One Health in Action: Bridging Animal and Human Health through Microbiome Research

Erika Ganda

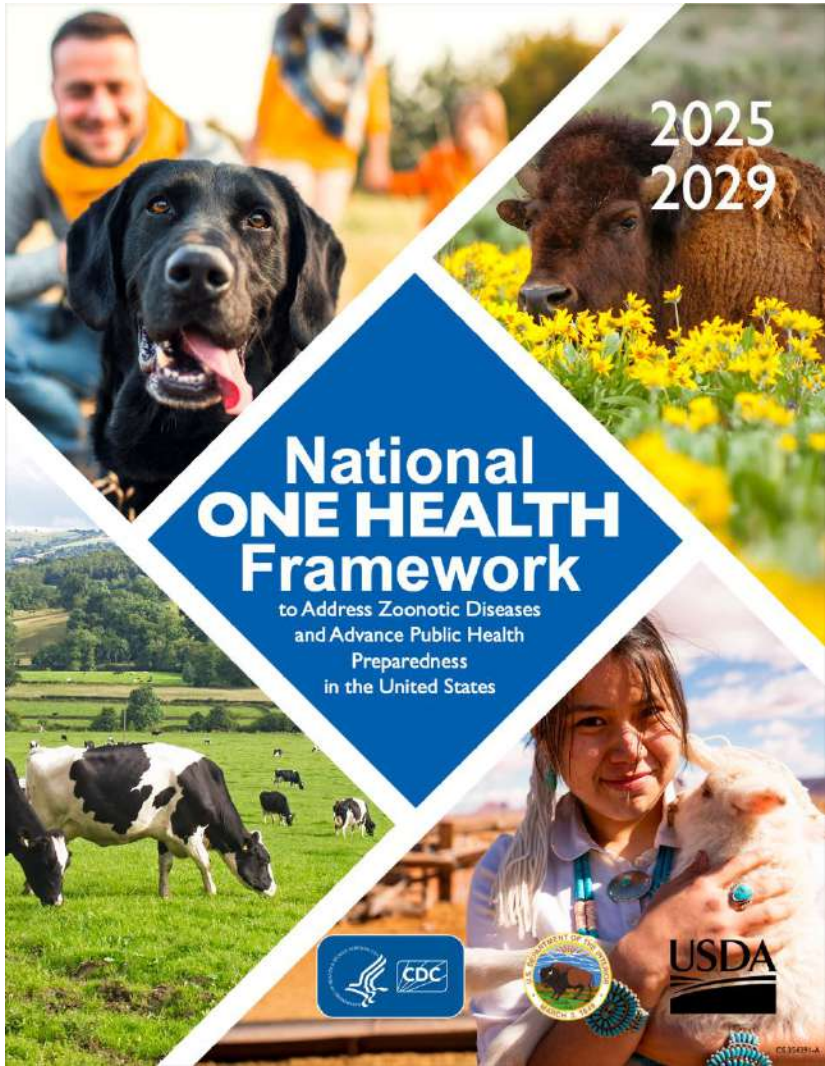
DVM,(BVSc) Ph.D.
Assistant Professor of Food Animal Microbiomes
The Pennsylvania State University

PLANT & ANIMAL GENOME

GANDA LABORATORY
Animal Microbiomes and One Health

One Health

National One Health Framework to Address Zoonotic Diseases and Advance Public Health Preparedness in the United States



One Health

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One Health

The world population is expected to reach 10 billion by 2060...

United Nations
Population Division 2024

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Animal Microbiomes and One Health

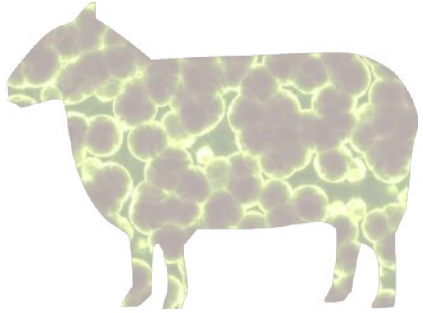
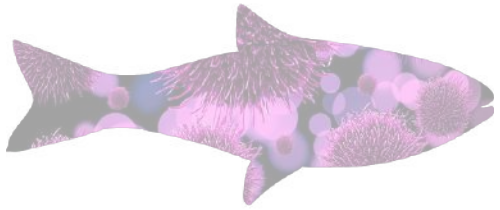
PennState

Goal

Develop

microbiome-based solutions

for use in the agricultural industry

What is the Microbiome?

microbiome noun

Save Word

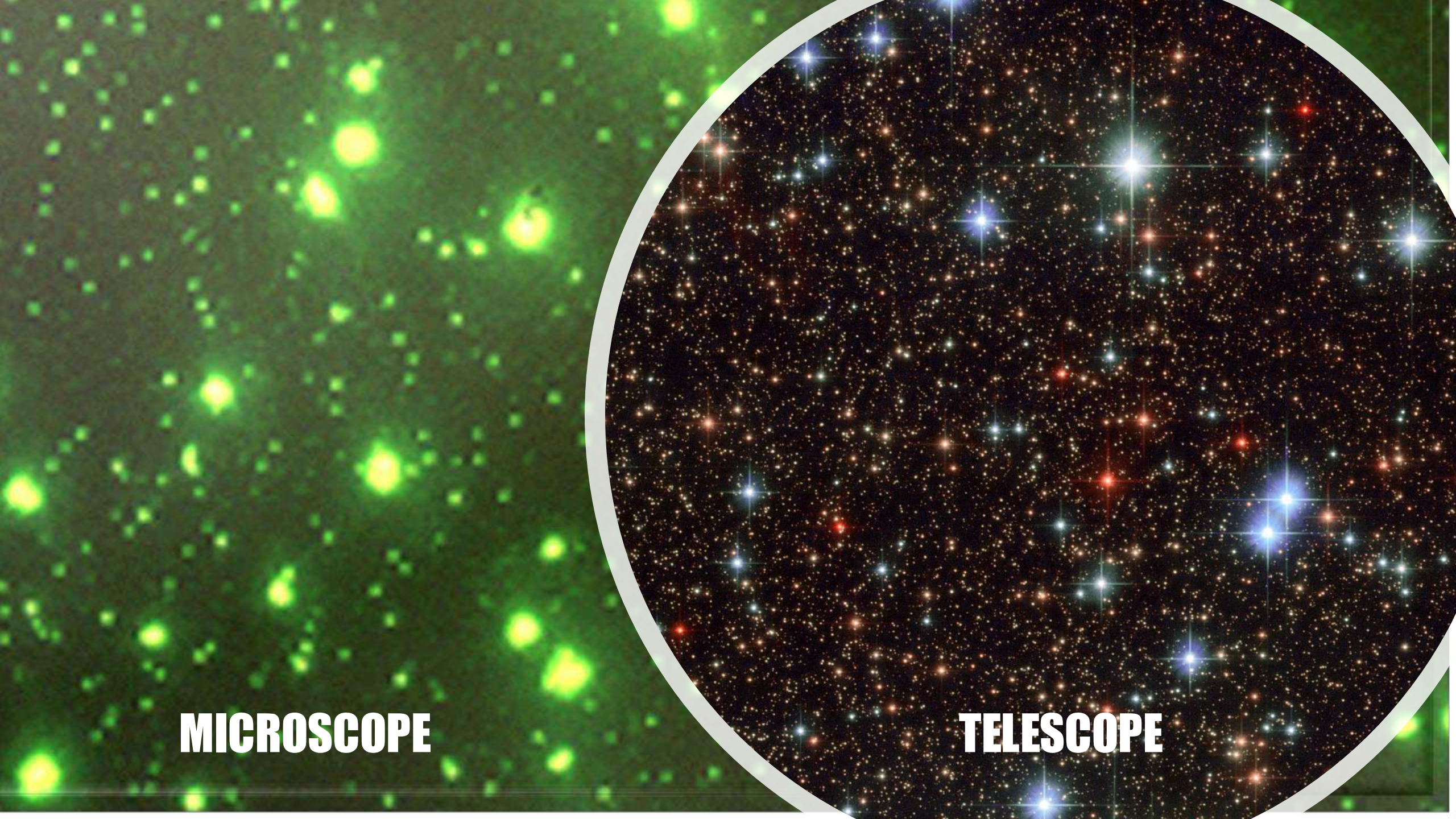
mi·cro·bi·ome | \ ˌmī-krō-ˈbī-ˌōm \

Definition of *microbiome*

1 : a community of microorganisms (such as bacteria, fungi, and viruses) that inhabit a particular environment and especially the collection of microorganisms living in or on the human body

// Your body is home to about 100 trillion bacteria and other microbes, collectively known as your *microbiome*.

— Carl Zimmer


MICROSCOPE
TELESCOPE

4 Billion Years of Microbial Life

Planet Microbe

10^{30}

BACTERIA ARE ON THE PLANET.
THERE ARE MORE BACTERIA ON
EARTH THAN STARS IN THE UNIVERSE.

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2019

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Penn State Microbiome Center

2023

Working at the Intersect

PennState | One Health Microbiome Center

MICROBIOME CENTERS CONSORTIUM

ONE HEALTH
ONE PLANET ONE FUTURE

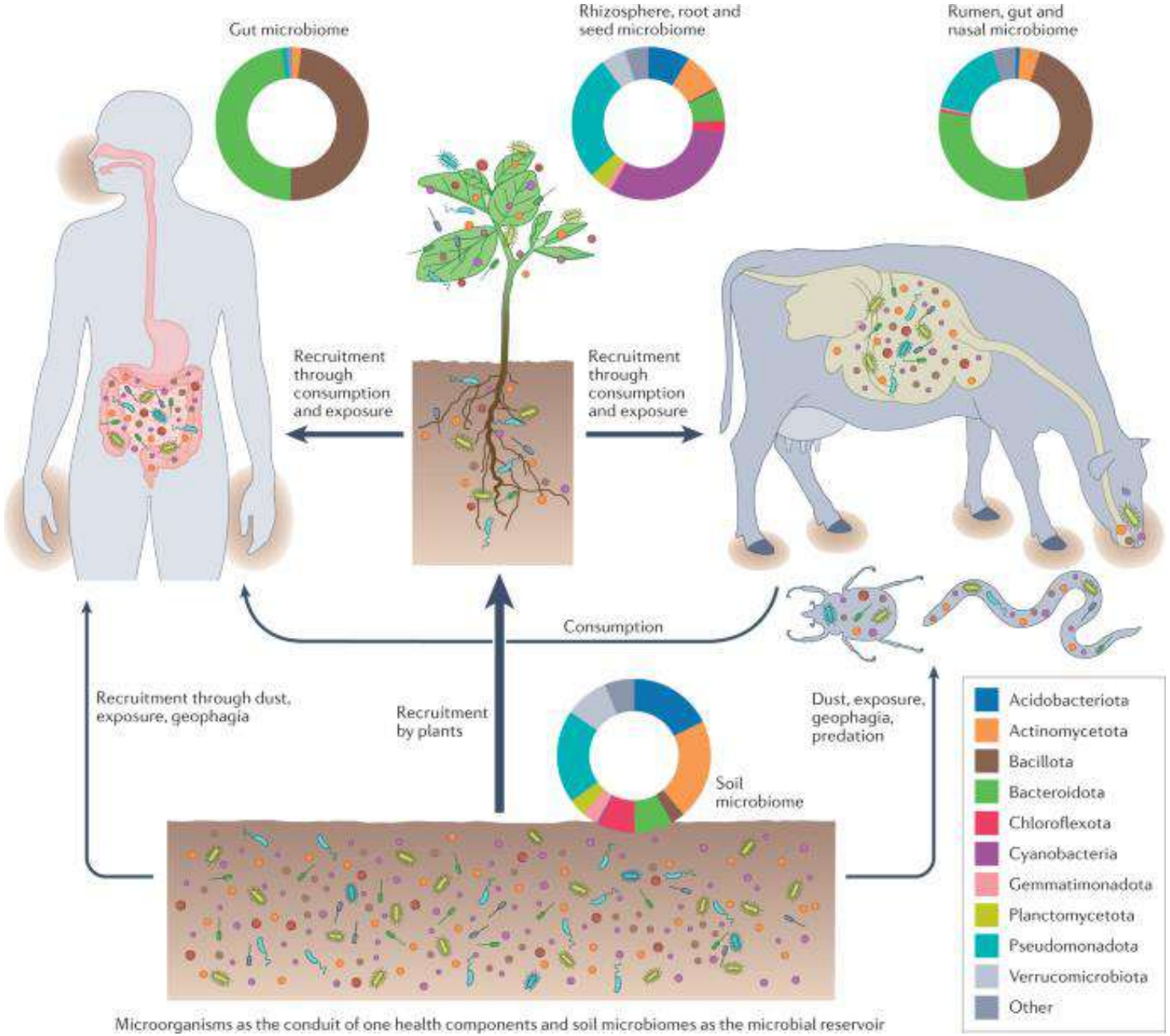
Soil tilling -> **Drought** adaptation ->
Plant health -> **Livestock** Health -> **Food** health

Pests & Vector-borne pathogens -> **Symbiont**
Control -> **Crop, Livestock, and Human** health

The National Academies of SCIENCES ENGINEERING MEDICINE

One Health Action Collaborative

CDC, WHO, DHS, USDA, USGS, Merck…



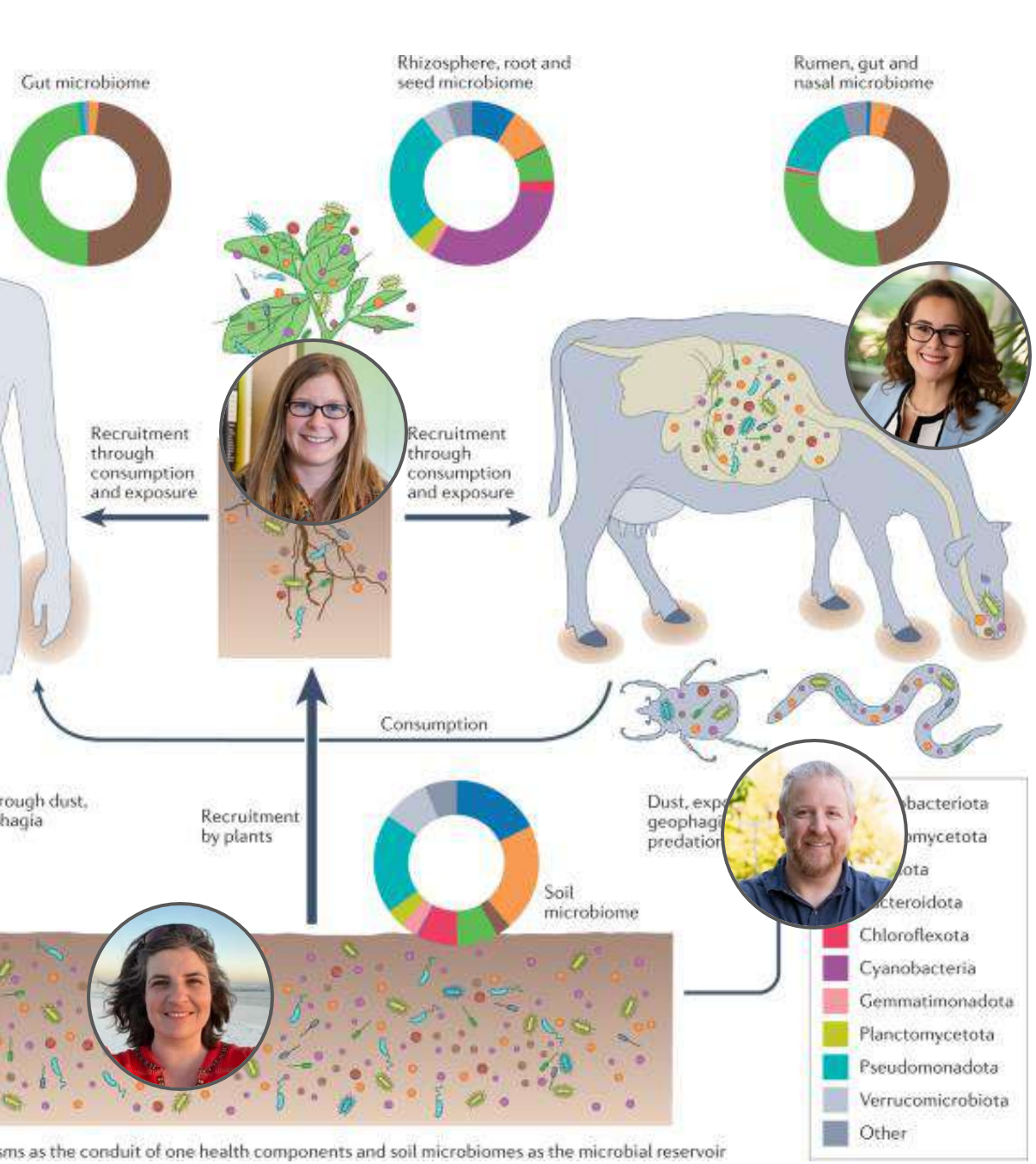
Microorganisms as the conduit of one health components and soil microbiomes as the microbial reservoir

The National Academies of SCIENCES ENGINEERING MEDICINE

One Health Action Collaborative

CDC, WHO, DHS, USDA, USGS, Merck…

Natural environments and wildlife



Microorganisms as the conduit of one health components and soil microbiomes as the microbial reservoir

Executive Committee

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Jordan Bisanz
Mol. Biol.

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Andrew Patterson
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3 campuses

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Jasna Kovac
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One Health Microbiome Center
Penn State University

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550 Members

125 Faculty in 42 Dept. from 10 colleges

2,000 articles in the last 5 years

Only Microbiome Sciences PhD Program

160 Graduate Students

microbiome.psu.edu

@PSUmBiome

One Health Microbiome Center
Penn State University

Monthly Informatic Workshops

Industry Partners: QIAGEN & more

USDA Training Grant

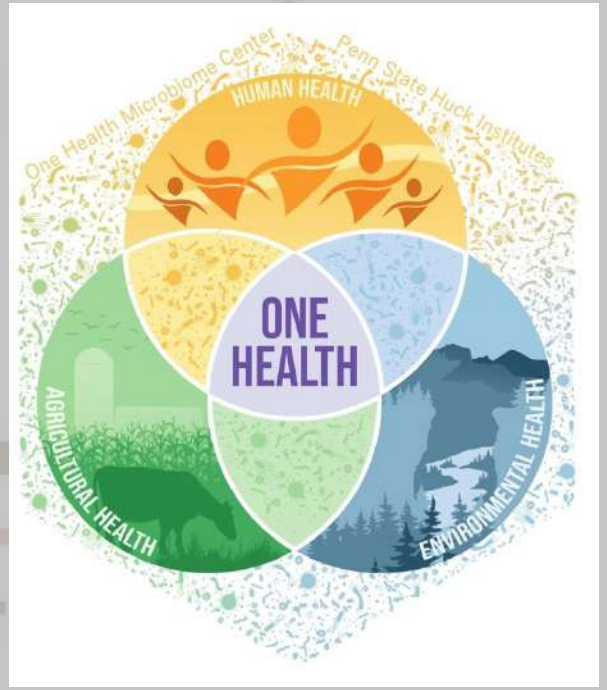
36 Courses in the Microbiome Sciences

Pilot Grants and Resource Calls

Sci-Art Synergies

1st & Only PhD in the Microbiome Sciences

Global Science Education Series



The *Wolbachia* Project
Discover the Microbes Within!

microbiome.psu.edu

@PSUmBiome

Macrobes for MICROBES

come for the free food, stay for the microbes

The graduate student club
for the advancement of the microbiome sciences

Develop your outreach skills!
K-12 demonstrations
citizen science projects
community workshops

Network and collaborate!
meet new people
talk about microbes
change the world

Professional development!
career development workshops
guest speakers from industry
writing and communication workshops
peer mentoring

sites.psu.edu/MacrobesForMicrobes/join

@PSUmacrobes

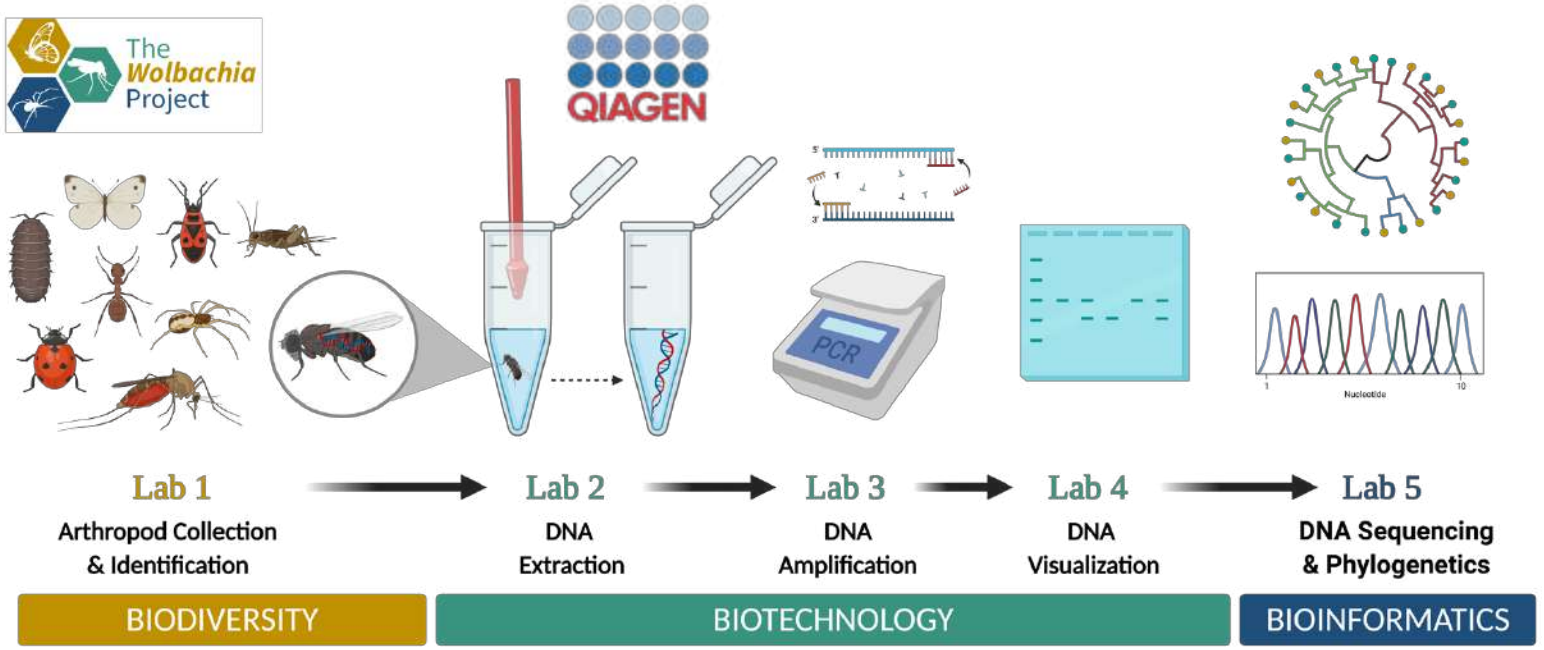
MacrobesForMicrobes@gmail.com

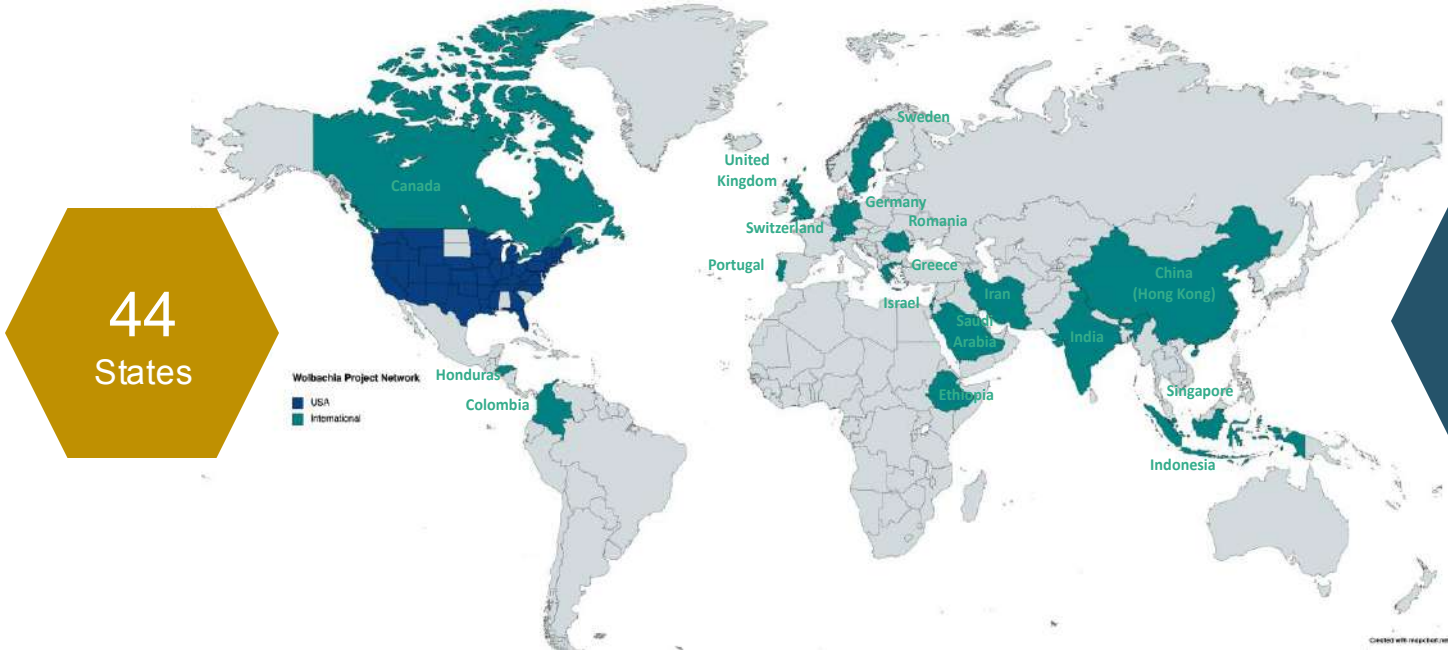
Data Analysis Working Group

The Wolbachia Project

Discover the Microbes Within!

