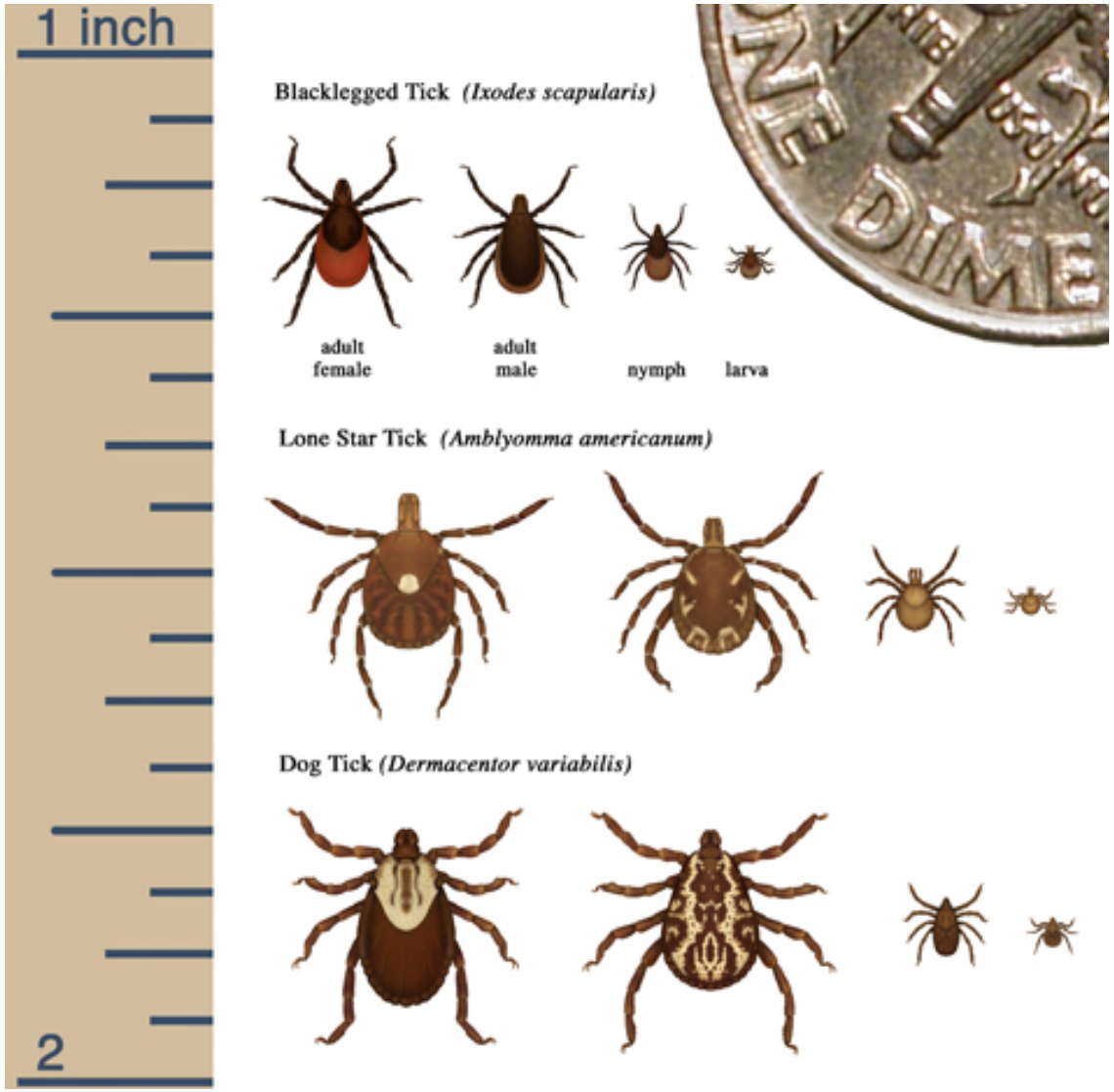
- Students are presented with a problem to solve in a progressive disclosure format.
- They work in small groups and can complete the project in a single class period.
- The One Health Lyme Disease Interrupted Case uses data and information from several studies and resource websites for students to analyze.
- Students examine Lyme disease ecology studies and develop solutions for reducing disease prevalence.
- Lyme disease is a “zoonotic” disease, meaning that it is a disease of animals that spreads to humans.
- In this case, it spreads by an insect vector—the black-legged tick (*Ixodes scapularis*).
- Lyme disease prevalence has a strong ecological component that will be explored in this case study.

Modified from Stein and Pardini. The Dilution Effect: How Biodiversity Can Affect Human Health
http://sciencecases.lib.buffalo.edu/cs/files/dilution_effect.pdf

LYME DISEASE

First cases described in 1975 in Lyme, Connecticut.

