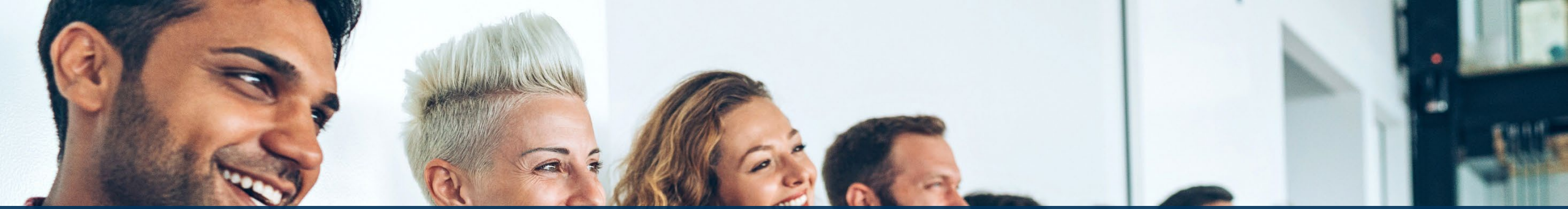


DC Health CPH Review Session

"Public Health Biology and Human Disease Risk"

Aliyar Cyrus Fouladkhah, PhD, MS, MPH, CFS, CPH

Founding Director, Public Health Microbiology Foundation

Associate Professor, Tennessee State University

May 12, 2022

CPH Certified in Public Health

by National Board of Public Health Examiners

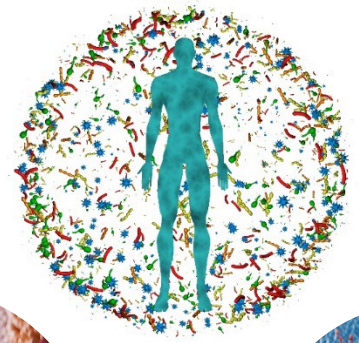
Presentation Content

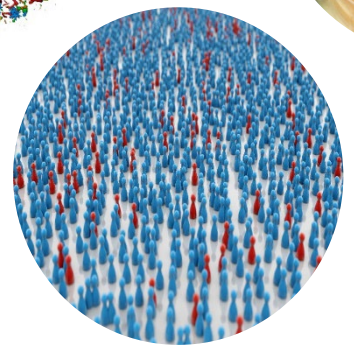
Part I: *Brief Introduction to my Program*

Part II: *Public Health Microbiology under the Landscape of Climate Change: An Epidemiological Perspective*

Part III: *Climate Change and Health**

Part IV: *Review of CPH Exam Practice Questions*





**Excerpts of this section was presented to CDC PHI Fellows and Yale Young Global Scholar Program. Some photo slides that provided by Climate Reality Project is gratefully acknowledged.*

- Microbiology and Food Safety, PhD (Colorado State University)
- Applied Statistics and Data Analysis, Graduate Certificate (CSU Statistics Dept.)
- Food Science & Human Nutrition, MS (CSU Food Science Dept.)

Colorado State University

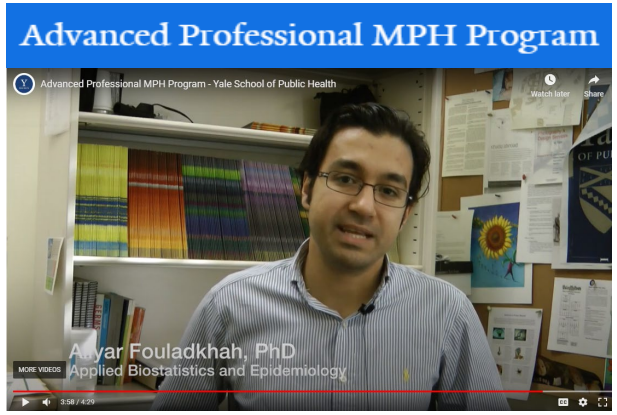
Microbac

BOULDER BRANDS

RODELLE established 1936

Yale SCHOOL OF PUBLIC HEALTH

- Biostatistics and Epidemiology, Advanced Professional MPH
- Food and Drug Regulatory Affairs, Graduate Certificate
- Climate Change and Health, Graduate Certificate



CPH Certified in Public Health

sas® Certified Base Programmer for SAS®9

Website: https://publichealth.yale.edu/education/degrees/mph/advanced/
Video: https://www.youtube.com/watch?v=IGVN9JfoIt8

Public Health Microbiology Program
Tennessee State University

Public Health Microbiology ™
Foundation
Dr. Aliyar Cyrus Fouladkhah

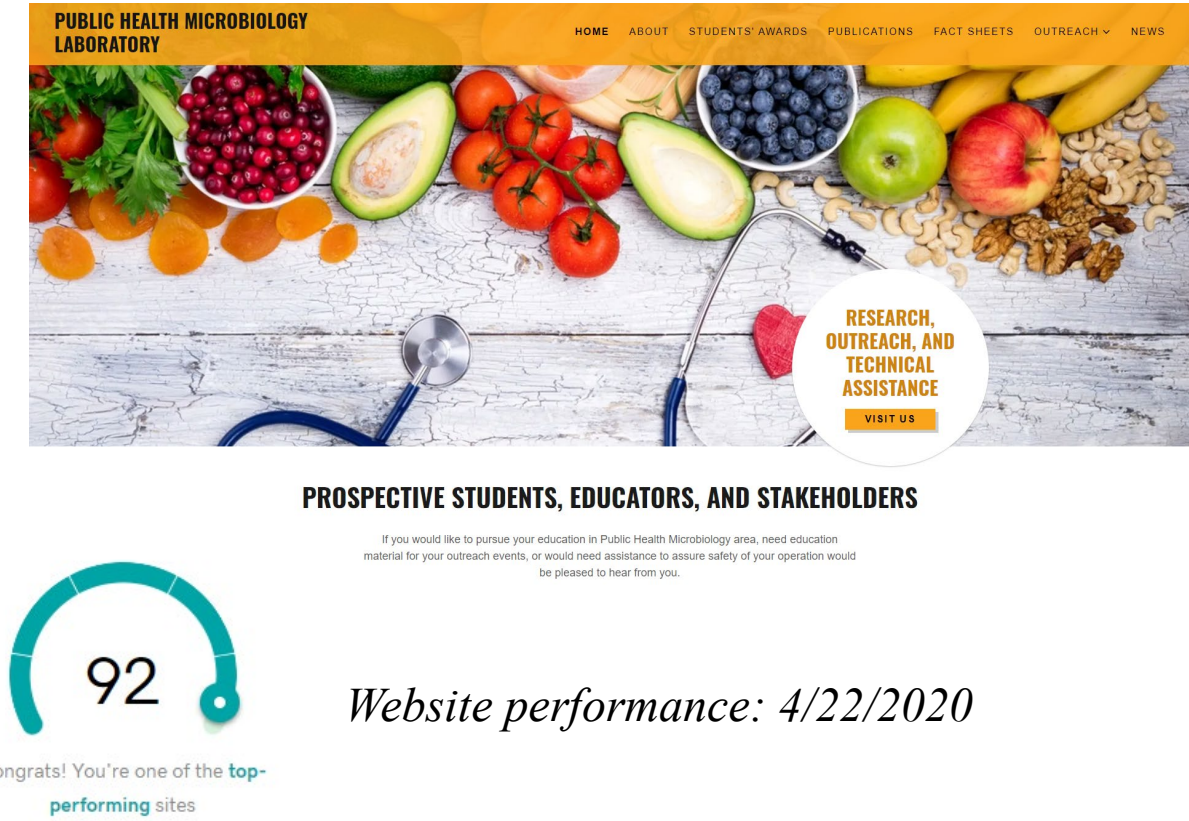
Funding sources

Extramural Funding: >$4.5M since 2015

- USDA-NIFA FSOP: **$299,995** (Role: PD, 2023-2026)
- National Institute of Health: $**33,680** (PD of Sub-award, 2020-21)*
- Pressure BioScience Inc.: **$35,000** (Role: PD, 2019-2024)
- USDA-NIFA CBG: **$350,000** (Role: PD, 2018-2022)
- USDA-NIFA HEC: **$50,000** (Role: PD, 2018-2021)
- USDA-NIFA FSOP: **$165,000** (Role: PD, 2018-2021)
- Pressure BioScience Inc.: **$23,500** (Role: PD, 2017-2019)
- USDA-NIFA FSOP: **$59,750** (Role: PD, 2016-2019)
- Pressure BioScience Inc.: **$9,400** (Role: PD, 2017-2019)
- NIFA FSOP.: **$880,000** (Role: CO-PD, 2019-2023)**
- USDA-NIFA FSOP.: **$1,197,751** (Role: CO-PD, 2015-2020)**
- NIFA CBG.: **$300,000** (Role: CO-PD, 2018-2022)

**Pending account setting and internal administrative approval.*
*** Sub-awardee of Southern Center Main Awards.*

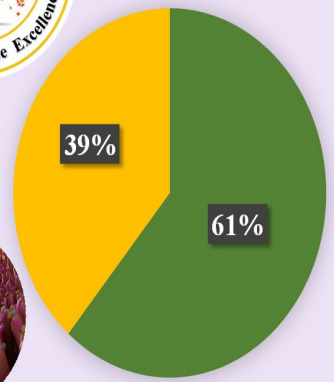
Website: https://publichealthmicrobiology.education/



Website performance: 4/22/2020

Public Health Microbiology Foundation *est. 2022*

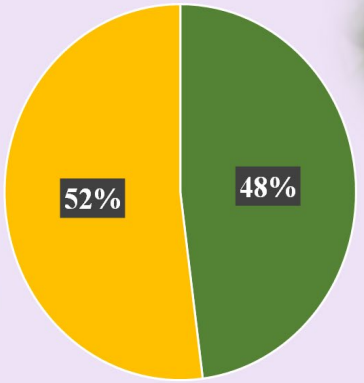
Stakeholders' Profile:
Food Processing Center Clients
(Updated January 2023)



- Start-up Entrepreneurs
- Stablished Companies

98 Entrepreneurs Supported

Demographics:
Clients Received Supported
(Updated January 2023)

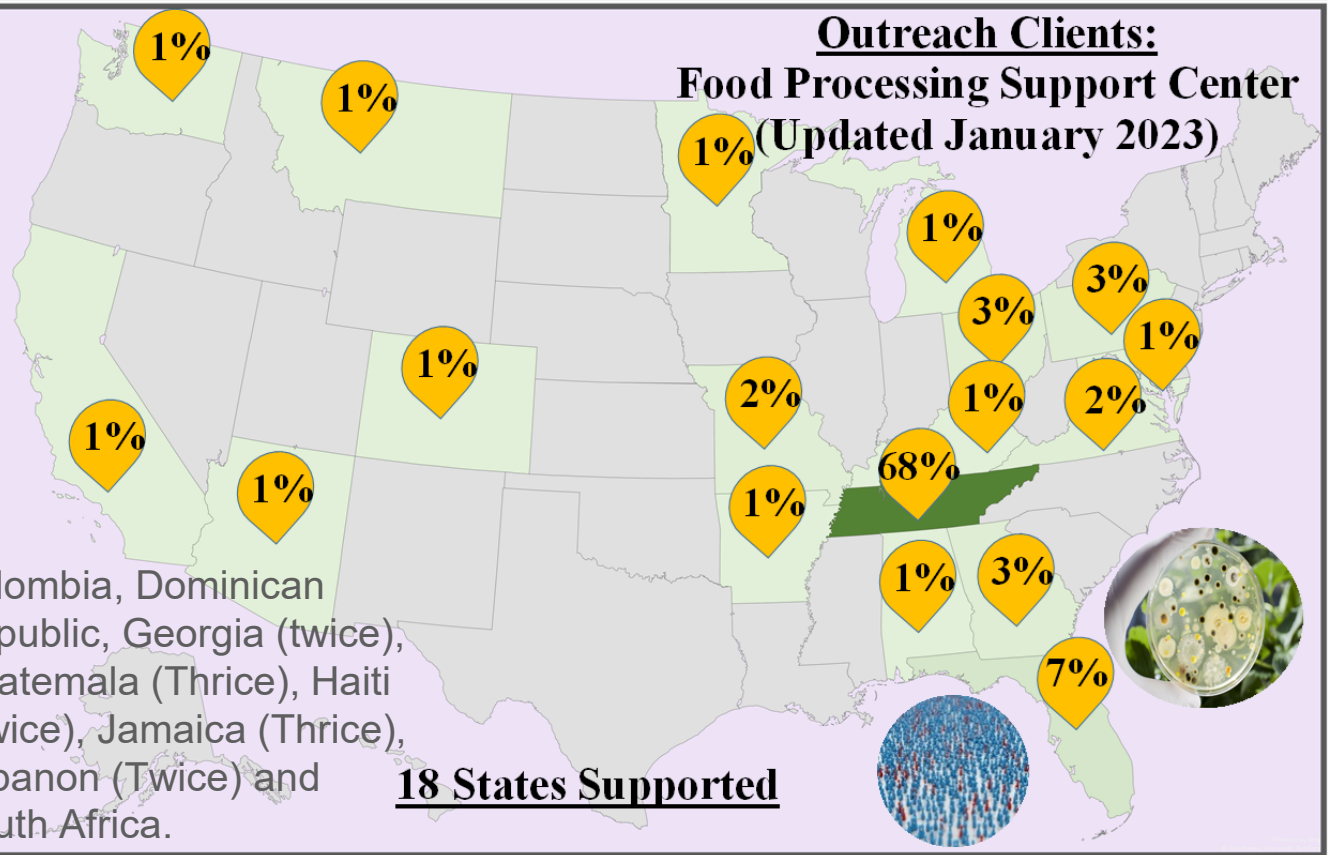


- Female
- Male

Foundation Updates As of February 2023

39	106	>178
Students Scholarship	Companies Supported (new products in market)	Food Safety Certifications

Outreach Clients:
Food Processing Support Center
(Updated January 2023)



Colombia, Dominican Republic, Georgia (twice), Guatemala (Thrice), Haiti (Twice), Jamaica (Thrice), Lebanon (Twice) and South Africa.

18 States Supported

Teaching Evaluations Available at: https://publichealthmicrobiology.education/stakeholders-evaluation

Teaching in Tennessee and Internationally

Graduate Course in Policy and Regulations

2022 Student Evaluation:

- *"…Dr. Fouladkhah is easily the nicest professor I have ever had the pleasure of meeting. He seriously cares about you and how you're doing."*
- *""I loved this class it was so interactive and different from any other class I have taken here at TSU!"*

Summary of Students' Evaluation of AGSC 5540- Food Policies and Regulations Course^		
Dr. Aliyar Cyrus Fouladkhah- Sole/Lead Instructor		
Year	Mean Score (5-point hedonic)	University/College/Department Status
2018	5.00/5.00	Ranked #1 in University, College, and Department.
2019	4.55/5.00	Ranked above University, College, and Department means in all 20 evaluation categories.
2020	4.83/5.00	Ranked above University, College, and Department means in all 20 evaluation categories.
2021	4.92/5.00	Ranked above University, College, and Department means in all 20 evaluation categories.
2022	4.86/5.00	Ranked #1 in 7 out of 20 categories compared to all courses of university. Ranked above University, College, & Department means on remaining 13 categories.
^ Complete evaluation data available upon request		

CIFOR Guideline
HACCP
Nutrition Labeling
FSMA PC QI

Typically, 3 to 10 additional enrollment from the Food Industry and Regulatory Agencies via Zoom

Global Health Programs Available at:
https://publichealthmicrobiology.education/global-health-programs

2021, 2022 Jamaica
Food industry Certifications

2020, 2022 (Ministry of Health)
Haiti Government, Fortification with iron, vitamin b12, and zinc

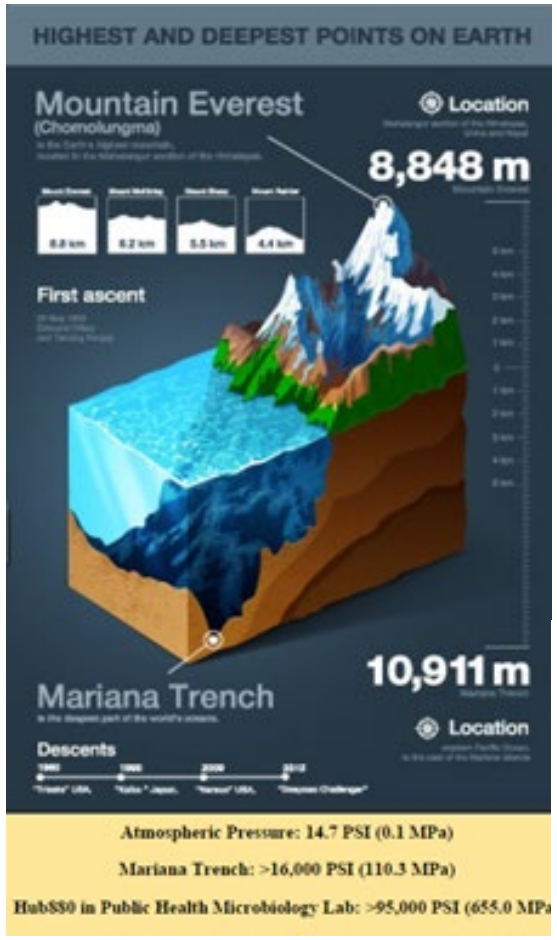
2019, Philippi Township, Cape Town, South Africa:
HIV Prevention Training

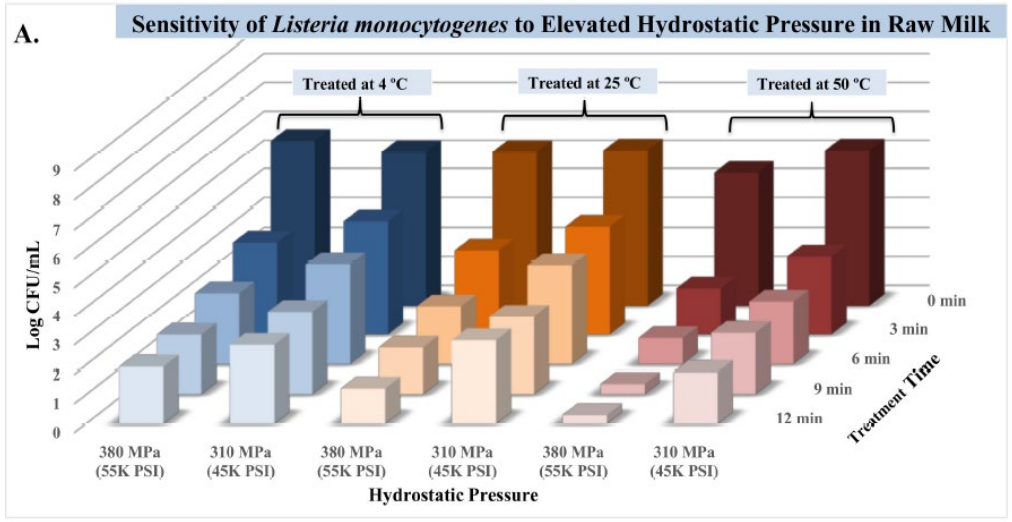
2018, 2020, 2021 Guatemala
Food Safety Training for Food Industry Leadership

2017 Santiago, Dominican Republic
USAID Public Health and Microbiology Training Faculty and Staff of ISA University

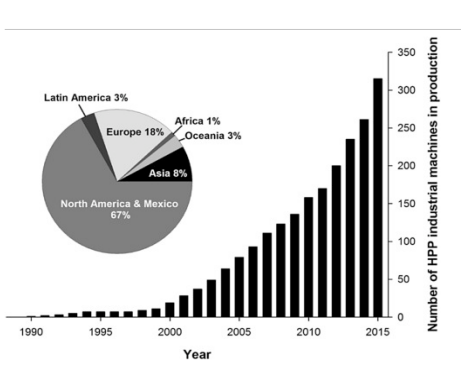
Research Responsibility:
1. Elevated Hydrostatic Pressure
2. Bacterial Biofilm
3. Effects of Climate Change on Infectious Diseases

- Elevated Hydrostatics Pressure:
- Hub880, up to **650 MPa**
- Deepest part of Oceans (Mariana Trench): c. **110 MPa**
- Programable unit Hub 440, 380 MPa
- Controlling the temperature
- Synergism with bacteriocin and bactericidal compounds





Allison et al., 2018

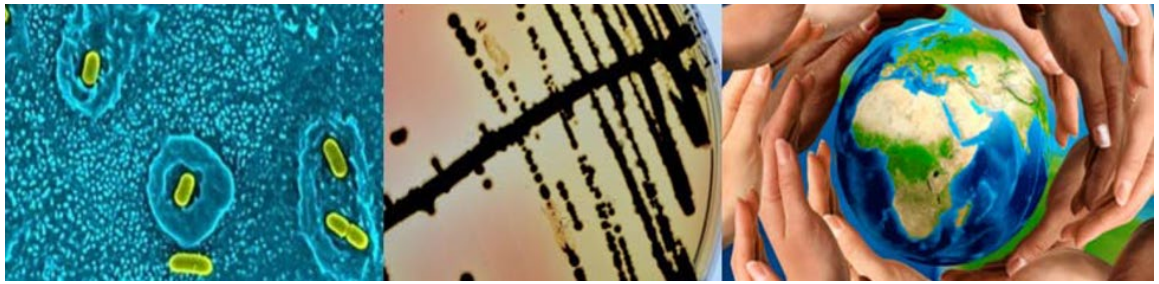


High Pressure Processing, Public Health Microbiology Laboratory

PBI Pressure BioSciences Inc.