Discovery-based, student-driven labs for pre-college, college, and citizen scientists





44 States

19 Countries

@WolbachiaProj

wolbachiaproject.org

SYNERGIES
IN ART AND SCIENCE

Luncheon & Panelist Discussion

Friday, November 8th from
1:30-2:30PM in Boreland 125

PennState | One Health Microbiome Center

ADRI
Arts & Design Research Incubator

Chad Fautt & Andrew Hieronymi

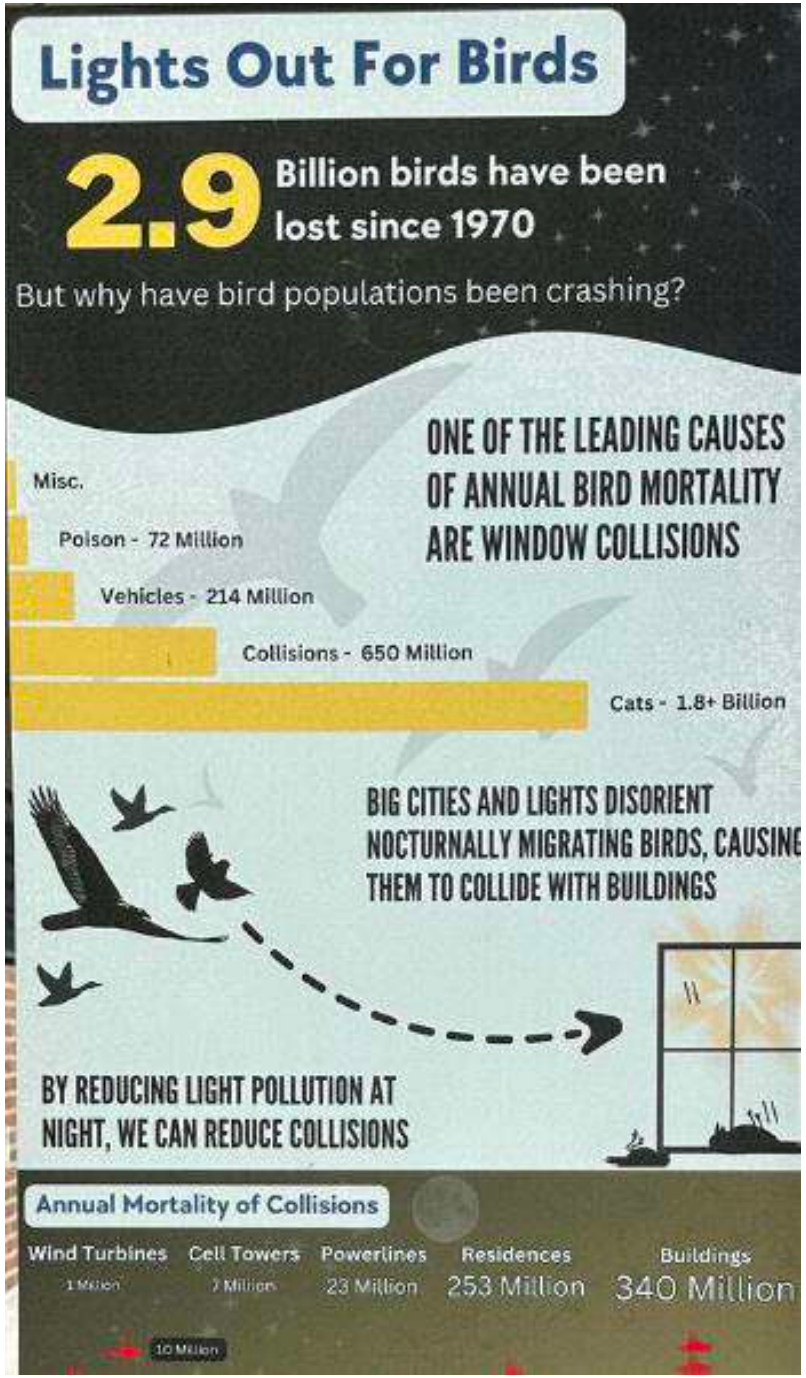
CONTACT: Gaming with Microbes

Cristin Millet

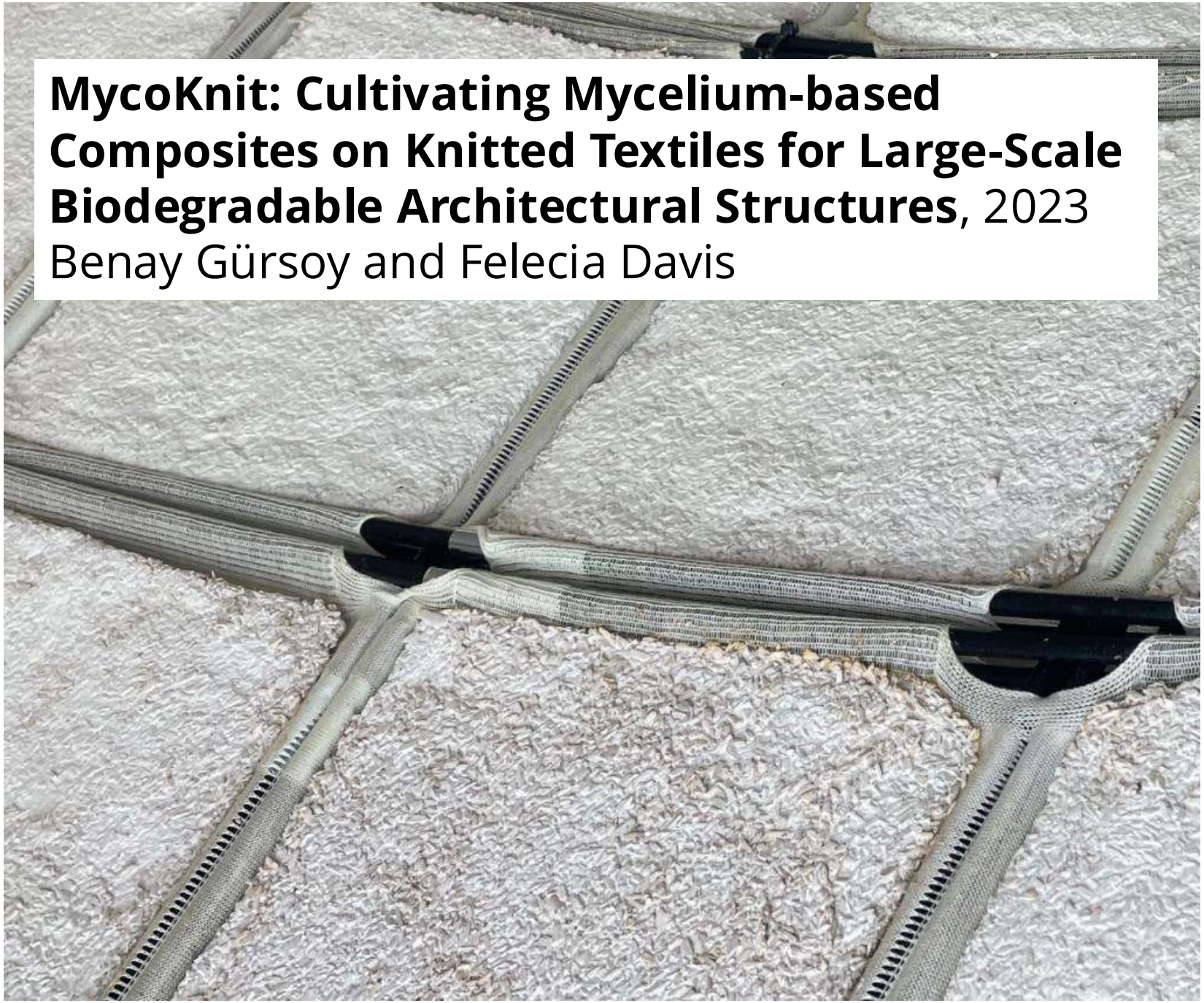
Ex-Utero: A Sculptural Exploration of Ectogenesis

Alale Mohseni & John Pecchia

Mycelium-Based Building Parts and Structures



Exhibition showcases art and science collaborations



MycoKnit: Cultivating Mycelium-based Composites on Knitted Textiles for Large-Scale Biodegradable Architectural Structures, 2023
Benay Gürsoy and Felecia Davis

Placen-Tech, 2024
Ex-Utero Collective (Cristin Millett, Cynthia White, and Ionat Zurr)

One Health Microbiome Symposium

PennState | One Health Microbiome Center

THE ONE HEALTH MICROBIOME SYMPOSIUM 2024

PennState | One Health Microbiome Center

KEYNOTE SPEAKERS:

Dr. Edith Hammer

"Windows to the underground - live broadcast from the world of the soil microbes"

Dr. Steffanie Strathdee

"From Bog to Bedside: The Story Behind the First Dedicated Phage Therapy Program in the United States."

Dr. Schulze-Lefert

"Reductionist approaches to determine functions of the plant root microbiota"

Dr. Gloria Dominguez-Bello

"The Microbiome in the Novacene"

THE ONE HEALTH MICROBIOME SYMPOSIUM

MAY 30-31, 2024

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One Health Microbiome Center

Applied Microbiology International

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Team:

Karah Cramer

Sophia Kenney

Dr. Ana Fonseca

Samantha Seibel

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Animal Microbiomes and One Health

Alumni:

Dr. Natalia Gaeta

Dr. Asha Miles

Dr. Emily Van Syoc

Stephanie Bierly

Dr. Jennine Lection

PennState Huck Institutes of the Life Sciences

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pennsylvania Department of Agriculture

pennsylvania Department of Health

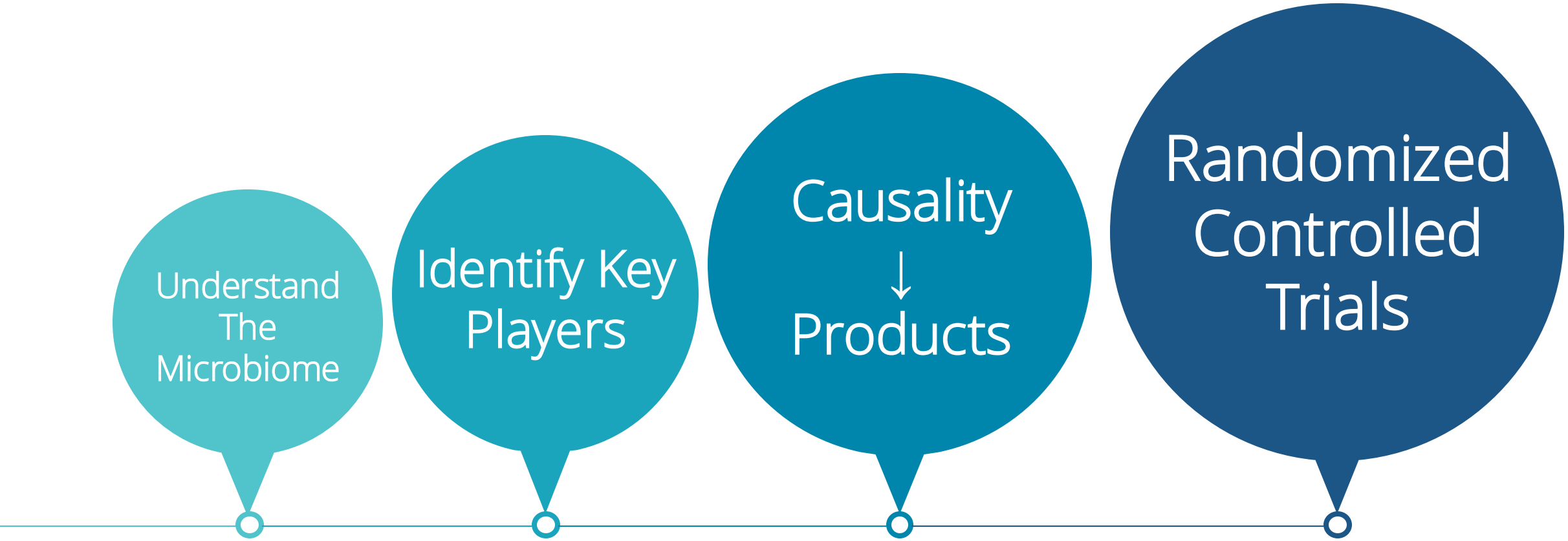
NIH

USDA APHIS

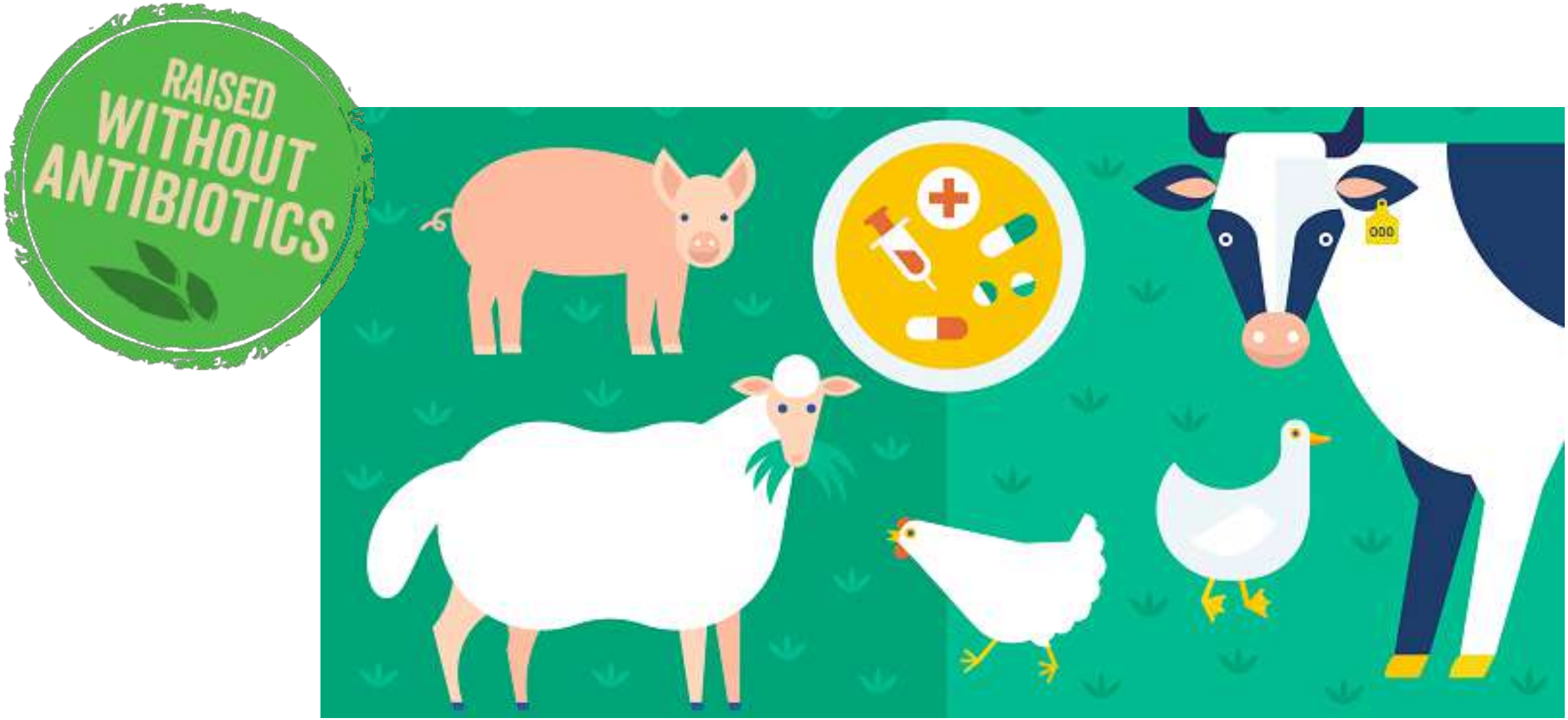
NIFA

Northeast SARE Sustainable Agriculture Research & Education

powered by dot.


Understand The Microbiome
Identify Key Players
Causality
↓
Products
Randomized Controlled Trials

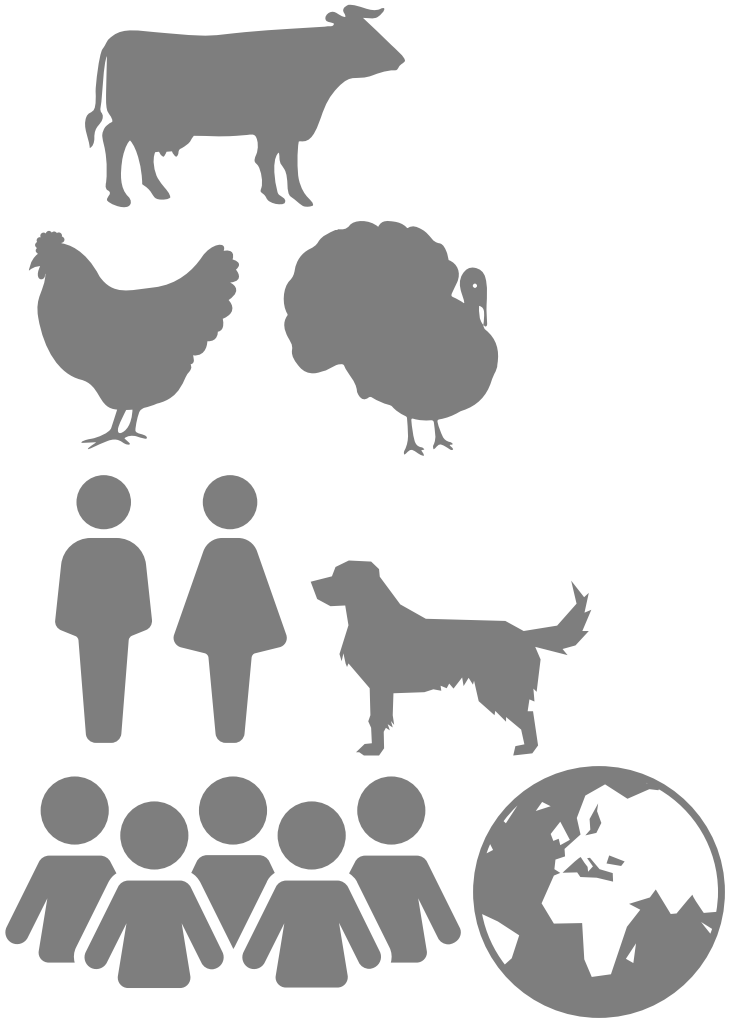
Animal Microbiomes and Antibiotic Resistance



