Pacific Northwest
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One Health Approach to Climate-Driven Emergence of Infectious Disease

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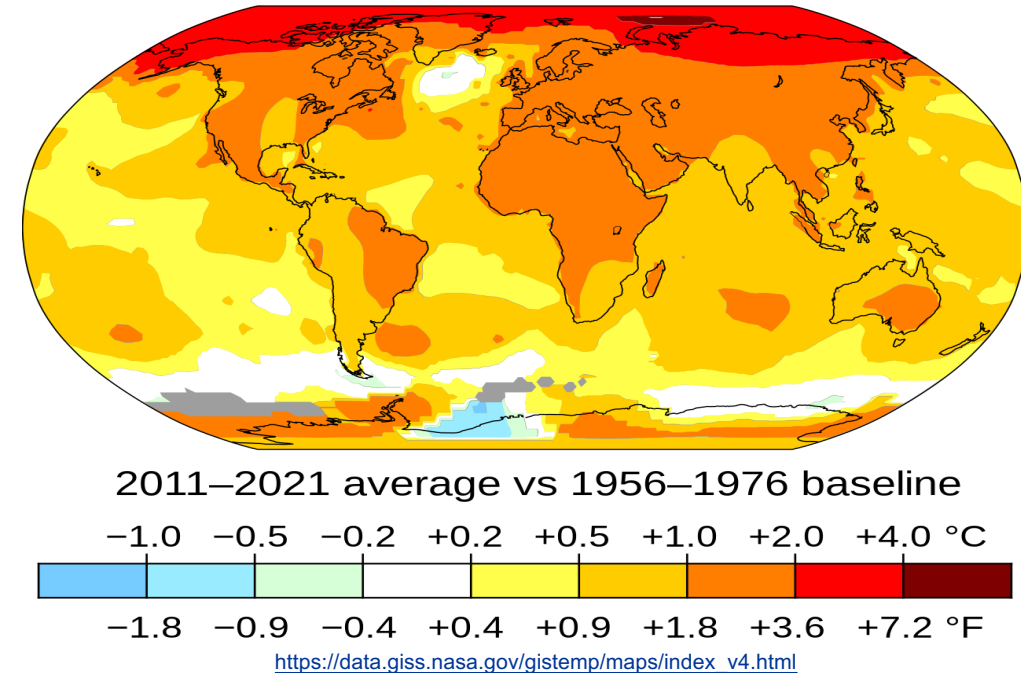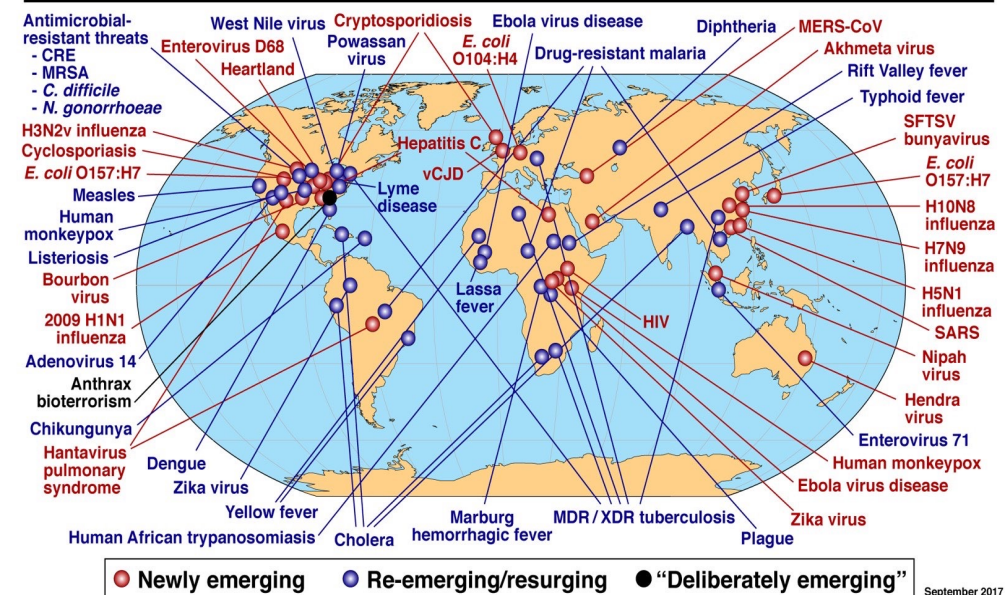Paul G. Allen School for Global Health