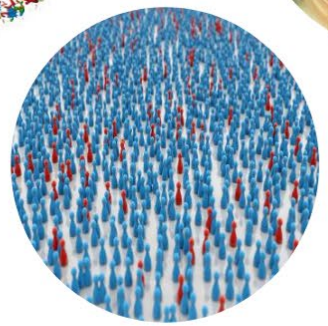
High Pressure Processing, Public Health Microbiology Laboratory

Information about the units: https://ir.pressurebiosciences.com/press-releases/detail/284/pressure-biosciences-announces-commercial-release-of-the

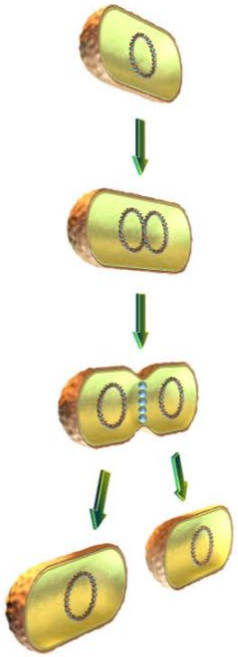


Public Health Microbiology Under the Landscape of Climate Change: An Epidemiological Perspective

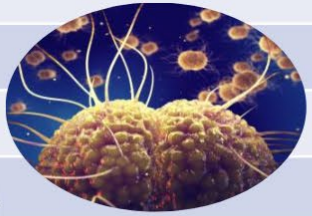
Bacterial Multiplication



Binary Fission: 20 minutes or less when intrinsic and extrinsic factors are optimal.



Time	# of Bacteria
0 minutes	1
20 minutes	2
40 minutes	4
1 hour	8
2 hours	64
4 hours	4,096
6 hours	262,144
8 hours	16,777,216
12 hours	68,719,476,736



Bacteria	Estimated Infective Dose*
Salmonella serovars	<10 cells
Shiga toxin-producing *E. coli*	10 to 100 cells
Cronobacter sakazakii	10 to 100 cells
Listeria monocytogenes	<1000 cells
Campylobacter spp.	5000 to 10,000 cells
Staphylococcus aureus	>100,000 cells
Vibrio cholerae	1,000,000 cells

Information and photos are modified and adopted from BBB of Food and Drug Administration, BAM Resources of Centers for Disease Control and Prevention. Photo Courtesy: Adobe Stock (standard license of photos purchased by the Public Health Microbiology laboratory)

** Calculated for oral ingestion based on epidemiological data from outbreaks and human feeding trials of volunteers. Data obtained from BBB of Food and Drug Administration (2nd edition).*

Public Health Microbiology Laboratory: Education, Research, Outreach, and Technical Assistance: https://publichealthmicrobiology.education/

Emerging pathogens

Vertical and Horizontal Gene Transfer and Emerging Pathogens

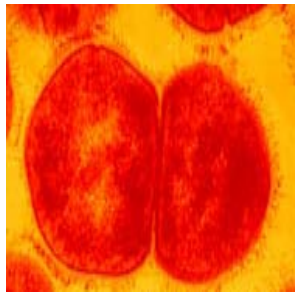
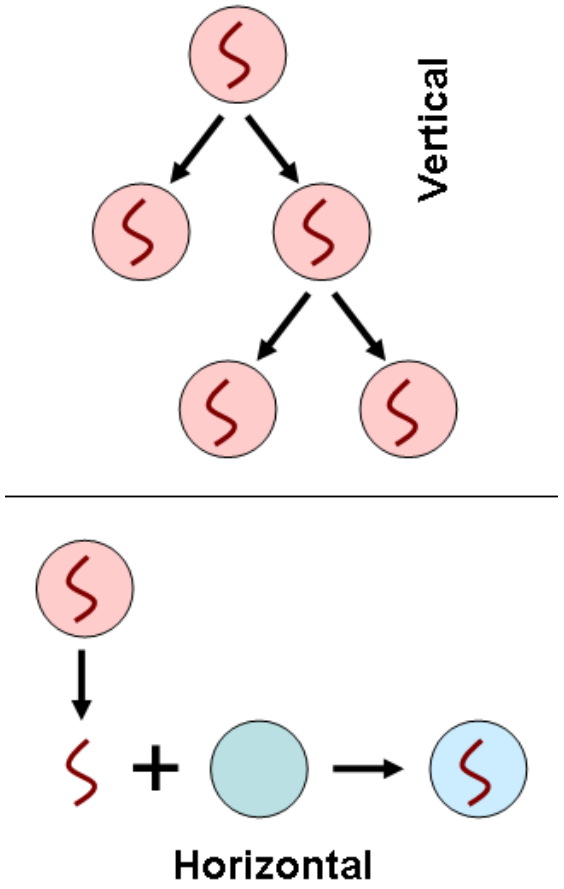
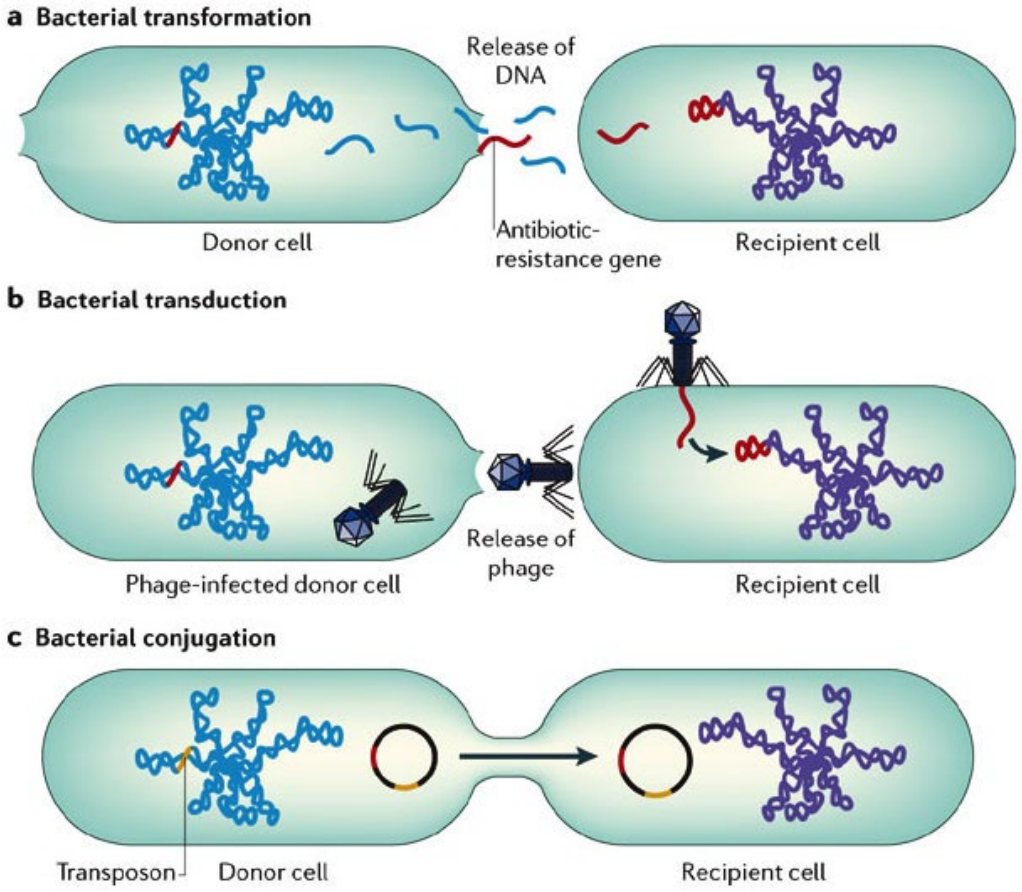
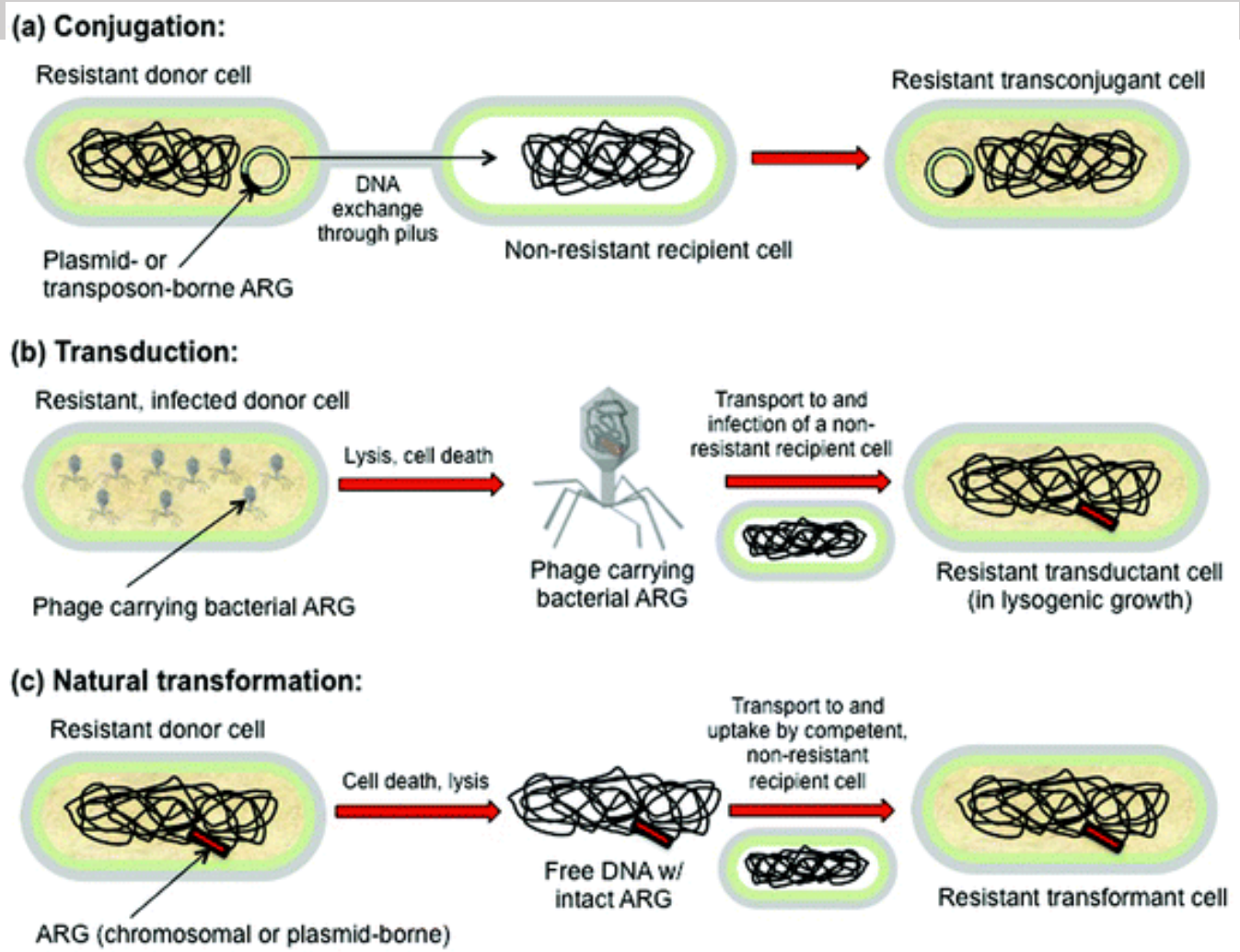


Photo Courtesy:
http://www.daviddarling.info/encyclopedia/B/binary_fission.html





Horizontal Gene Transfer



Donn, 2012

Planktonic cells and Biofilm Communities

Biofilm formation on **biotic** and **abiotic** surfaces

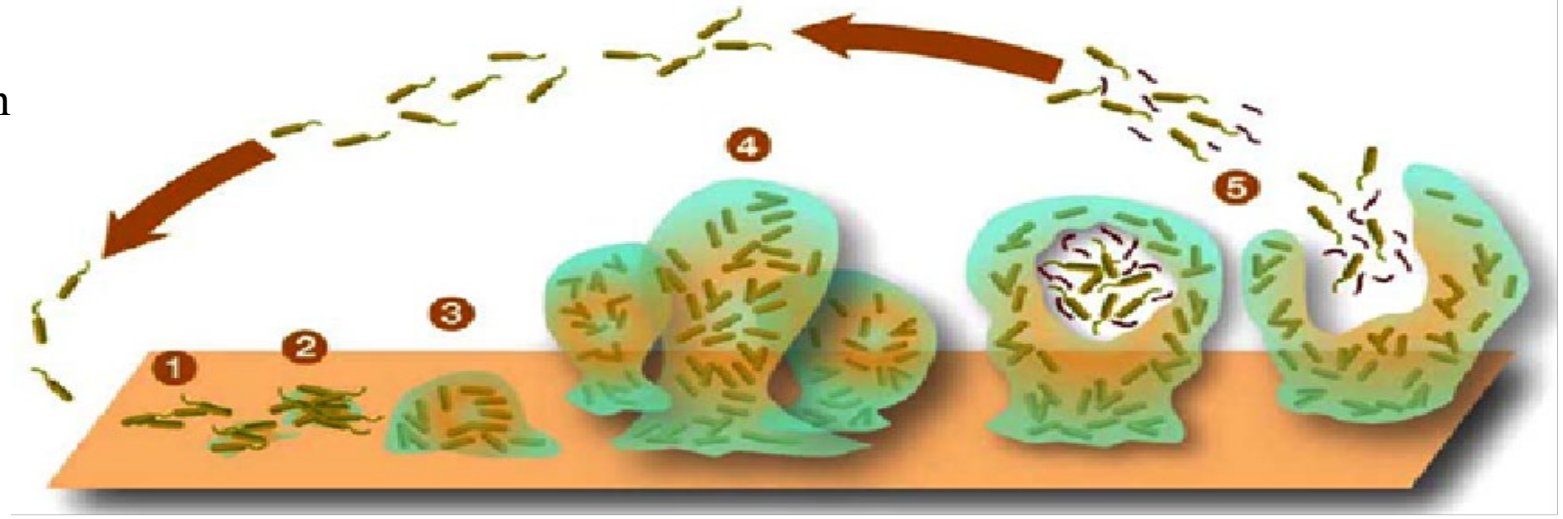


Photo Courtesy: http://prometheus.matse.illinois.edu/glossary/biofilms/

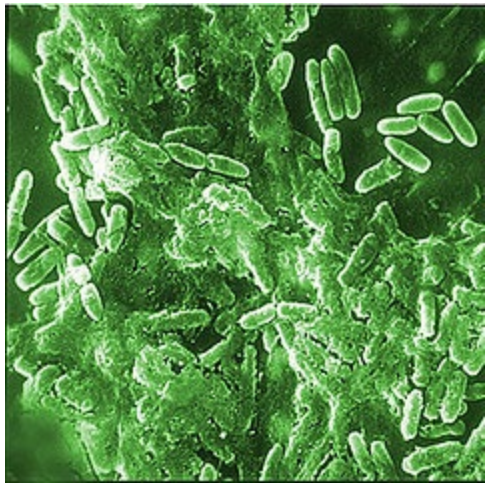


Photo Courtesy: http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

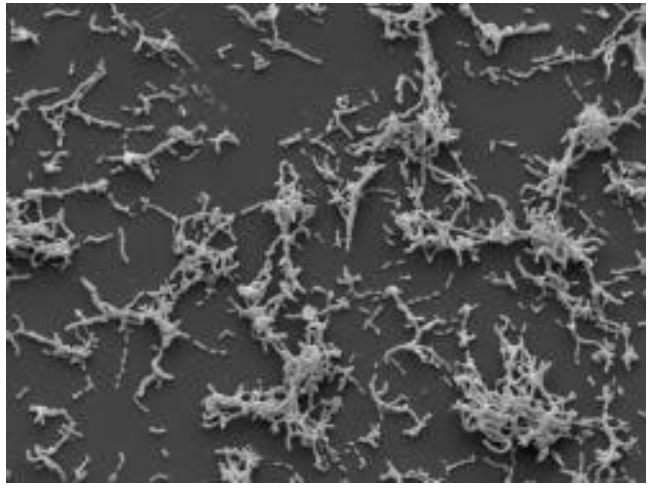


Photo Courtesy: http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php

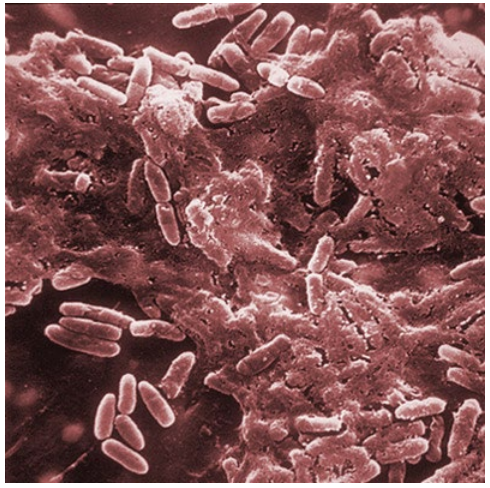
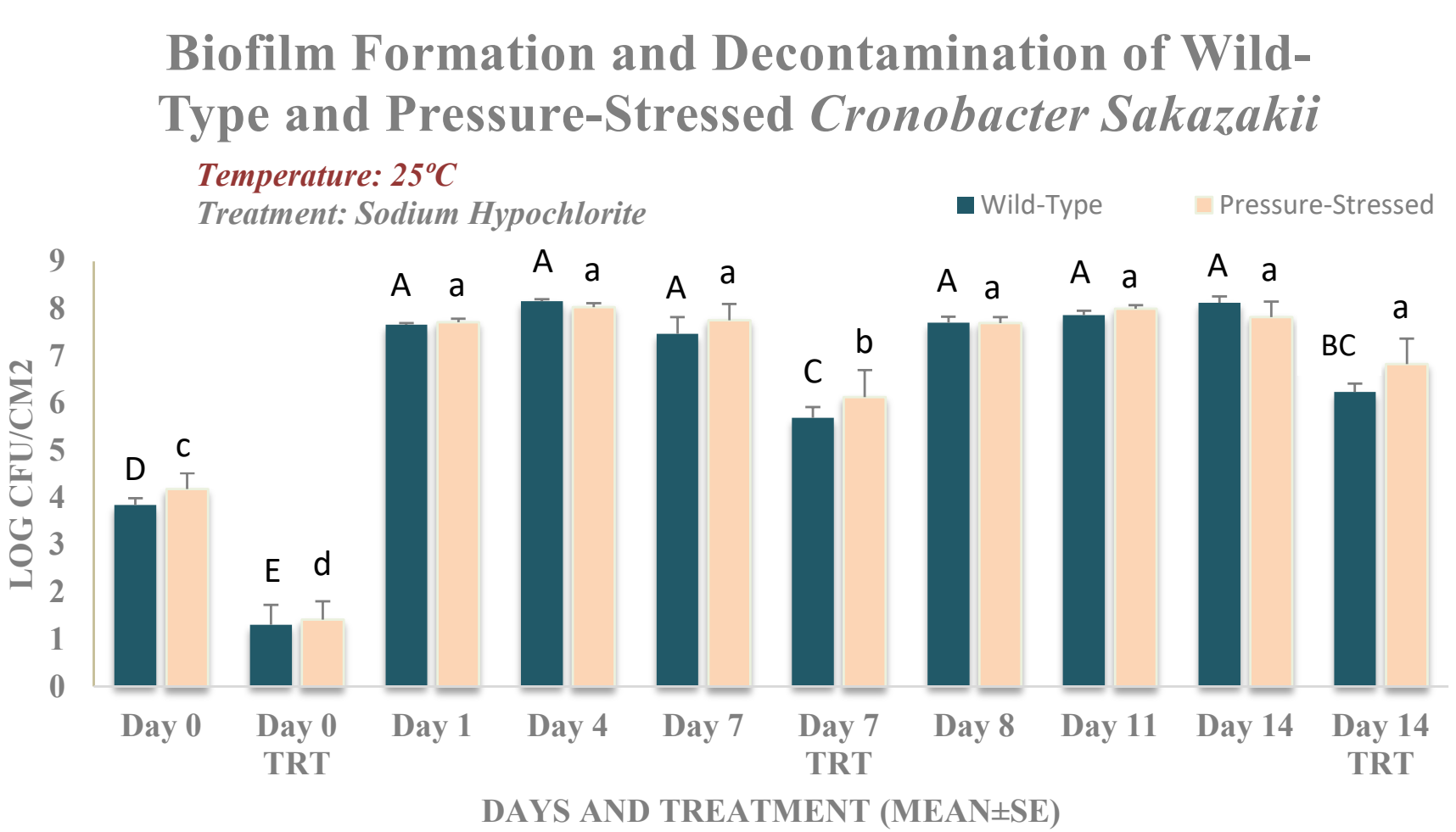
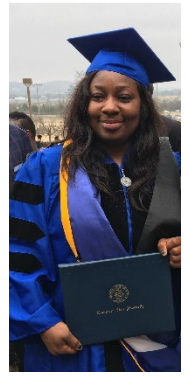