https://foodanimalconcernstrust.org/food-labels

https://www.eufic.org/en/food-production/category/animal-welfare

Agricultural Microbiomes



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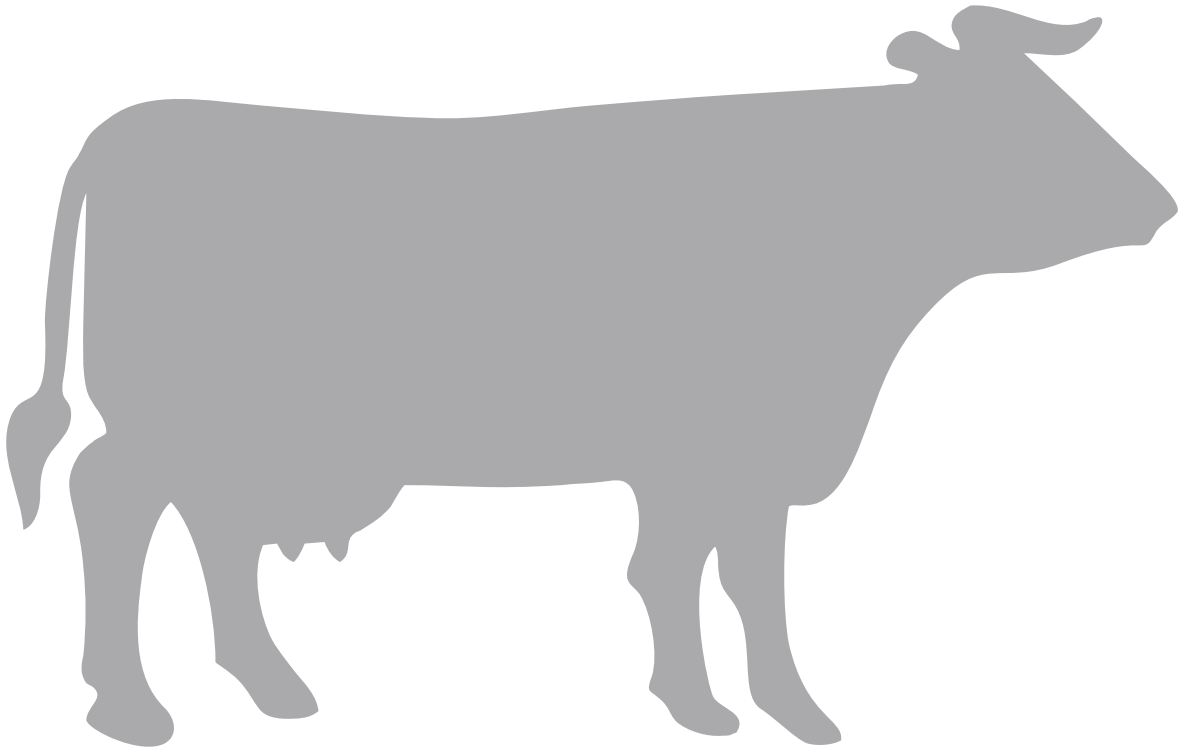
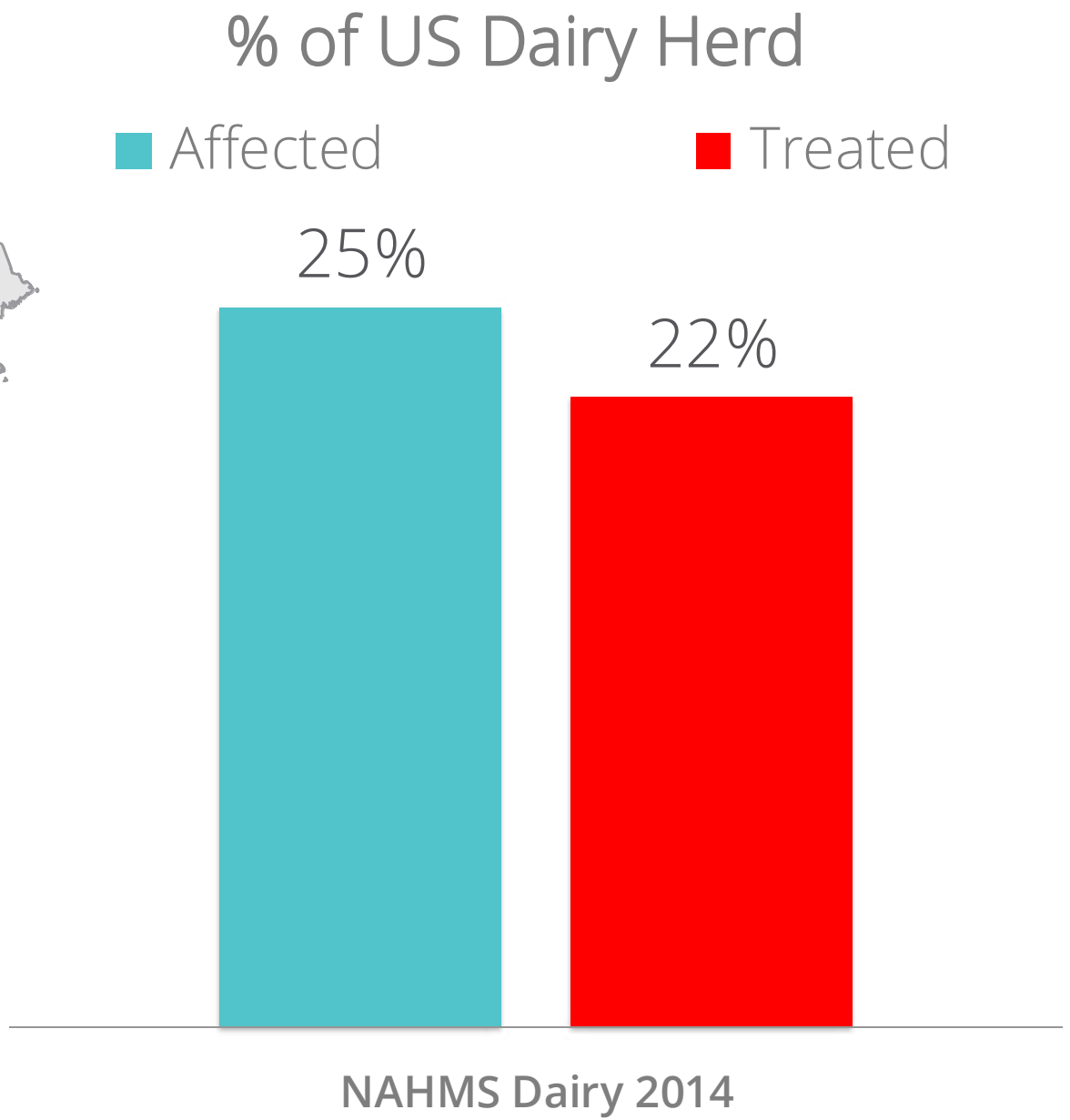


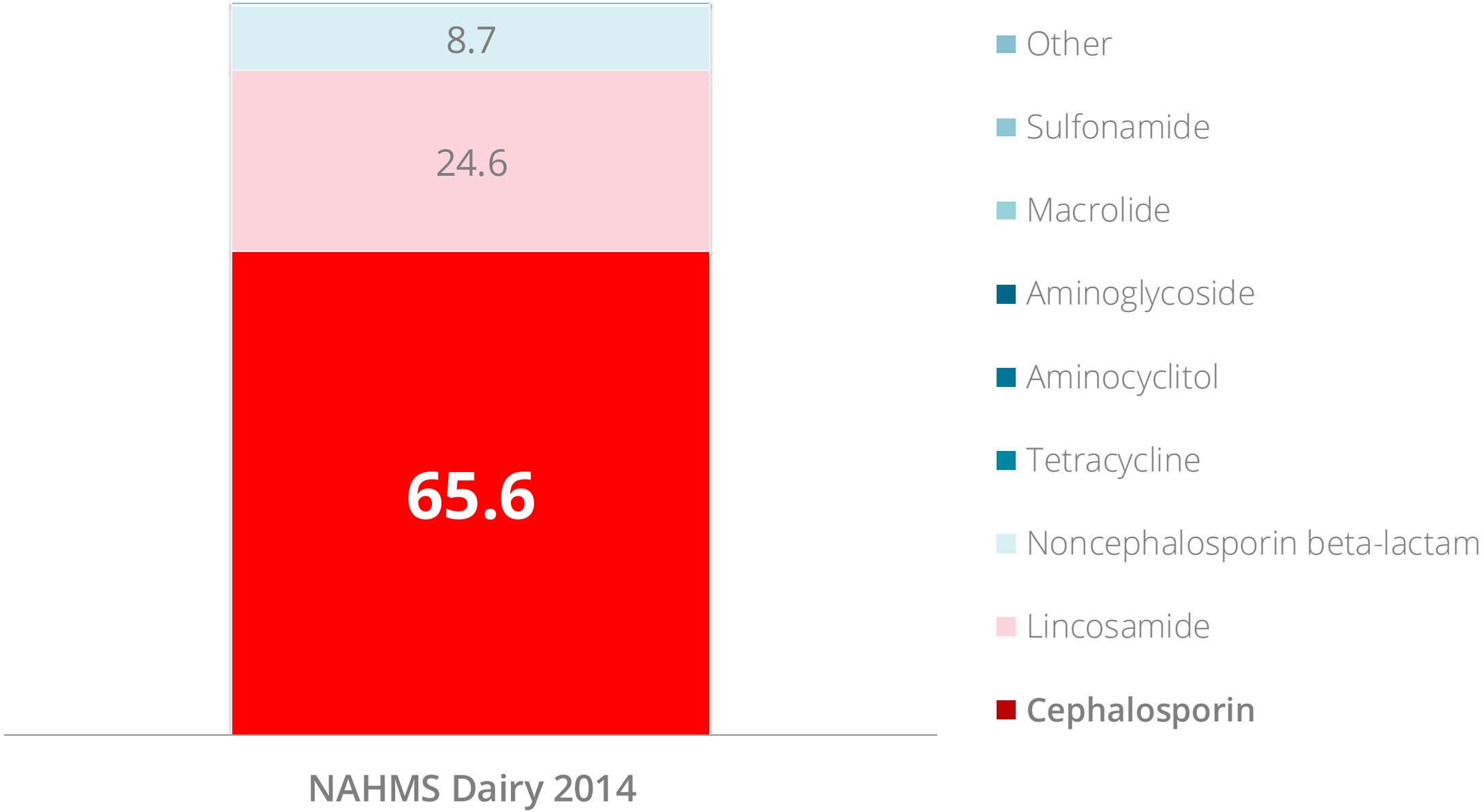
The Dairy Value Chain

9.2

million



Antimicrobials used for Treatment of Mastitis



The Problem

Third-generation Cephalosporins and mastitis

Gram –
Improved bacteriological cure.

Schukken et al., 2011

WHO
Suojala, 2013

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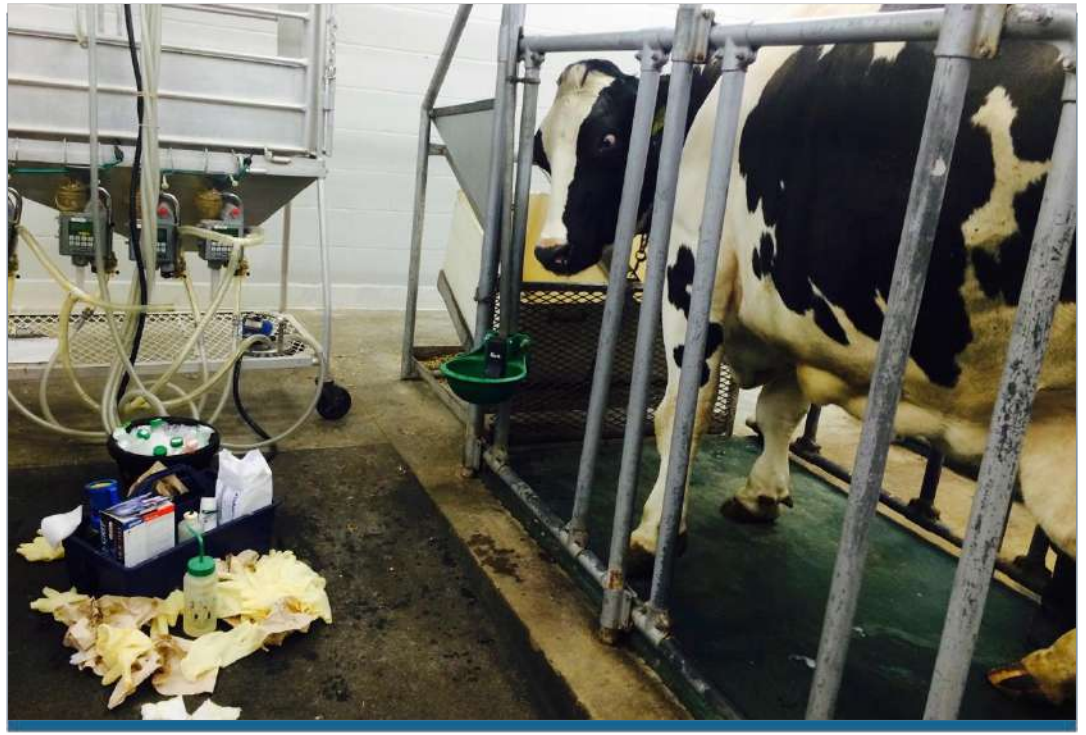
The Application of Next Generation Sequencing to Further Understand the Microbial Dynamics of Bovine Clinical Mastitis

Naturally Infected



Experimentally Infected

Resilience of Milk Microbiome

Independent of antimicrobial treatment

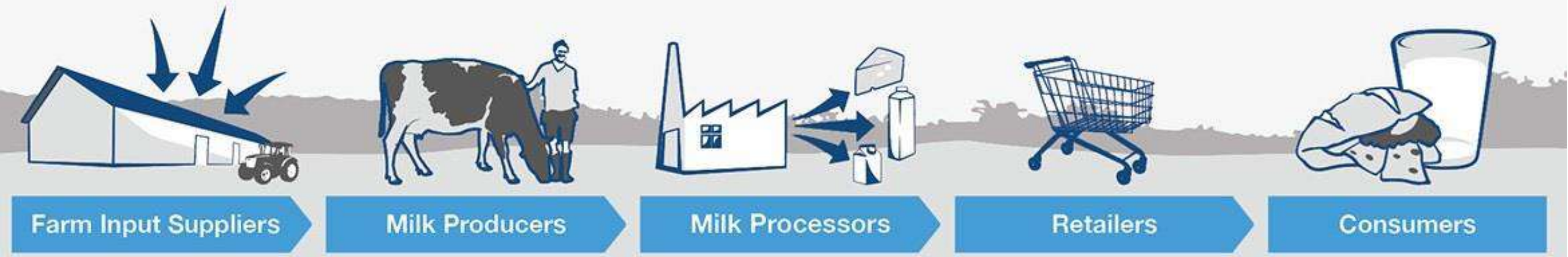
In mild and moderate cases of *E. coli* mastitis treated with ceftiofur

Image Source: Canadian Imrestor Mode of Action Video (https://www.youtube.com/watch?v=sLJsCB4wZ3M)

The Dairy Value Chain

Postdoc in Food Science

Molecular Sequencing and Artificial Intelligence to improve food safety



Adapted from: http://www.delavalcorporate.com/sustainability/our-take/the-dairy-value-chain/

RESEARCH

AI decodes microbes' message in milk safety testing approach

DNA sequencing combined with artificial intelligence could detect anomalies that signal trouble in dairy production, researchers report

IBM

AMERICAN SOCIETY FOR MICROBIOLOGY | mSystems

Check for updates

| Applied and Industrial Microbiology | Research Article

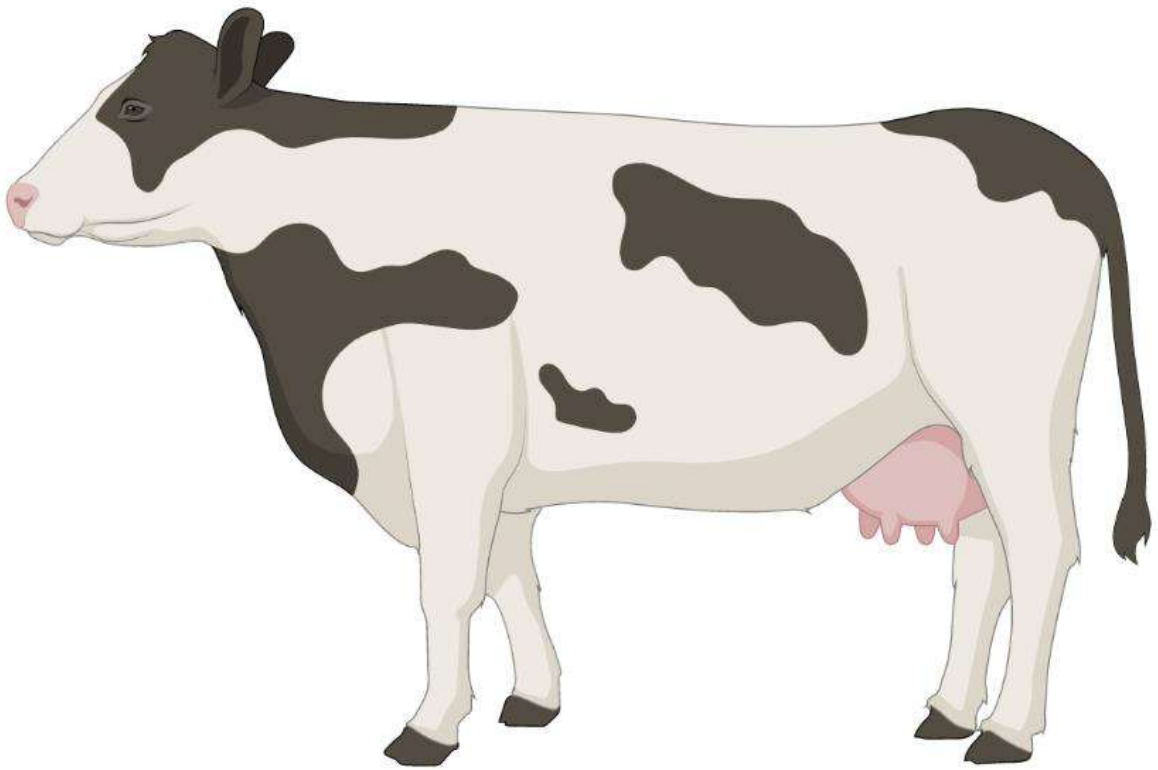
Development and evaluation of statistical and artificial intelligence approaches with microbial shotgun metagenomics data as an untargeted screening tool for use in food production

Kristen L. Beck,[1] Niina Haiminen,[2] Akshay Agarwal,[1] Anna Paola Carrieri,[3] Matthew Madgwick,[3] Jennifer Kelly,[3] Victor Pylro,[4] Ban Kawas,[1] Martin Wiedmann,[5] Erika Ganda[6,7]

Salmonella Dublin is a poster child of a One-Health challenge

Why

"TYPHOID MARY"
MOST HARMLESS AND YET THE MOST DANGEROUS WOMAN IN AMERICA



"TYPHOID MARY"

MOST HARMLESS AND YET THE MOST DANGEROUS

cow IN your herd

Created in Biorender.com

Salmonella Dublin is a poster child of a One-Health challenge

Zoonotic Potential

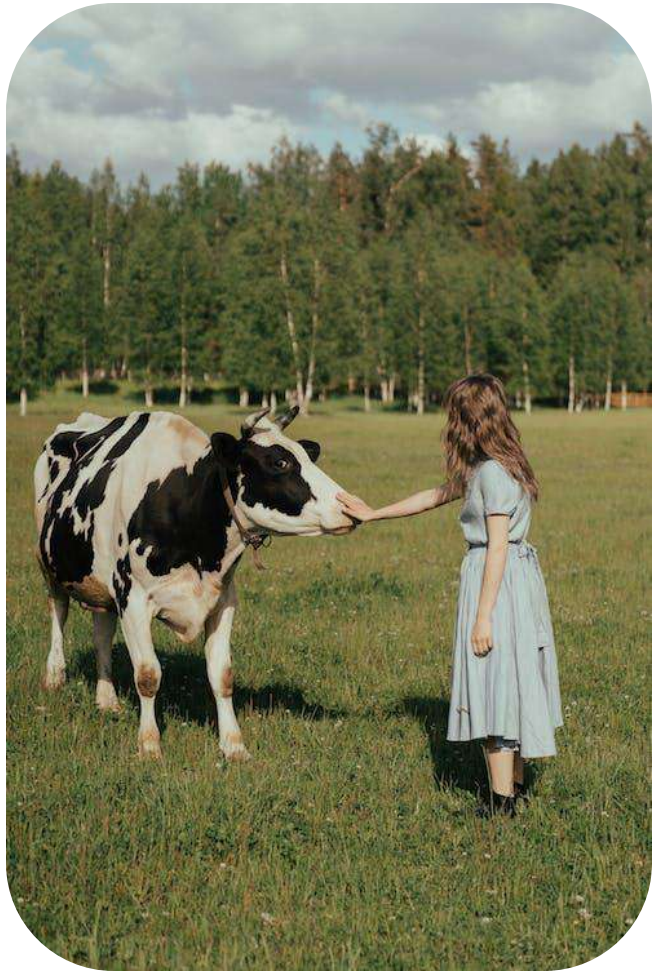


Photo credit: Pexels CC BY

Salmonella Dublin is a poster child of a One-Health challenge

- Responsible for acute invasive disease, marked by nonclassical salmonellosis in calves
- Subclinical carriers contribute to herd endemicity
- Zoonotic potential via animal contact and consumption of contaminated beef or dairy products

Sophia Kenney
Graduate Student
USDA APHIS

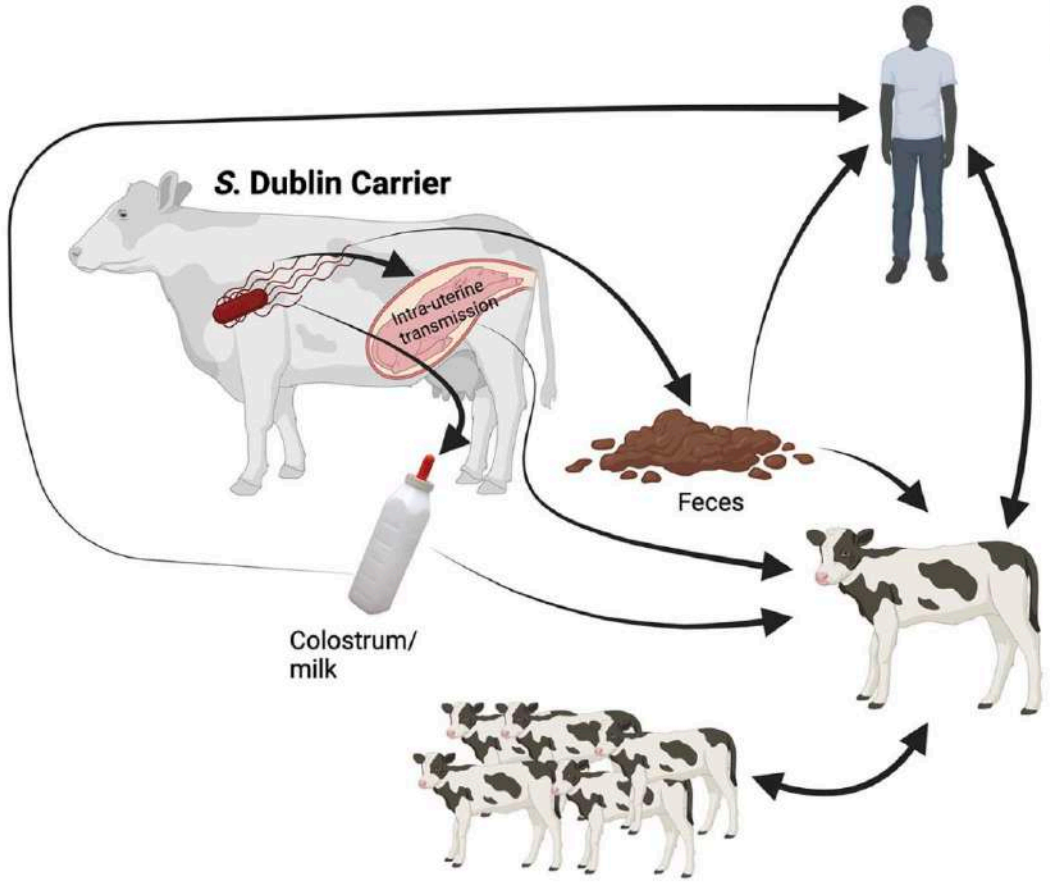


Figure 1. Velasquez-Munoz et al., 2024

Salmonella Dublin is a poster child of a One-Health challenge

Sophia Kenney

Graduate Student

Increasing antimicrobial resistance in *S.* Dublin strains isolated from cattle and humans