Lyme Disease is transmitted by infected black-legged ticks



https://www.cdc.gov/ticks/life_cycle_and_hosts.html

Signs and symptoms of untreated Lyme Disease

"Classic" erythema migrans rash

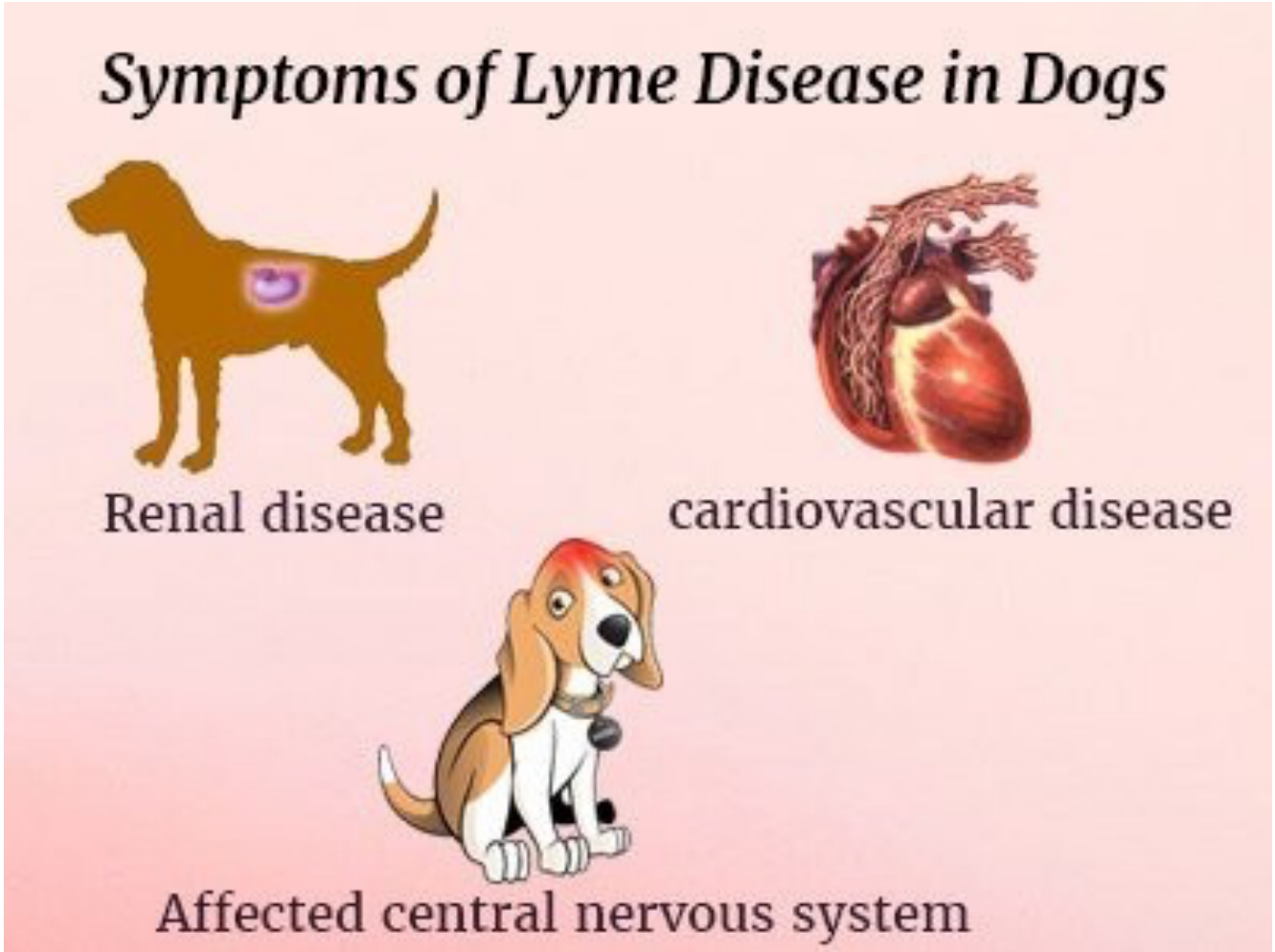
Facial palsy

Swollen knee

Rash in 70 to 80% infected people

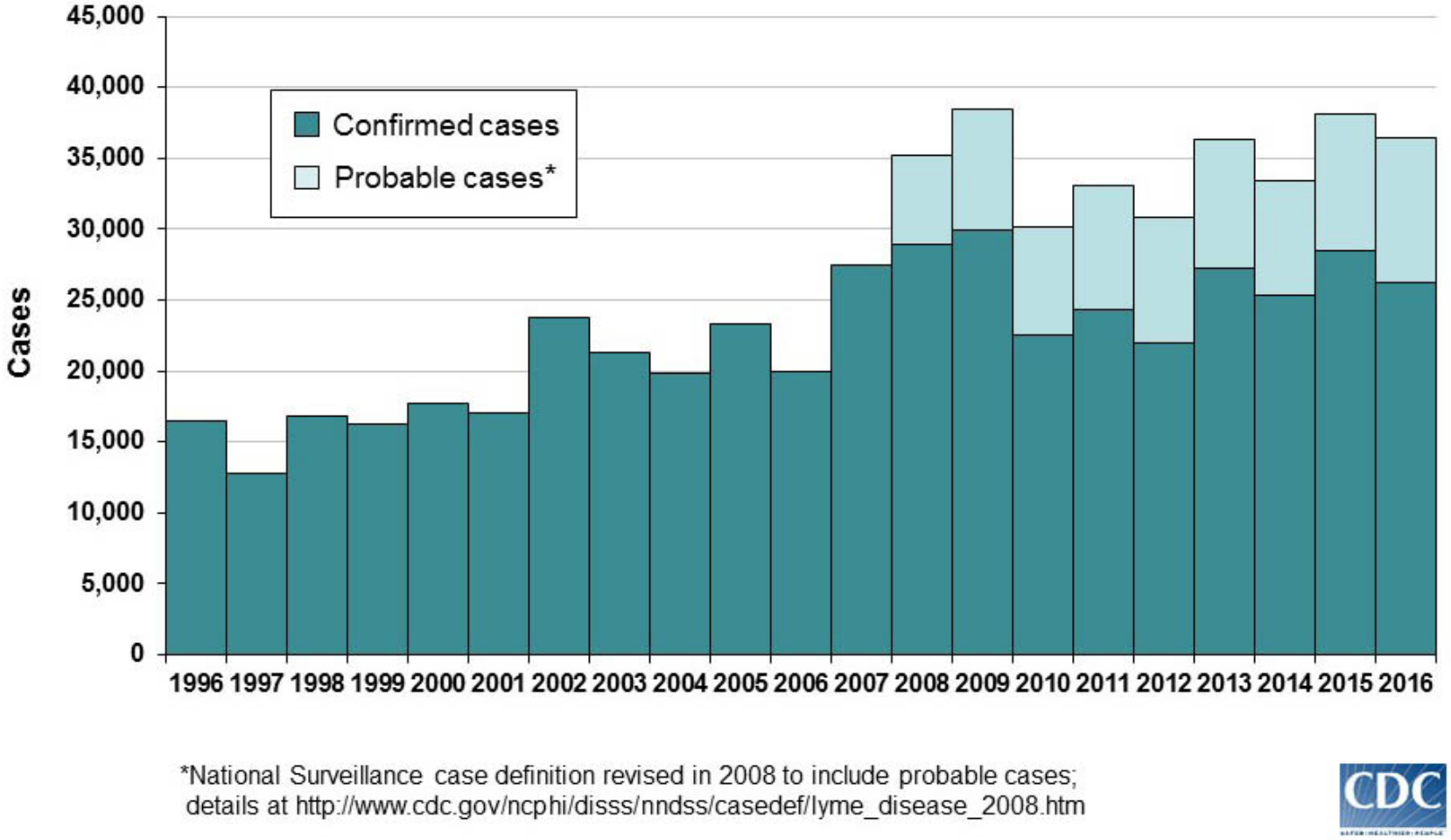
Treatment is antibiotics.

https://www.cdc.gov/lyme/signs_symptoms/index.html



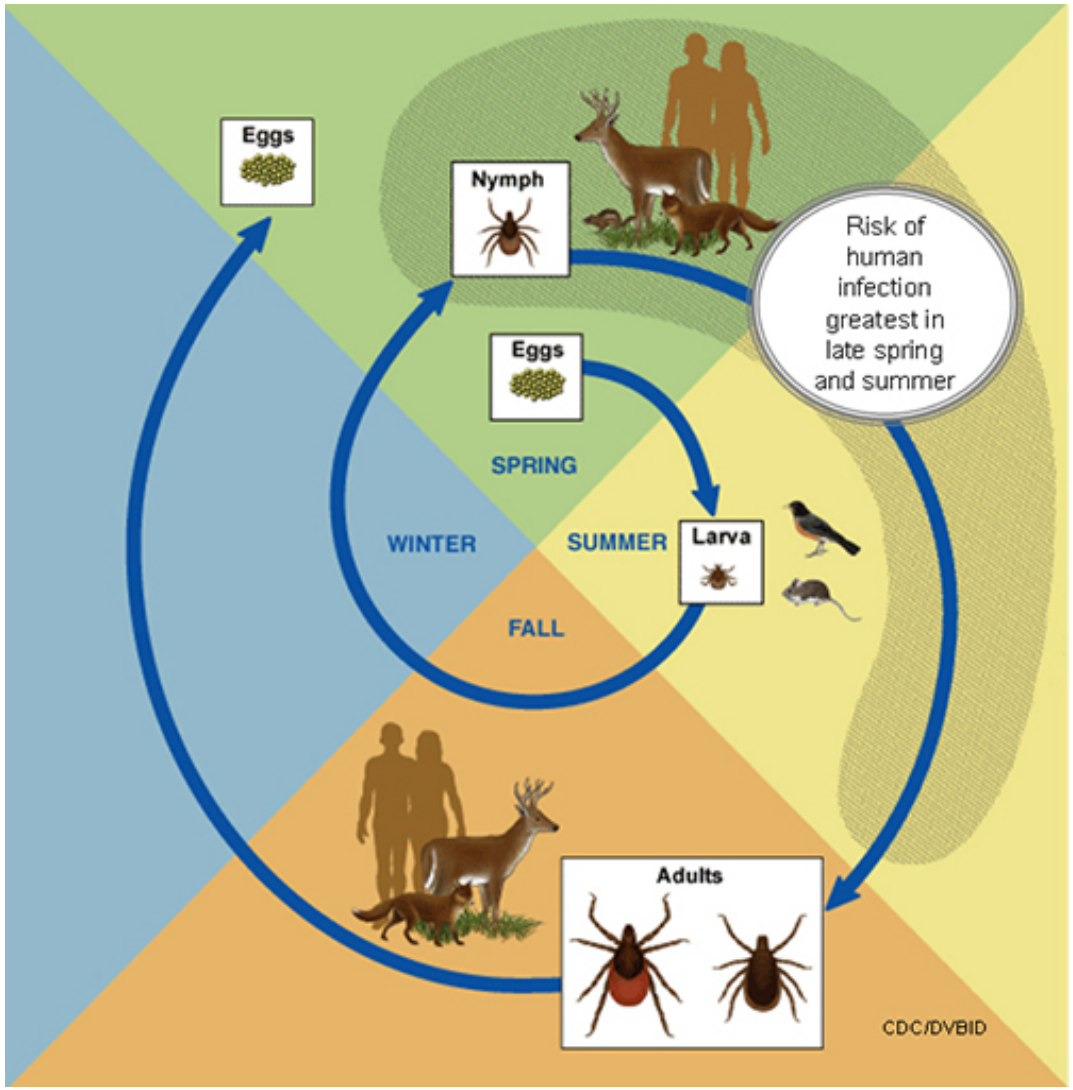
https://www.avma.org/public/PetCare/Pages/lyme-disease.aspx

Reported Human Lyme Disease cases by year, U.S., 1996-2016



https://www.cdc.gov/lyme/stats/graphs.html

Two Year Life-Cycle of Black-legged Tick



Lyme disease is the most common tick-borne infection
In the U.S., around 300,00 cases are reported each year.