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/

Cronobacter sakazakii
Two outbreaks in Tennessee (1998, Memphis; 2001 Knoxville)





Allison et al., 2020

Quorum Sensing and Biofilm formation

Shiga toxin producing *E. coli*, not antibiotic treatment due to Quorum Sensing Concerns

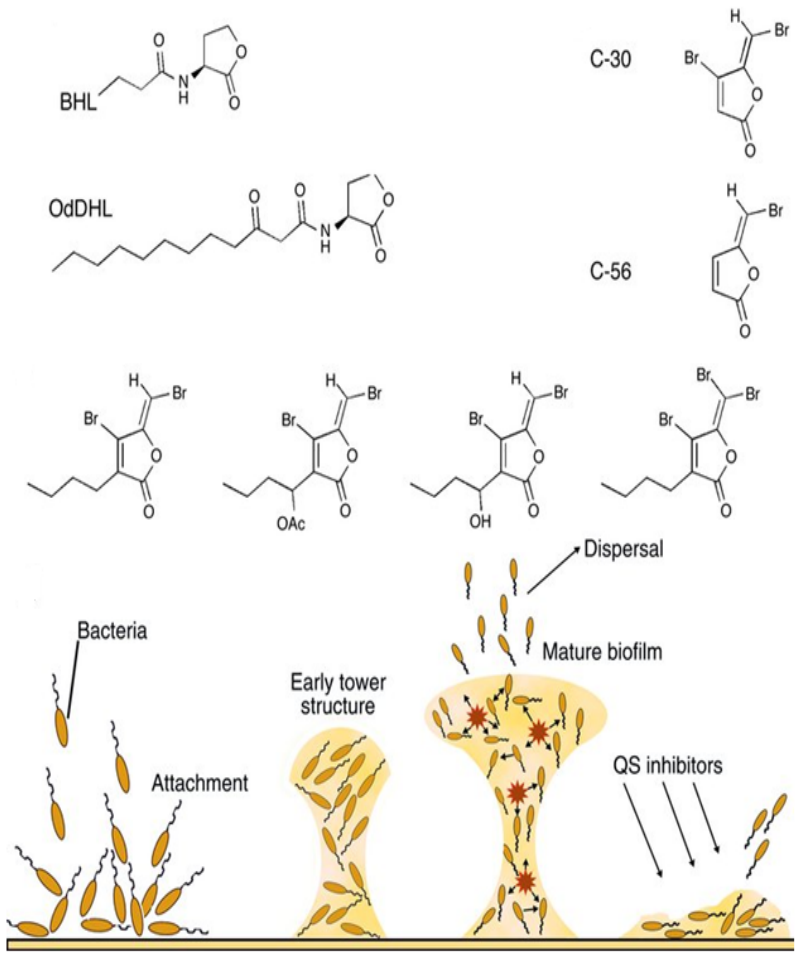


Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

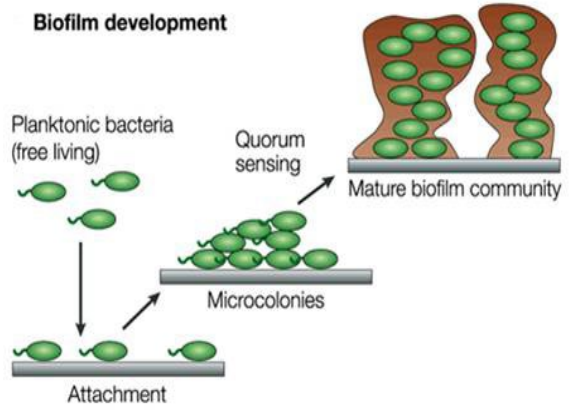


Photo Courtesy: http://labrat.fieldofscience.com/2010/07/quorum-sensing-and-biofilms.html

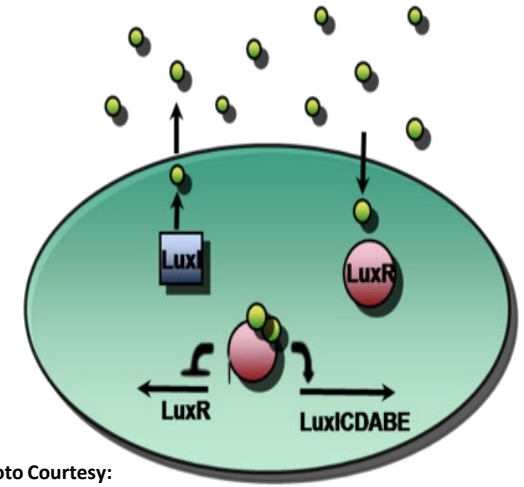


Photo Courtesy: http://2009.igem.org/Team:Aberdeen_Scotland/WetLab/quorumsensing

Infectious Diseases is a Moving Target…

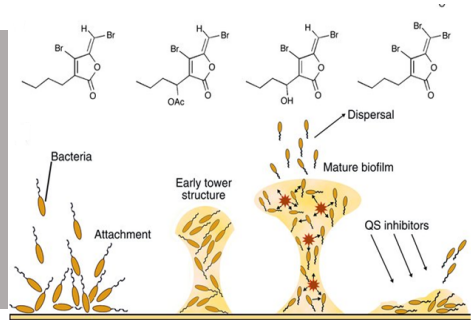


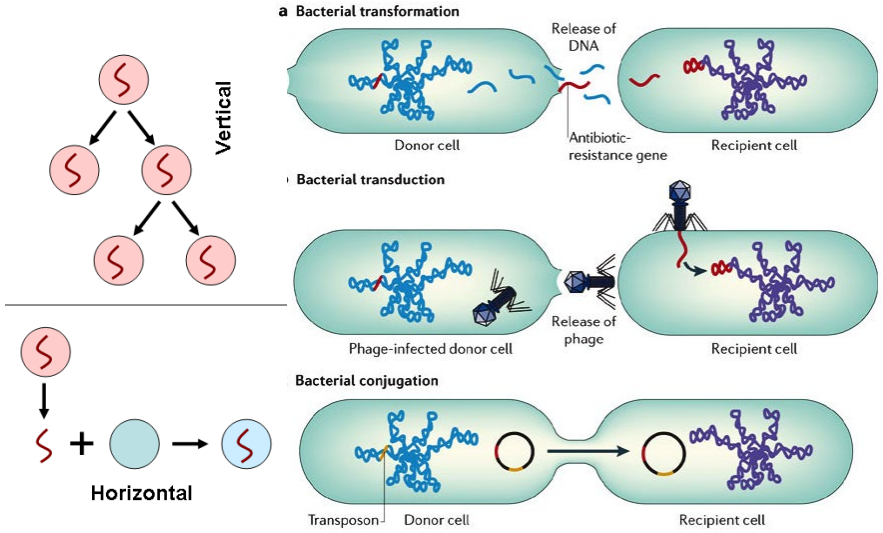
Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

- It is estimated only 1% of microbial community has been identified.
- Currently **etiological agent** of 80.3% of foodborne illnesses, **56.2% of hospitalization**, and 55.5% of deaths remain unknown (in a typical year, Scallan et all., 2011).

4.5 Billion, 3.5 Billion years
100,000 to 300,000 years

"Emerging" Pathogens:

- Vertical and horizontal gene transfer spores and biofilm formation
- Quorum sensing and cell to cell communication



"*It is the microbes who will have the last word.*"

-Louis Pasteur

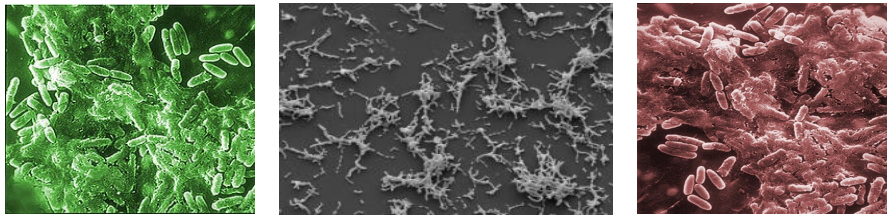


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/
http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php
http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

Epidemiology of Foodborne Diseases in the United States

Based on data from 1990s: *(Mead et al., 1999)*

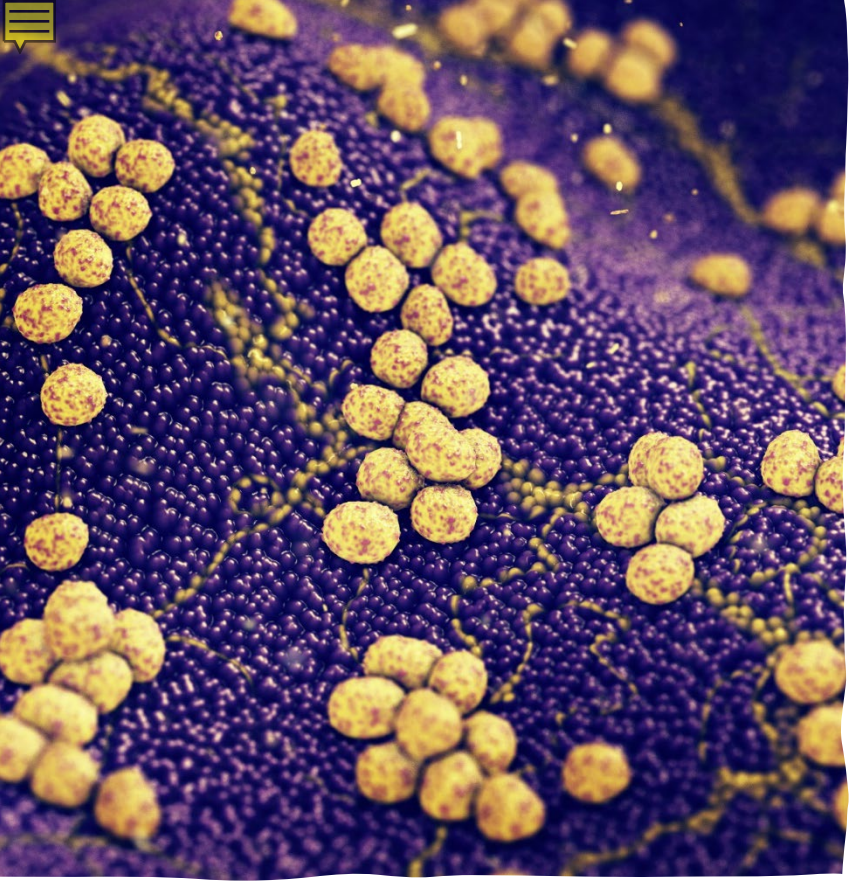
76 million illnesses, 323,000 hospitalizations, 5,200 deaths in the United States.

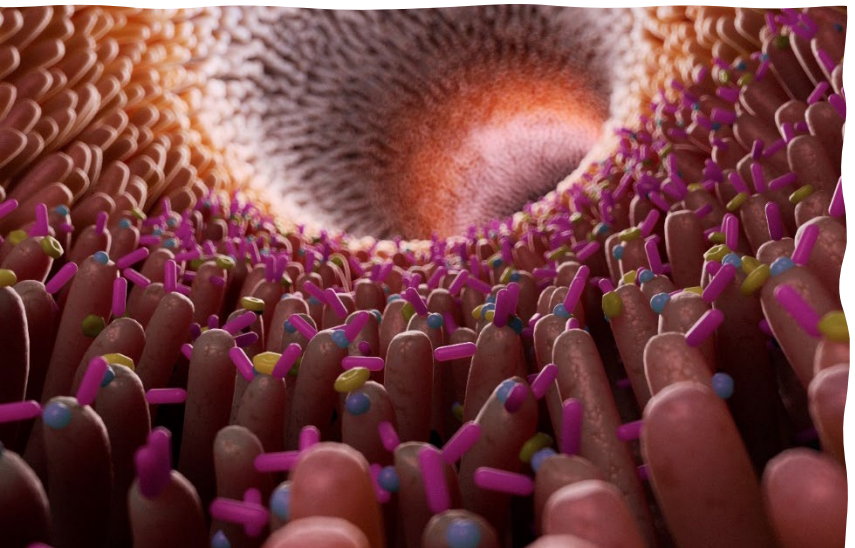
More recent estimates show: *(Scallan et al., 2011)*

- **47.8 million illnesses**, 127,839 hospitalizations, and more than **3,037** deaths in the United States. **(c. 1.7M cases 300K deaths/year of sepsis)**
- 9.4 million illnesses, 55,961 hospitalizations, and 1,351 deaths are cause by 31 known foodborne agents.
- In addition to consumer insecurity, foodborne diseases cause around $**77.7 billion** for losses in productivity and economical losses. **(2021 GPD of Jamaica 14.7 Billion)**
- Approximately **30% of population** are especially “at risk” for foodborne diseases (The YOPI’s: The young, the old, Pregnant, and Immunocompromised)

Significant foodborne pathogens…
based on Mead et al., 1999 and Scallan et al., 2011 studies

- **Leading etiological agents for illnesses**: *Norovirus* (58%), Nontyphoidal *Salmonella* serovars (11%), *Clostridium perfringens* (10%), and *Campylobacter* spp (9%).
- **Leading etiological agents for hospitalization:** Nontyphoidal *Salmonella* serovars (35%), *Norovirus (26%), Campylobacter* spp (15%), and *Toxoplasma gondii* (8%).
- **Leading etiological agents for death:** Nontyphoidal *Salmonella* serovars (28%), *T. gondii* (24%), *Listeria monocytogenes* (19%), and *Norovirus (11%).*





Signs and Symptoms of Foodborne Diseases

- Mild illness (no medical care sought)
- **Guillain–Barré syndrome** (*Campylobacter* and *Salmonella*)
- **Post-infectious irritable bowel syndrome** (*Campylobacter* and *Salmonella*)
- **Reactive arthritis** (*Campylobacter* and *Salmonella*)
- **Haemolytic uraemic syndrome** (*E. coli* O157)
- **End-stage renal disease** (*E. coli* O157)
- Death

Significant foodborne pathogens…
based on Scallan et al., 2015 study

- **Disability adjusted life year** (DALY). *DALY: Loss of life and health due to illness*
- Non-typhoidal *Salmonella* (329000)
- Toxoplasma (32700)
- *Campylobacte*r (22500)
- Norovirus (9900)
- *Listeria monocytogenes* (8800)
- *Clostridium perfringens* (4000)
- *Escherichia coli* O157 (1200)

One DALY can be thought of as one **lost year of "healthy" life**.

DALY= YLL+YLD

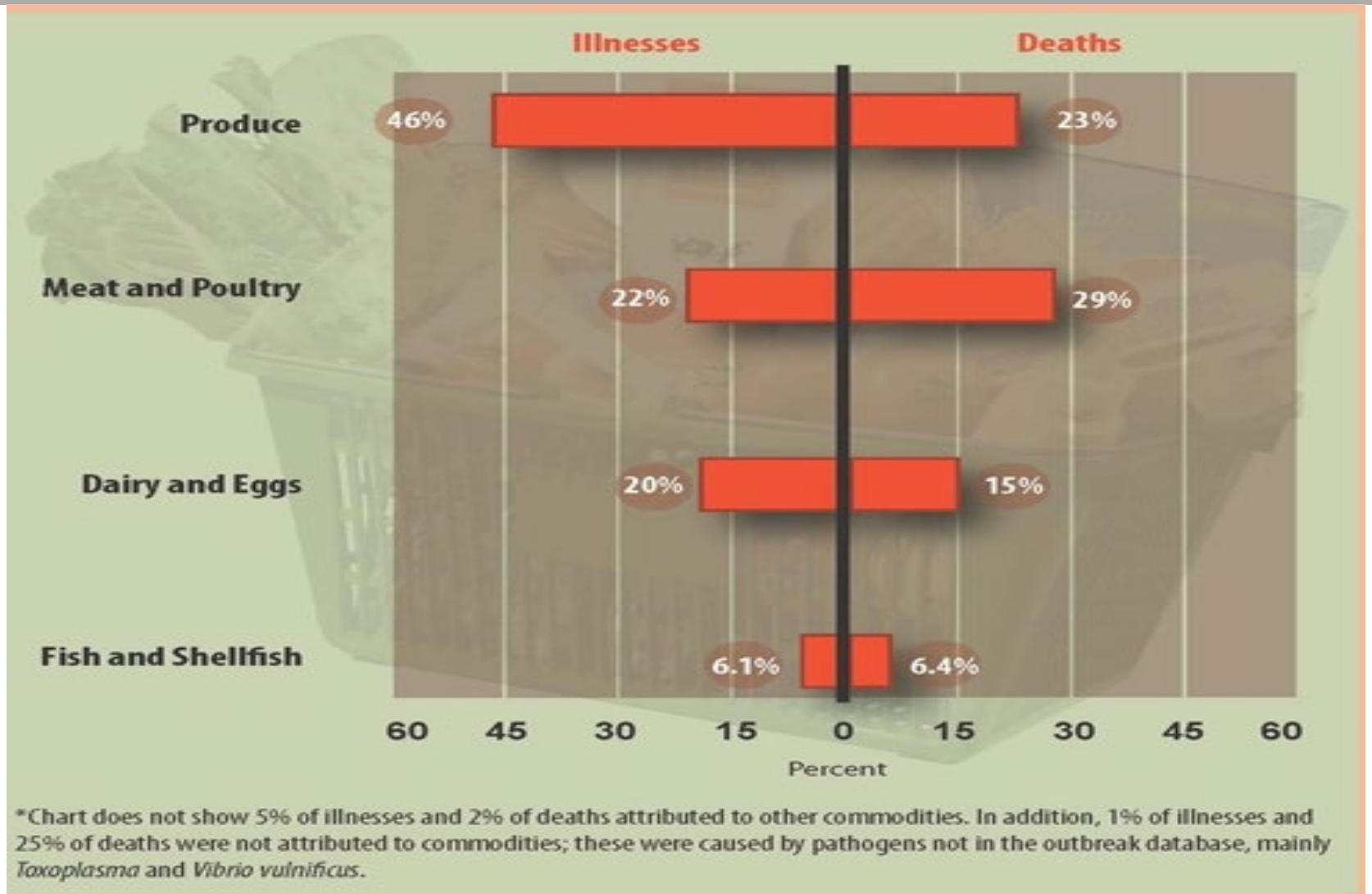
YLL: Years of Life Lost (YLL) due to **premature mortality** in the population
YLD: Years Lost due to Disability (YLD) for **people living with the health condition**

Source: WHO, 2019

62% bacterial agents; 29% parasitic agents; 9% viral agents

CDC Estimates of Food Safety Burden

http://www.cdc.gov/foodborneburden/attribution-image.html#foodborne-illnesses



National-wide and Regional Foodborne Episodes

- Centers for Disease Control and Prevention: Foodborne diseases episodes 1998 to 2019.

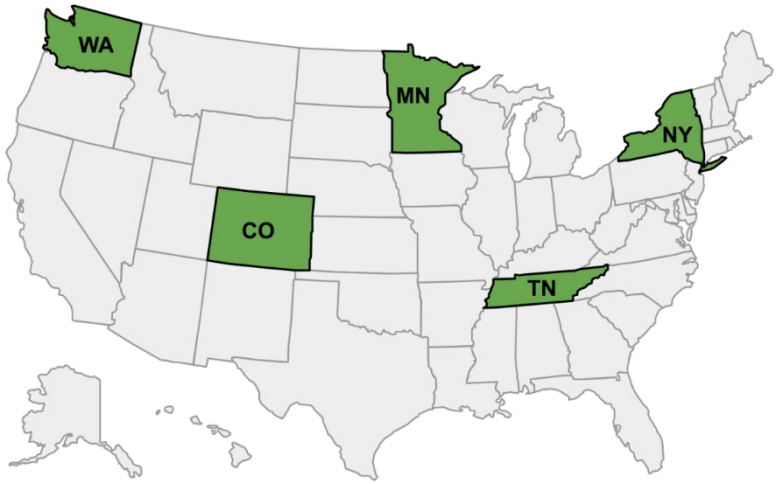
*Etiological agents for Tennessee episodes:

>200 species of bacteria, viruses, parasites, and chemical toxins.