Antimicrobial drug resistance in *Salmonella enterica* serotype Dublin and other *Salmonella*, United States, 1996–2013*

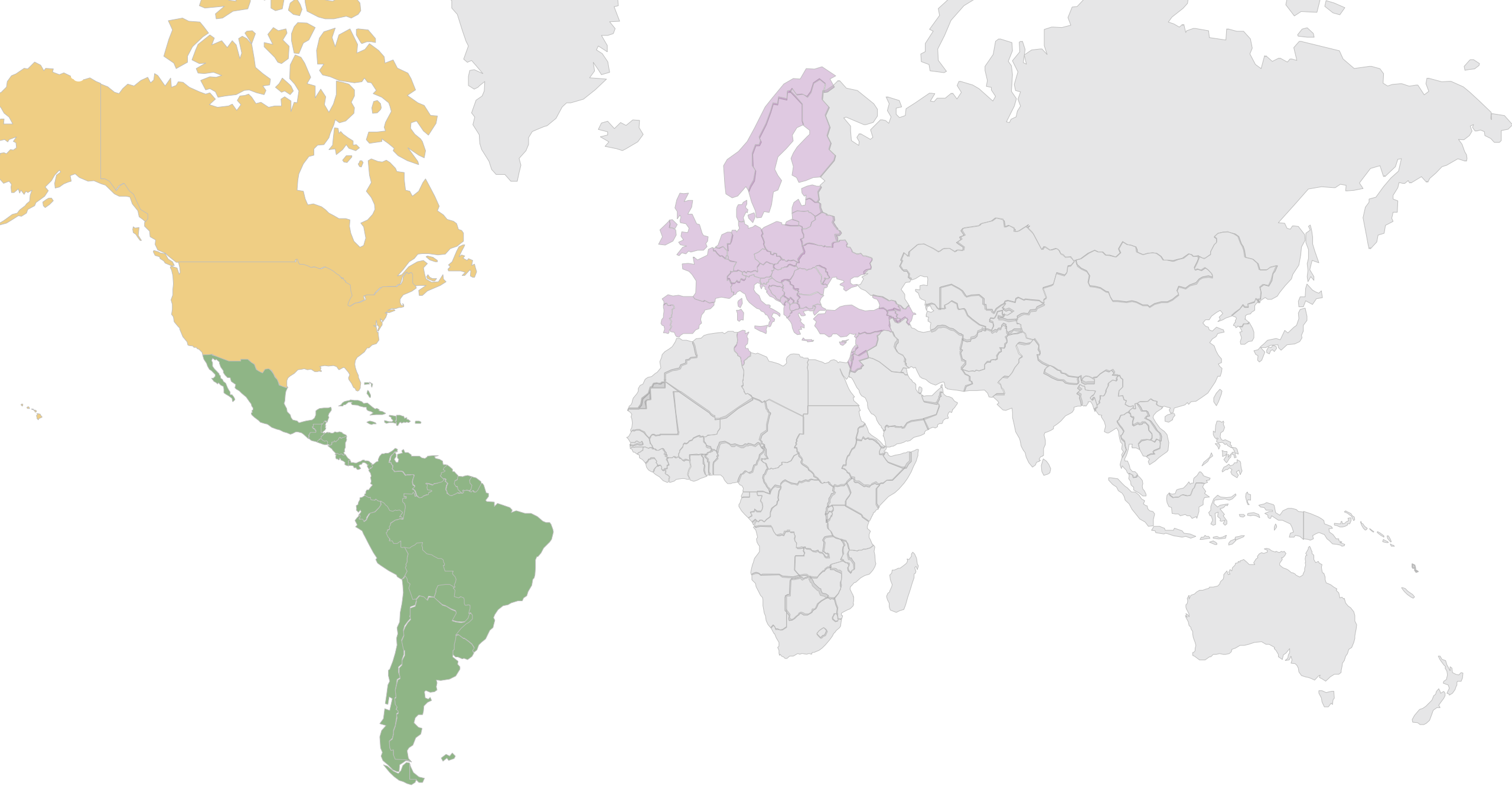
Resistance pattern	*Salmonella* Dublin, no. (%), n = 102	Other *Salmonella*, no. (%), n = 33,415
Pansusceptible	42 (41)	26,552 (79)
Resistant to ≥1 class	60 (59)	6,863 (21)
Resistant to ≥3 classes	56 (55)	4,013 (12)
Resistant to ≥5 classes	47 (46)	2,374 (7)
Resistant to ≥7 classes	32 (31)	601 (2)
Resistant to at least ACSSuT†	42 (41)	2,156 (6)
Resistant to at least ACSSuTAuCx‡	29 (28)	581 (2)
Resistant to ceftriaxone	32 (31)	947 (3)
Resistant to nalidixic acid	6 (6)	643 (2)
Resistant to nalidixic acid and ceftriaxone	4 (4)	39 (0.1)

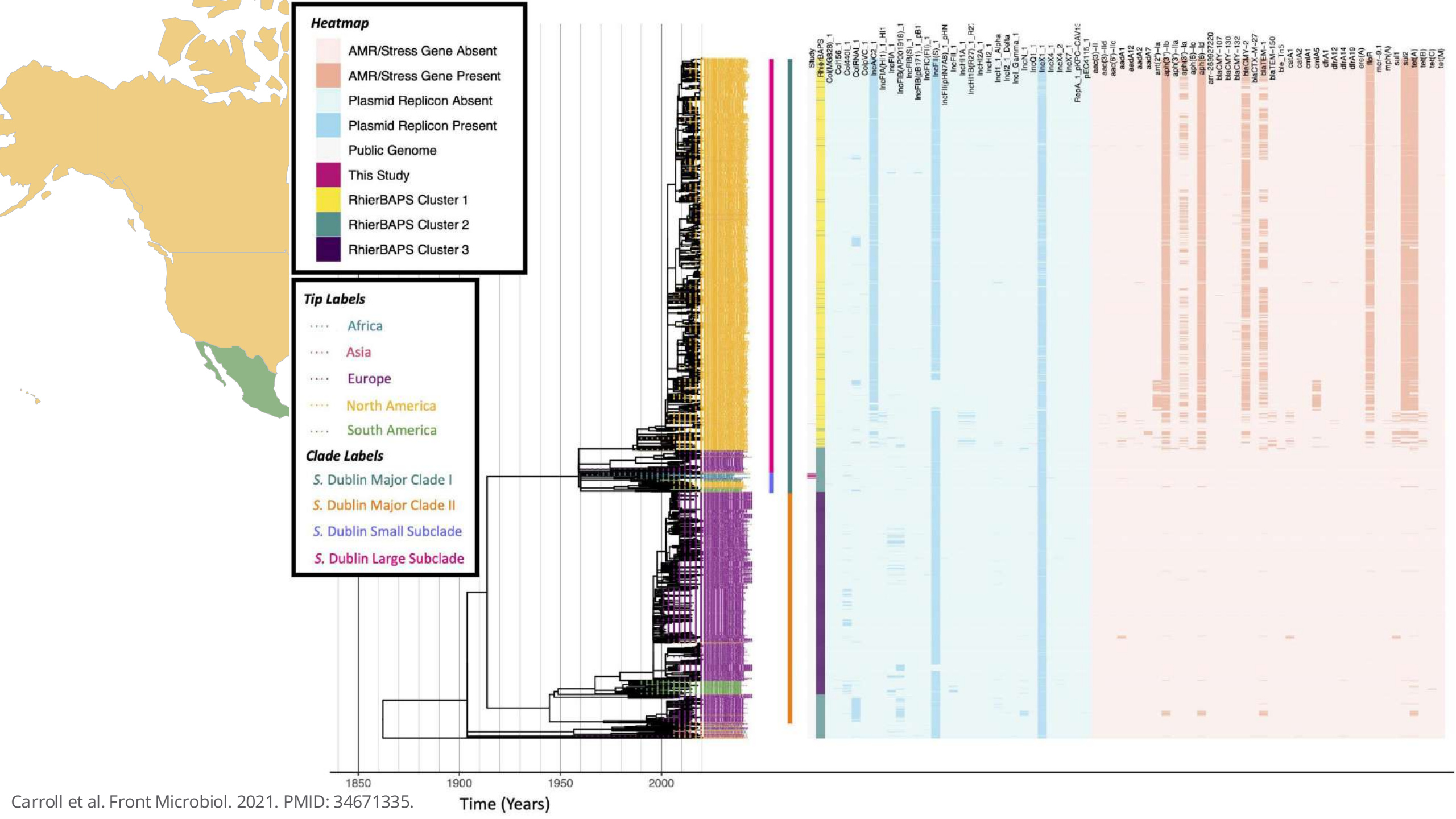
*Data from the National Antimicrobial Resistance Monitoring System. $p<0.01$ for all.

†Resistant to ampicillin, chloramphenicol, streptomycin, sulfamethoxazole/sulfisoxazole,and tetracycline.

‡Resistant to ACSSuT, amoxicillin–clavulanic acid, and ceftriaxone.

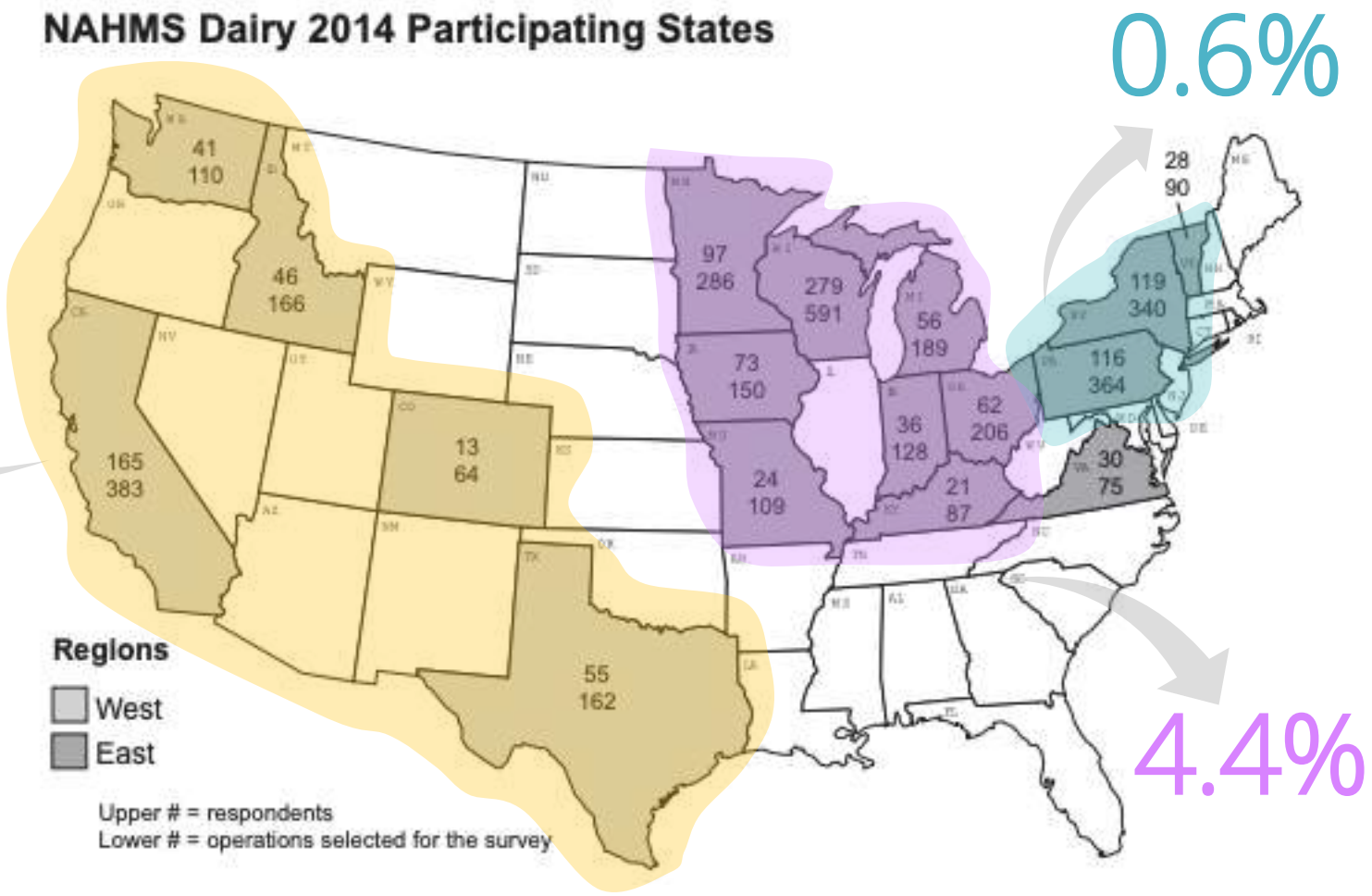
Harvey et al, 2017





Carroll et al. Front Microbiol. 2021. PMID: 34671335.

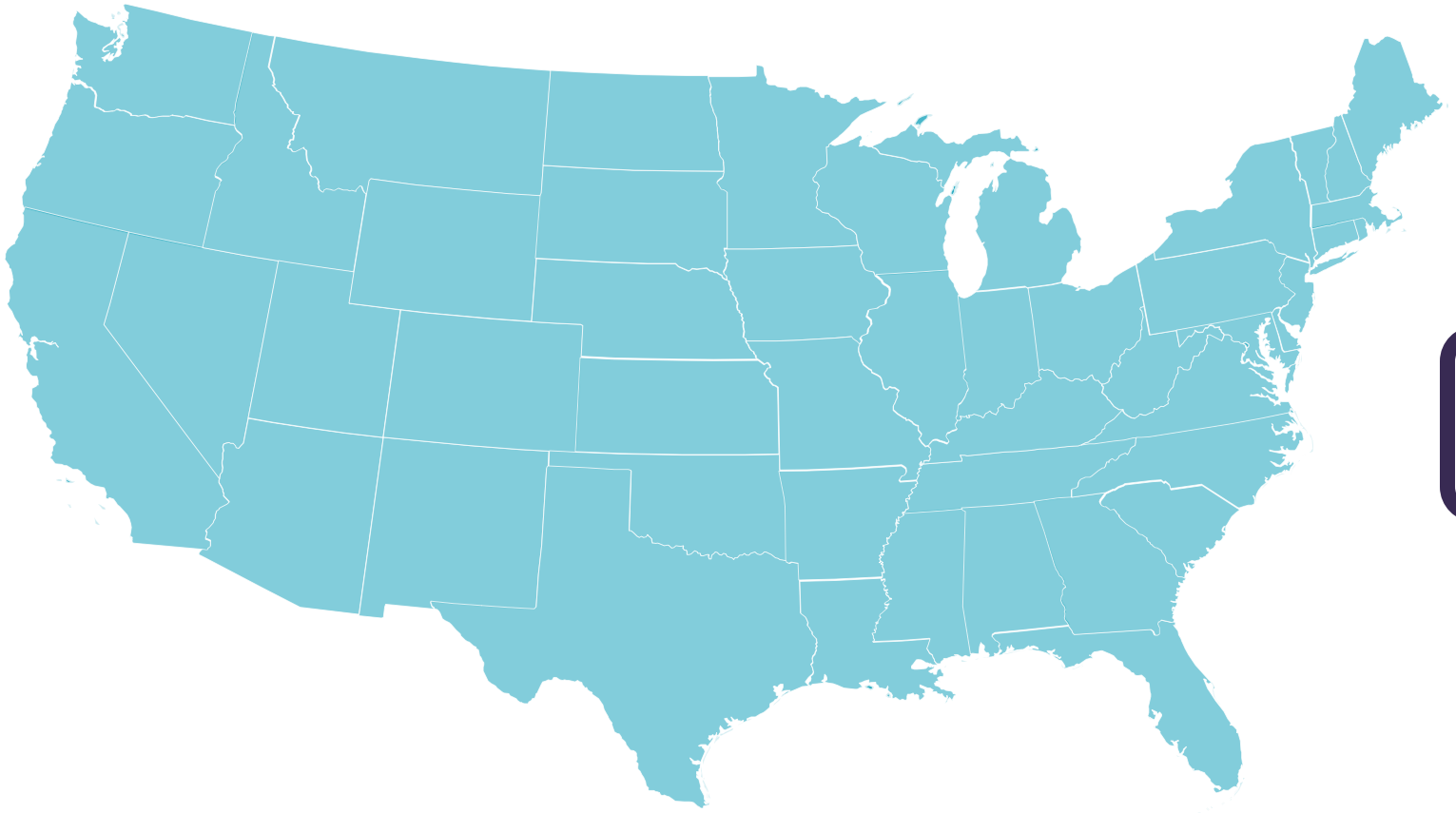
2014

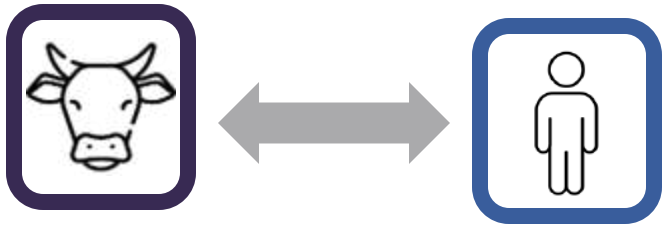


Bulk tank milk and milk filter samples were tested for *Salmonell*a, *Campylobacter* and *Listeria*. Additional testing was conducted specifically for *Salmonella* Dublin.

The prevalence of *S.* Dublin ranged from 1.1 % of small herds to 40 % of large herds.

What do we know about *S.* Dublin in in cattle and humans in the United States?





NARMS
National Antimicrobial Resistance Monitoring System

National Antimicrobial Resistance Monitoring System
For Enteric Bacteria
(NARMS)

Humans

Centers for Disease Control and Prevention

Animals

- ARS
- FSIS
- APHIS

Food Products

State Health Depts + Universities

- CFSAN
- HAACP

https://www.cdc.gov/narms/about/partners.html

National Center for Biotechnology Information

NCBI

NCBI Pathogen Detection Project

Centralized system integrating genomic sequence data for bacterial pathogens

Includes surveillance efforts from public health agencies and researchers over areas of:

- food-borne illness outbreaks
- animals
- production facilities
- clinical specimens

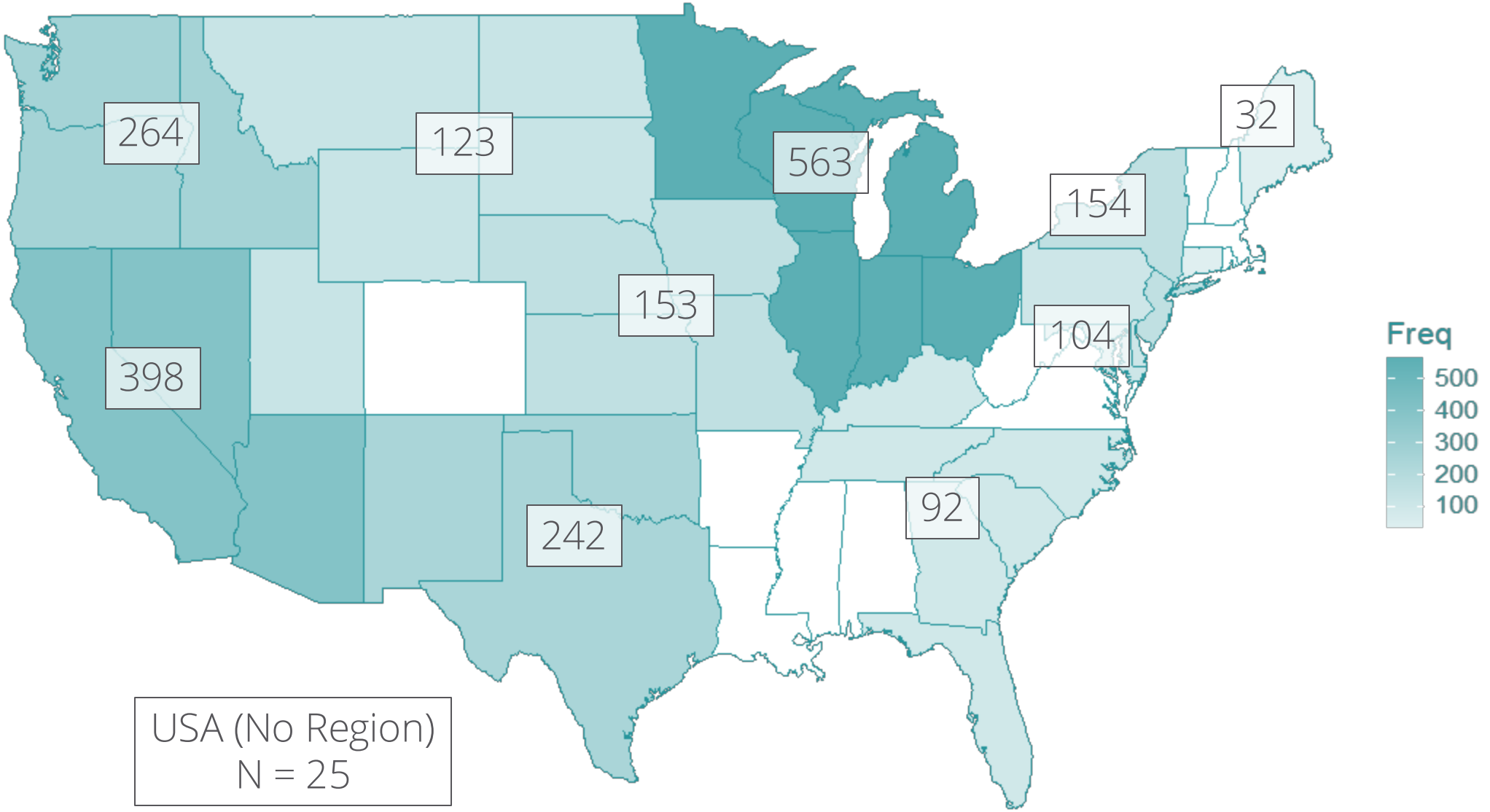
https://ftp.ncbi.nlm.nih.gov/pub/factsheets/Factsheet_Pathogen_Detection.pd