Ticks feed on amphibians, birds, mammals, and reptiles. They prefer blood meals from different host animals at different stages of their lives.

Ticks have a 3-stage life cycle: larva, nymph, adult

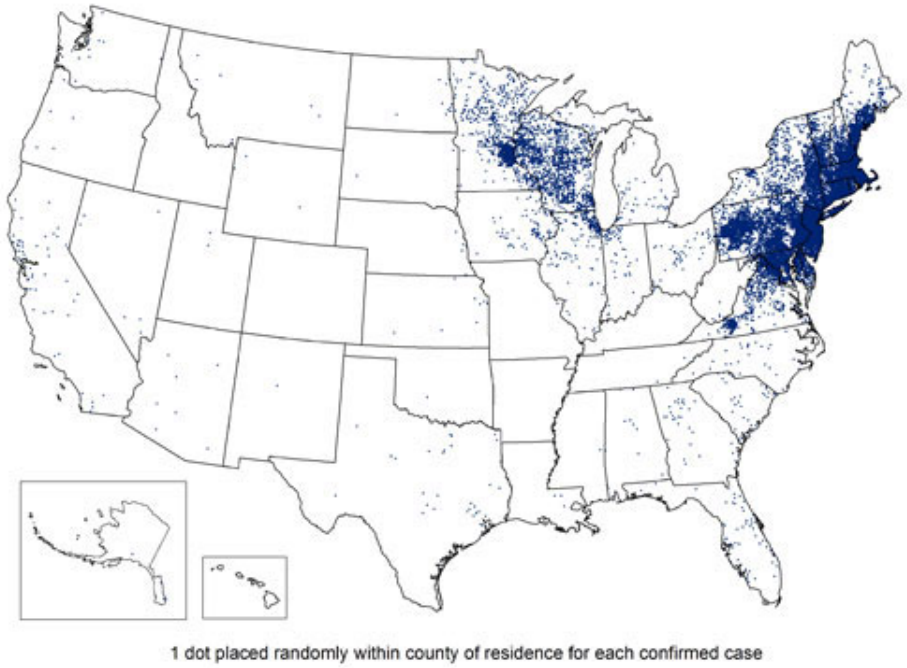
Tick eggs do not carry *Borrelia burgdorferi* the spirochete-shaped bacteria causing Lyme disease.

Ticks must acquire *Borrelia burgdorferi* during their initial (larval) blood meal in order to transmit it later during their blood meal as a nymph. They can also transmit the disease as adults.

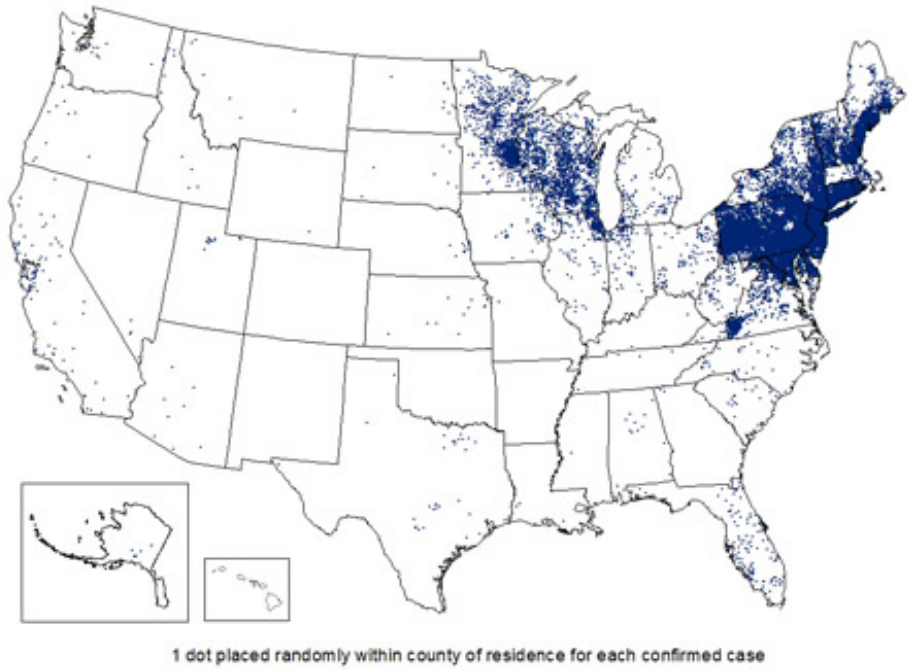
Q1: Which tick stage is the most dangerous to humans?
Q2: Explain why this stage is so dangerous.

https://www.cdc.gov/ticks/life_cycle_and_hosts.html
https://entomologytoday.org/2015/03/30/understanding-the-complex-life-cycle-of-the-blacklegged-tick-to-combat-lyme-disease/

Lyme Disease maps—United States 2012-2016
Reported Human Lyme Disease Cases



2012

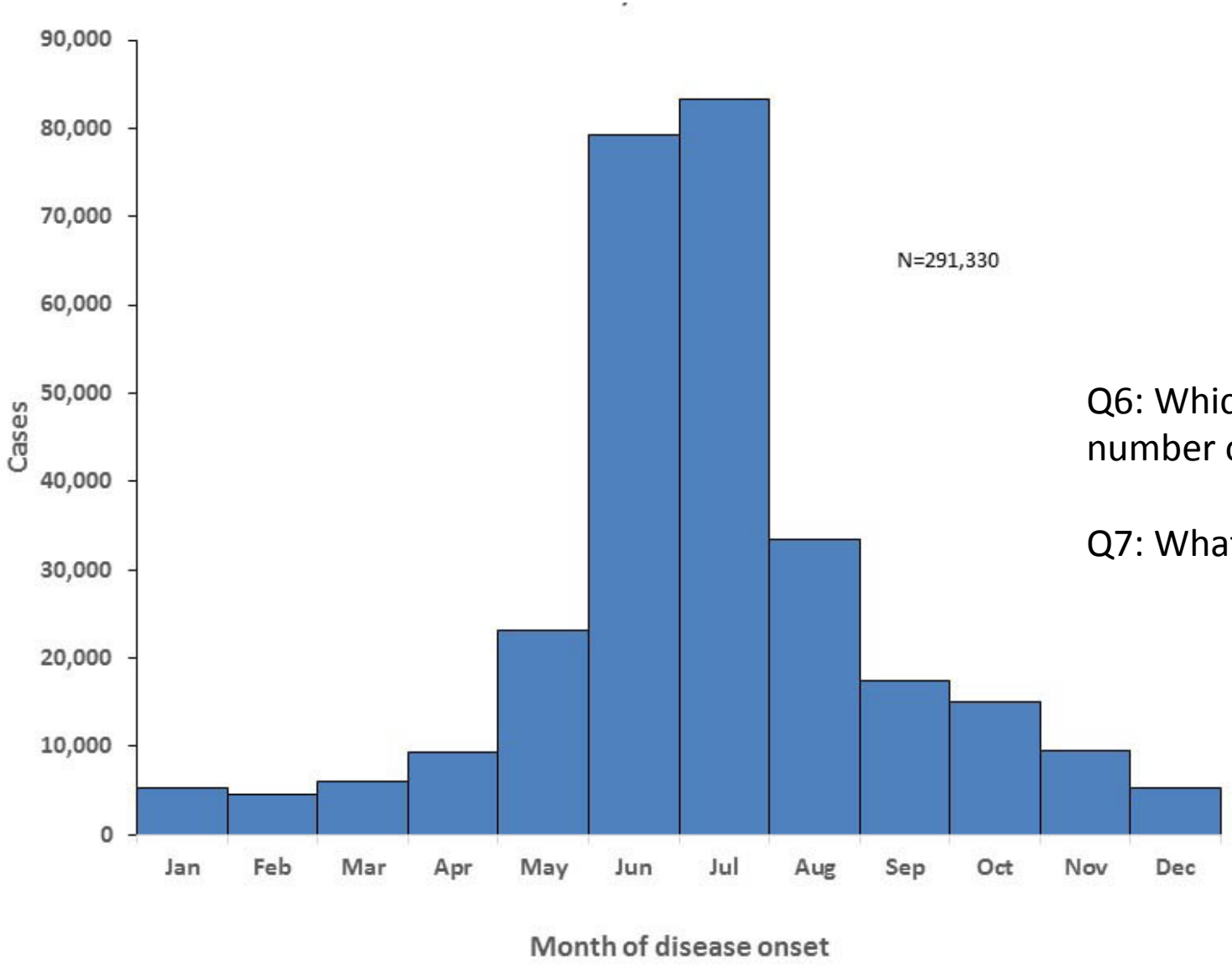


2016

In 2015, 95% of confirmed Lyme Disease cases were in 14 U.S. states.
Q3: Which states were these?
Q4: Comparing Lyme disease cases from 2012 to 2016, what changed?
Q5: What could explain these findings?

