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)?

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

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<td>Food Security (A fancy term for “preventing hunger”)</td>
<td>Crop &amp; Livestock Production, Ecosystem Disruption (Deforestation, Waste Production, Pesticides)</td>
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**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](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

Climate change threatens agriculture

Time of Complex Life on Earth

Paleozoic Era

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://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.

Genetically Modified Organisms (GMOs)

Golden Rice with Vitamin A

Have generated considerable political opposition...

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?

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

Tick on a human

Ticks on a dog
# Emerging Diseases (e.g. Vector-borne)

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<tr>
<td>Emerging Diseases (e.g. Vector-borne)</td>
<td>Deforestation &amp; Ecosystem Disruption for Agriculture &amp; Development. Spread of Vectors (Arthropods/Insects).</td>
<td>Insects prefer warmer climates, likely to spread to higher elevations.</td>
<td>Higher Vector-borne Disease Rates in Humans &amp; Domesticated Animals. HS-ESS3-1 and HS-LS2-7</td>
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**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/topic-arrangement/hshuman-sustainability)
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.

*Borrelia burgdorferi*, the bacteria that cause Lyme disease.
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

- Rash in 70 to 80% infected people
- Treatment is antibiotics.

https://www.cdc.gov/lyme/signs_symptoms/index.html
Symptoms of Lyme Disease in Dogs

Renal disease

Cardiovascular disease

Affected central nervous system

https://www.avma.org/public/PetCare/Pages/lyme-disease.aspx
Reported Human Lyme Disease cases by year, U.S., 1996-2016

*National Surveillance case definition revised in 2008 to include probable cases; details at http://www.cdc.gov/ncphi/disse/mmisis/casedef/lyme_disease_2008.htm

https://www.cdc.gov/lyme/stats/graphs.html
Lyme disease is the most common tick-borne infection. In the U.S., around 300,000 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.
Lyme Disease maps—United States 2012-2016
Reported Human Lyme Disease Cases

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?

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?
One Health Case Study #3: Human, Animal, and Ecosystem Health

Why Is Food Making Us Sick?
## Food Safety

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<tr>
<td>Food Safety</td>
<td>Increased Human &amp; Animal Wastes Adversely Impact Ecosystems</td>
<td>Waste Contaminates Soils &amp; Waters &amp; Degrades the Environment</td>
<td>High Microbial Burden in Environment Leads to Higher Disease Rates &amp; Consumption of Antibiotics <strong>HS-ETS1-1 and HS-LS2-7</strong></td>
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**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-ets1-engineering-design)
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

Almost 1 in 10 people worldwide get sick every year from eating contaminated food; 420,000 die as a result.

550 million people get sick and 230,000 die from diarrheal diseases every year. This is more than half of all foodborne diseases worldwide.

Children younger than 5 are at high risk from foodborne disease; 220 million get sick and 96,000 die every year.
The Well-Traveled Salad. 
Do You Know Where Your Food Has Been?

As consumers, many of us fail to recognize that even our domestic and local food supplies are part of a global network. The daily activity of consuming food directly links our health as humans to the health of crops and produce, food animals, and the environments in which they are produced.

A “One Health” approach to food safety—bringing together expertise and resources from the clinical, veterinary, wildlife, health, and ecology communities—has the potential to reveal the sources, pathways, and factors driving the outbreaks of foodborne illnesses and possibly prevent them from occurring in the first place.

NOTE: Countries are listed in alphabetical order and not by volume of export.

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

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

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?

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

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

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://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!)

<table>
<thead>
<tr>
<th></th>
<th>Chickens</th>
<th>Pigs</th>
<th>Cattle</th>
<th>Humans</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016 global population</td>
<td>22.7 X 10^9</td>
<td>98 X 10^7</td>
<td>1.5 X 10^9</td>
<td>7.5 X 10^9</td>
</tr>
<tr>
<td>Average Manure per Day (lbs)</td>
<td>70.3</td>
<td>63.1</td>
<td>70.0</td>
<td>0.28</td>
</tr>
<tr>
<td>Total Manure per Day (lbs)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total Manure per Year (lbs)</td>
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<tr>
<td>Grand Total Manure Produced per Year (lbs)</td>
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<tr>
<td>Grand Total Manure Produced (tons)</td>
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Population data for chickens, pigs, and cattle obtained from FAOSTAT
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
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Curriculum guide - Lesson plans – Case studies - Links

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created and hosted by

One Health Commission

One Health Platform

check www.onehealthday.org for more information