National Center for Biotechnology Information
NCBI

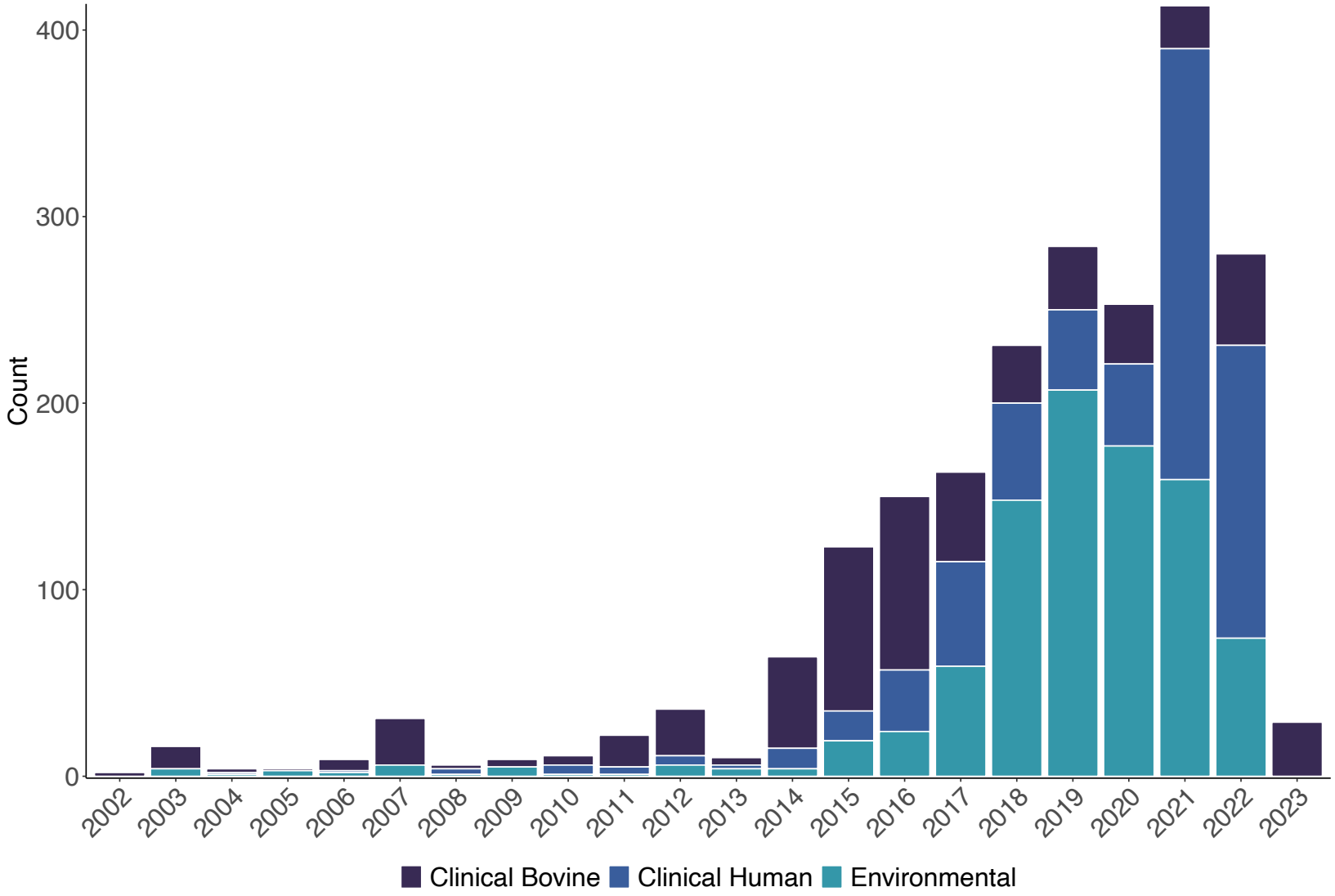
Study Objective

Leverage **existing biosurveillance infrastructure** to evaluate genomic characteristics and evolutionary relationships **of *S.* Dublin from cattle and human sources in the USA**

Geographic Distribution



Collection Year and Host Association

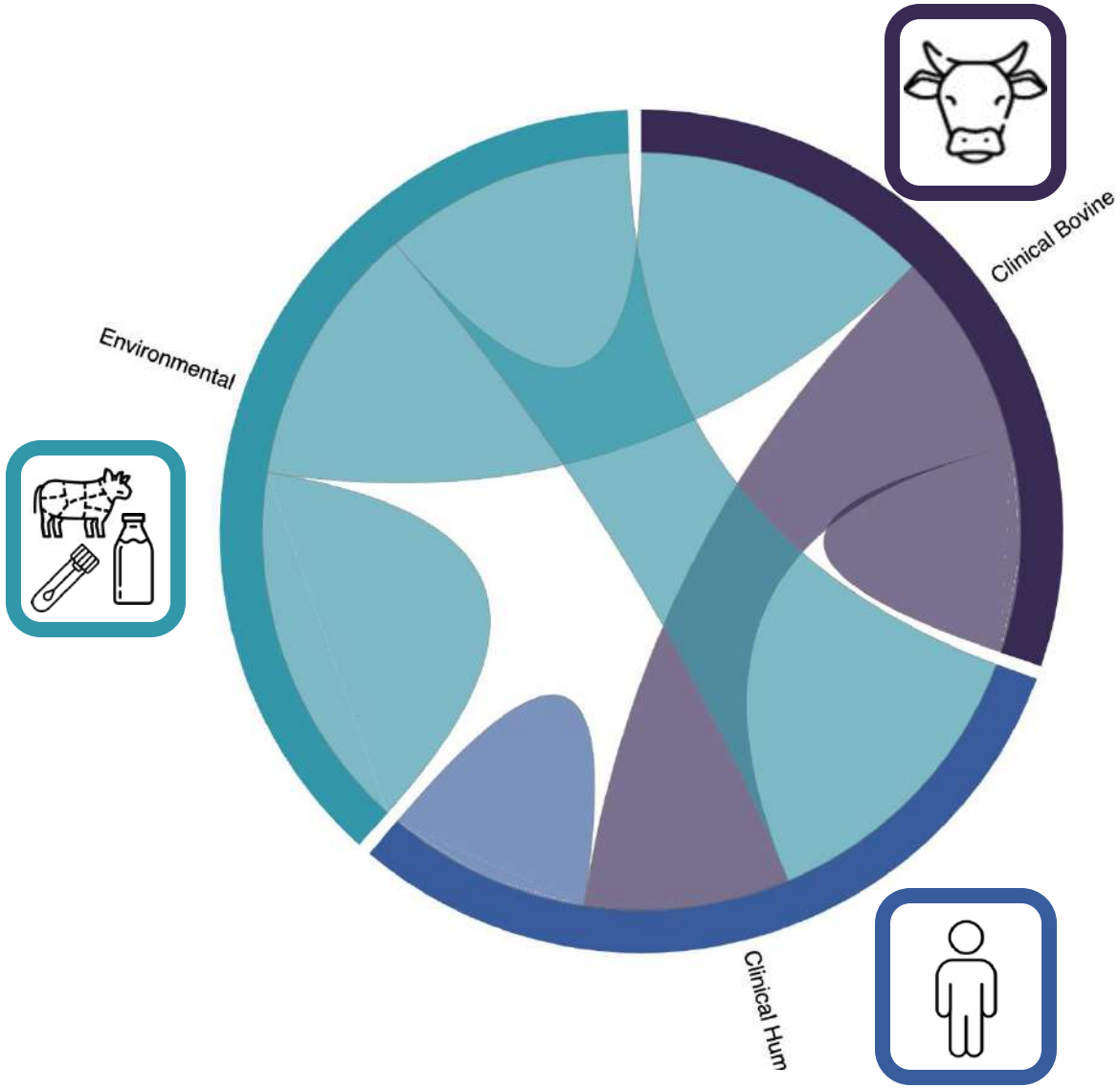


N=581

N=664

N=906

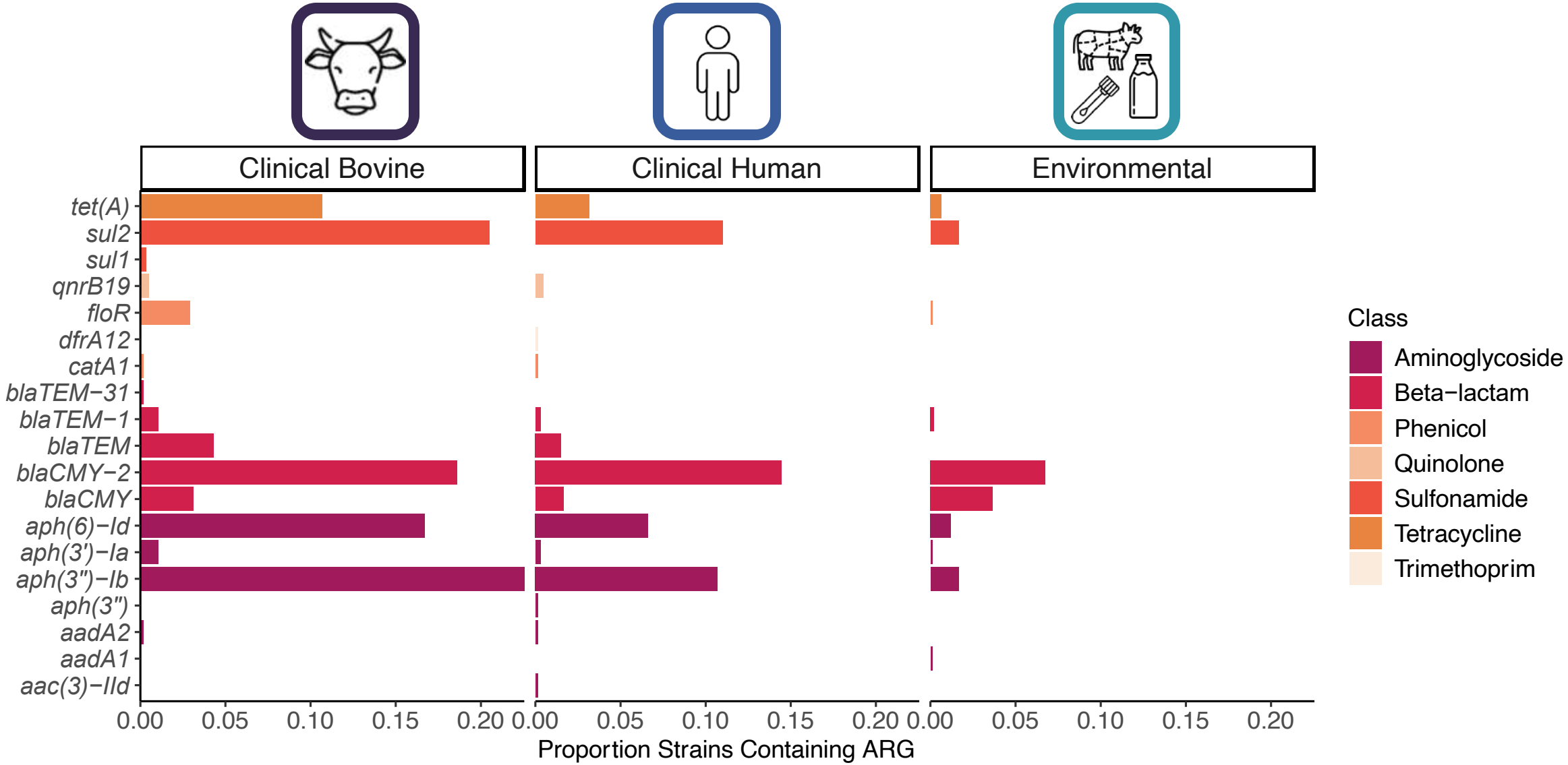
Core Genome SNPs



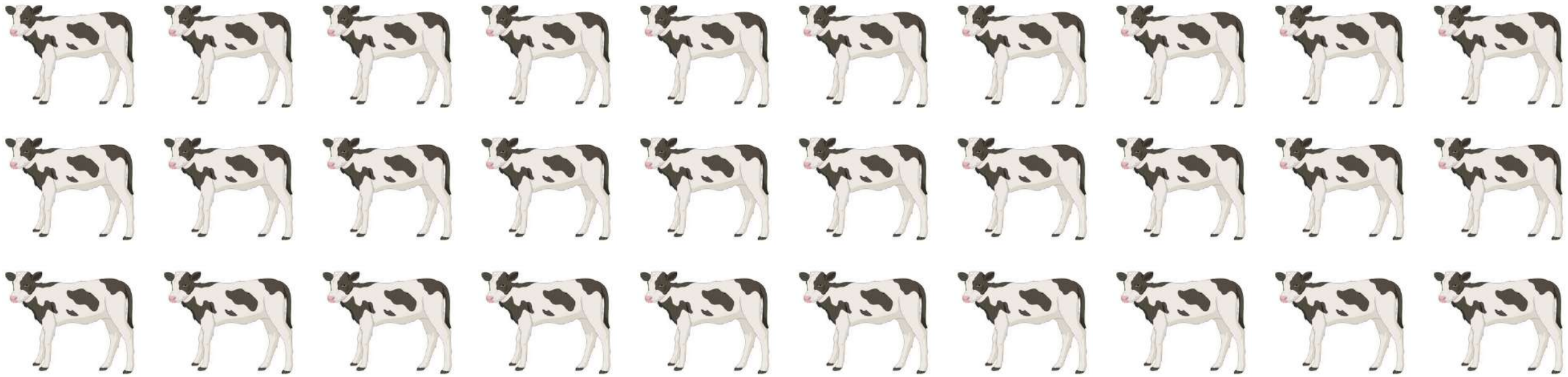
All pairwise filtered to: 10 < SNP differences ≤ 20 only

N = 1,512,020 strain pair comparisons

Antimicrobial Resistance Genes



Salmonella Dublin infections in calves

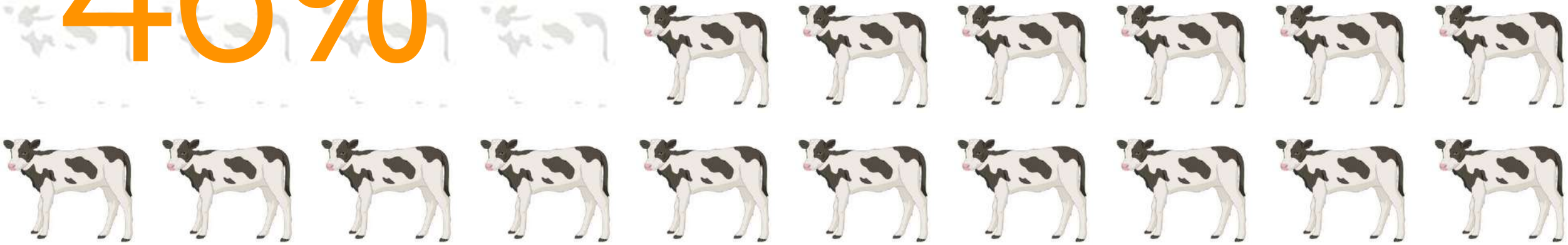


Created in Biorender.com

Salmonella Dublin infections in calves

20-100% mortality

46%



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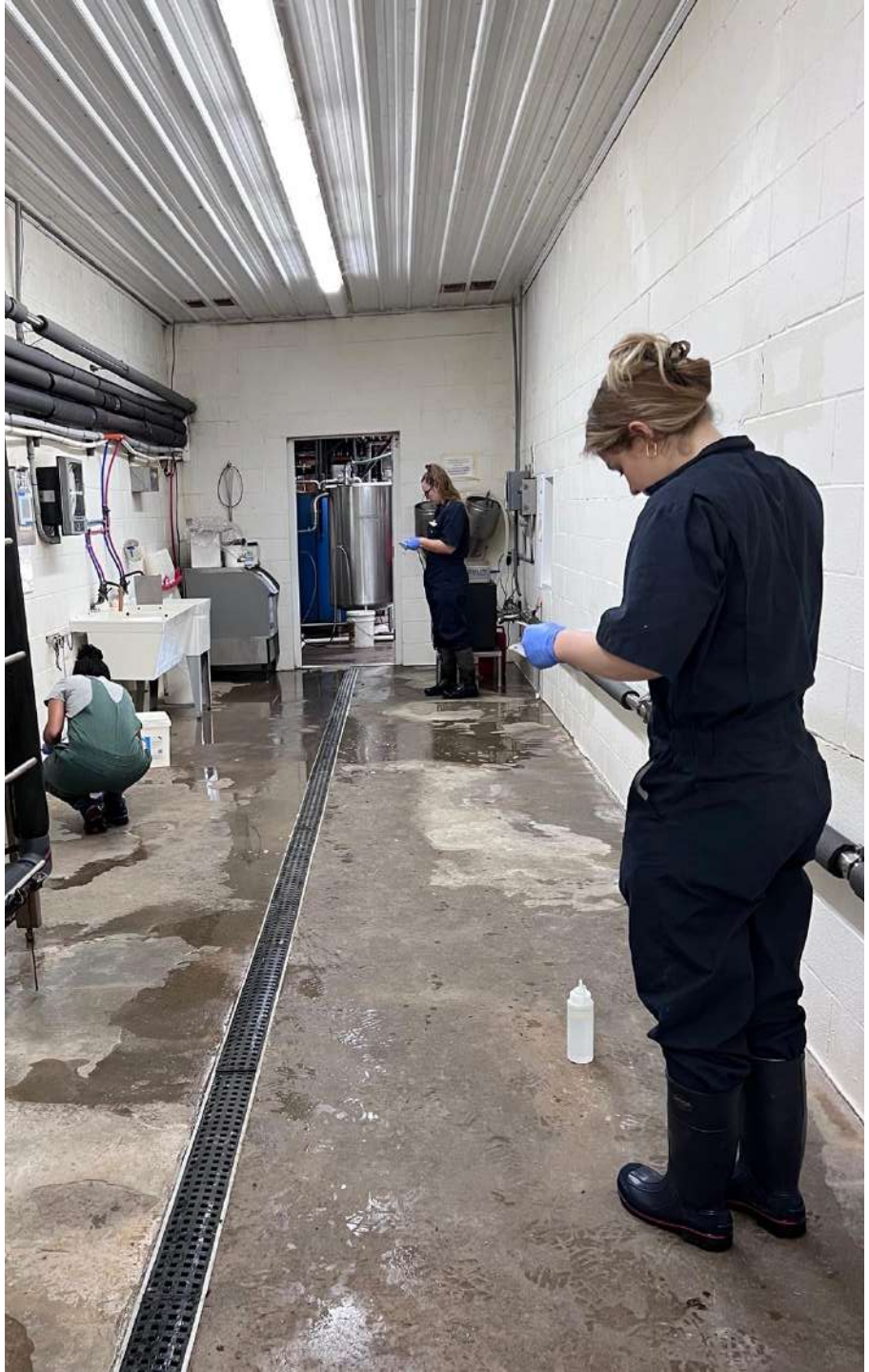
Darck



GAUZE PADS

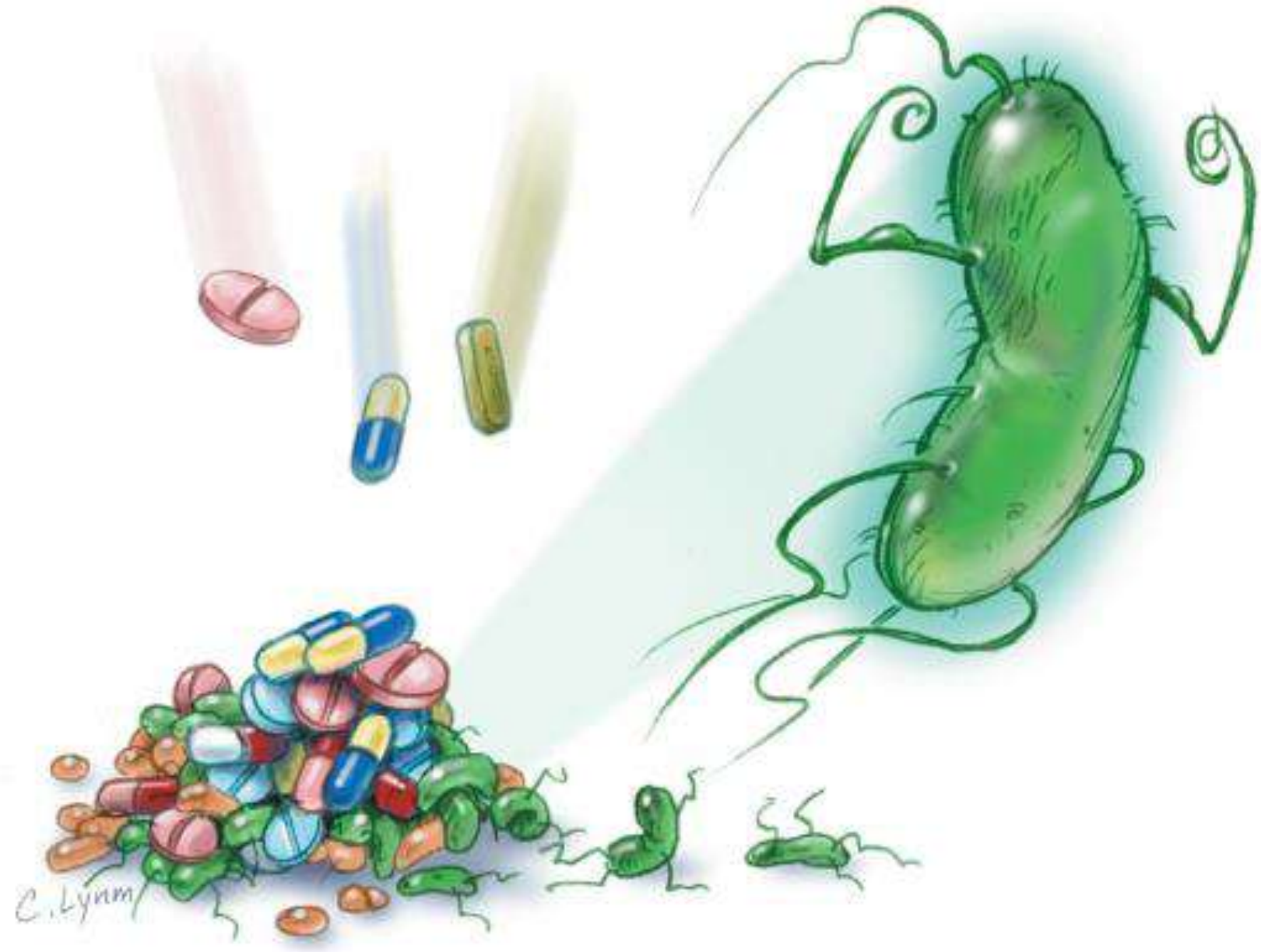
5576
5576
5577
5578

STANLEY

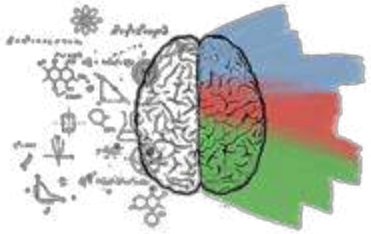
SystemSURE
OK

6-7-22
5573
6-7-22
5573

Antimicrobial Resistance



HUCK HITS



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PennState Huck Institutes of the Life Sciences