https://www.cdc.gov/lyme/stats/maps.html

Confirmed Lyme disease cases by month of disease onset, U.S., 2001-2016

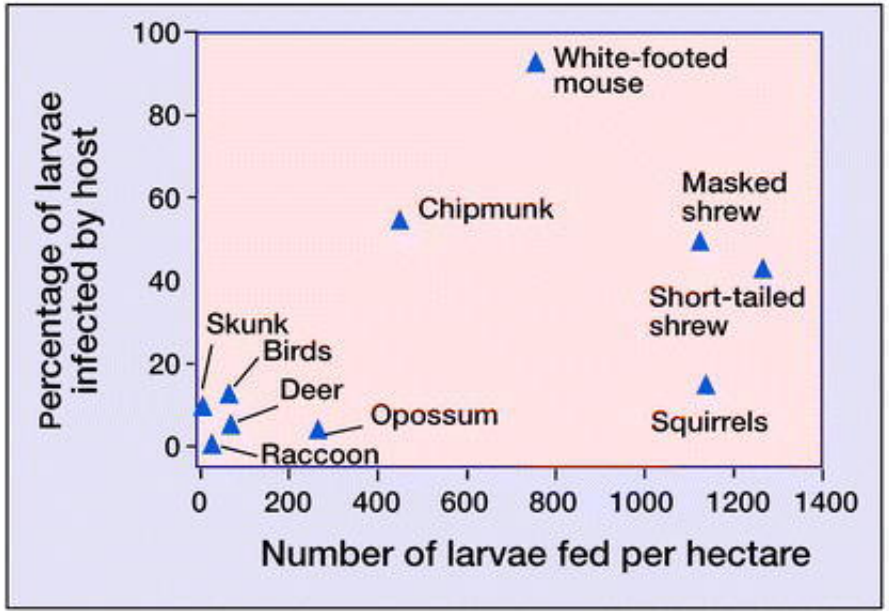


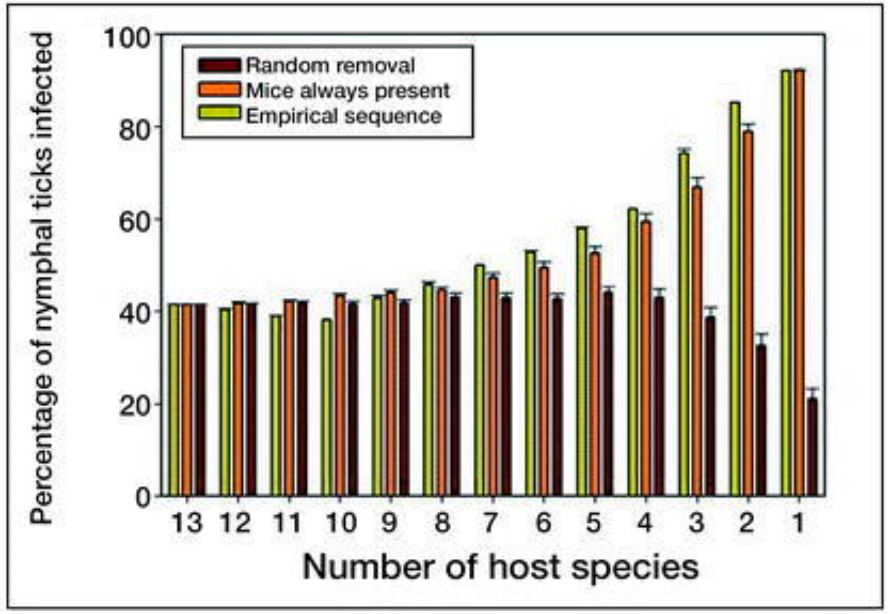
Q6: Which months have the highest number of reported cases?

Q7: What might explain this finding?

https://www.cdc.gov/lyme/stats/graphs.html

The role of biodiversity in protecting humans from Lyme disease exposure





Left graph: Species-specific effects on human exposure risk.

Q8: Which host species feed the most larvae per hectare?

Q9: Which host species feed the least larvae per hectare?

Q10: Which host species infects the highest percentage of larvae?

Q11: Which host species infects the lowest percentage of larvae?

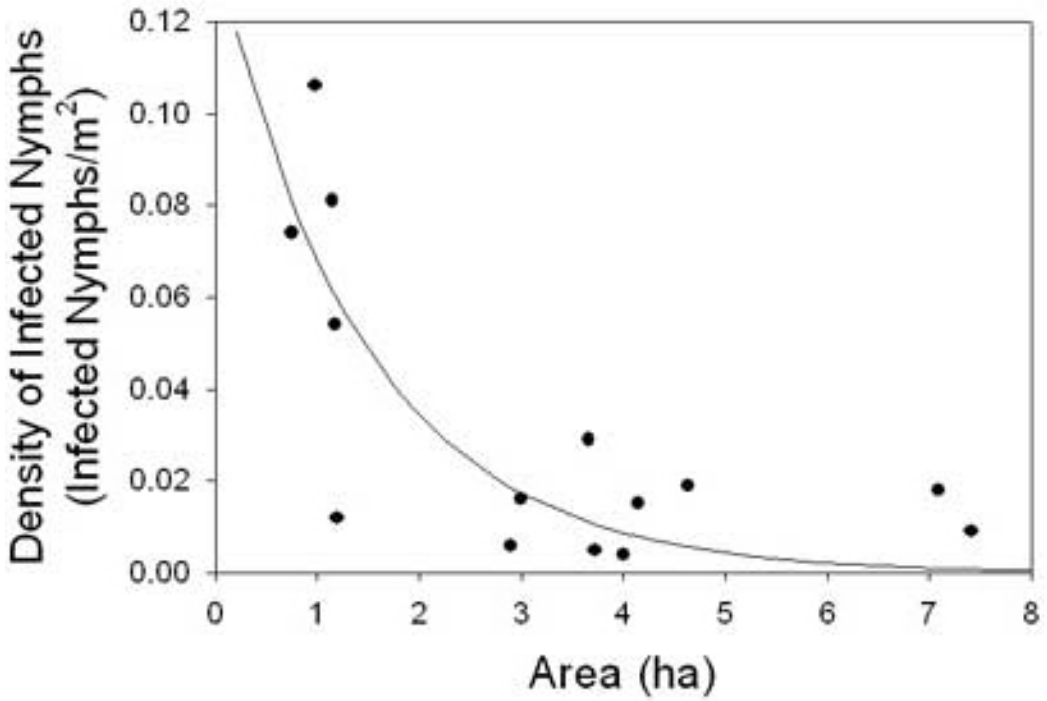
Right graph: computer model of number of host species on human exposure risk.

Q12: Does the percentage of infected nymphs change as the number of host species change? If yes, how?

Q13: How might increased biodiversity influence Lyme disease risk?

Kremen C and Ostfeld RS. A call to ecologists: measuring, analyzing, and managing ecosystem services. Frontiers Ecol Environment. 2005; 3(10): 540-548.
https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/1540-9295%282005%29003%5B0540%3AACTEMA%5D2.0.CO%3B2

Forest fragmentation and Lyme disease risk



White-footed mice are highly resilient to habitat fragmentation and destruction and increase in population density when other vertebrate or natural predator populations diminish or disappear.

Examine the graph on the left.
Q14: What is the relationship between forest patch area (X-axis) and density of infected nymphs (Y-axis)?

Q15: What would explain these findings?

Q16: Given these results, explain why Lyme disease risk is so high in some U.S. states.

Q17: What strategies could these states implement to reduce Lyme disease risk?