Total	Outbreaks	Illness	Hospitalization	Deaths
Nation-wide	36,680*	999,364	25,332	1,404
California	1,154	29,642	4,257	123
Tennessee	982	39,005	3,717	104
Maryland	1,043	13,243	4,430	23

Per 100K	Outbreaks	Illness	Hospitalization	Deaths
Nation-wide	11.1	304.5	7.7	0.4
California	2.9	75.0	10.7	0.3
Tennessee	14.4	571.2	54.4	1.5
Maryland	16.9	214.8	7.2	0.4

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™



*Pentilla et al., 2023 (Recently completed); Data source: CDC NORS/

Are these outbreaks associated with corporates and lager manufactures?

Prevalence of Pathogens in medium-sized Poultry Operations

- 200–300 ft houses, 3000 to 5000 birds, conventional operation

(Alali et al., 2010)

	Salmonella serovars
Fecal samples (n=420)	38.8%
Feed (n=140)	27.5%

- Total of 135 sample from commercial free-range chicken producers (Bailey et al., 2005)

	Salmonella serovars
Chicken Carcasses in Operation 1	64%
Chicken Carcasses in Operation 2	31%

Alali et al., 2010, J Foodborne Pathogens and Diseases; Bailey et al., 2005, J Food Protection

Prevalence of Pathogens in Small Poultry Farms

- Study of 60 Small poultry slaughterhouses (fewer than 200 birds slaughtered per day)

Sampling sites	*Salmonella* serovars (*Albany, Hadar, Indiana, and Enteritidis sub-species*)
Carcasses after slaughter	42%
Utensils	23.1%
Storage freezers and refrigerators	71.4%

- The Study concluded "*The widespread occurrence of Salmonella in small slaughterhouses reinforces the need for implementation of effective control measures…*"

Terumi et al., 2000, Journal of Food Protection

Water Safety Study

microorganisms

MDPI

Article

Fate and Biofilm Formation of Wild-Type and Pressure-Stressed Pathogens of Public Health Concern in Surface Water and on Abiotic Surfaces

Md Niamul Kabir [1], Sadiye Aras [1], Sabrina Wadood [1], Shahid Chowdhury [1] and Aliyar Cyrus Fouladkhah [1,2,*]

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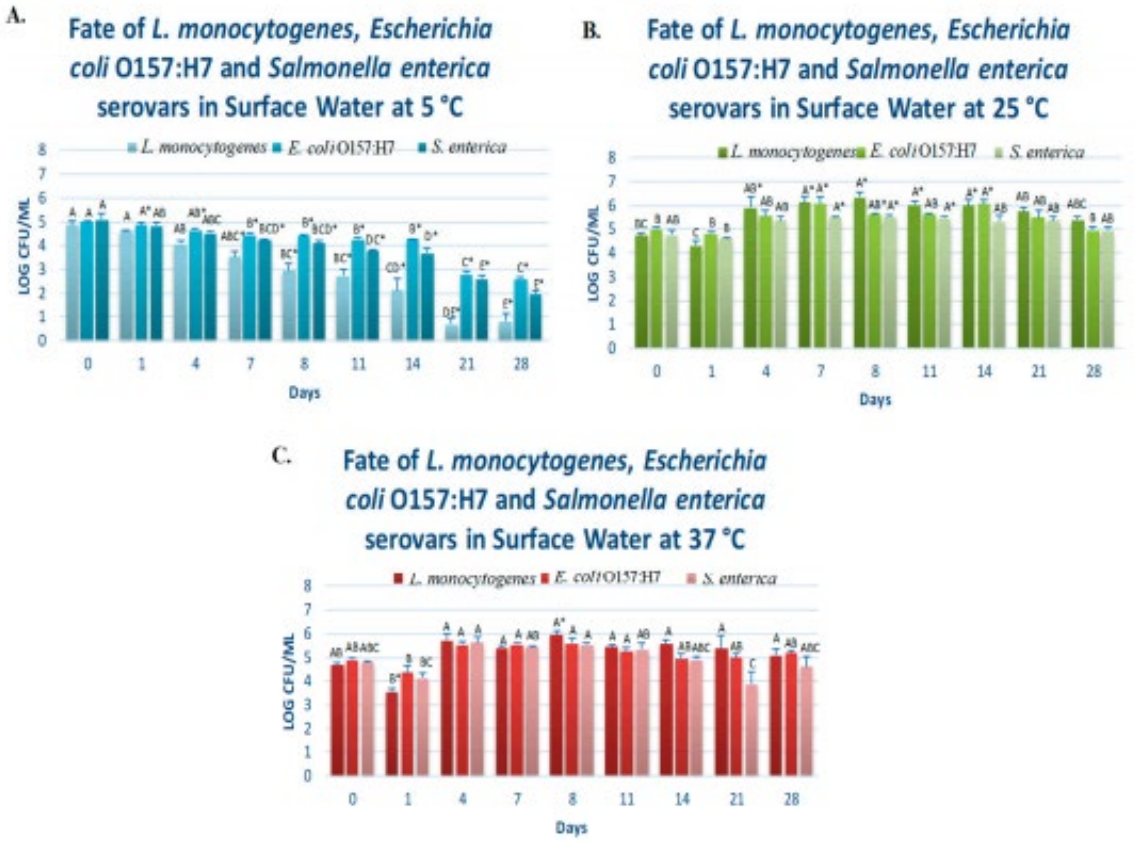
Received: 18 February 2020; Accepted: 11 March 2020; Published: 13 March 2020

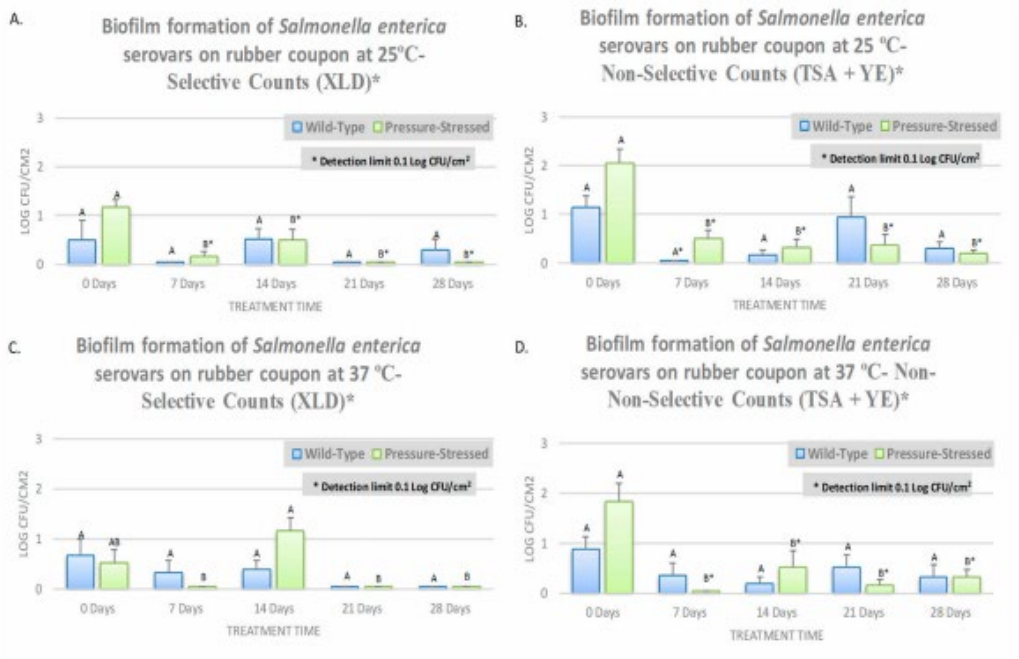
Public Health Burden of Waterborne Disease

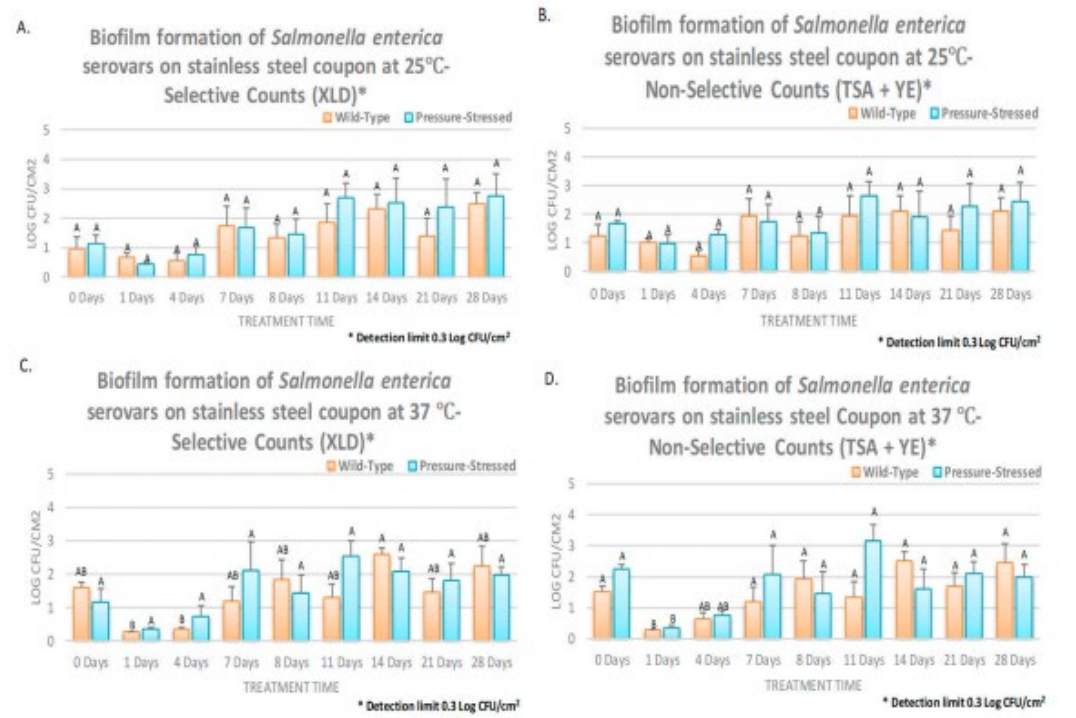
17 waterborne pathogens cause estimated: (Collier et al., 2021)

601,000 **illness**; 118,000 **hospitalization**; 6,630 **deaths**, and cost the economy up to $ 8.77 **billions.**



Water Safety Study-
Biofilm Formation on Abiotic Surfaces





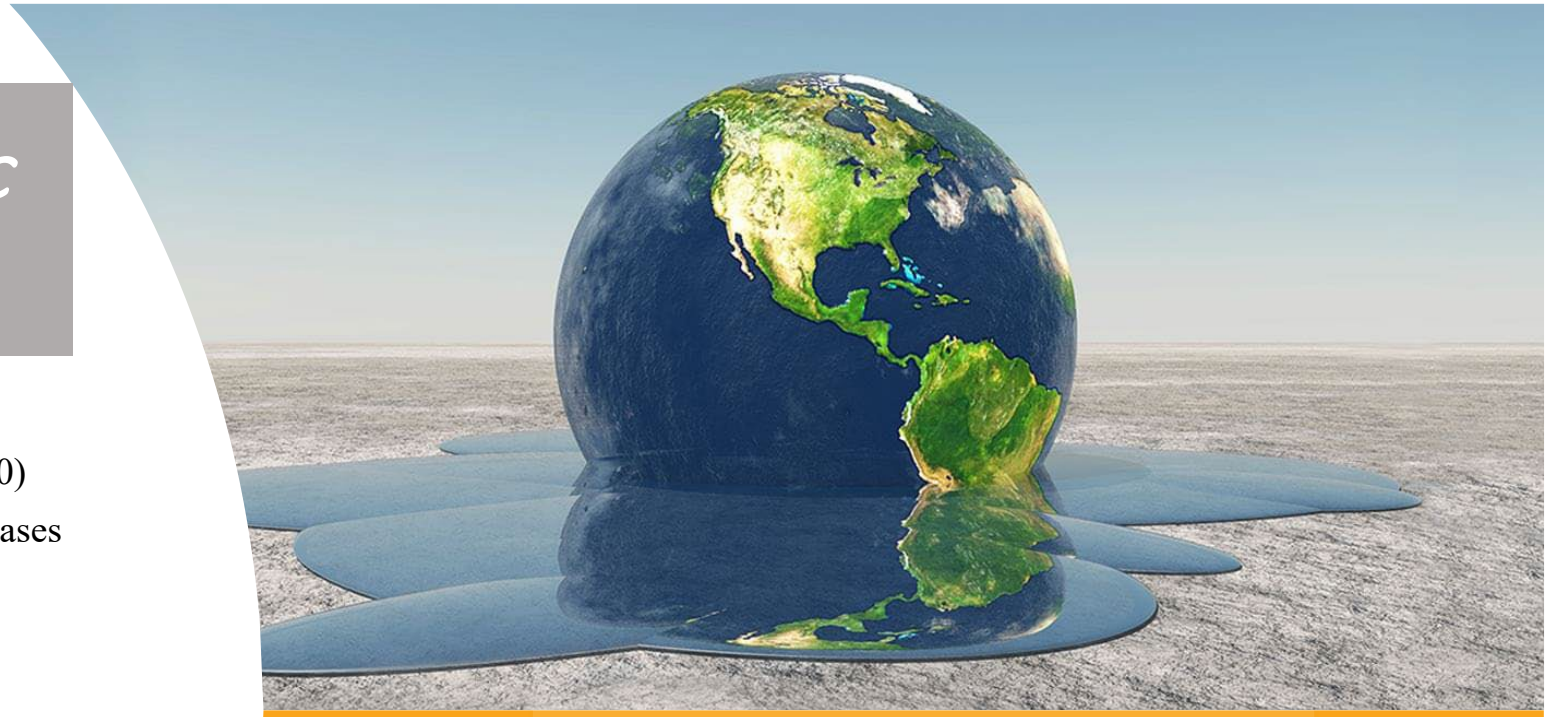
Salmonella serovars (Non-typhoidal)

- **Annual illness (death): 1,027,561 (378) in humans**
- **Infection** causes nausea, vomiting, diarrhea, fever, headache
- **Primary sources**: Intestinal tract of people and animals
- **Transmitted by** meat, poultry, eggs, raw milk, unpasteurized juice, many other foods (nuts, spices, produce, chocolate, flour)
- **Contributing factors**: cross-contamination, undercooked food, poor agricultural practices

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5.2°C)	95-109°F (35-43°C)	115°F (46.2°C)
pH	3.7	7-7.5	9.5
a_W	0.94	0.99	>0.99
Other	Non-spore former		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition, Scallan et al., 2011, and FSPCA

Climate Change and Public Health Microbiology



Non-typhoidal *Salmonella enterica* serovars

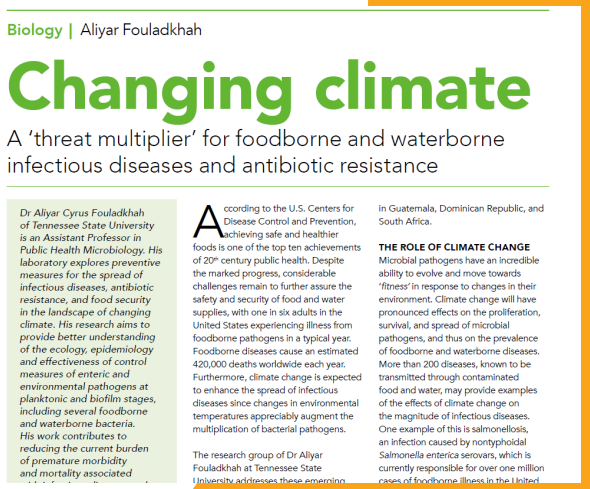
- **Global death:** 50,000 global death in 2010 (WHO, 2020)
- **Public Health Burden in the U.S.:** >1 million annual cases in 2011 (CDC, 2011)

Climate Change:

- **1 °C increase : 5 to 10% increases in Salmonellosis (WHO, 2010)**
- 2500 to 5000 additional global death
- 50,000 to 100,000 U.S. morbidity

At our current rate (2021 IPCC report)

- >1.5 °C by 2040
- >4.8 °C by 2100



Biology | Aliyar Fouladkhah

Changing climate

A 'threat multiplier' for foodborne and waterborne infectious diseases and antibiotic resistance

Dr Aliyar Cyrus Fouladkhah of Tennessee State University is an Assistant Professor in Public Health Microbiology. His laboratory explores preventive measures for the spread of infectious diseases, antibiotic resistance, and food security in the landscape of changing climate. His research aims to provide better understanding of the ecology, epidemiology and effectiveness of control measures of enteric and environmental pathogens at planktonic and biofilm stages, including several foodborne and waterborne bacteria. His work contributes to reducing the current burden of premature morbidity and mortality associated

According to the U.S. Centers for Disease Control and Prevention, achieving safe and healthier foods is one of the top ten achievements of 20th century public health. Despite the marked progress, considerable challenges remain to further assure the safety and security of food and water supplies, with one in six adults in the United States experiencing illness from foodborne pathogens in a typical year. Foodborne diseases cause an estimated 420,000 deaths worldwide each year. Furthermore, climate change is expected to enhance the spread of infectious diseases since changes in environmental temperatures appreciably augment the multiplication of bacterial pathogens.

The research group of Dr Aliyar Fouladkhah at Tennessee State University addresses these emerging

in Guatemala, Dominican Republic, and South Africa.

THE ROLE OF CLIMATE CHANGE

Microbial pathogens have an incredible ability to evolve and move towards 'fitness' in response to changes in their environment. Climate change will have pronounced effects on the proliferation, survival, and spread of microbial pathogens, and thus on the prevalence of foodborne and waterborne diseases. More than 200 diseases, known to be transmitted through contaminated food and water, may provide examples of the effects of climate change on the magnitude of infectious diseases. One example of this is salmonellosis, an infection caused by nontyphoidal *Salmonella enterica* serovars, which is currently responsible for over one million cases of foodborne illness in the United

microorganisms MDPI

Editorial

Safety of Food and Water Supplies in the Landscape of Changing Climate

Aliyar Cyrus Fouladkhah [1,*], Brian Thompson [2] and Janey Smith Camp [3]

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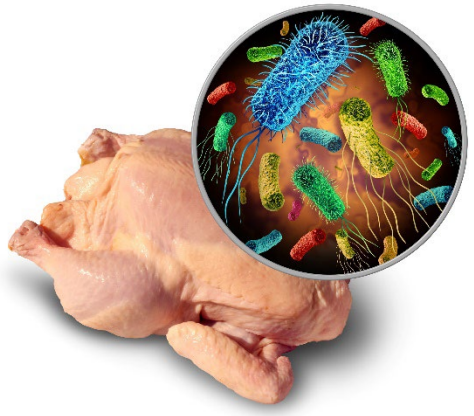
check for updates

In response to evolving environmental, production, and processing conditions, microbial communities have tremendous abilities to move toward increased diversity and fitness by various pathways such as vertical and horizontal gene transfer mechanisms, biofilm formation, and quorum sensing [1,2]. As such, assuring the safety of water and food supplies from various natural and anthropogenic microbial pathogens is a daunting task and a moving target. Recent outbreaks of *Listeria monocytogenes* in South Africa associated with a ready-to-eat product (affecting close to 1000 individuals) and the 2018 outbreak of Shiga toxin-producing *Escherichia coli* O26 associated with ground meat in the United States (leading to the recall of more than 132,000 pounds of products) are bitter reminders of the devastating influences of foodborne diseases on the public health and food manufacturing [3,4].

Recent epidemiological studies of world populations indicate that 420,000 people lose their lives every year due to foodborne diseases, with around one-third of those being 5 years of age or younger. It is further estimated that every year, 1 in 10 individuals experience foodborne diseases around the globe, leading to an annual loss of 33 million healthy life years [5]. These episodes of food and water

Campylobacter spp.