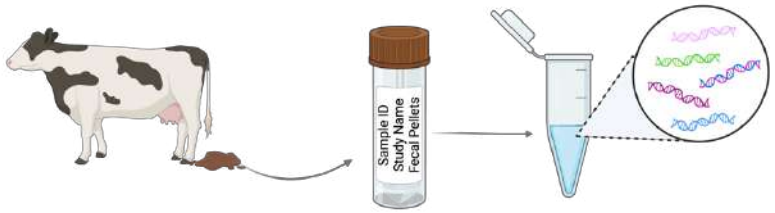
AMR profiling method development

Patent submitted

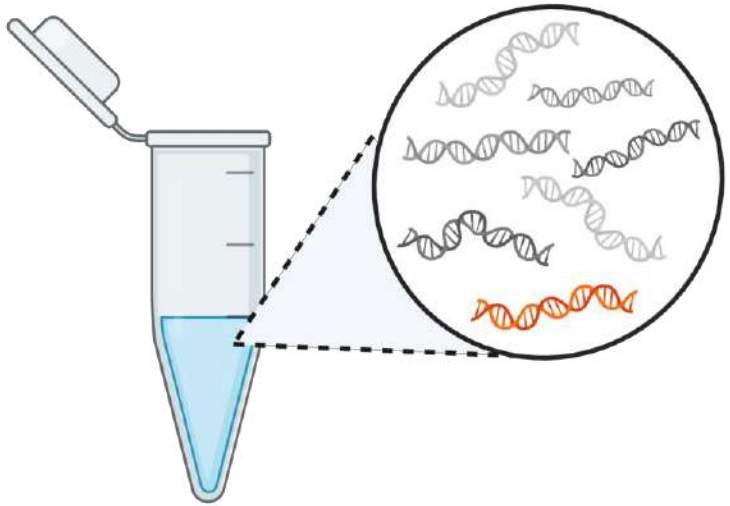
~$250 / sample

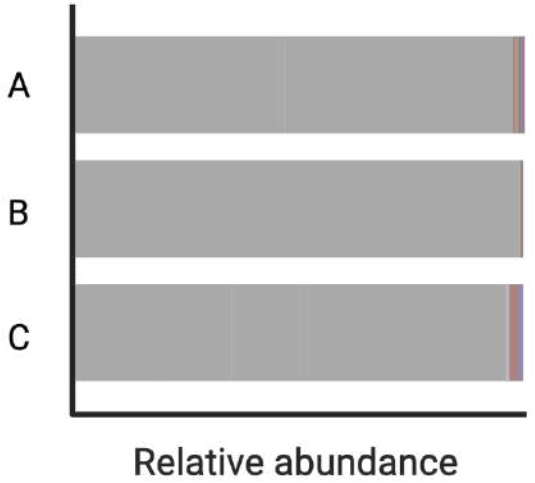
Samantha Seibel

Graduate Student



< 0.1 % AMR





HUCK HITS

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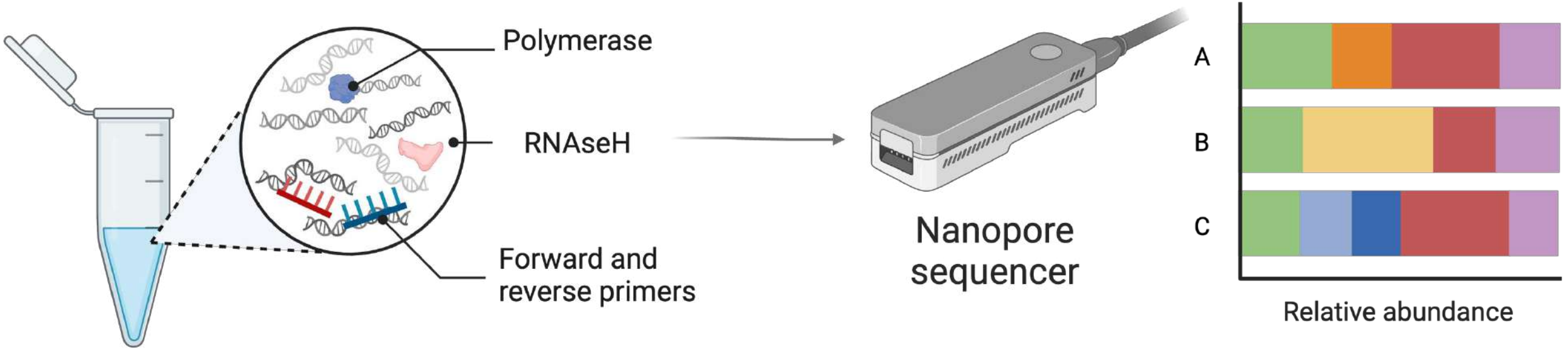
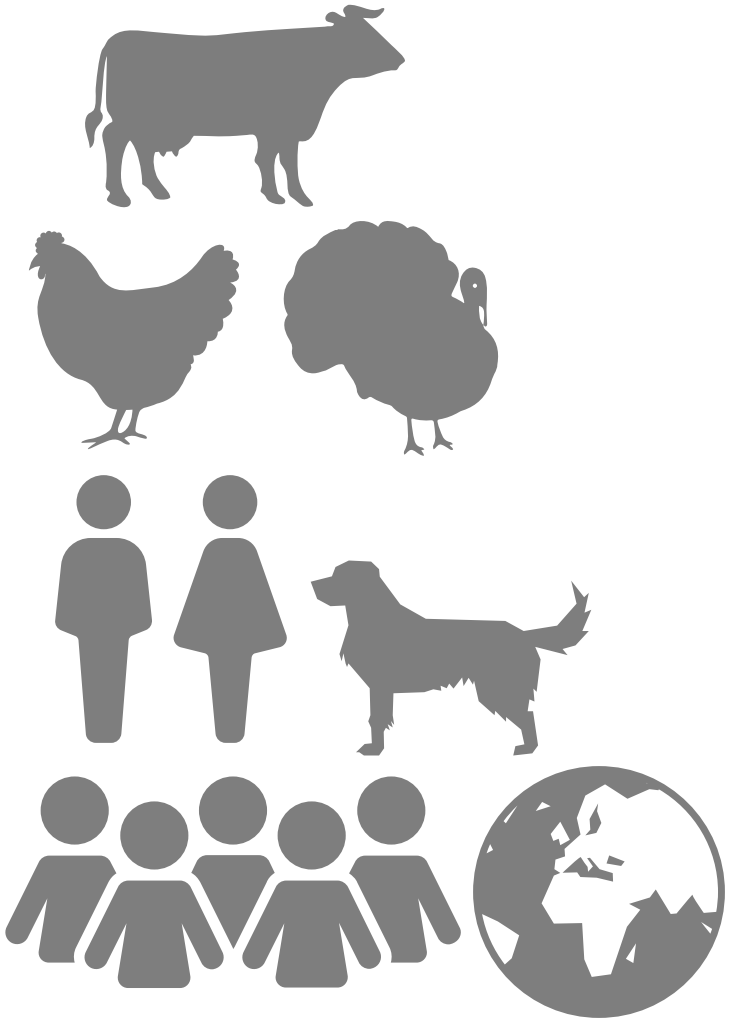


Agricultural Microbiomes



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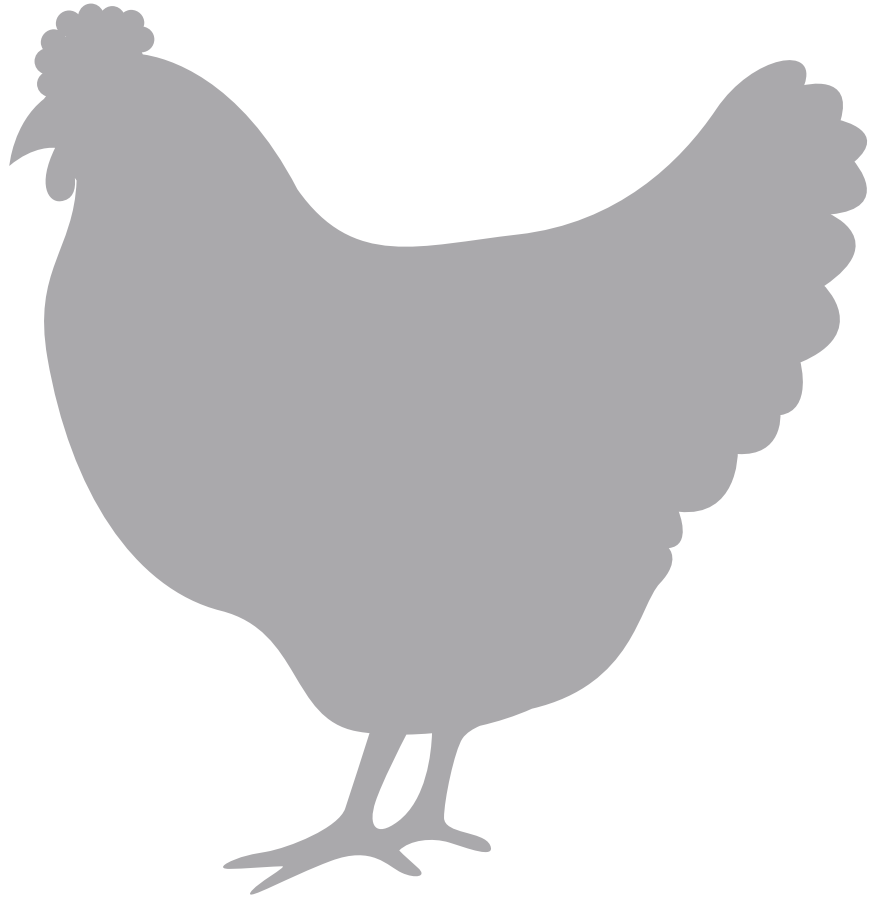
College of Agricultural Sciences

PennState | One Health Microbiome Center

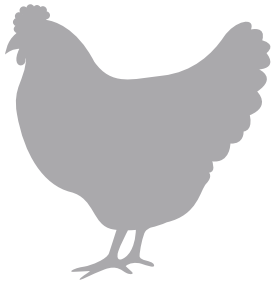
GANDA LABORATORY
Animal Microbiomes and One Health



rhAMR: A comprehensive and cost-effective method refined and applied to understand the impact of feed additives on antimicrobial resistance

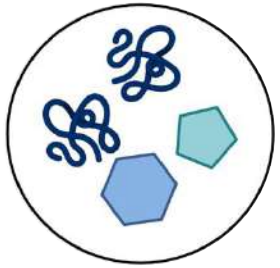
Ana Fonseca, DVM
Graduate Student

Samantha Seibel
Graduate Student

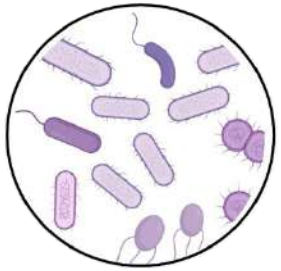


rhAMR: A comprehensive and cost-effective method refined and applied to understand the impact of feed additives on antimicrobial resistance

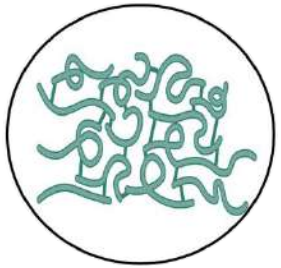
Postbiotics

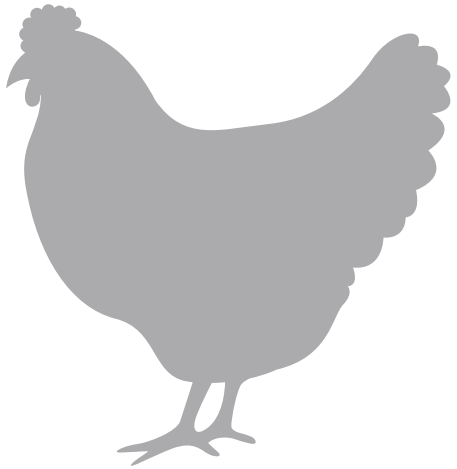


Probiotics



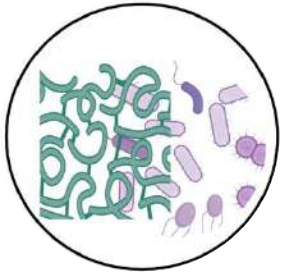
Prebiotics





Phytotherapeutics

Symbiotics



rhAMR: A comprehensive and cost-effective method refined and applied to understand the impact of feed additives on antimicrobial resistance

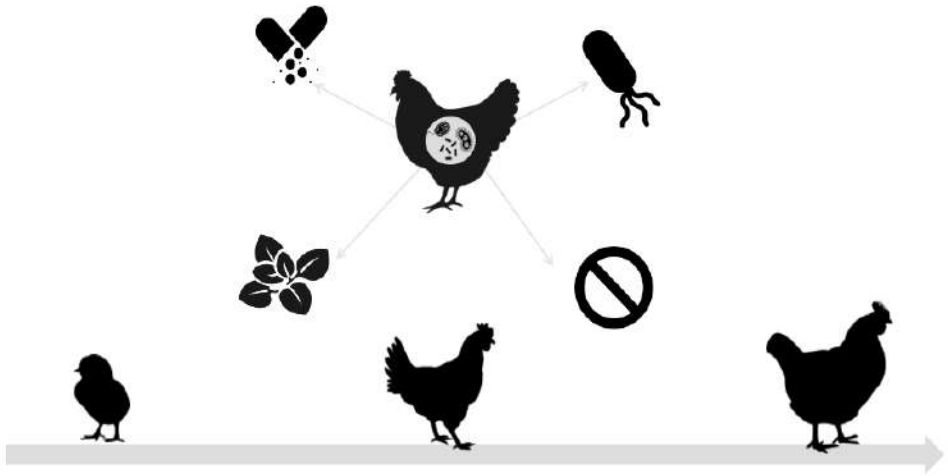
Ana Fonseca, DVM
Graduate Student

Samantha Seibel
Graduate Student

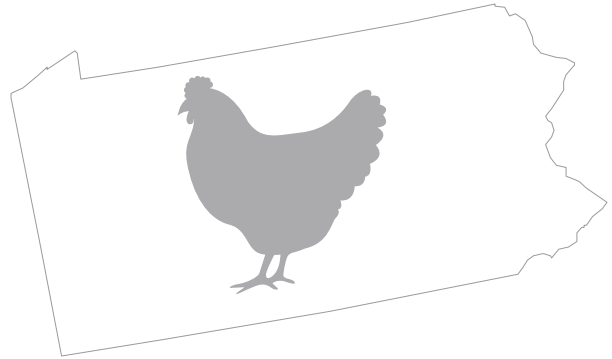
Alternatives to Antibiotic Growth Promoters

Do they impact performance?

What is the impact in broiler microbiome?



New method will be used to answer the question



IMPACT

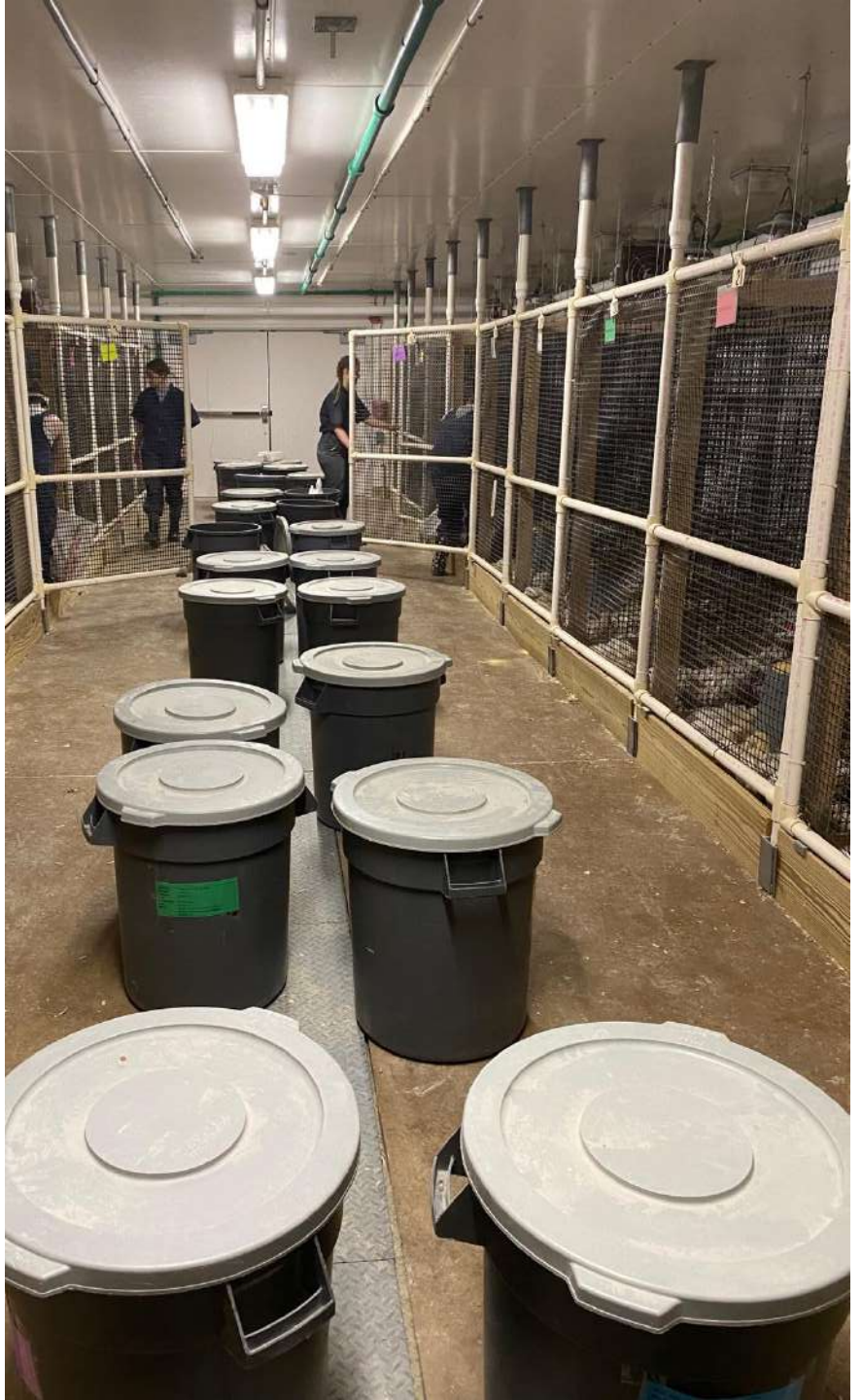
- ✓ Provide **unbiased** science-based information for poultry producers on commercially available feed additives
- ✓ Respond to consumer demand
- ✓ Maintain profitability

102

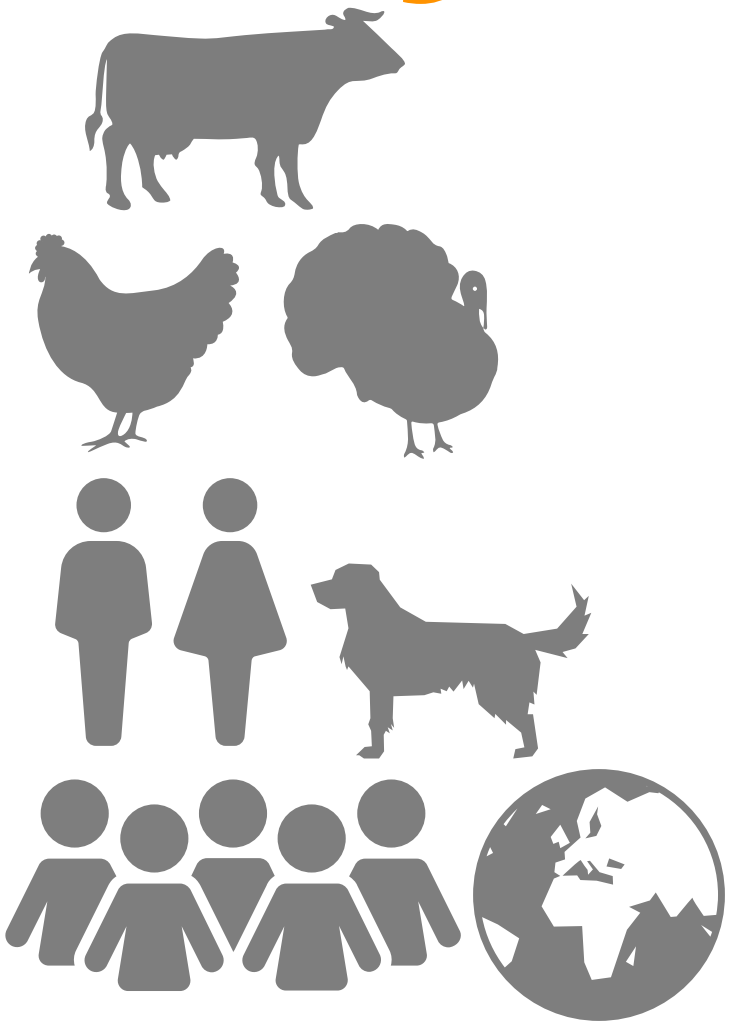
190
Ziploc
Ziploc
Baby
Chicks

STORAGE
108

RIGERATED



Beyond Agricultural Microbiomes



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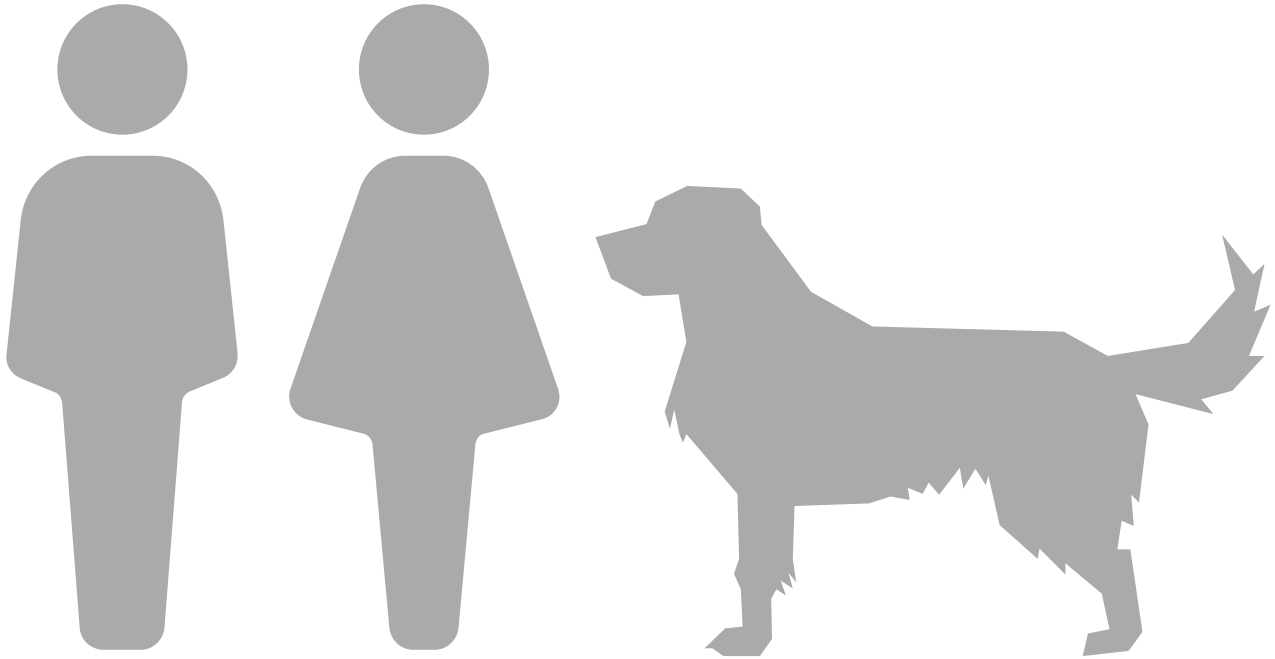
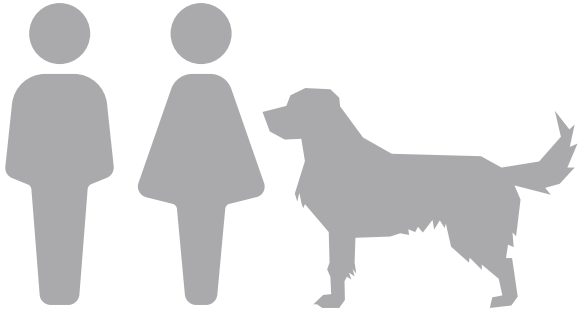


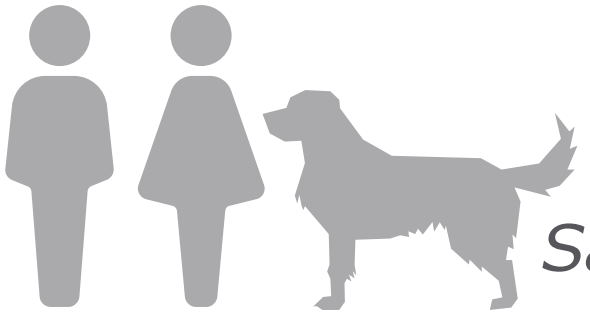


AMR *Salmonella*

Sophia Kenney

Graduate Student

What is the situation regarding AMR *Salmonella* isolated from pets and humans?