Allan BF, Keesing F, Ostfeld RS. Effect of Forest Fragmentation on Lyme Disease Risk. Conservation Biology. 2003; 17: 267-272.
http://www.caryinstitute.org/sites/default/files/public/reprints/Allan_et_al_2003_Cons_Bio_17_267-272.pdf

One Health Case Study #3: Human, Animal, and Ecosystem Health
Why Is Food Making Us Sick?

https://www.foodsafetymagazine.com/magazine-archive1/octobernovember-2011/developing-and-assessing-gaps-programs-in-preparation-for-the-food-safety-modernization-act/
https://www.medicalnewstoday.com/articles/315449.php

Food Safety

One Health Issue	Interdependent Relationships in Ecosystems	Earth Systems/ Weather & Climate	Human Sustainability
Food Safety	Increased Human & Animal Wastes Adversely Impact Ecosystems	Waste Contaminates Soils & Waters & Degrades the Environment	High Microbial Burden in Environment Leads to Higher Disease Rates & Consumption of Antibiotics **HS-ETS1-1 and HS-LS2-7**

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

https://www.nextgenscience.org/dci-arrangement/hs-ets1-engineering-design
https://www.nextgenscience.org/dci-arrangement/hs-ls2-ecosystems-interactions-energy-and-dynamics

Student Case Type: Analysis

NGSS Standards

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Learning Objectives

- Students will be able to use data to understand the risk of foodborne illness.
- Students will be able to create strategies to combat foodborne illness and improve food safety.

Student Case Type: Analysis

- Students are presented with data to analyze about food safety
- Some questions might require them to calculate their answers about food safety.
- This case study will focus on bacterial contamination of food
- Students can either work individually or in small groups
- They should discuss their answers at the end of class

What's the difference between food safety and food security?

Food Safety

Food free from contamination (e.g. harmful bacteria, viruses, parasites, toxins or other dangerous chemical substances.

A pathogen is a microbe that makes you sick

Food Security

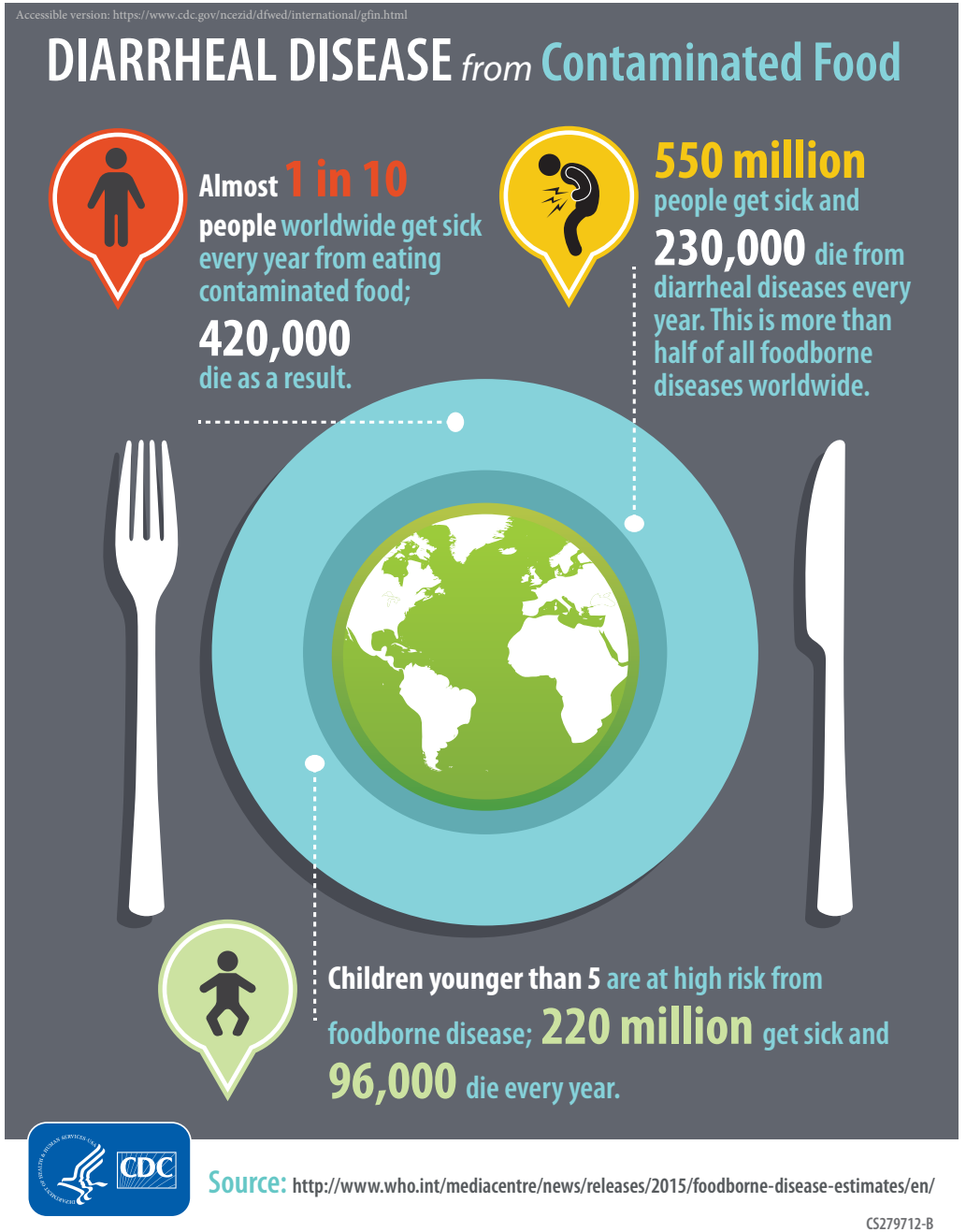
Food Security = No Hungry People

UN FAO estimates 795 million people out of 7.3 billion (1 in 9) suffer from chronic undernourishment in 2014-2016.

Prevention of hunger

- Food availability
- Food affordability
- Food use/waste

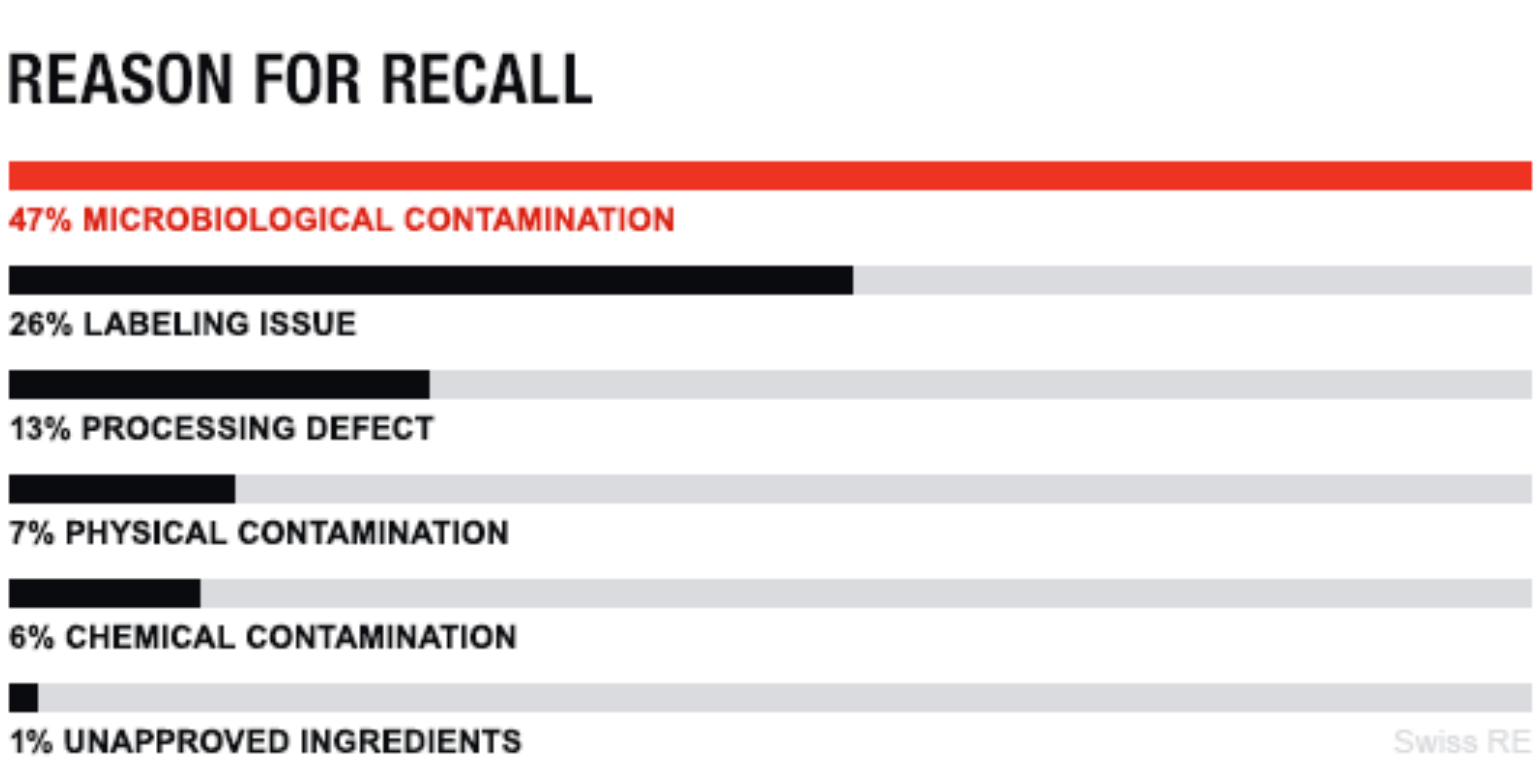
http://www.worldhunger.org/2015-world-hunger-and-poverty-facts-and-statistics/