- **Annual illness (death): 845,024(76)**
- Infection causes diarrhea, and potential nerve damage
- **Primary sources**: Intestinal tract of animals
- **Transmitted** by raw poultry, raw milk products, contaminated water, poultry
- **Contributing factor**: cross contamination and undercooking



Growth parameters	Minimum	Optimum	Maximum
Temperature	86°F (30°C)	108-109°F (42-43°C)	113°F (45°C)
pH	4.9	6.5-7.5	9.5
a_W	>0.987	0.997	-
Other	Non-spore former		
Atmosphere	3-5% oxygen optimum		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition and FSPCA

Shiga Toxin-Producing *Escherichia coli* (STEC)

- **Annual illness (death): 176,152 (20)**
- **Infection causes** bloody diarrhea, and sometimes kidney failure and death *(HUS, kids under the age of 5)*
- **Primary sources**: Intestinal tract of ruminant animals (e.g., cows, sheep)
- **Transmitted** by raw and undercooked beef, poultry, leafy greens, and unpasteurized milk and juices
- **Contributing factors**: poor GAP, inadequate heating, and person-to-person

Growth parameters	Minimum	Optimum	Maximum
Temperature	44°F (6.5°C)	95-104°F (35-40°C)	121°F (49.4°C)
pH	4	6-7	10
a_w	0.95	0.995	-
Other	Non-spore forming		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition,Scallan et al. 2011, and FSPCA

Yersinia enterocolitica

- **Infection causes** abdominal pain, fever and diarrhea. May mimic appendicitis.
- **Primary sources**: Raw pork, raw milk
- **Contributing factors**: Cross contamination between raw pork products and RTE foods
- Causes only **mild clinical signs in cats and dogs of short duration**, usually with no mortality

Yersinia pestis 14th Century Outbreak in Europe, c. 30 to 50% of the population

Antoni van Leeuwenhoek: Discovery of bacteria in 1676 (c. 350 years)

Viruses discovered in 1890s

Growth parameters	Minimum	Optimum	Maximum
Temperature	30°F (-1.3°C)	77-99°F (25-37°C)	108°F (42°C)
pH	4.2	7.2	10
a_W	0.945	-	-
Other	Non-sporeformer		
Atmosphere	Facultative - grows with or without oxygen		

Sources: Seafood Hazards Guide, ICMSF 1995, and Bad Bug Book

Listeria monocytogenes

- **Infection causes** severe illness in susceptible people – mortality 15-30%
- **Primary sources**: Occurs widely in agriculture (soil, plants and water)
- **Transmitted by**: Refrigerated RTE foods that support growth *(pathogen of concern during pregnancy)*
- **Contributing factors**: Environmental (ubiquitous) pathogen spread by environmental contamination, equipment, people, incoming raw ingredients (in absence of Gram-negative bacteria?)
- **Common in domesticated ruminates particularly** sheep, poultry, and birds.
- **Could cause sporadic and farm outbreaks in ruminants**
- **Could cause: Encephalitis, late abortion, and GI problems in ruminants**.

Growth parameters	Minimum	Optimum	Maximum
Temperature	31°F (-0.4°C)	99°F (37°C)	113°F (45°C)
pH	4.4	7.0	9.4
a_W	0.92	-	-
Other	Non-spore former		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition

microorganisms

MDPI

Review

Outbreak History, Biofilm Formation, and Preventive Measures for Control of *Cronobacter sakazakii* in Infant Formula and Infant Care Settings

Monica Henry [1] and Aliyar Fouladkhah [1,2,*]

[1] Public Health Microbiology Laboratory, Tennessee State University, Nashville, TN 37209, USA; mhenry3@my.tnstate.edu
[2] Cooperative Extension Program, Tennessee State University, Nashville, TN 37209, USA
* Correspondence: afouladk@tnstate.edu or aliyar.fouladkhah@aya.yale.edu; Tel.: +1-970-690-7392

Received: 18 January 2019; Accepted: 9 March 2019; Published: 12 March 2019

check for updates

Abstract: Previously known as *Enterobacter sakazakii* from 1980 to 2007, *Cronobacter sakazakii* is an opportunistic bacterium that survives and persists in dry and low-moisture environments, such as powdered infant formula. Although *C. sakazakii* causes disease in all age groups, infections caused by this pathogen are particularly fatal in infants born premature and those younger than two months. The pathogen has been isolated from various environments such as powdered infant

Cronobacter sakazakii

- **Recently reclassified** bacteria (2006-07), formerly known as ***Enterobacter sakazakii***
- The **Genus *Cronobacter*** was derived from the Greek term “Cronos,” a Titans of ancient mythology who swallowed each of his infants as soon as they were born (he was afraid to be replaced by his infants).
- The **species name, *sakazakii***, is named in honor of the Japanese microbiologist, Riichi Sakazaki, when the bacterium was first explained in 1980.
- Gram-negative, rod-shaped bacteria.
- Facultative anaerobic
- The growing temperature range is 6°C-45°C
- Primarily associated with **Powered Infant Formula**
- There has been several outbreaks associated with the bacterium and neonatal meningitis and death including two outbreaks in **Tennessee** (**1998 and 2001**).

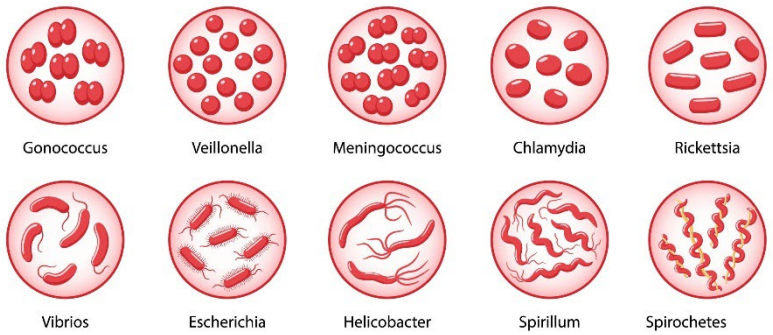
APHA Compendium of Methods, Salfinger and Lou Tortorello, Fifth Edition

Bad Bug Book

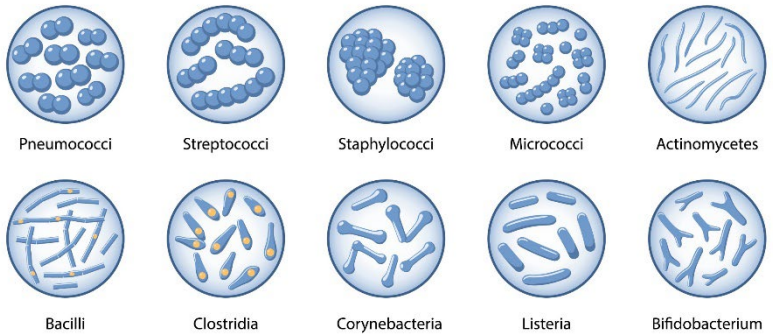
Bad Bug Book (Second Edition)

Foodborne Pathogenic Microorganisms and Natural Toxins Handbook

Gram negative bacteria



Gram positive bacteria



Bad Bug Book

Handbook of Foodborne Pathogenic Microorganisms and Natural Toxins

Introduction

Food safety is a complex issue that has an impact on all segments of society, from the general public to government, industry, and academia. The second edition of the Bad Bug Book, published by the Center for Food Safety and Applied Nutrition, of the Food and Drug Administration (FDA), U.S. Department of Health and Human Services, provides current information about the major known agents that cause foodborne illness. The information provided in this handbook is abbreviated and general in nature, and is intended for practical use. It is not intended to be a comprehensive scientific or clinical reference.

Under the laws administered by FDA, a food is adulterated if it contains (1) a poisonous or otherwise harmful substance that is not an inherent natural constituent of the food itself, in an amount that poses *a reasonable possibility* of injury to health, or (2) a substance that is an inherent natural constituent of the food itself; is not the result of environmental, agricultural, industrial, or other contamination; and is present in an amount that *ordinarily* renders the food

BIOFILMS, DRUG RESISTANCE, AND CLIMATE CHANGE

How Climate Change is Affecting Bacterial Biofilms and Drug Resistance

PUBLIC HEALTH BURDEN OF FOOD AND WATERBORNE DISEASES

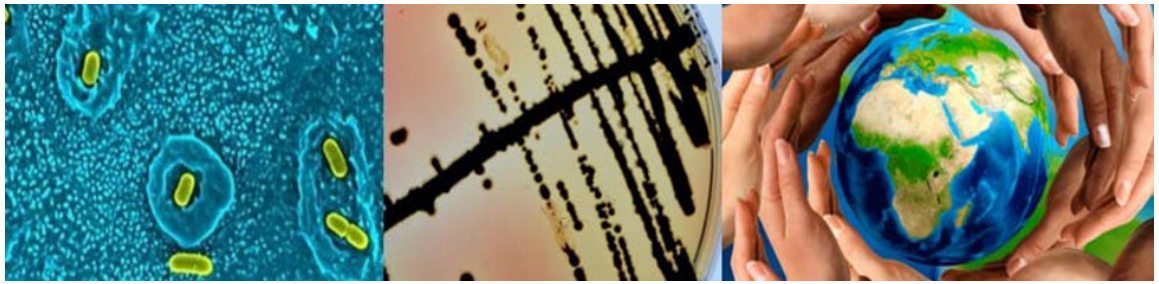
Reducing the public health burden of food and waterborne diseases

INFANT FORMULA AND CRONOBACTER SAKAZAKII

How significant are biofilm and planktonic cells of Cronobacter sakazakii?

How can we reduce the public health burden of food and waterborne diseases?

Podcast featuring Dr. Aliyar Cyrus Fouladkhah Research Group Publications



Climate Change & Health

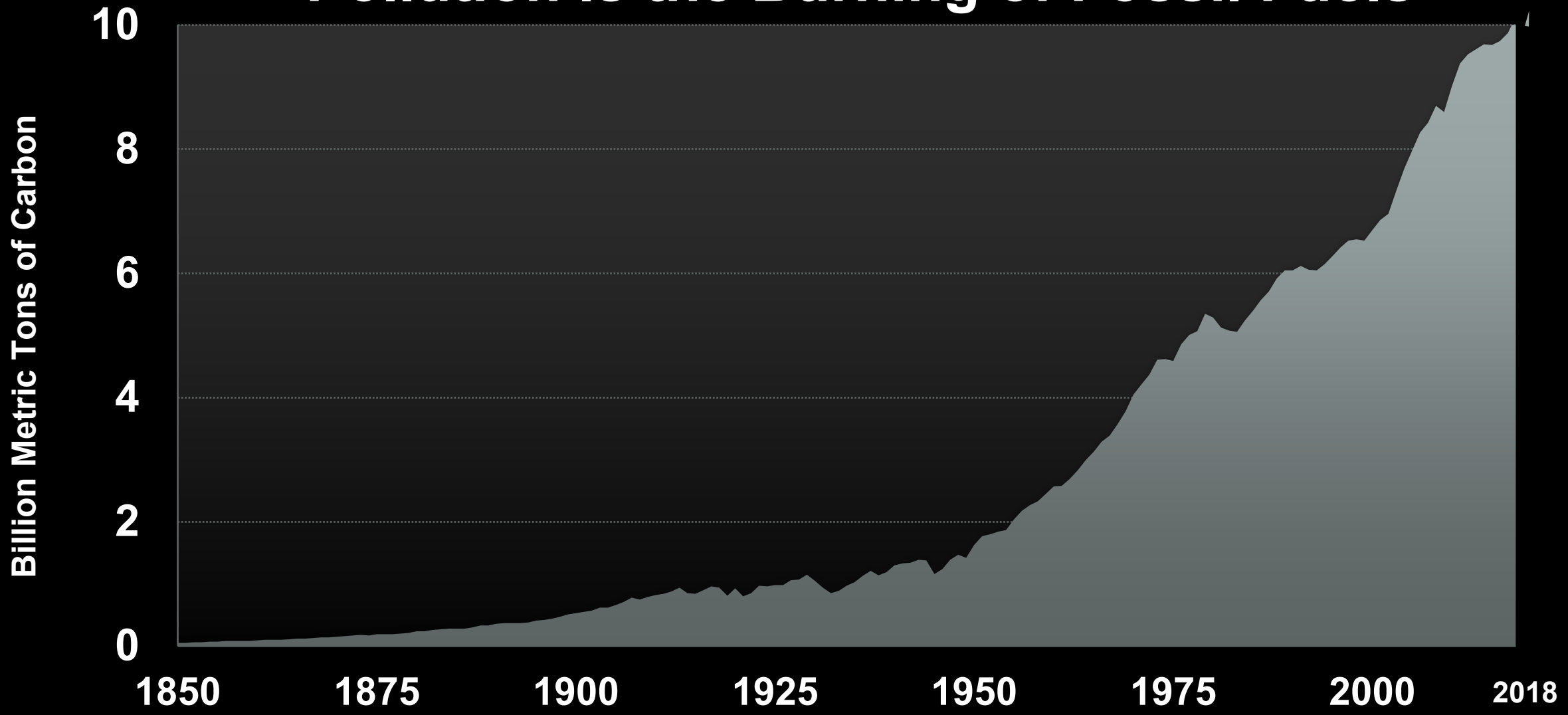
Public Health Microbiology Foundation
Compassion Service Excellence

CLIMATE REALITY
LEADERSHIP
CORPS

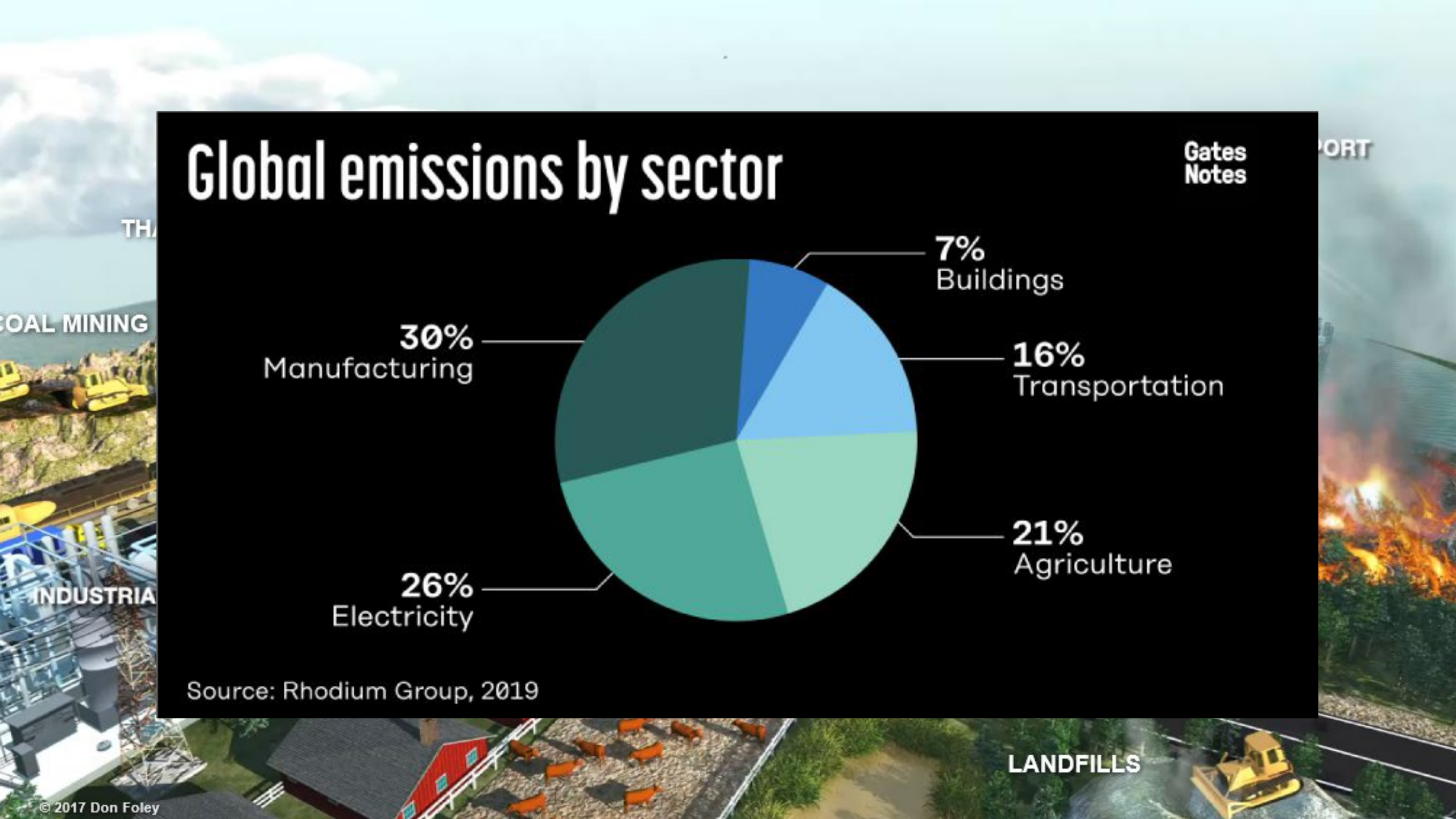
Source: NASA

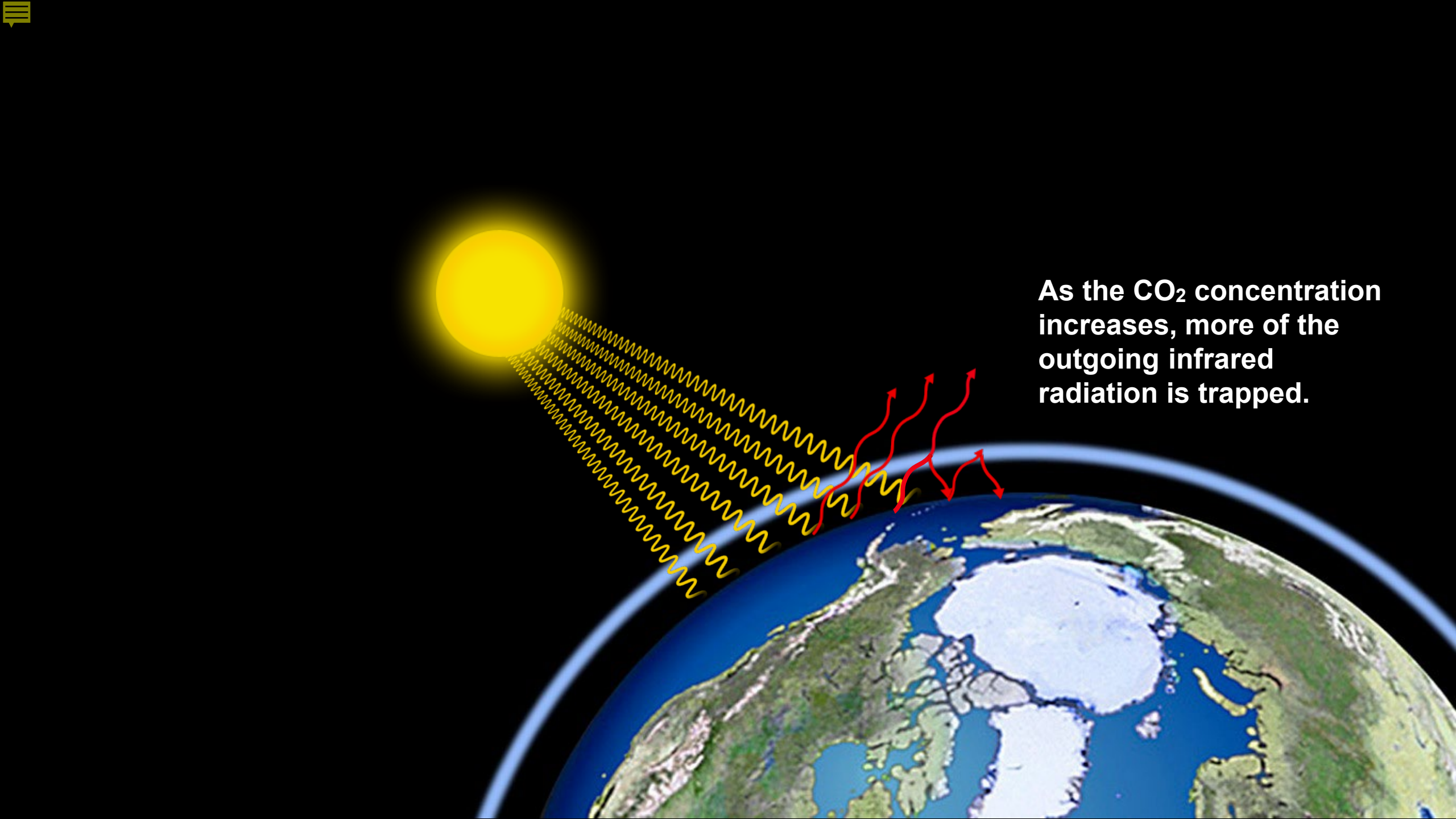
Source: NASA

The Largest Source of Global Warming Pollution Is the Burning of Fossil Fuels



Data: U.S. Department of Energy/CDIAC


Global emissions by sector
Gates Notes
7%
Buildings
16%
Transportation
21%
Agriculture
26%
Electricity
30%
Manufacturing
Source: Rhodium Group, 2019
COAL MINING
INDUSTRIA
LANDFILLS
© 2017 Don Foley


As the CO_2 concentration increases, more of the outgoing infrared radiation is trapped.