Trends in Climate & Infectious Disease

- Over the past 50 years
  - Climate change became **undeniable**
  - The number of re/emerging infectious diseases **quadrupled**

- Emerging & re-emerging diseases
  - **75%** infect both humans and animals
  - **> 60%** originated from wildlife

Temperature change in the last 50 years

2011–2021 average vs 1956–1976 baseline

−1.0	−0.5	−0.2	+0.2	+0.5	+1.0	+2.0	+4.0 °C

−1.8	−0.9	−0.4	+0.4	+0.9	+1.8	+3.6	+7.2 °F

https://data.giss.nasa.gov/gistemp/maps/index_v4.html

Global Examples of Emerging and Re-Emerging Infectious Diseases 2017

*By Anthony Fauci - https://www.niaid.nih.gov/sites/default/files/main%20map.jpg
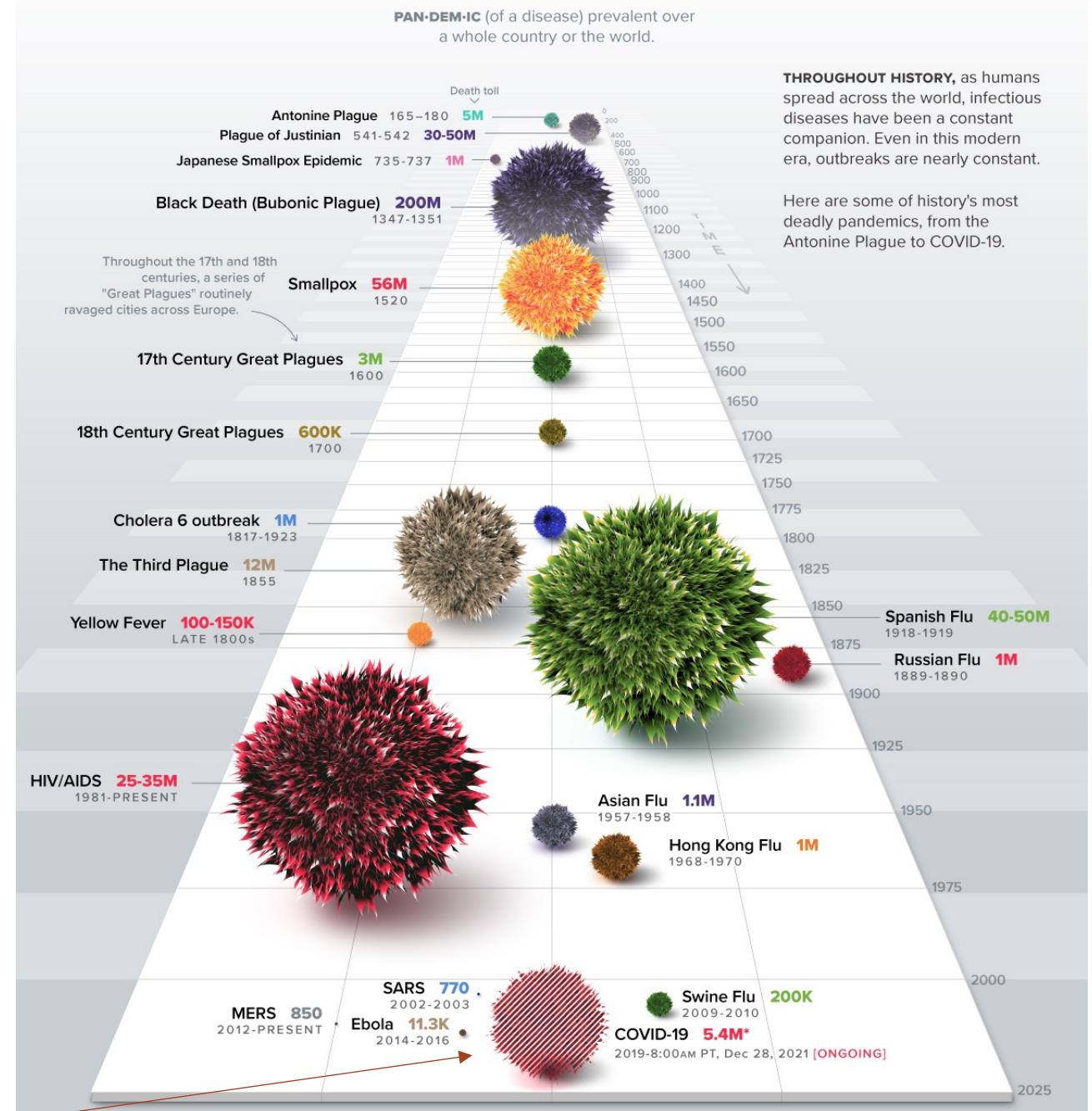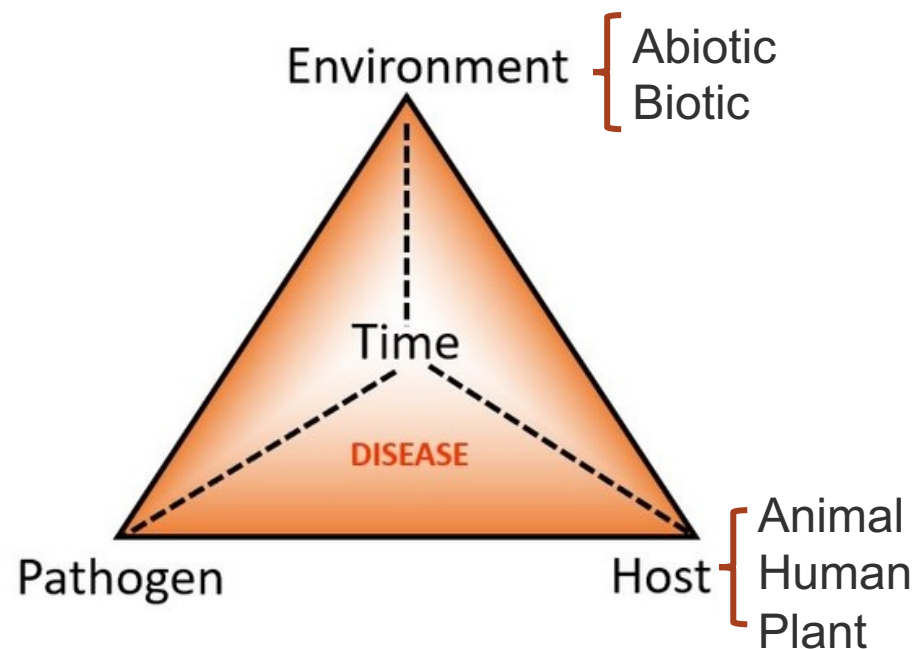
Infectious Diseases of Great Consequence