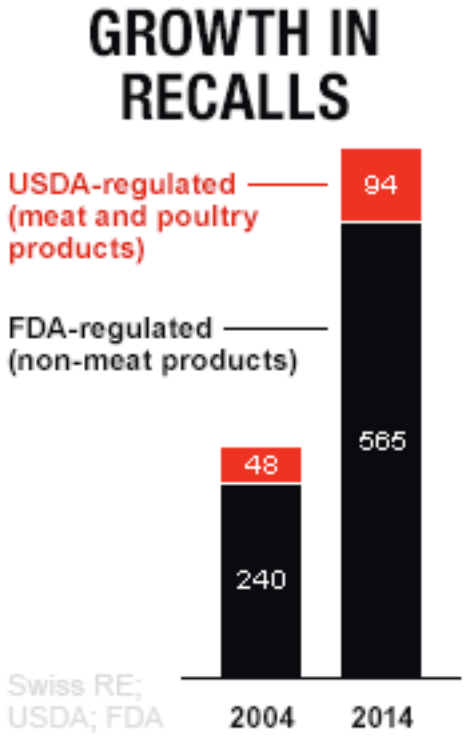


https://www.cdc.gov/ncezid/dfwed/international/gfin.html

http://resources.nationalacademies.org/widgets/Food-origins/infographic.html?keepThis=true&

Food Recalls Are Becoming More Common





CDC estimates that 48 million Americans get sick, 128,000 are hospitalized, and 3,000 die from foodborne diseases each year.

http://fortune.com/food-contamination/
https://www.cdc.gov/foodborneburden/estimates-overview.html

Estimated annual number of illnesses, hospitalizations, and deaths due to 31 known pathogens and unspecified agents each year in the United States.

Foodborne agents	Estimated annual number of illnesses (%)	Estimated annual number of hospitalizations (%)	Estimated annual number of deaths (%)
31 known pathogens	37.2 million (21%)	228, 744 (47%)	2,612 (42%)
Unknown agents	141.8 million (79%)	258,033 (53%)	3,574 (58%)
Total	179 million (100%)	486, 777 (100%)	6,186 (100%)

Examine the table above.

Q1: What are the estimated annual number of illnesses, hospitalizations, and deaths from the 31 known pathogens? What are the percentages?

Q2: What are the estimated annual number of illnesses, hospitalizations, and deaths from the unknown agents? What are the percentages?

Q3: From the answers in Q1 and Q2, what causes more illnesses, hospitalizations, and deaths? Known pathogens or unknown agents?

Q4: What should be done to address the finding in Q3?

CDC Estimates of Foodborne Illness in the United States. Modified chart. https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html

Eight known pathogens are estimated to account for the majority of domestically acquired foodborne illnesses, hospitalizations, and deaths.

- Go to the CDC's website, Estimates of Foodborne Illness in the United States to answer the following questions. https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html

Q5: Which are the top 5 pathogens contributing to domestically acquired *foodborne illnesses*?

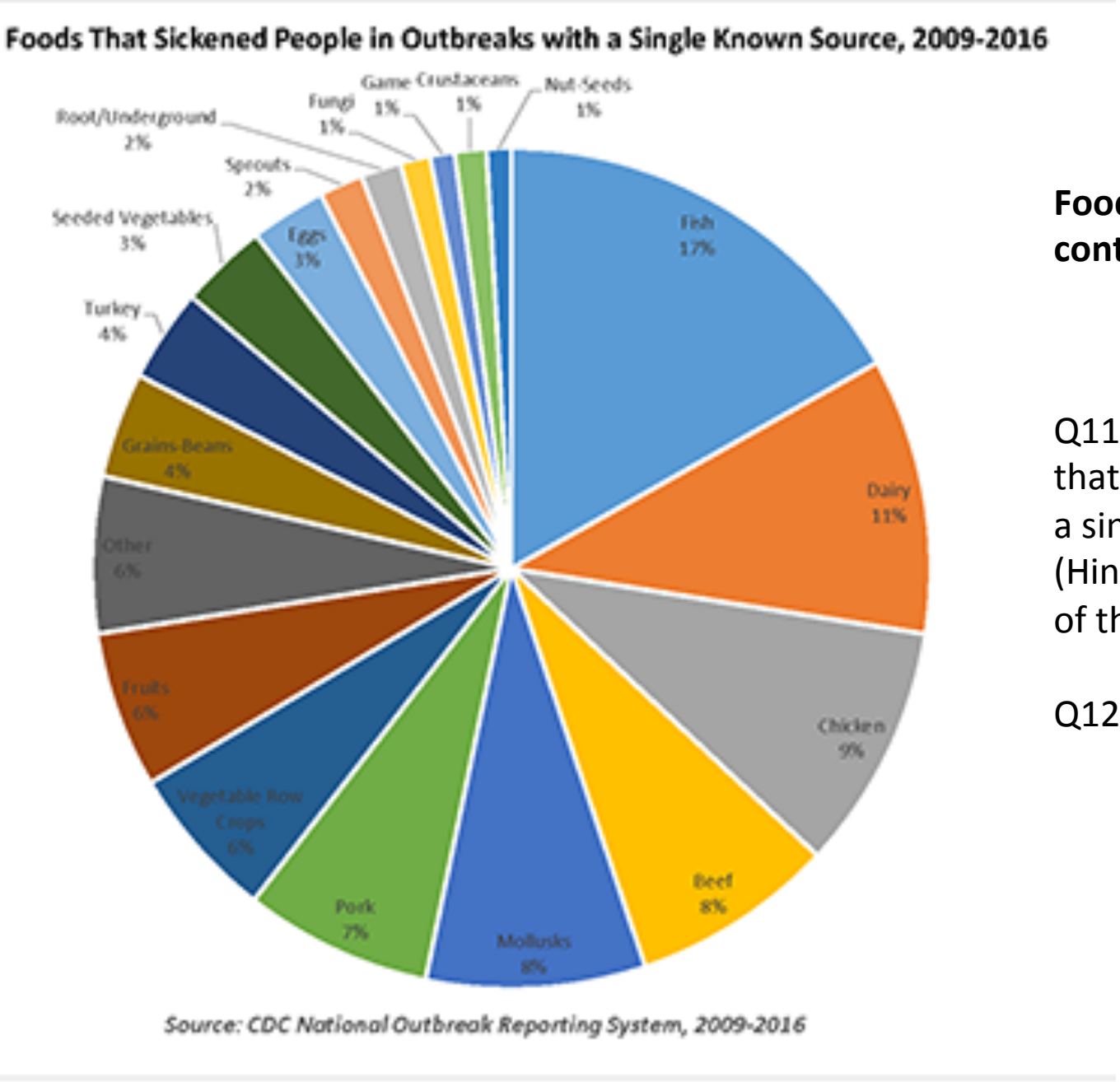
Q6: Which are the top 5 pathogens contributing to domestically acquired foodborne illnesses resulting in *hospitalizations*?