The energy trapped by man-made global warming pollution is now "…equivalent to exploding

600,000

First-generation atomic bombs per day 365 days per year."

James Hansen
Former Director, NASA Goddard Institute for Space Studies

At least 224 locations around the world set all-time heat records in 2018.

The Hottest of All Have Been the Last Seven Years

19 of the 20 Hottest Years on Record Have Occurred Since the Year 2002

2020	2016	2019	2017	2015	2018	2014	2010	2013	2005
2007	2009	2012	2006	2002	2003	2011	1998	2008	2004

Data: NASA/GISS

The U.S. Southeast is projected to warm up to 8 °F this century.

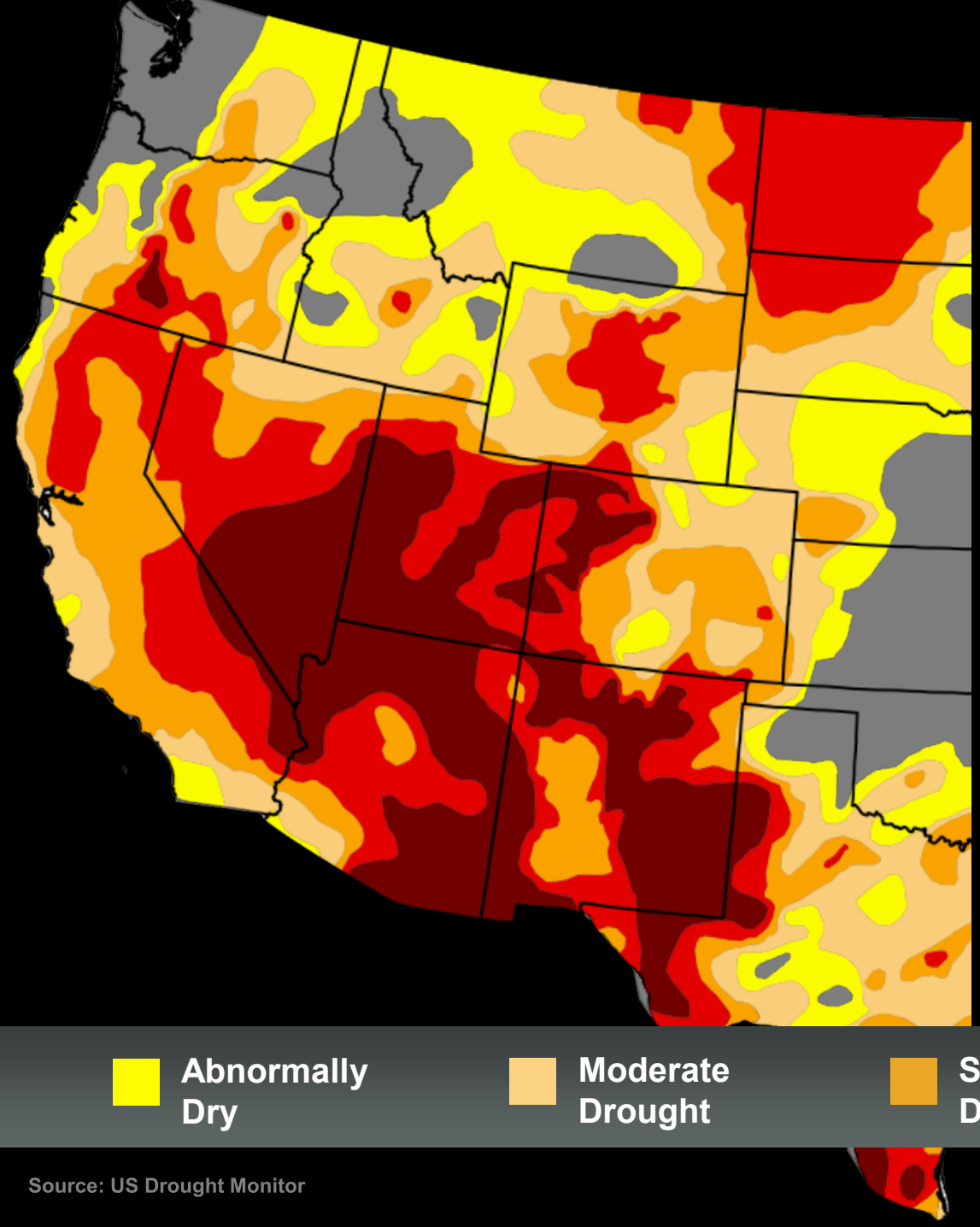
Without steep cuts in greenhouse gas emissions, the average temperature in South America could rise 6.7° C by 2100.

In Central America, the temperature could rise by 4°C.

Los Angeles, California

September 6, 2020

Los Angeles County set a new all-time heat record of 121° F (49.4° C) on September 6th.



93% of California is currently in drought.

April 15, 2021

78% of the U.S. West is experiencing moderate to exceptional drought. Utah, Arizona, New Mexico and Nevada are particularly hard-hit.

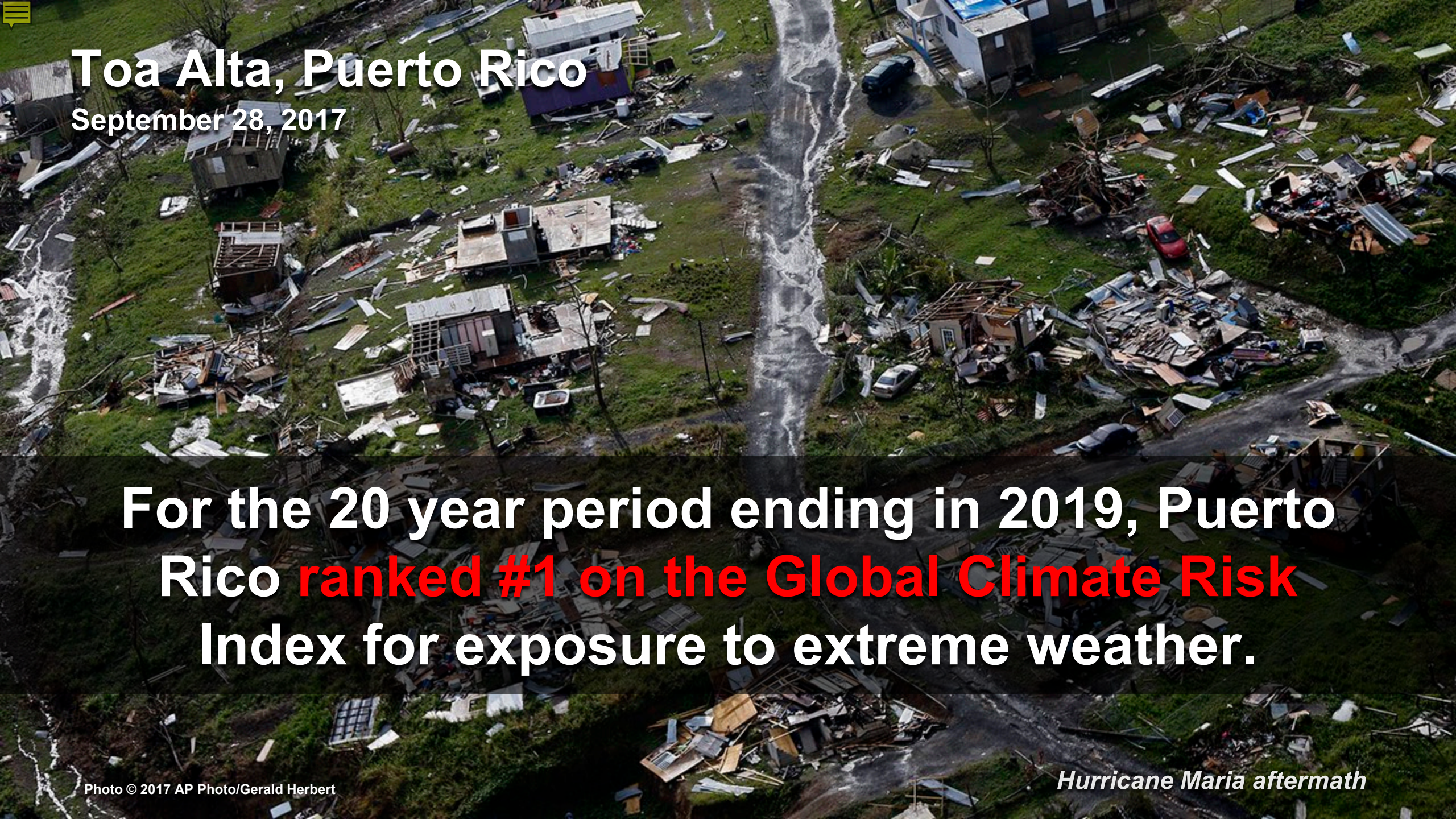
Abnormally Dry | Moderate Drought | Severe Drought | Extreme Drought | Exceptional Drought

Source: US Drought Monitor

Data: Global News Canada
Photo © 2018 Graham Hughes/The Canadian Press via AP


Berkshire, England
July 5, 2018
TERBERG
Recycle One More Thing
© Wessex News Agency


Tacloban City, Philippines
November 10, 2013
© 2013 Reuters /Erik De Castro

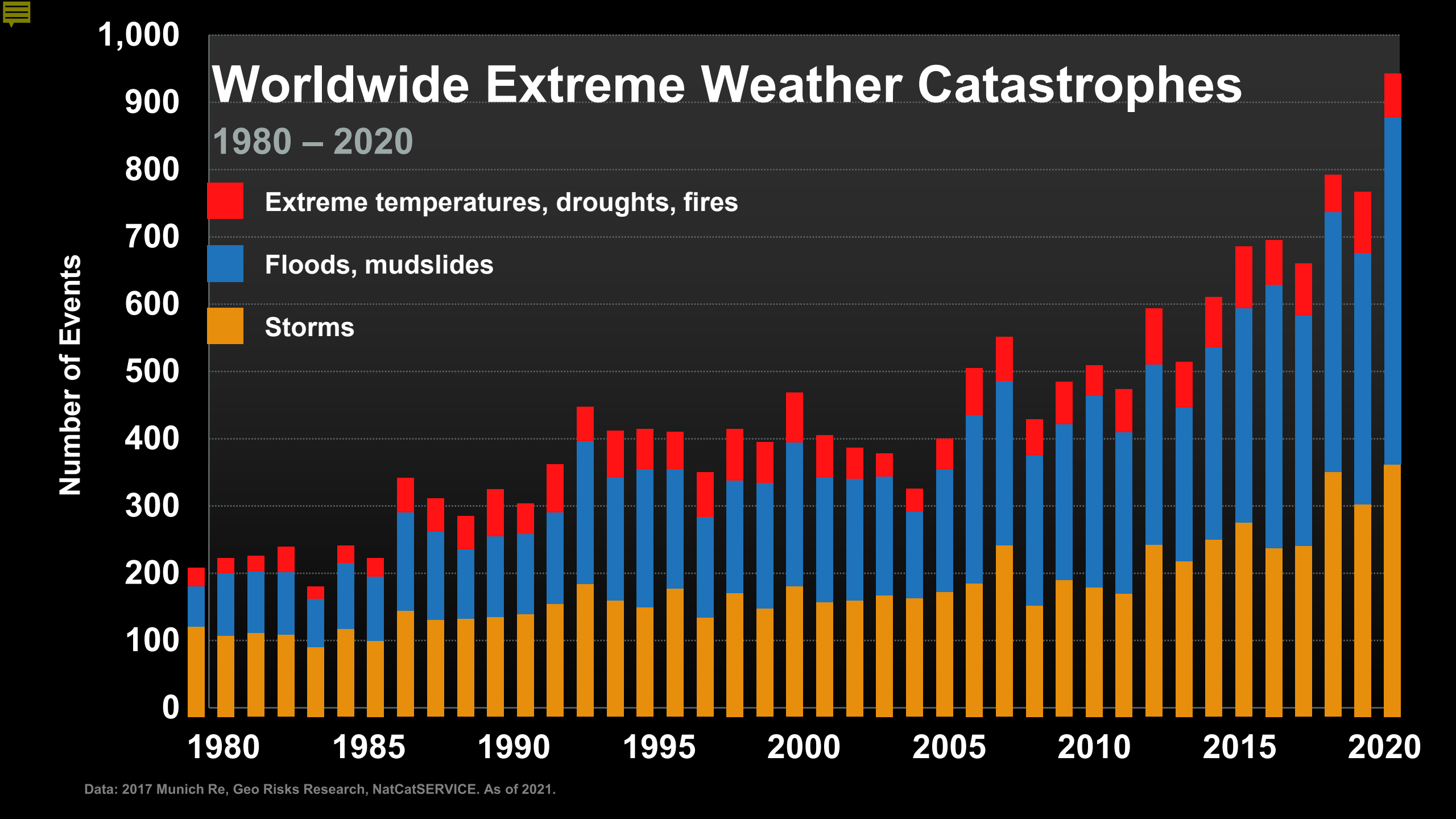

Toa Alta, Puerto Rico
September 28, 2017
For the 20 year period ending in 2019, Puerto Rico ranked #1 on the Global Climate Risk Index for exposure to extreme weather.
Photo © 2017 AP Photo/Gerald Herbert
Hurricane Maria aftermath

Houston, Texas

August 27, 2017

Risk of Hurricane Sandy-Intensity Events in New York

Data: A.J. Garner, et al., "Impact of climate change on New York City's coastal flood hazard: Increasing flood heights from the preindustrial to 2300 CE," *PNAS*, October 2017
Image: 2012 NASA


Worldwide Extreme Weather Catastrophes
1980 – 2020
Extreme temperatures, droughts, fires
Floods, mudslides
Storms
Number of Events
1,000
900
800
700
600
500
400
300
200
100
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
Data: 2017 Munich Re, Geo Risks Research, NatCatSERVICE. As of 2021.

Gila National Forest, New Mexico

June 24, 2018

The Buzzard fire burned over 50,000 acres.


Edwards, Colorado
April 1, 2018
The fire season in the U.S. west is now 105 days longer than in 1970.
Photo: © 2018 Chris Dillmann/Vail Daily via AP Source: Climate Central Western Wildfires—A Fiery Future, 2016

Durango, Colorado

June 12, 2018

The 2006 – 2010 drought
turned 60% of Syria's
fertile land into desert

…and drove
1.5 million people
into Syria's
already crowded cities

“…the Syrian minister of agriculture …stated publicly that economic and social fallout from the drought was ‘beyond our capacity as a country to deal with.’”

Cable from the U.S. Embassy in Damascus
to the State Department

November 8, 2008

United Nation Building Entrance, NY, USA

"Human beings are members of a whole,
In creation of one essence and soul.
If one member is afflicted with pain,
Other members uneasy will remain.
If you have no sympathy for human pain,
The name of human you cannot retain."

Poem from S. Shirazi 1210-1291

“In future, the climate in large parts of the world could… render some regions **uninhabitable,** which will surely contribute to the pressure to migrate.”

Jos Lelieveld
The Max Planck Institute for Chemistry
May 2016

The heat index in
Bandar Mahshahr reached

165° F

(74° C) on July 31, 2015

Safe Minimum Internal Temperature for Food Preparation

Source: https://www.fsis.usda.gov

Beef, Pork, & Lamb:
145 °F (62.8 °C) + rest for 3 min

Ground Meats: 160 °F (71.1 °C)

Ground Poultry: 165 °F (73.9 °C)

Leftovers & Casseroles:
165 °F (73.9 °C)

Ham (fresh uncooked):
145 °F (62.8 °C) + rest for 3 min

All Poultry: 165 °F (73.9 °C)

Eggs: 160 °F (71.1 °C)

Fish & Shellfish: 145 °F (62.8 °C)

Public Health Microbiology Laboratory: Education, Research, Outreach, and Technical Assistance: https://publichealthmicrobiology.education/

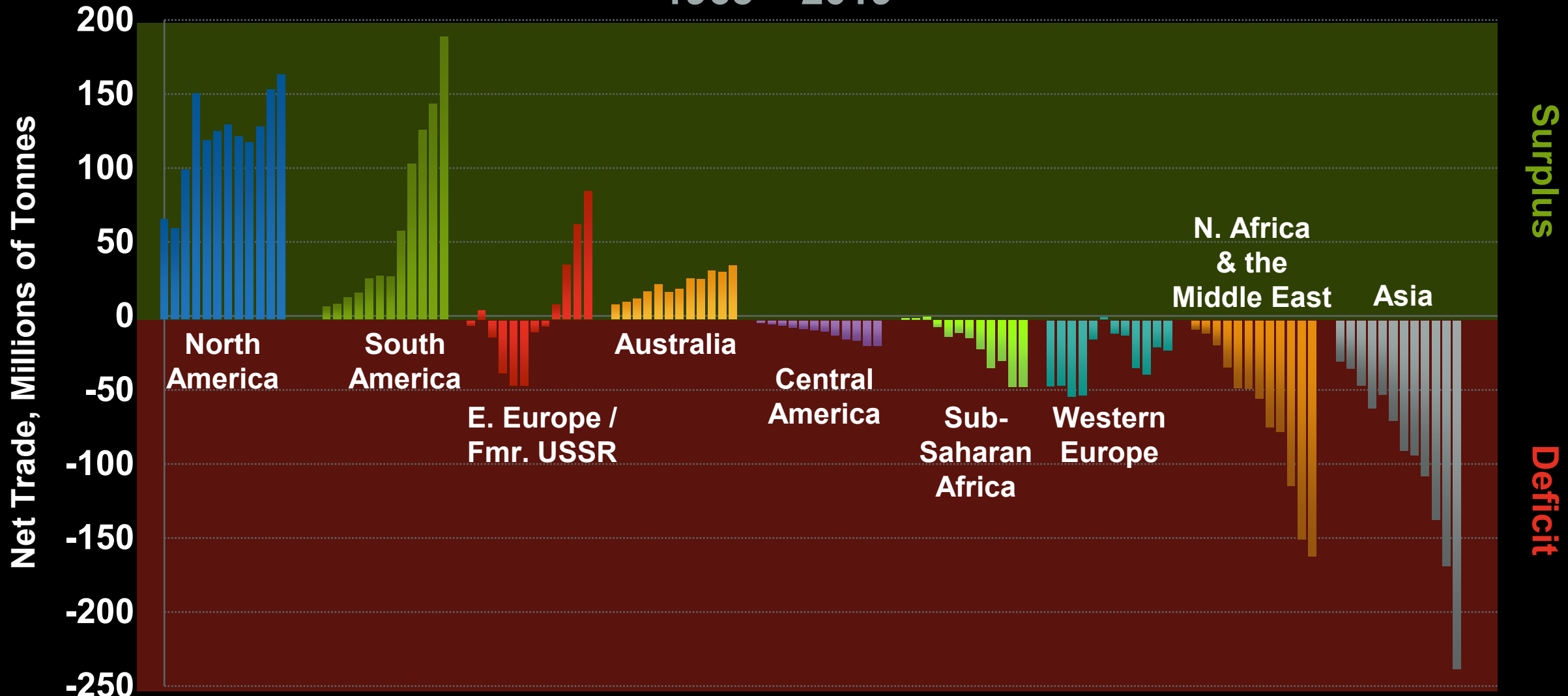
The world could see over
1 billion climate migrants
by the end of this century.

The Lancet Countdown Report

October 2017

Food Surpluses and Deficits

1965 – 2019



Projected Yield Declines For Each 1° C of Warming

These four crops make up two thirds of human caloric intake.

Data: Chuang Zhao, et al., "Temperature increase reduces global yields of major crops in four independent estimates," *PNAS*, August 29, 2017. Images: [Corn:] © EggHeadPhoto/Shutterstock; [Wheat:] © AlenKadr/Shutterstock; [Rice:] © ekotamak/Shutterstock; [Soy:] © Jiang HongYan/Shutterstock

Data: S. Machalaba, WB Karesh, "Vector-borne Diseases: Animals and Patterns," *Forum on Microbial Threats,* National Academies of Sciences, Engineering and Medicine, 2016
Photo © 2018 Mohssen Assanimoghaddam/picture-alliance/dpa/AP Images

**Source: https://www.cdc.gov/onehealth/index.html and * Salyer, 2017*

Namibia

Allergies Will Be Much Worse by 2040

2000

Grains of pollen per cubic meter:

8,455

2040

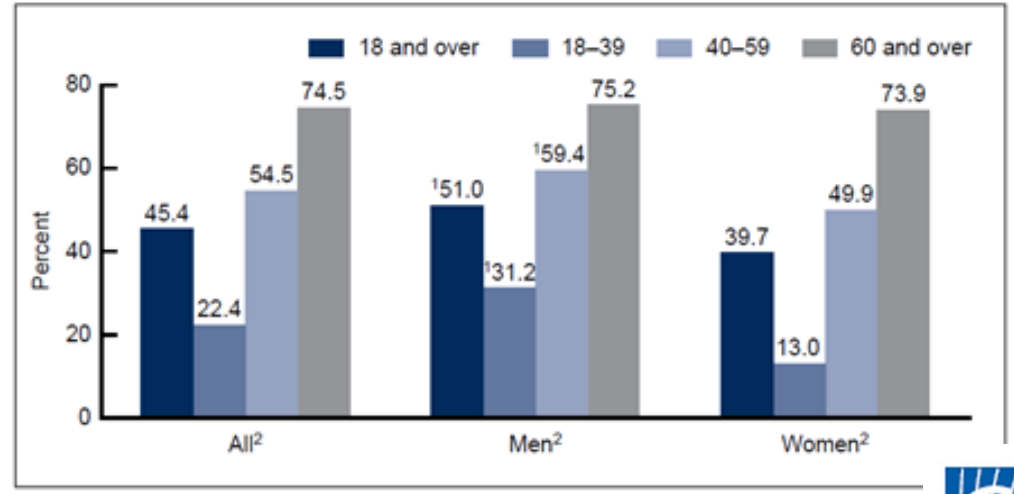
Grains of pollen per cubic meter:

21,735

Average pollen counts are specific to North America

Source: Dr. Leonard Bielory, Visiting Professor, Center for Environmental Prediction, SEBS, Rutgers University.