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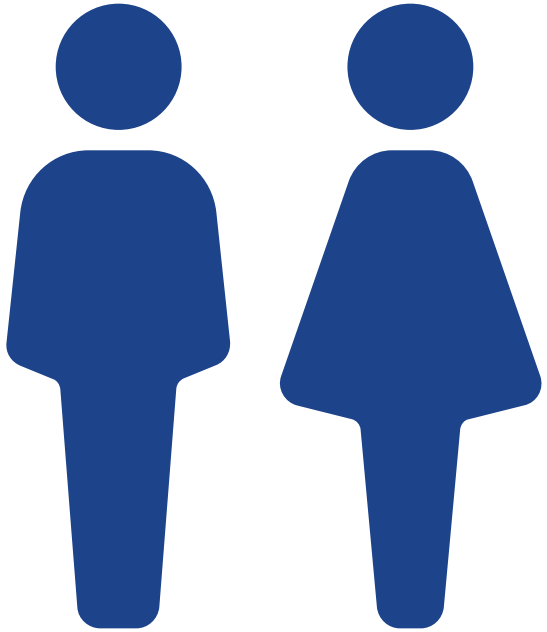
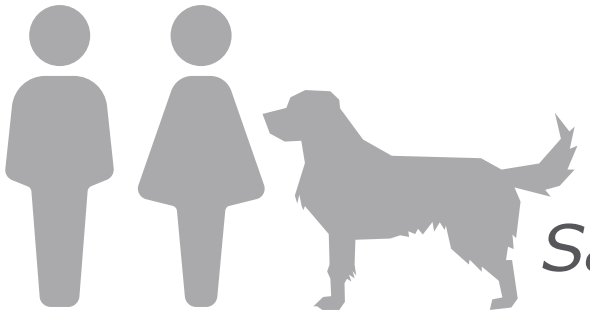


N=77

N=87

Kenney et al 2024, *Zoonosis and Public Health*



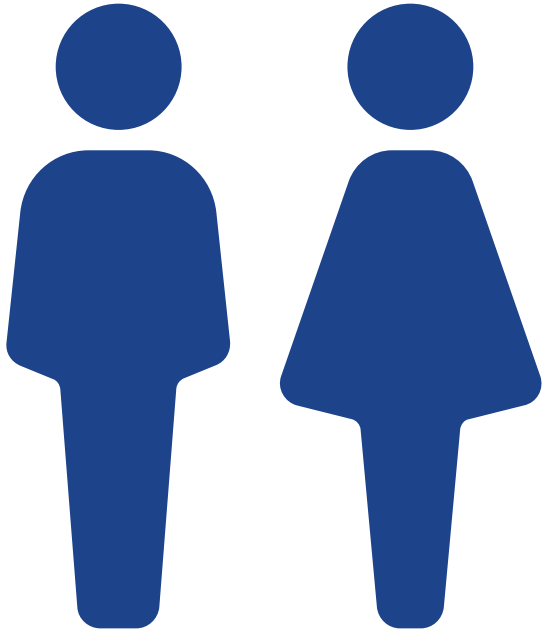
AMR *Salmonella*

What is the situation regarding AMR *Salmonella* isolated from pets and humans?

Sophia Kenney

Graduate Student

99.9996% identical
<20 SNPs difference



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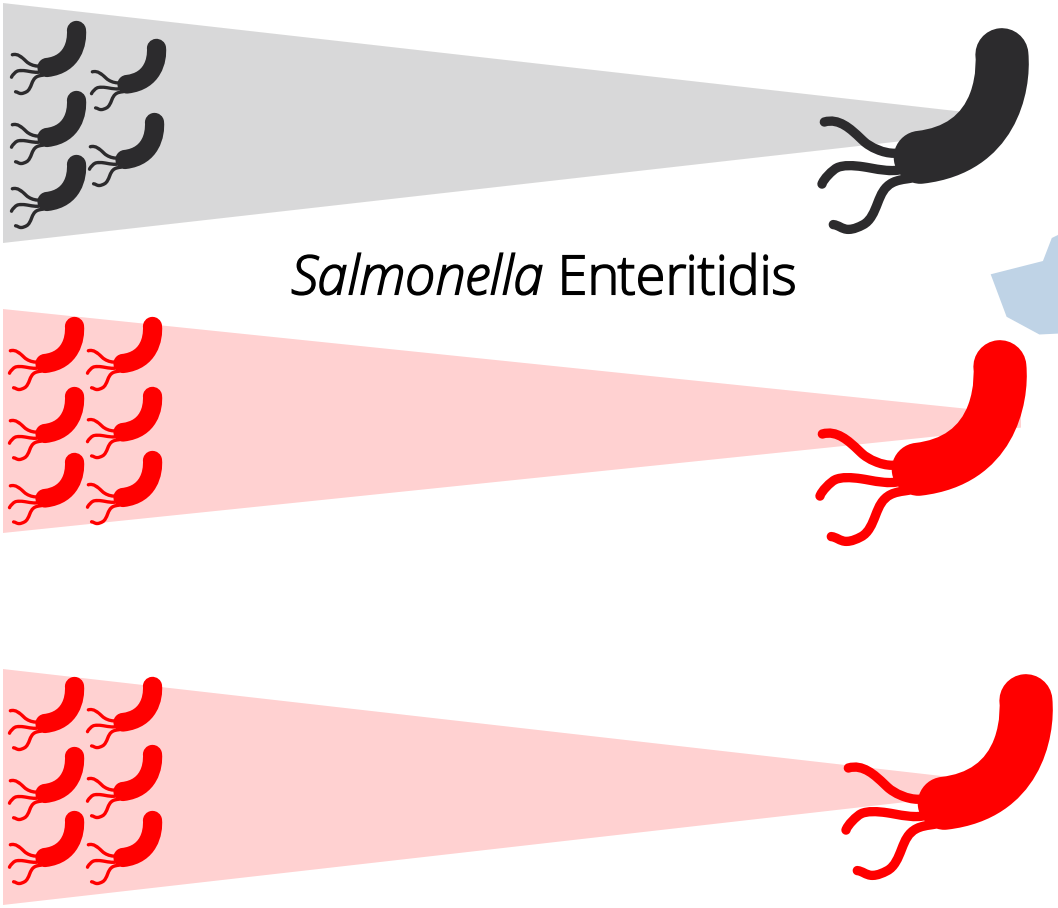
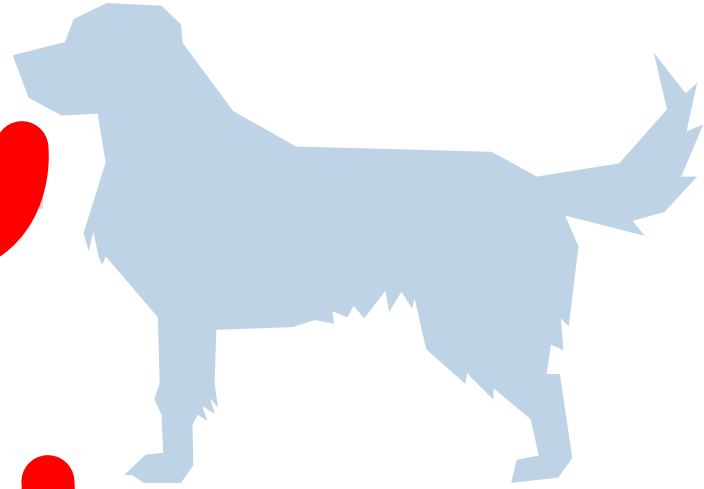
Salmonella Infantis

Salmonella Enteritidis

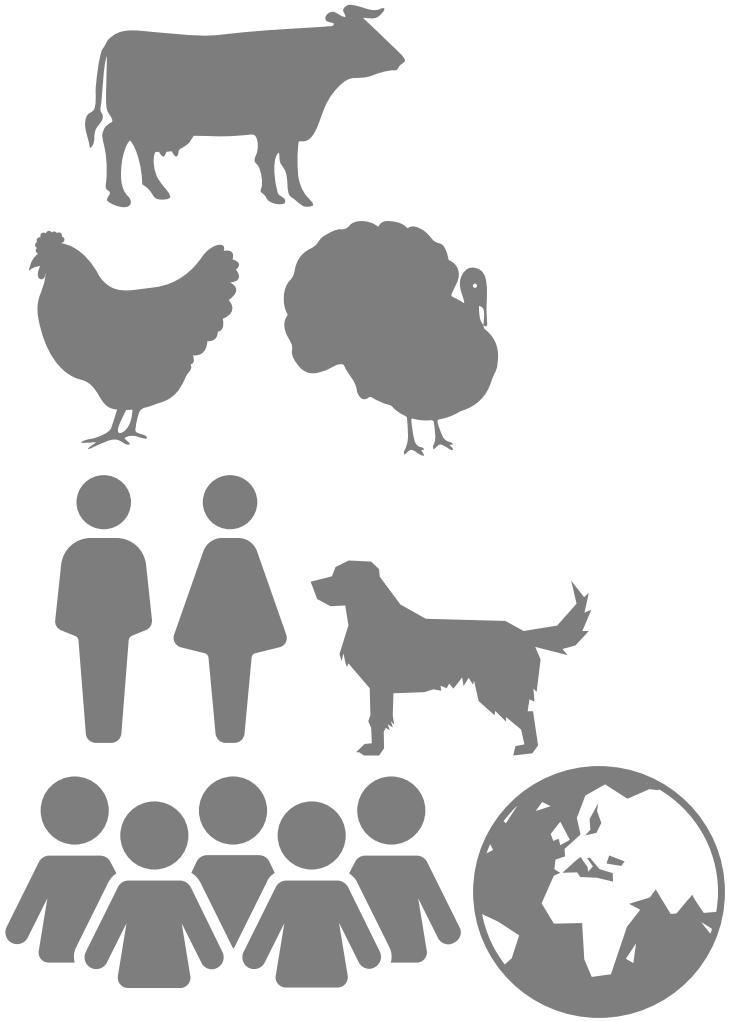


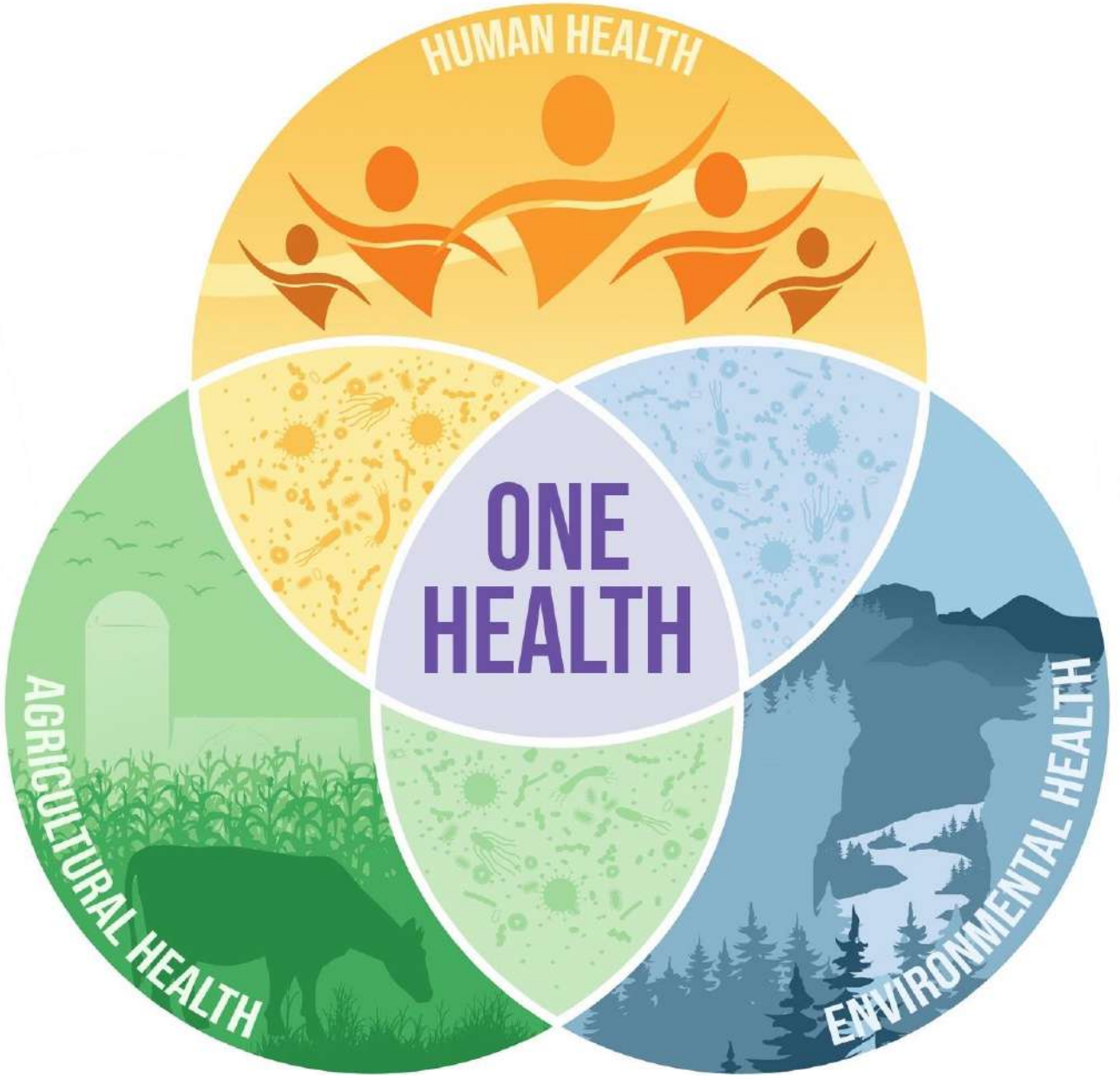


N=87

Kenney et al 2024, *Zoonosis and Public Health*

Beyond Agricultural Microbiomes





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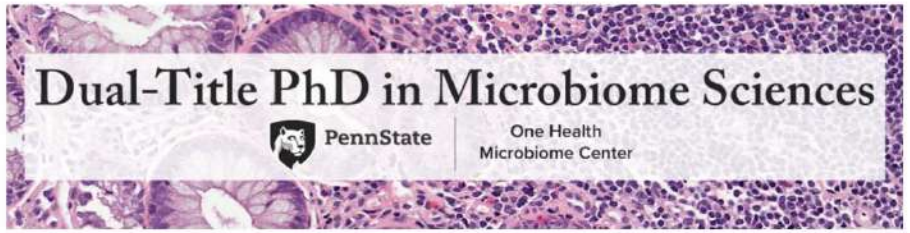
College of Agricultural Sciences

PennState
Huck Institutes of the Life Sciences

Dual-Title PhD in Microbiome Sciences

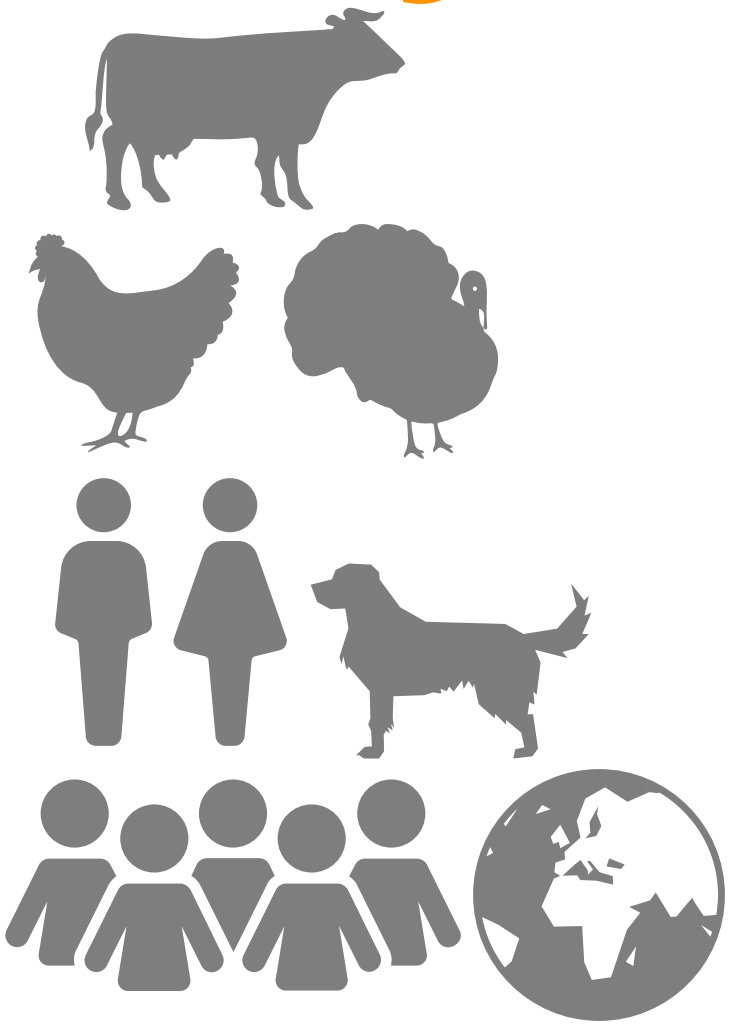
One Health Microbiome Center

- About
- Research
- Education
  - Outreach
  - Clubs



Microbiome Sciences Degree at Penn State

Beyond Agricultural Microbiomes



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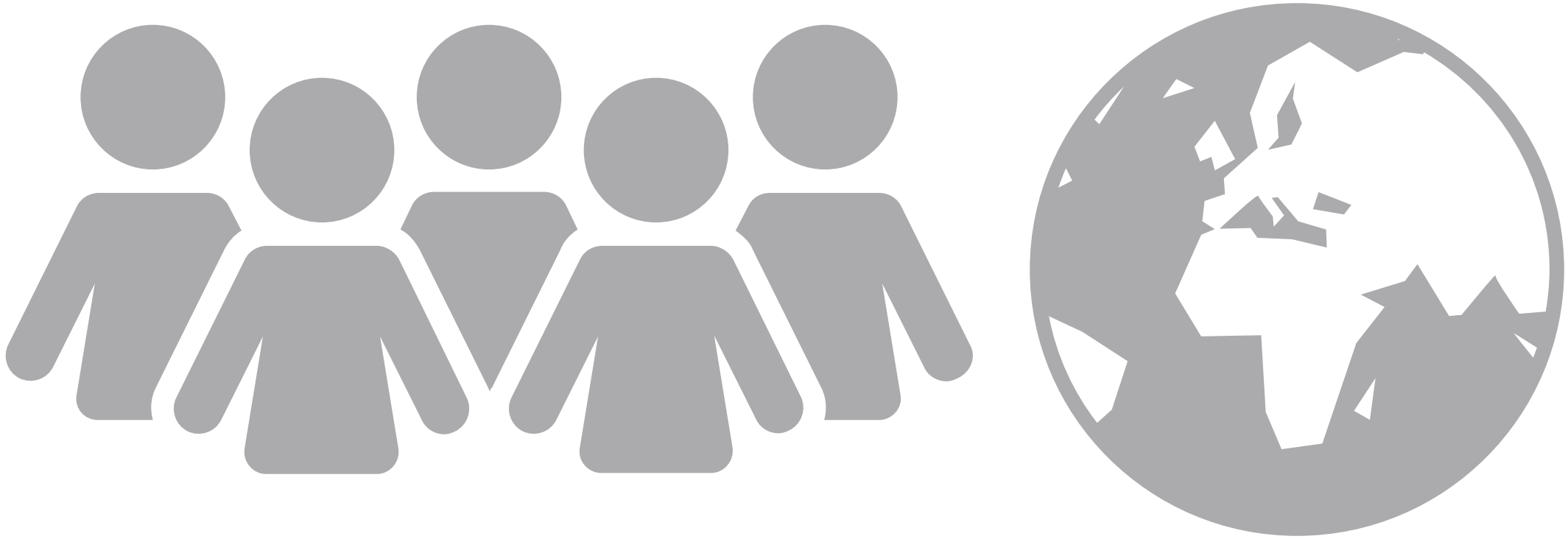
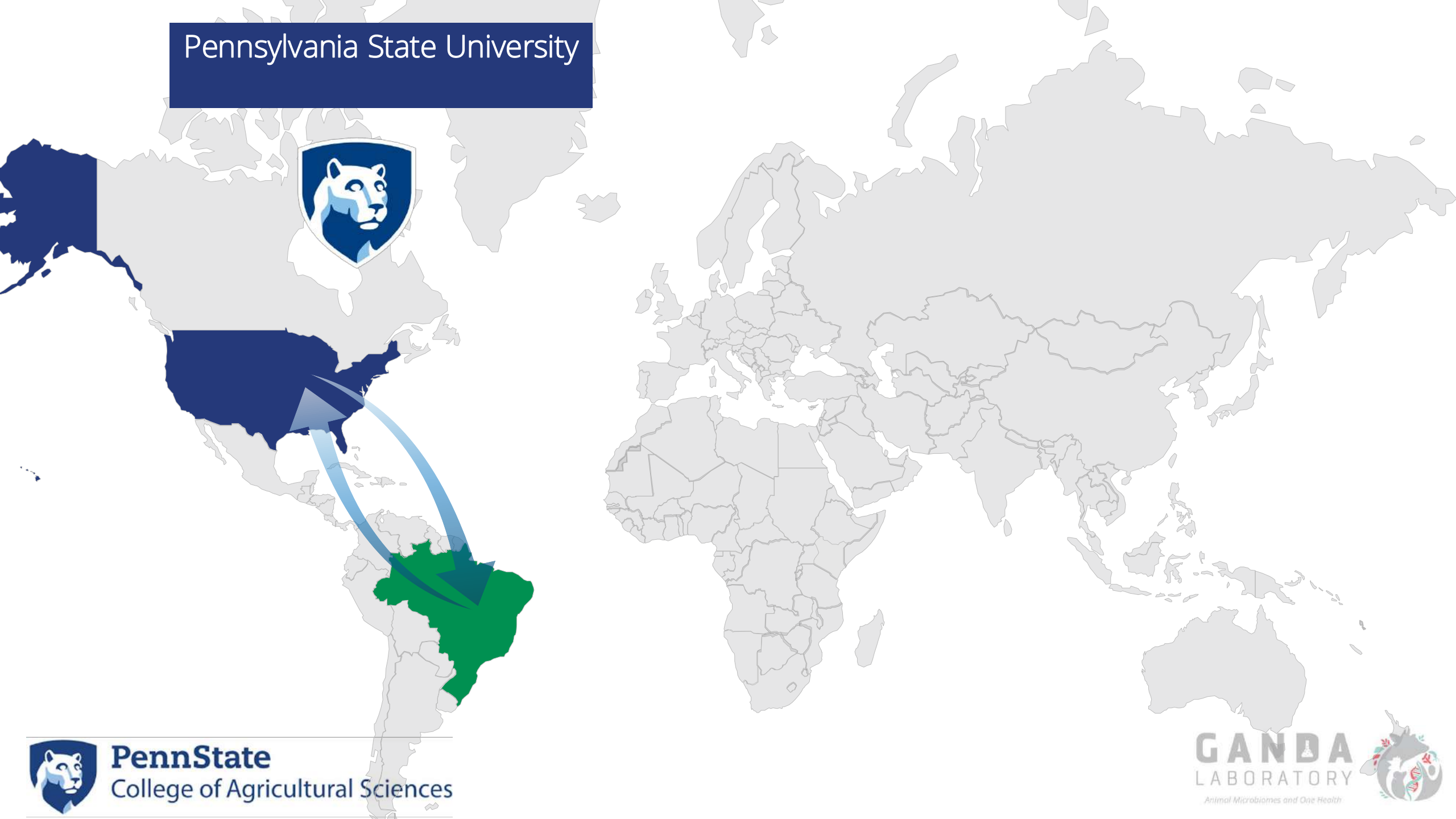
PennState | One Health Microbiome Center