Q7: Which are the top 5 pathogens contributing to domestically acquired foodborne illnesses resulting in *death*?

Q8: Which pathogen causes the most hospitalizations and deaths?

Q9: Where does this pathogen come from?

Q10: What can be done to prevent it?



Foodborne illnesses generally arise from fecal contamination due to poor sanitation and hygiene.

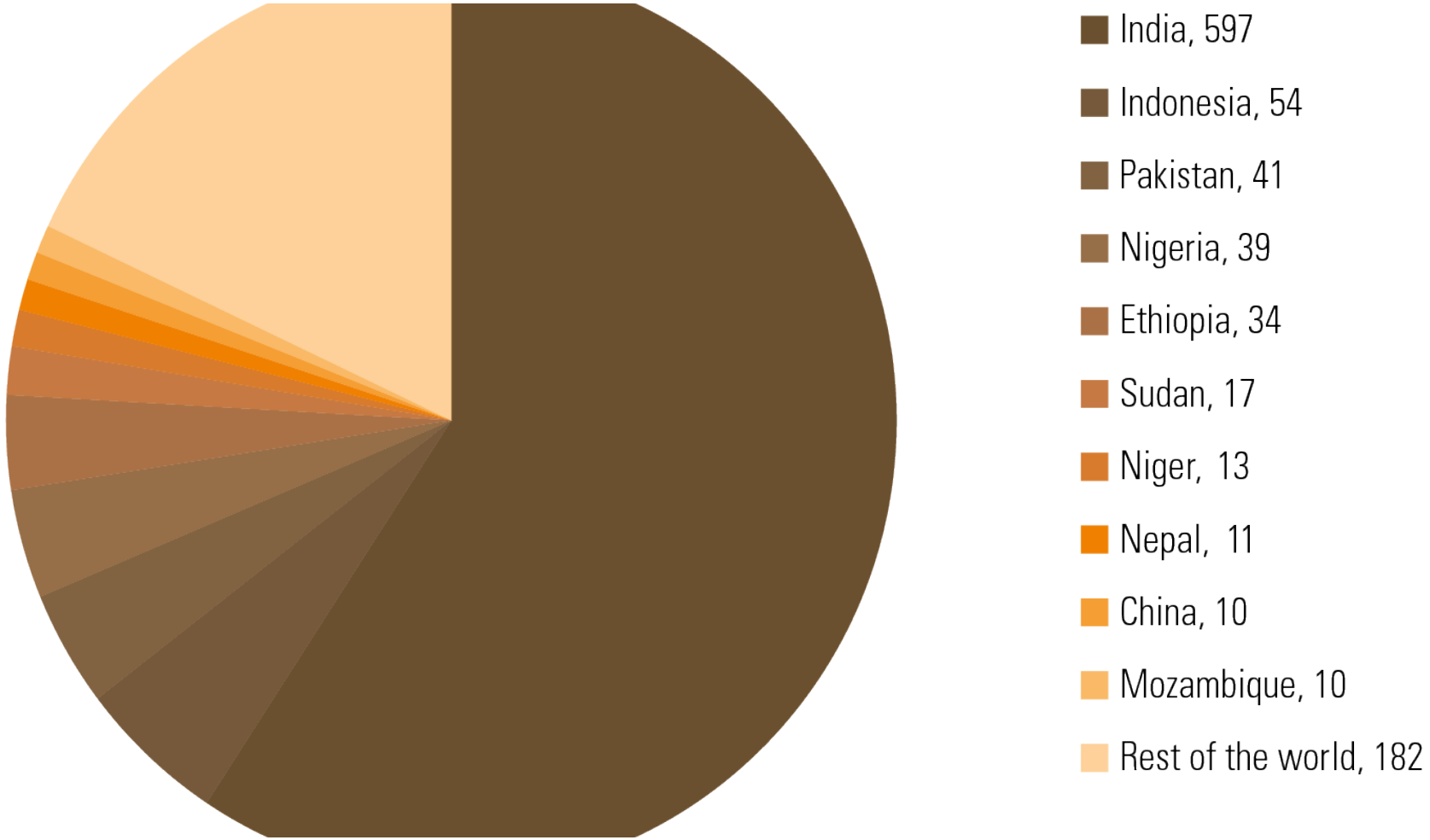
Q11: Which foods constitute the largest percentage that have sickened people in outbreaks with a single known source?
(Hint: Together, they constitute 53% of the single known sources.

Q12: What feature do they have in common?

https://www.cdc.gov/foodsafety/communication/graphics.html

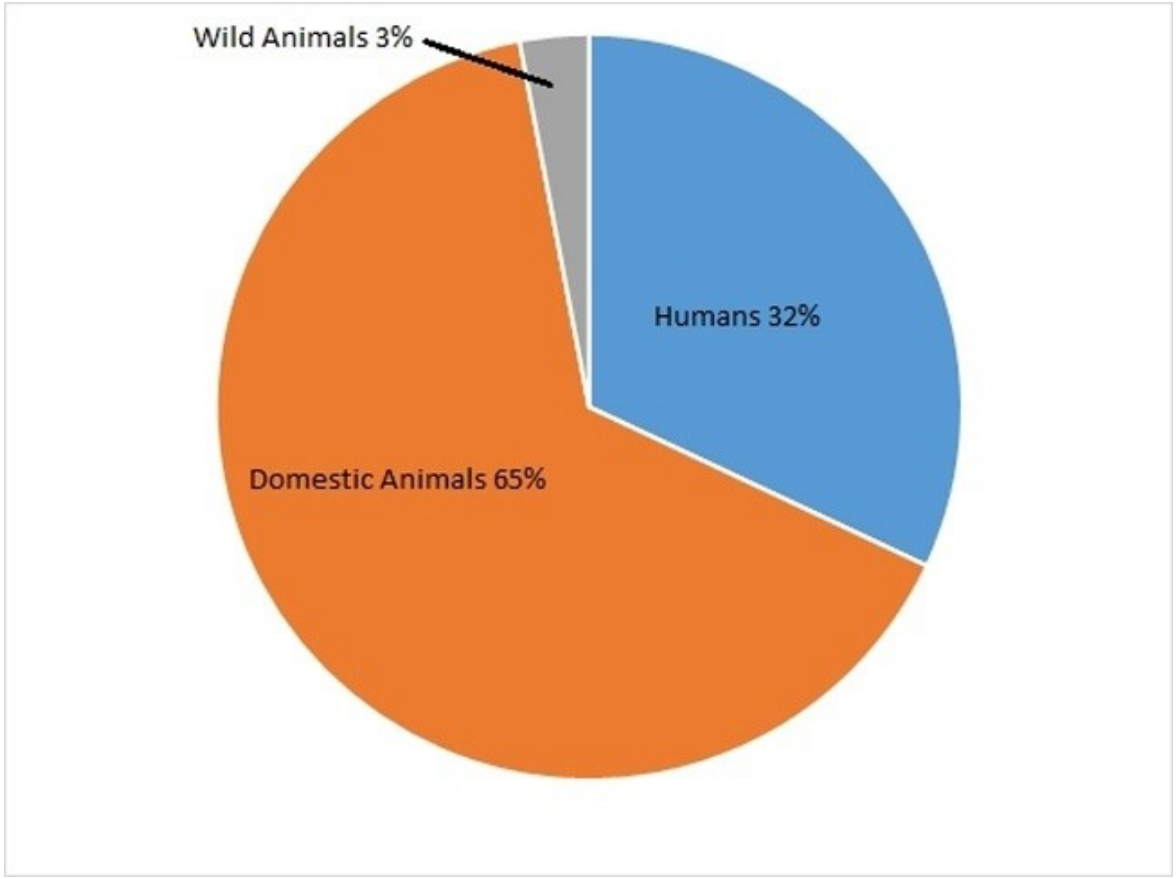
1 Billion People (14% World's Population) Openly Defecate