We now risk losing up to 50% of all land-based species in this century



Source: Nicholas Stern, *The Economics of Climate Change*
Photo: © Dirk Ercken/Shutterstock

Most common blood pressure medication (ACE Inhibitor- Captopril) is originally isolated from a snake Venom…

We only have access to non-extinct species.

Vibrio spp.

V. cholera
V. vulnificus
V. parahaemolyticus

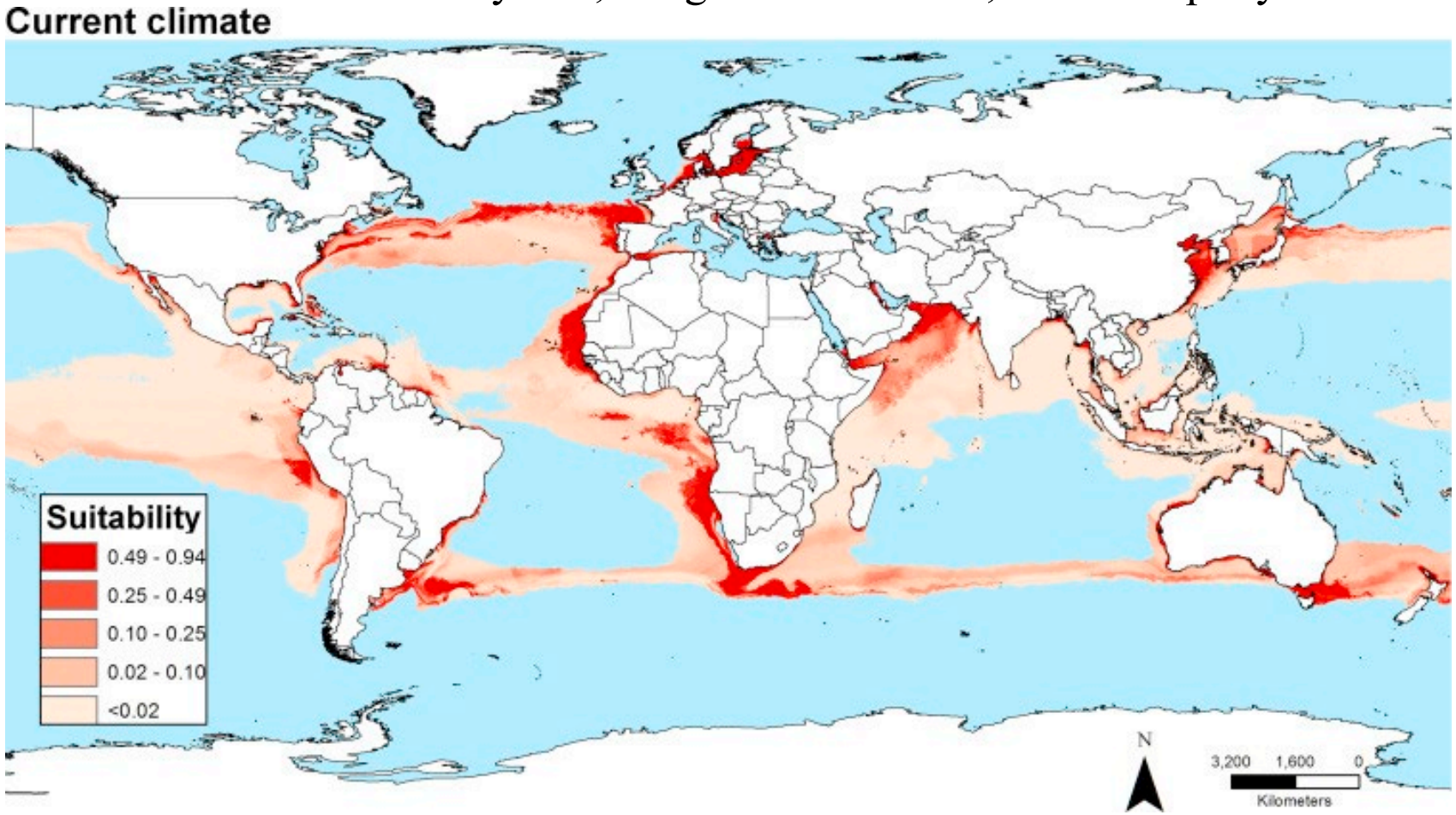
- Causing about **80,000 illness and 100 death** annually in the United States.
- **Infection symptoms** vary depending on strain, ranging from diarrhea to high fever
- Vibrio is a **halophilic bacterium** and is a major concern in aquaculture industry
- **Primary sources**: Salt water environments and seafood
- Requires salt to reproduce (halophile)

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5°C)	99°F (37°C)	114°F (45.3°C)
pH	4.8	7.8-8.6	11
a_W	0.94	0.98	0.996 (10% NaCl)
Other	Non-sporeformer, requires salt		
Atmosphere	Facultative - grows with or without oxygen		

Sources: Seafood Hazards Guide 2011, ICMSF 1995 and Bad Bug Book 2nd edition

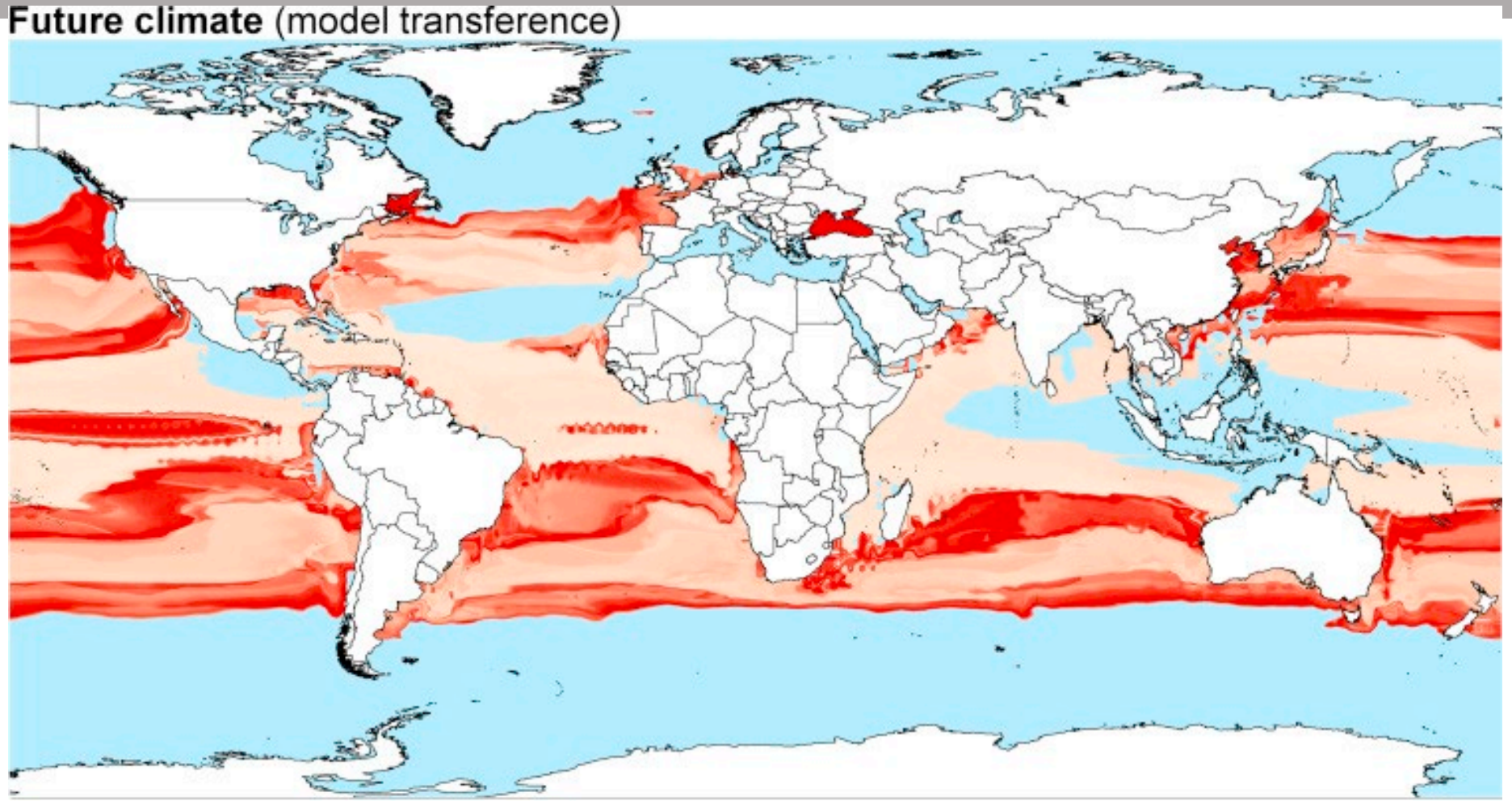
Vibrio cholerae proliferation in sea water: Current Climate

***Vibrio Cholerae*:** currently 760,000 global illness/24,000 death per year



Escobar LE et al. Acta Tropica 2015;149:202-11

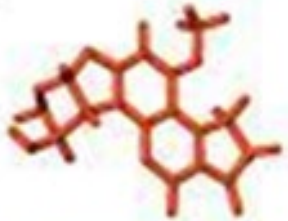
Vibrio cholerae proliferation in sea water:
Business-as-Usual Projection in 2100



Escobar LE et al. Acta Tropica 2015;149:202-11

Other Climate-Sensitive Challenges

- **Mycotoxins (At 2°C increase, aflatoxin, North America and Europ**
  - **Aflatoxins:** Peanuts, dried corn (maize), **tree nuts, certain spices**
  - **Ochratoxin A:** Coffee, raisins, wine, cereal grains, certain spices
  - **Patulin:** Fruits (apple and apple juice)
- Attraction of **pests, plant diseases, weeds**
- Changes in **pesticide use pattern is likely**
- Survival and **proliferation of the pathogen** (*e.g. Salmonella* serovars
- **Antibiotic use and antibiotic residue**
- Changes in **migration pathways** (*e.g.* for avian influenza)
- Changes in **carriers and vectors** (*e.g.* Zika virus)
- Changes in **natural ecosystem**
- **Phycotoxins**



microorganisms

MDPI

Editorial

The Threat of Antibiotic Resistance in Changing Climate

Aliyar Cyrus Fouladkhah [1,*], Brian Thompson [2] and Janey Smith Camp [3]

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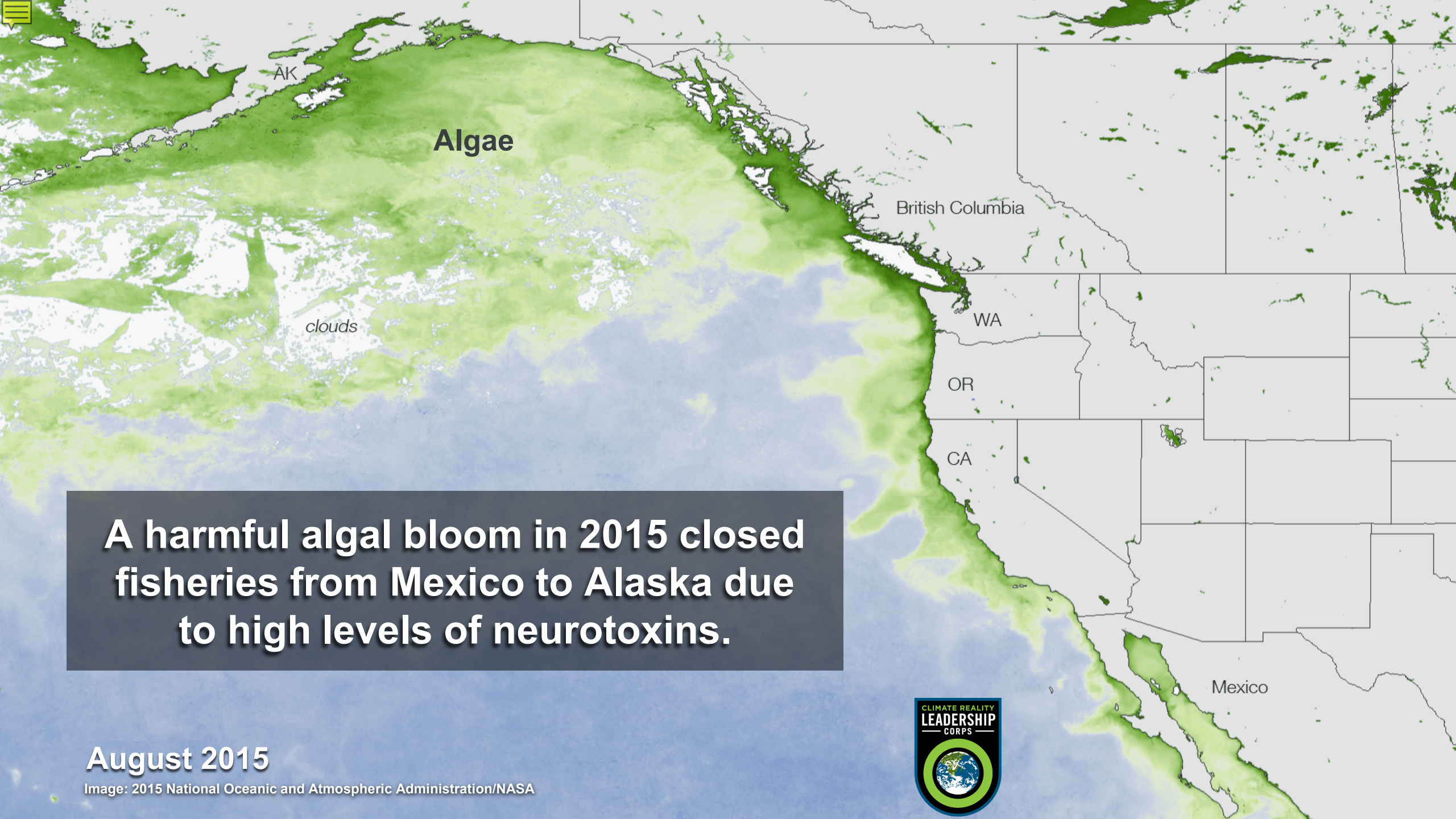
check for updates

As the earliest form of life, microorganisms have elaborate mechanisms for adapting to changes



A harmful algal bloom in 2015 closed fisheries from Mexico to Alaska due to high levels of neurotoxins.

August 2015

Image: 2015 National Oceanic and Atmospheric Administration/NASA

CLIMATE REALITY LEADERSHIP CORPS

Biology | Aliyar Fouladkhah

Changing climate

A 'threat multiplier' for foodborne and waterborne infectious diseases and antibiotic resistance

Dr Aliyar Cyrus Fouladkhah of Tennessee State University is an Assistant Professor in Public Health Microbiology. His laboratory explores preventive measures for the spread of infectious diseases, antibiotic resistance, and food security in the landscape of changing climate. His research aims to provide better understanding of the ecology, epidemiology and effectiveness of control measures of enteric and environmental pathogens at planktonic and biofilm stages, including several foodborne and waterborne bacteria. His work contributes to reducing the current burden of premature morbidity and mortality associated with infectious diseases and antibiotic resistance.

According to the U.S. Centers for Disease Control and Prevention, achieving safe and healthier foods is one of the top ten achievements of 20th century public health. Despite the marked progress, considerable challenges remain to further assure the safety and security of food and water supplies, with one in six adults in the United States experiencing illness from foodborne pathogens in a typical year. Foodborne diseases cause an estimated 420,000 deaths worldwide each year. Furthermore, climate change is expected to enhance the spread of infectious diseases since changes in environmental temperatures appreciably augment the multiplication of bacterial pathogens.

The research group of Dr Aliyar Fouladkhah at Tennessee State University addresses these emerging and re-emerging challenges. His laboratory utilises new technologies, in Guatemala, Dominican Republic, and South Africa.

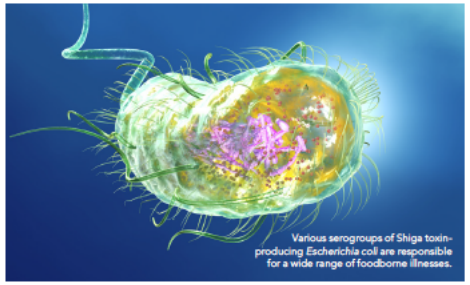
THE ROLE OF CLIMATE CHANGE

Microbial pathogens have an incredible ability to evolve and move towards 'fitness' in response to changes in their environment. Climate change will have pronounced effects on the proliferation, survival, and spread of microbial pathogens, and thus on the prevalence of foodborne and waterborne diseases. More than 200 diseases, known to be transmitted through contaminated food and water, may provide examples of the effects of climate change on the magnitude of infectious diseases. One example of this is salmonellosis, an infection caused by nontyphoidal *Salmonella enterica* serovars, which is currently responsible for over one million cases of foodborne illness in the United States in a typical year.

of these treatments is diminishing, with resistance in many of the common bacterial pathogens now categorised as a public health threat.

Dr Fouladkhah comments that, although there is a focus on identifying new classes of antibiotics, this strategy alone is not sufficient to alleviate the public health challenge of antibiotic resistance. He emphasises that a holistic 'one health' approach should be embraced, which includes limiting the use of current antibiotics to those individuals with dire need for antibiotic therapies and incorporating evidence-based stewardship programmes such as susceptibility testing and watchful waiting in hospitals. This also requires eliminating or minimising the prophylactic and sub-therapeutic use of antibiotics in animal husbandry as the spread of antibiotic resistance in animal populations could be very closely associated with human health complications. Additionally, continuing the search for new antibiotics and antimicrobials, implementing microbial hurdle validation studies in processing and manufacturing, and multiagency efforts to mitigate climate change could assure the control of antibiotics resistance.

Ultimately, Dr Fouladkhah states that the "climate change-induced antibiotic resistance threat will affect citizens of countries with suboptimal public heath



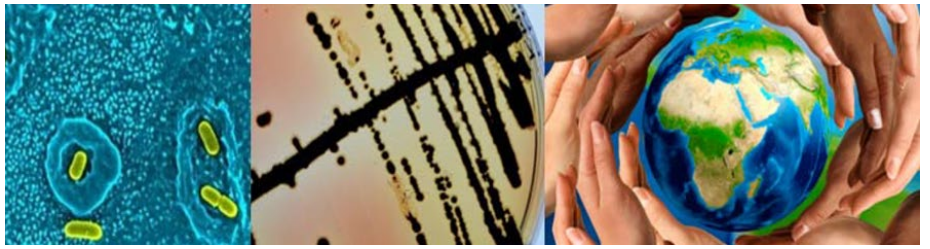
Various serogroups of Shiga toxin-producing *Escherichia coli* are responsible for a wide range of foodborne illnesses.

Climate change is one of the most significant public health challenges of our time and threatens the safety of our food and water supplies.

three bacteria of public health concern in waters of different temperatures (5, 25 and 37°C) and on stainless steel and rubber surfaces. They found that the bacteria included in the study could survive in surface water and form complex biofilms (a collection of microbes which stick to each other and the surface they live on) on abiotic surfaces, detectable for up to 28 days. These results suggest that the occurrence of contamination in water supplies can

do not receive any additional processing or treatment before consumption.

Various serogroups of *Escherichia coli* (*E. coli*) are among the top causes of foodborne illnesses, in particular O157 *Shiga toxin-producing E. coli* (STEC) and non-O157 *Shiga toxin-producing E. coli* (nSTEC). The majority of illnesses relating to these serogroups are derived from foodborne infections.