GANDA LABORATORY
Animal Microbiomes and One Health



Pennsylvania State University



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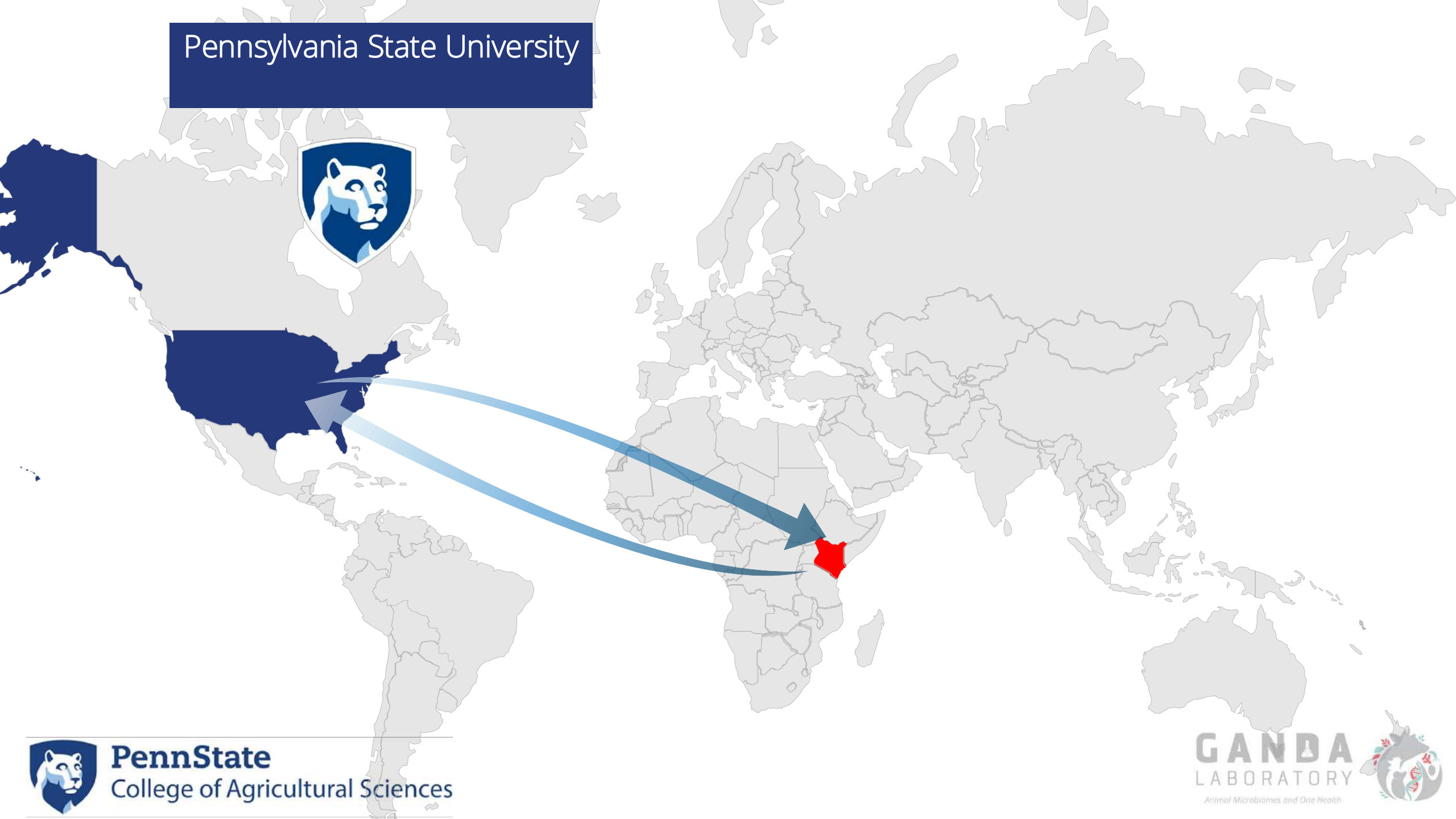
Animal Microbiomes and One Health

Pennsylvania State University



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AMR and Heavy Metals in Brazil

November 5, 2015

Credits: David Gormezano, Tommaso Protti, Sam Cowie | Studio Graphique France Médias Monde | http://webdoc.france24.com/brazil-dam-mining-disaster-mariana/

AMR and Heavy Metals in Brazi

Exposure to metal-contaminated environments associated with rise in AMR genes within dairy cattle microbiomes

› Front Microbiol. 2020 Nov 16:11:590325. doi: 10.3389/fmicb.2020.590325. eCollection 2020.

A Cross-Sectional Study of Dairy Cattle Metagenomes Reveals Increased Antimicrobial Resistance in Animals Farmed in a Heavy Metal Contaminated Environment

Natalia Carrillo Gaeta [1], Emily Bean [2 3], Asha Marie Miles [2], Daniel Ubriaco Oliveira Gonçalves de Carvalho [1], Mario Augusto Reyes Alemán [1], Jeferson Silva Carvalho [1], Lilian Gregory [1], Erika Ganda [2]

Credits: David Gormezano, Tommaso Protti, Sam Cowie | Stu

World Organisation
for Animal Health
Founded as OIE
COLLABORATING CENTRE FOR ECONOMICS OF
ANIMAL HEALTH IN THE AMERICAS REGION
LEB
Laboratório de
Epidemiologia
e Bioestatística
FMVZ USP

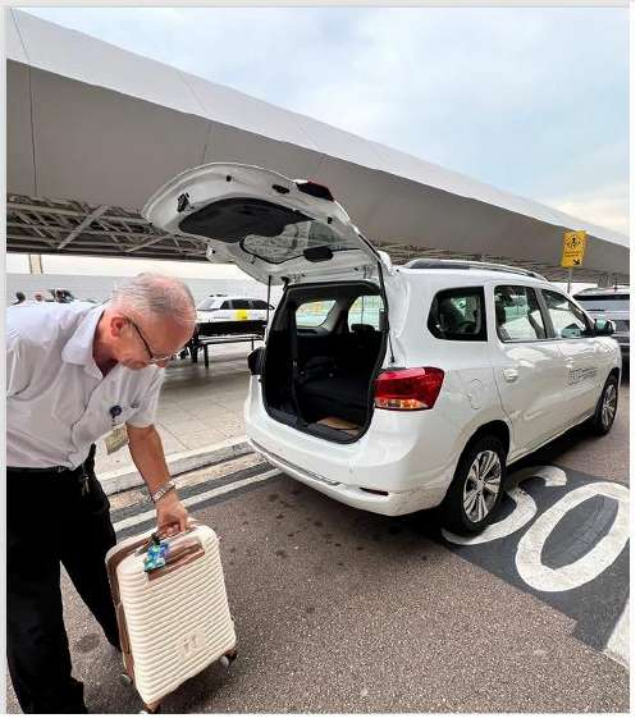
Erika Ganda

VETERINÁRIA USP

FMVZ USP

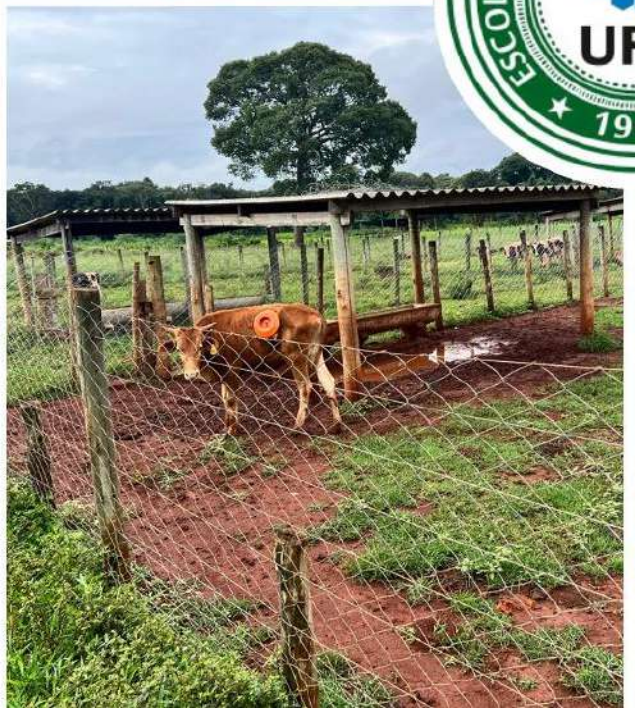
DNA
Transcription
RNA
Translation
Protein

FMVZ USP

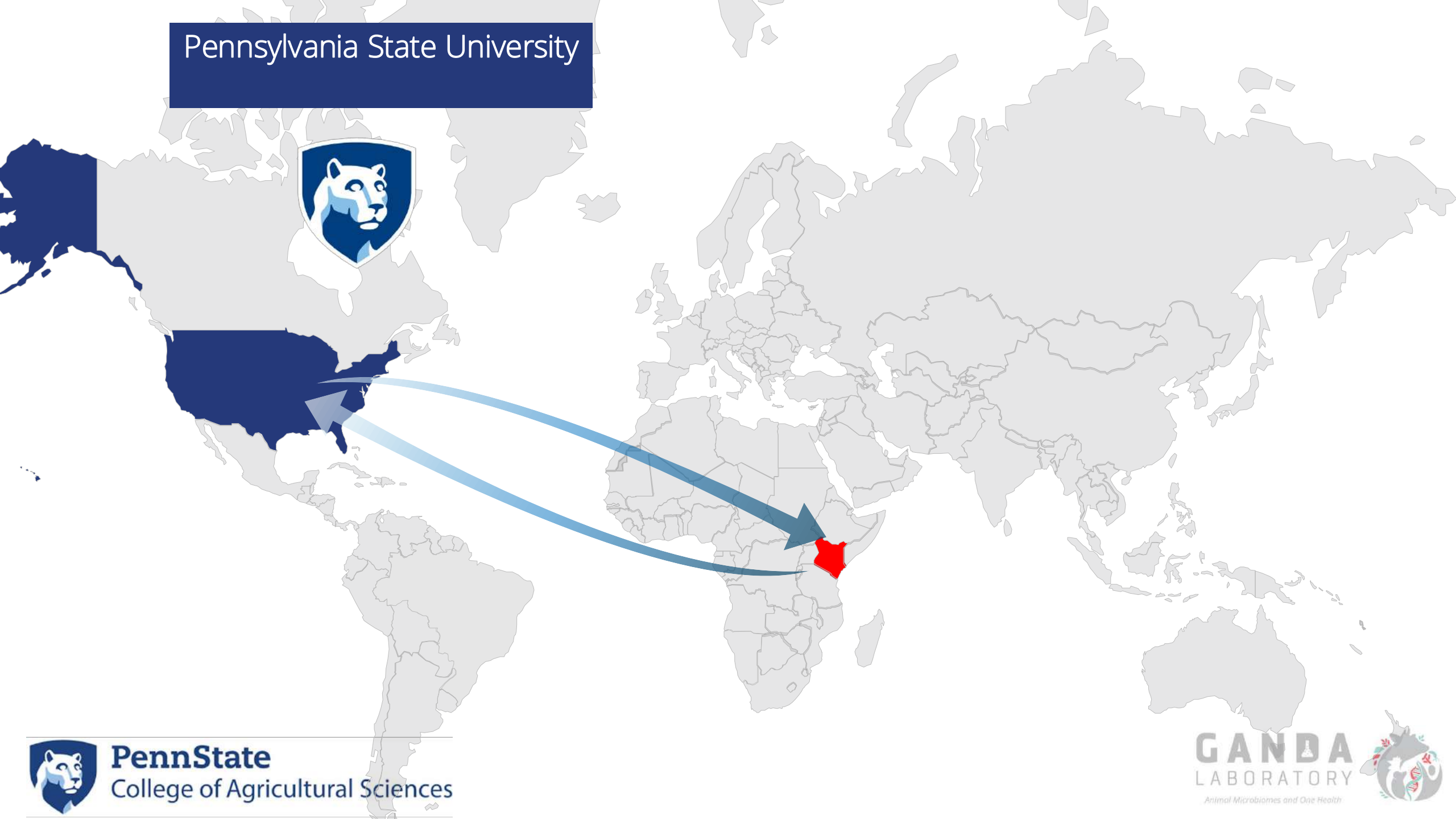


UNIVERSIDADE DE SÃO PAULO
FACULDADE DE MEDICINA VETERINÁRIA E ZOOTECNIA
FZEA USP

PPGCA
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIA ANIMAL
VISÃO
Consolidar-se como pós-graduação pública de excelência e referência em Ciência Animal, no contexto do Bioma Cerrado, no âmbito nacional, e internacional, por meio da formação de pessoas sob os pilares do desenvolvimento social, econômico e ambiental, pautados pela geração e transferência de conhecimento científico básico, aplicado e translacional.
VALORES
• Comprometimento
• Cooperação
• Criatividade
• Ética e Integridade
• Humanização e Inclusão
• Inovação
• Solidariedade e Sustentabilid



Pennsylvania State University



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College of Agricultural Sciences

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Animal Microbiomes and One Health

RESEARCH //

New partnership will address health and food safety challenges in Kenya

Representatives from Penn State, Meru University of Science and Technology, and Meru County in Kenya signed a memorandum of understanding in a ceremony in Kenya to formally commence their new partnership. This collaboration also will involve the Technical University of Denmark.

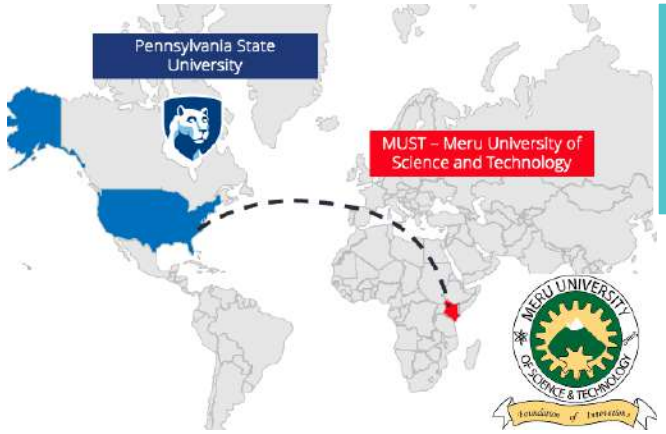
NANOPORE
BIOBASE
miniOne
INNOVATION

CAPACITY BUILDING

CAPACITY BUILDING

WE ARE

Human and Ethical Dimensions of Antimicrobial Resistance (AMR) on Dairy Farms in Kenya

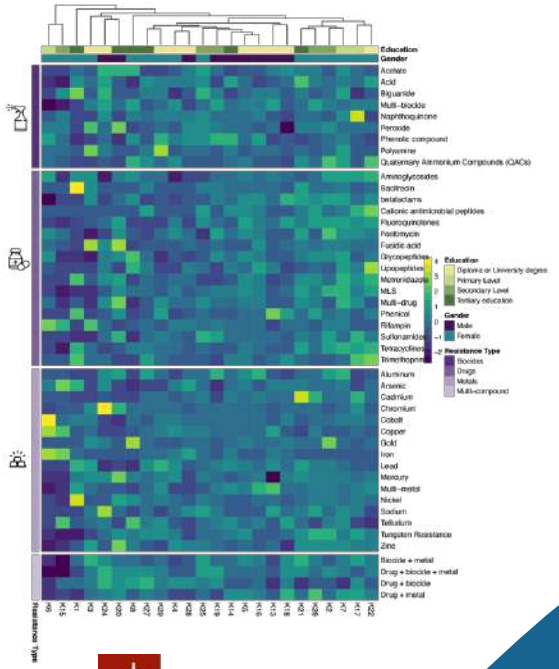


Sample Collection
24 Dairy Farms

Molecular Biology Training

Bioinformatics Tutorial

Data Analysis



Joan Simam
Ph.D.

Frank Onyambu
Ph.D.

Stephanie Bierly

Elizabeth Ransom
Ph.D.

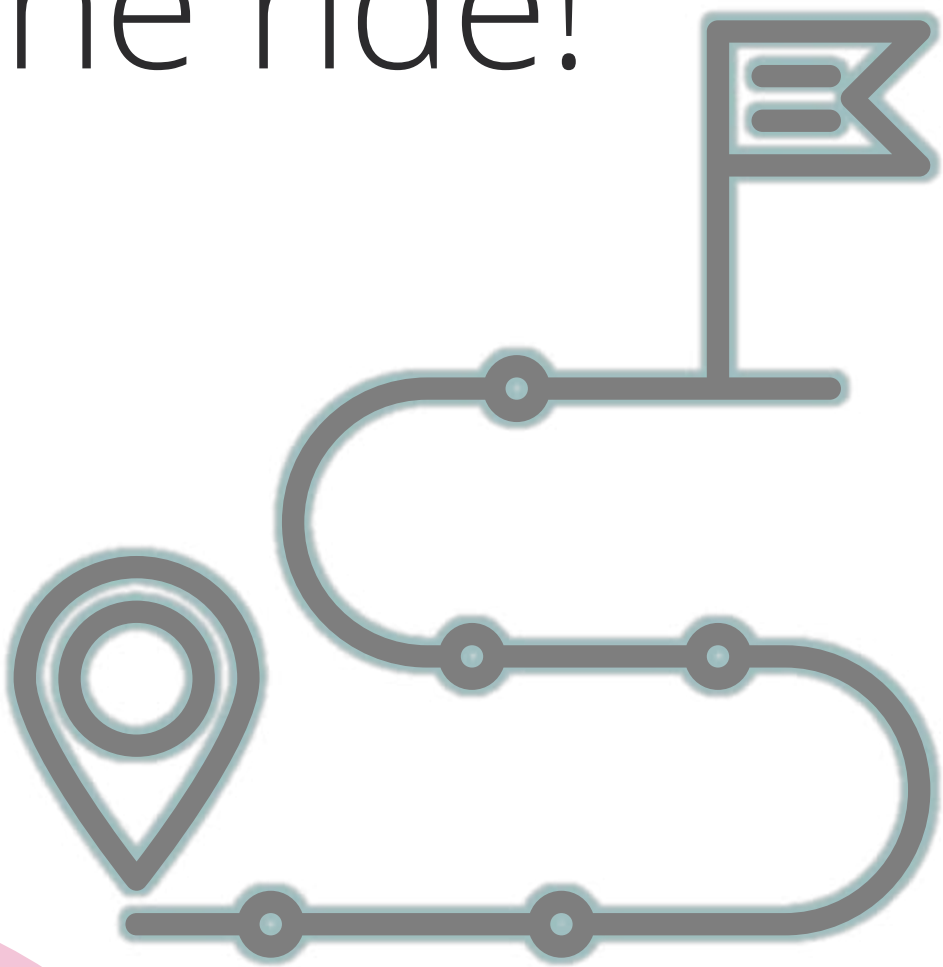
Manuscript in Preparation

PennState

AMERICAN SOCIETY FOR MICROBIOLOGY

GANDA LABORATORY
Animal Microbiomes and One Health

I hope you enjoyed the ride!



Acknowledgements

Penn State College of Ag Faculty Development Award
One Health Microbiome Center
Meru University of Science and Technology
Meru County
Kenya Wildlife Services
Plant Village – Samburu team

PennState College of Agricultural Sciences

PlantVillage

KENYA WILDLIFE SERVICE

THE COUNTY GOVERNMENT OF MERU

GANDA LABORATORY
Animal Microbiomes and One Health

Acknowledgements

PennState Extension

Dr. Melissa Cantor

Dr. Ernest Hovingh

Dr. Adrian Barragan

Dr. Lisa Holden

Cornell University Founded A.D. 1865

Dr. Belinda Thompson

Dr. Kevin Cummings

pennsylvania DEPARTMENT OF AGRICULTURE

NIH

pennsylvania DEPARTMENT OF HEALTH

Center for Dairy Excellence

USDA

Northeast SARE Sustainable Agriculture Research & Education

USDA APHIS

BEEF BEEF

Lancaster DHIA

PennState

GANDA LABORATORY Animal Microbiomes and One Health

Thank you!

powered by dot.

@Erika_Ganda

/in/erikaganda/

ganda@psu.edu

www.gandalab.org