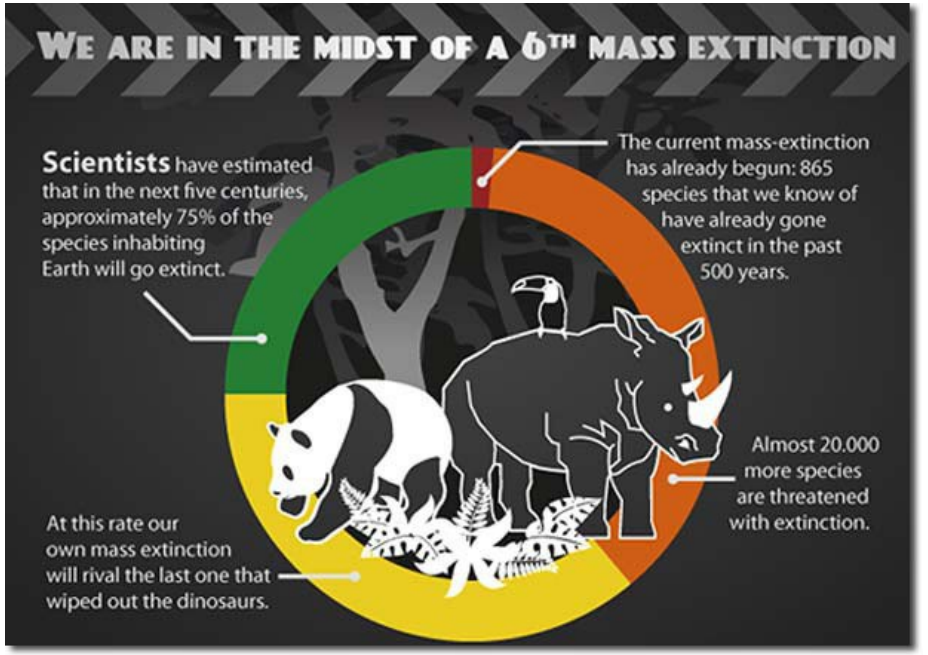
Q13: Which country constitutes 60% of the 1 billion people that openly defecate?



Source: Unicef data http://data.unicef.org/water-sanitation/sanitation

Q14: Humans and Domesticated Animals Make Up Approximately What Percentage of Total Mammalian Zoomass on Earth? Together, they make a lot of manure.





Side Note: Many animals are going extinct.

https://www.ecowatch.com/earth-is-facing-most-severe-extinction-crisis-in-65-million-years-1882085041.html
https://howwegettonext.com/pandemic-proofing-the-world-98222a38782#.fwwutac03
https://www.theodysseyonline.com/quick-facts-sixth-mass-extinction

Q15: Fill out the table below and estimate the total manure produced per year by people and their domesticated food animals (Note: For the purposes of this question, the weights of the animals in the calculations are not needed!)

	Chickens	Pigs	Cattle	Humans
2016 global population	22.7 X 10^9	98 X 10^7	1.5 X 10^9	7.5 X 10^9
Average Manure per Day (lbs)	70.3	63.1	70.0	0.28
Total Manure per Day (lbs)				
Total Manure per Year (lbs)				
Grand Total Manure Produced per Year (lbs)				
Grand Total Manure Produced (tons)				

Population data for chickens, pigs, and cattle obtained from FAOSTAT
http://www.fao.org/faostat/en/?#data
Global Human Population Estimate: http://www.worldometers.info/world-population/world-population-by-year/

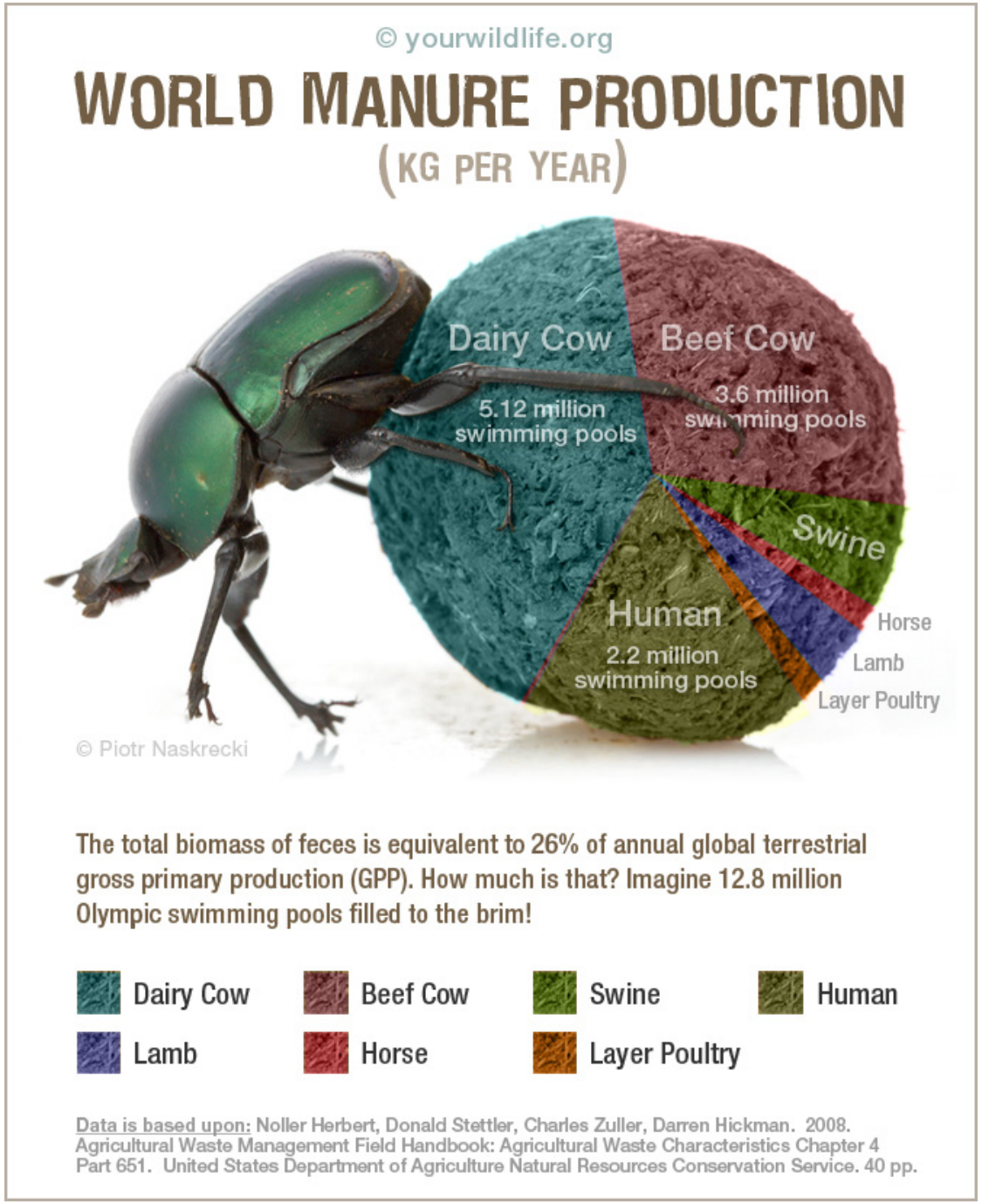
Q16: What happens to feces after being flushed down the toilet?

Q17: Describe the sewage treatment process. How might it be improved, particularly in poor countries?

Q18: What can be done with manure besides using it as fertilizer?

Q19: Describe how food becomes contaminated with fecal matter from humans and animals.

Q20: If you were in charge of global food safety, what would you do with all of the human and animal manure produced to reduce the risk of foodborne illness?



Other trans-disciplines like One Health

- Ecology of Health (EcoHealth)
  - http://ecohealth.net/en/
  - https://www.ecohealthalliance.org/
- Conservation Medicine
  - http://vet.tufts.edu/center-for-conservation-medicine/
  - https://www.stlzoo.org/conservation/institute-for-conservation-medicine/
- Geological Health (GeoHealth)
  - https://liemohnjgrspace.wordpress.com/2016/12/02/agus-new-journal-geohealth/
  - https://geohealth.hhs.gov/arcgis/home/
- Planetary Health
  - https://www.rockefellerfoundation.org/our-work/initiatives/planetary-health/
  - https://planetaryhealthalliance.org/
  - http://www.thelancet.com/infographics/what-is-planetary-health

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http://www.onehealthinitiative.com

Preparing Society to Create the World We Need through One Health Education

One Health Educational Resources

Curriculum guide - Lesson plans – Case studies - Links

https://www.onehealthcommission.org/en/resources__services/one_health_educational_resources/

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