Impact Analyses

Outreach Article Available at:

https://researchoutreach.org/articles/changing-climate-threat-multiplier-foodborne-waterborne-infectious-diseases-antibiotic-resistance/

Twitter @ResOutreach analysis

The link to your Twitter post

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Device stats

iOS 43%

Android 47%

Desktop 10%

Demographics

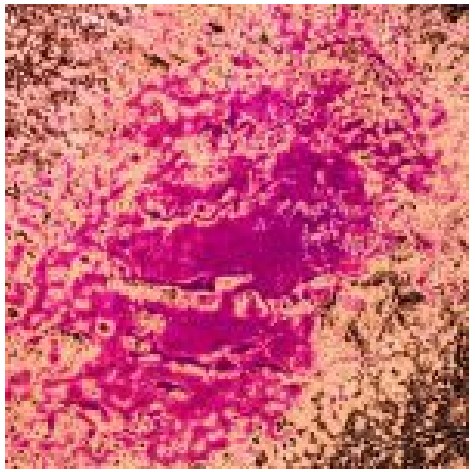
Male	Female	Unknown
57%	40%	3%

Key metrics for all content promoted on Twitter

Audience	Engagements
42605	3256

Top interests

Technology	Biology	Healthcare
68%	53%	48%



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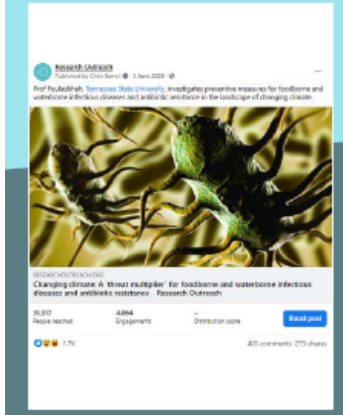

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Device stats

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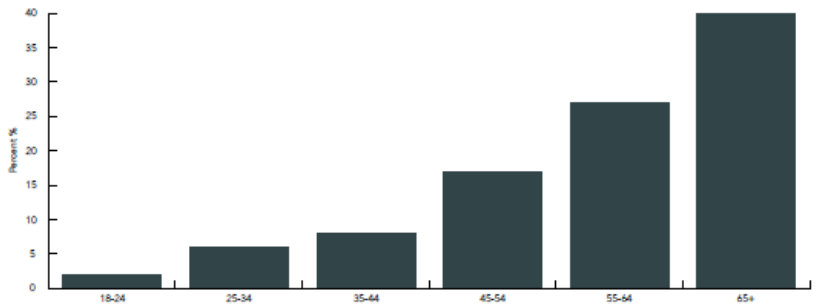
Female 35%

Key metrics for all content promoted on Facebook

People reached	Engagements
31317	4064

Age range



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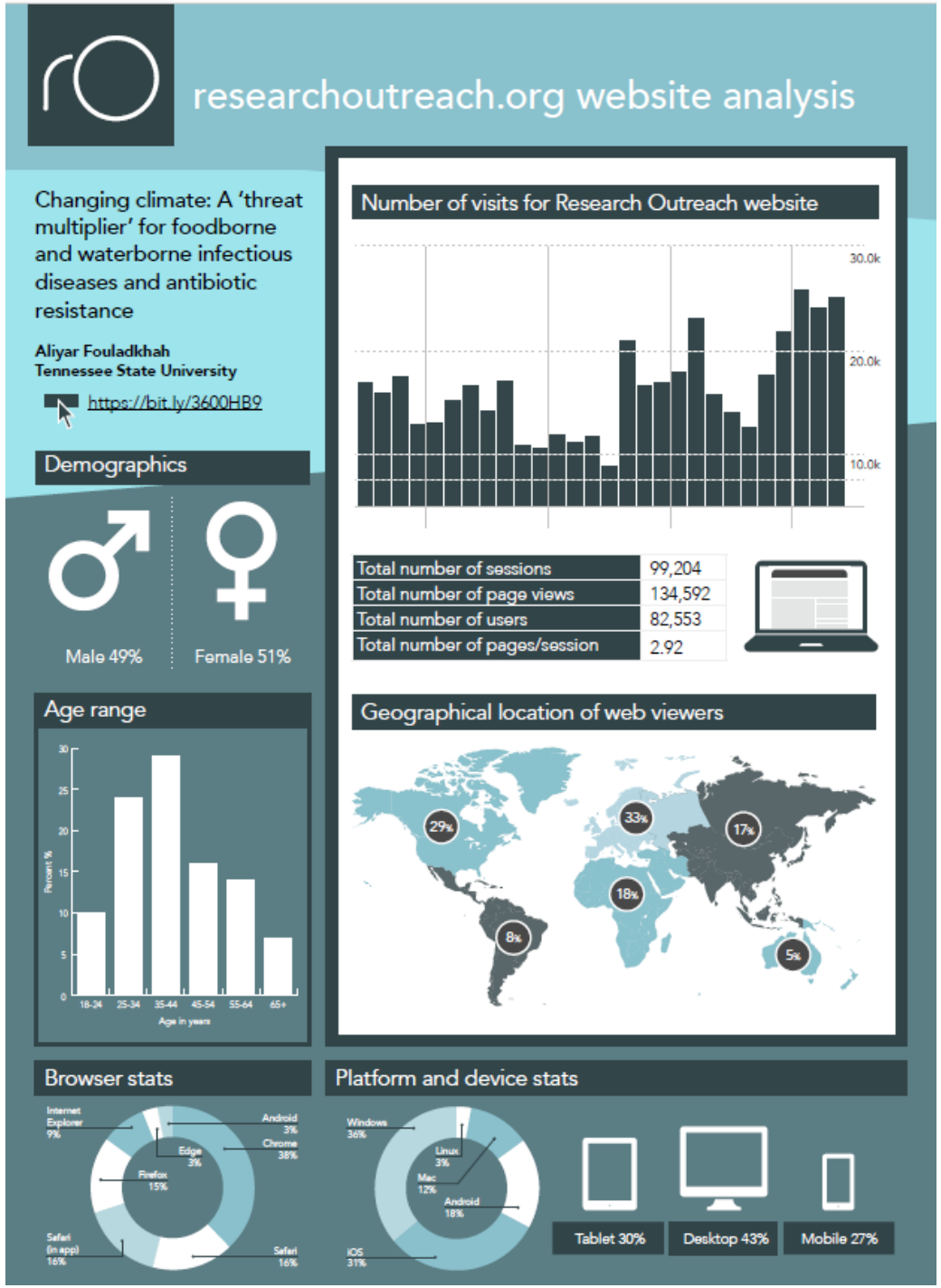

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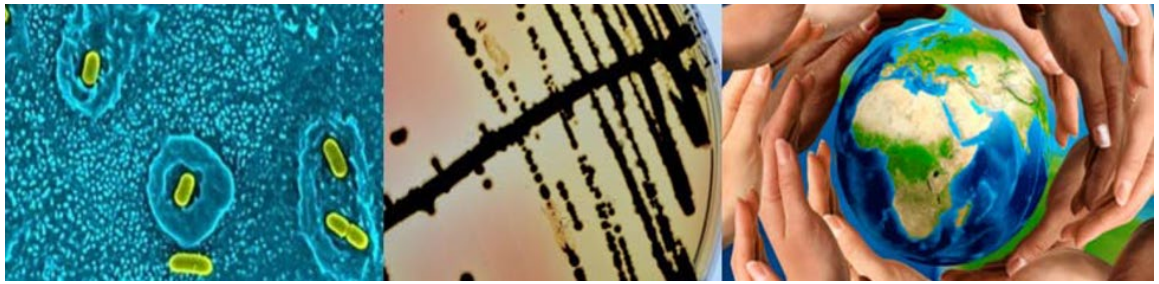
Source: NASA



Review of CPH Exam Practice Questions

NATIONAL BOARD OF PUBLIC HEALTH EXAMINERS
Credentialing **Public Health** Professionals

What is the main foodborne pathogen of concern for processed ready-to-eat food commodities that could cause health complications such as fever, muscle aches, stiff neck, confusion, loss of balance, and convulsions as well as miscarriage, stillbirth, premature delivery in pregnant women?

A.	*Listeria monocytogenes*
B.	Non-Typhoidal *Salmonella* serovars
C.	Pathogenic *Cronobacter* spp.
D.	Shiga Toxin-Producing *Escherichia coli*

Among the pathogens listed below, what is the leading causative agent for foodborne hospitalizations and death episodes in the United States, according to the Centers for Disease Control and Prevention active surveillance epidemiological data?

A.	*Listeria monocytogenes*
B.	Non-Typhoidal *Salmonella* serovars
C.	Pathogenic *Cronobacter* spp
D.	Shiga Toxin-Producing *Escherichia coli*

Among the listed microbial agents, which pathogen has been associated with several domestic and international outbreaks of infant formula and could cause health complications in preterm infants and newborns?

A.	*Listeria monocytogenes*
B.	*Shigella* spp
C.	*Cronobacter sakazakii*
D.	Shiga Toxin-Producing *Escherichia coli*

Among the listed metrics, which is/are the fundamental and most often utilized epidemiological metric(s) for the study of infectious disease dynamics as an indicator of the contagiousness or transmissibility?

A.	Disability Adjusted Life Year (DALY)
B.	Kruskal-Wallis test
C.	D-value and Z-value
D.	The basic reproduction number (R0)

What is the name of the largest legislation associated with food safety in last 70 years that was signed into law in January 4, 2011 by President Barack Obama.

A.	Food Safety Modernization Act
B.	Federal Food, Drug, and Cosmetic Act
C.	Pure Food and Drug Act
D.	Federal Meat Inspection Act

According to Morbidity and Mortality Weekly Report of the U.S. Centers for Disease Control and Prevention, which answer contains the top 10 Public Health Achievements of First Decade of 21st Century?

A.	Vaccine-Preventable Diseases, Prevention and Control of Infectious Diseases, and Maternal and Infant Health
B.	Cardiovascular Disease Prevention, Cancer Prevention, and Improved Public Health Preparedness and Response
C.	Occupational Safety, Motor Vehicle Safety, Tobacco Control, and Childhood Lead Poisoning Prevention
D.	All of the above are among the top 10 Public Health Achievements of First Decade of 21st Century

Vaccination against polio provides lifelong protection, whereas influenza vaccines have to be administered each year. Which of the following statements best explains this difference in vaccine action?

A.	Influenza vaccines are prepared from killed viruses, but polio vaccines are prepared from live, attenuated viruses.
B.	Influenza vaccines have to be administered by injection, but the oral polio vaccine can be ingested.
C.	Influenza viruses mutate at a much higher rate than poliovirus.
D.	Poliovirus can only cause disease in humans, whereas influenza viruses can infect other species.

A 22-year-old Latina woman brings her 13-month-old daughter to a health department clinic for routine well-child care. Both are enrolled in the Medicaid program. They live in an inner-city apartment building that the mother describes as "old and run down." The infant's diet consists of table foods; the principal protein sources are eggs, peanut butter, cheese, and canned tuna. Screening of the infant for which of the following conditions is recommended by the Centers for Disease Control and Prevention (CDC)?

A.	Allergies and asthma
B.	Pesticide exposure
C.	Elevated blood lead concentration
D.	Mercury poisoning

The introduction of sewage into a stream is most likely to cause a measurable change in which of the following ways?

A.	Decrease in decomposing organic concentration
B.	Increase in biochemical oxygen demand
C.	Increase in dissolved oxygen concentration
D.	Stabilization of biochemical oxygen demand

Which of the following terms refers to the systematic method by which environmental exposure to a substance is quantified using information about the hazardous properties of the substance, human exposure to the substance, dose-response relationships, and risk characterization?

A.	Risk management
B.	Risk assessment
C.	Risk communication
D.	Risk control

In addition to ozone and particulates, which of the following pollutants is most likely to aggravate asthma?

A.	Arsenic
B.	Carbon monoxide
C.	Lead
D.	Sulfur dioxide

Under the Asbestos Hazard Emergency Response Act (AHERA), schools must be inspected for asbestos hazards. Which of the following is the public health basis for this regulation?

A.	Children are likely to have behaviors that will expose them to asbestos in schools.
B.	It is not feasible to regulate exposures in the home environments and schools are the next best location.
C.	Asbestos was primarily placed in schools because the fire-retardant properties are protective of children.
D.	Diseases associated with exposure to asbestos may have an extended latency period, putting exposed children at risk later in their lives.

Recreational water quality in the United States is most affected by which of the following types of pollution?

A.	Urban runoff after a rain event
B.	Factory wastewater
C.	Oil spilled from boat motors
D.	Organic decomposition from weeds and rushes

The outbreak of hantavirus pulmonary syndrome in 1993 in the Four Corners area of the Southwest resulted from an explosion in the population of deer mice. It is believed that the population increase resulted from an unusually wet spring that produced a more abundant than usual crop of piñon nuts, the major food source of the deer mouse in that area. An understanding of which of the following concepts is likely to be most pertinent to public health practitioners in preventing future outbreaks of this disease?

A.	Biotic potential of the piñon nut
B.	Effect of rainfall on homeostatic controls
C.	Environmental resistance factors of the deer mouse
D.	Environmental factors that limit the size of the deer mouse population

A mother and her child have lived in an area with poor air quality for several years, yet only the child shows symptoms of an environmentally linked respiratory disease. Which of the following is the most likely reason?

A.	Young children show symptoms earlier than adults.
B.	Young children have higher metabolic and respiratory rates.
C.	Adults living in these areas develop tolerance to air pollutants.
D.	Adults are more likely to have comorbidities that mask the symptoms.

Which of the following complaints is most likely to result in the investigation of a restaurant?

A.	One person reported becoming ill after eating at the restaurant.
B.	Two people became ill, one with a migraine headache and one with diarrhea, after eating at the restaurant.
C.	Three friends became ill with vomiting within 4 hours of eating the same food items.
D.	Five family members developed diarrhea within 48 hours of eating at the restaurant.

Which of the following terms means that a tumor has spread to other locations within the body?

A.	Malignant
B.	Metastatic
C.	Benign
D.	Hyperplastic

Which of the following can be considered a concern with live, attenuated vaccines?

A.	They are very expensive to produce
B.	They produce a weak response and require booster shots
C.	They can cause disease in an immunocompromised individual
D.	People can develop allergic reactions to them

Characteristics, attributes or exposures such as hypertension, unsafe sex, alcohol consumption, unsafe water that can increase the likelihood of developing disease or injury are known as

A.	Risk factors
B.	Environmental factors
C.	Causal factors
D.	Community factors

Which of the following methods is the most accurate exposure assessment in workers?

A.	Determination of the chemical in the air
B.	Biomonitoring of chemicals or metabolites of the chemicals in blood and urine
C.	Determination of the chemical on the skin
D.	Estimation of the exposure by taking an occupational history

Which of the following disinfection methods is most commonly used in US drinking water supply systems?

A.	Ozonation
B.	Bromination
C.	Chlorination
D.	Ultraviolet irradiation

The nutrient-rich solids produced as a byproduct of municipal sewage treatment and often proposed for use as a soil amender in agriculture is termed:

A.	Hazardous waste
B.	Suspended Solids
C.	Biochemical Oxygen Demand (BOD)
D.	Sludge

High level of nitrates in groundwater are of particular concern in rural communities that rely on well water because:

A.	Nitrates can cause "Blue-Baby Syndrome" in infants
B.	Nitrates are potent carcinogens in adults
C.	The well water will be undrinkable due to taste, odor, and color problems
D.	The well water will form nitric acid and become corrosive to metal pipes in the water system

Three-Part Question

In a small community in the highlands (elevation of 1,000 meters above sea level) of Ecuador, locals earned their living by manufacturing rugs. Rugs were made in indoor, closed rooms. The crowded rooms were heated by an open charcoal fire, provided approximately 5 cubic meters of air volume per person.

Workers began to complain of stiffness in the shoulders, backache, fatigue, and dizziness. As the disease progressed, workers became short of breath on exertion and experienced tightness and pain below the breast bone, numbness in the arms and hands, and swelling of the face. The attacks of shortness of breath occurred mostly at night, whereas the episodes of pain and tightness around the heart, a condition known as angina pectoris, followed light work during the day.

The most likely contaminants causing the described symptoms was:

A.	Sulfur dioxide
B.	Particulates
C.	Carbon Monoxide
D.	Carbon Dioxide

The carboxyhemoglobin levels in the exposed workers:

A.	Dropped below 10% of normal levels
B.	Stayed the same
C.	Was found in the kidneys
D.	Was elevated

What is a solution to the problem posed in the scenario?

A.	Larger, well-ventilated rooms
B.	Providing a medical staff to monitor workers
C.	Moving the industry to sea level
D.	Changing the material used to make the rugs

Which term is used to characterize the social conditions of unequal distribution of environmental hazards?

A.	Environmental equity
B.	Environmental justice
C.	Environmental pollution
D.	Environmental democracy

Blood lead levels are a public health concern, specifically for children. Until 2012, children were identified as having a blood lead "level of concern" if test results were 10 or more micrograms of lead per deciliter of blood. CDC is no longer using the term "level of concern" and is instead using the reference value to identify children who have been exposed to lead and require case management.

Experts now use a reference level of 5 micrograms per deciliter to identify children with elevated blood lead levels. This new level is based on the US population of children aged 1 to 5 years who are in the highest 2.5% of children tested for lead in their blood. This reference value is based on the 97th percentile of the National Health and Nutrition Examination Survey's (NHANES's) blood lead distribution in children. The new lower value means more children will likely be identified as having lead exposure, allowing parents, doctors, public health officials, and communities to take action earlier to reduce the child's future exposure to lead.

Which of the following is this an example of?

A.	How evidence-based biological claims can influence legislation enacted to protect the health of the public
B.	How children remain the most vulnerable in our society
C.	An overcautious approach
D.	How political agendas can influence legislation

There are many chemical agents that can cause diseases or disorders in humans. Which of the following would public health professionals suspect if a patient had symptoms of muscle spasms, nausea, vomiting, and abdominal pain? Another clue is that the product that is suspected to carry the agent is fertilizer.

A.	Arsenic
B.	Mercury
C.	Asbestos
D.	Organic solvents

Which of the following is **true** about vaccines?

A.	In some cases a person who completed all doses of a vaccine can still get the particular disease that it is expected to prevent
B.	Vaccines have been shown to increase the incidence of autism in several studies
C.	Most vaccines are not necessary these days because the infectious diseases they prevent are uncommon in the U.S.
D.	Risks associated with vaccines are greater than the benefits in most cases

In the US, which is the largest source of radiation does to the general public?

A.	Automobiles
B.	Medical use of x-rays
C.	Radon gas
D.	Nuclear waste

The Clean Air Act directs the Environmental Protection Agency (EPA) to establish national _____ air quality standards?

A.	Polluted
B.	Ambient
C.	Surrounding
D.	Clean

Which of the following is currently the most common cause of unintentional death in the U.S.?

A.	Motor vehicle (traffic) accidents
B.	Unintentional poisoning (e.g. drug abuse)
C.	Unintentional gunshot wounds
D.	Unintentional falls

All of the following are true EXCEPT…

A.	Environmental factors can cause mutations in our DNA
B.	Changes in the environment can lead to altered levels of hormones in our bodies
C.	Environmental factors are less important than genetics in the etiology of common diseases in the U.S.
D.	Infectious diseases occur due to interactions between genetic and environmental factors

Which of the following best describes how vaccines work?

A.	Most vaccines work by triggering the body's adaptive immune system including antibody production that can target a specific pathogen
B.	Most vaccines work by providing artificially produced antibodies that can attack specific pathogens
C.	Most vaccines trigger the body's innate immune system which results in macrophages that engulf the pathogens
D.	Most vaccines work through epigenetic mechanisms that turn on genes that produce specific antibodies

Which of the following is true about newborn screening programs?

A.	All states in the U.S. screen for the same set of genetic conditions in newborns
B.	Most of the genetic conditions screened for follow an autosomal recessive pattern of inheritance
C.	Almost all babies who have a positive newborn screen end up being diagnosed with the condition
D.	In the U.S., most state newborn screening programs began in the 1990's

All of the following are true about gene expression **EXCEPT...**

A.	Differences in gene expression explain why different cell types look and function differently
B.	Gene expression can be controlled by preventing the transcription of DNA to form RNA
C.	Gene expression can be controlled by preventing mRNA from being translated to create a protein
D.	Identical twins have nearly identical gene expression throughout their lifetime

Which of these groups of conditions include one or more single gene disorders that are part of the recommended uniform newborn screening panel?

A.	Metabolic disorders (e.g., PKU, fatty acid oxidation disorders)
B.	Endocrine disorders (e.g., congenital adrenal hyperplasia)
C.	Hemoglobin disorders (e.g., sickle cell disease) and Hearing loss (e.g., connexin26)
D.	All of the above

Good Luck

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