- Pandemics
  - **100%** since 1970s infect both humans and animals
  - **85%** of all known pandemics originated from animals (n = 17/20)
- Potential bioterrorism agents
  - **80%** infect both humans and animals

https://www.visualcapitalist.com/history-of-pandemics-deadliest/

COVID-19 6.9M deaths by March 16

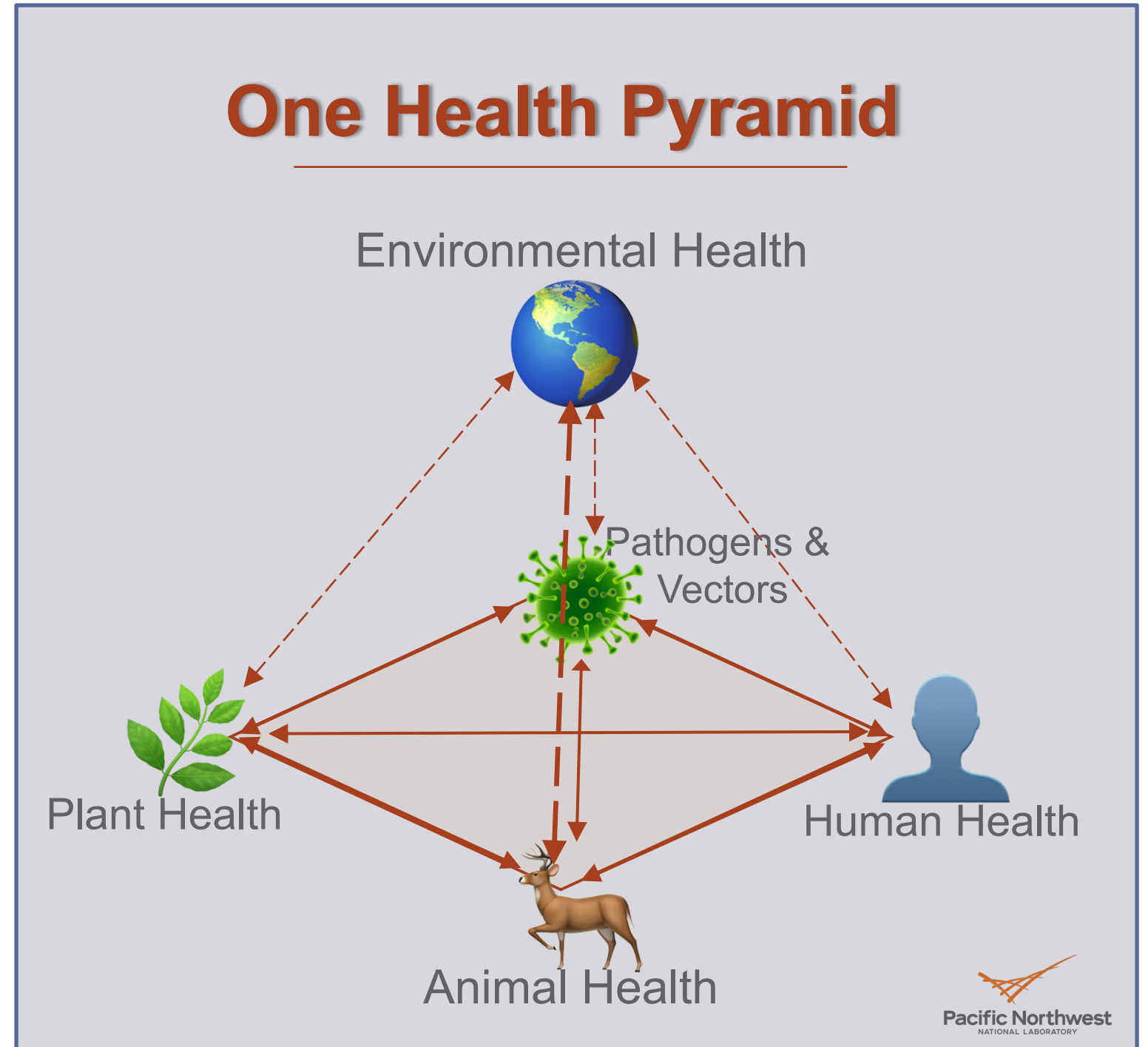# Origins of Disease and Disease Outbreaks

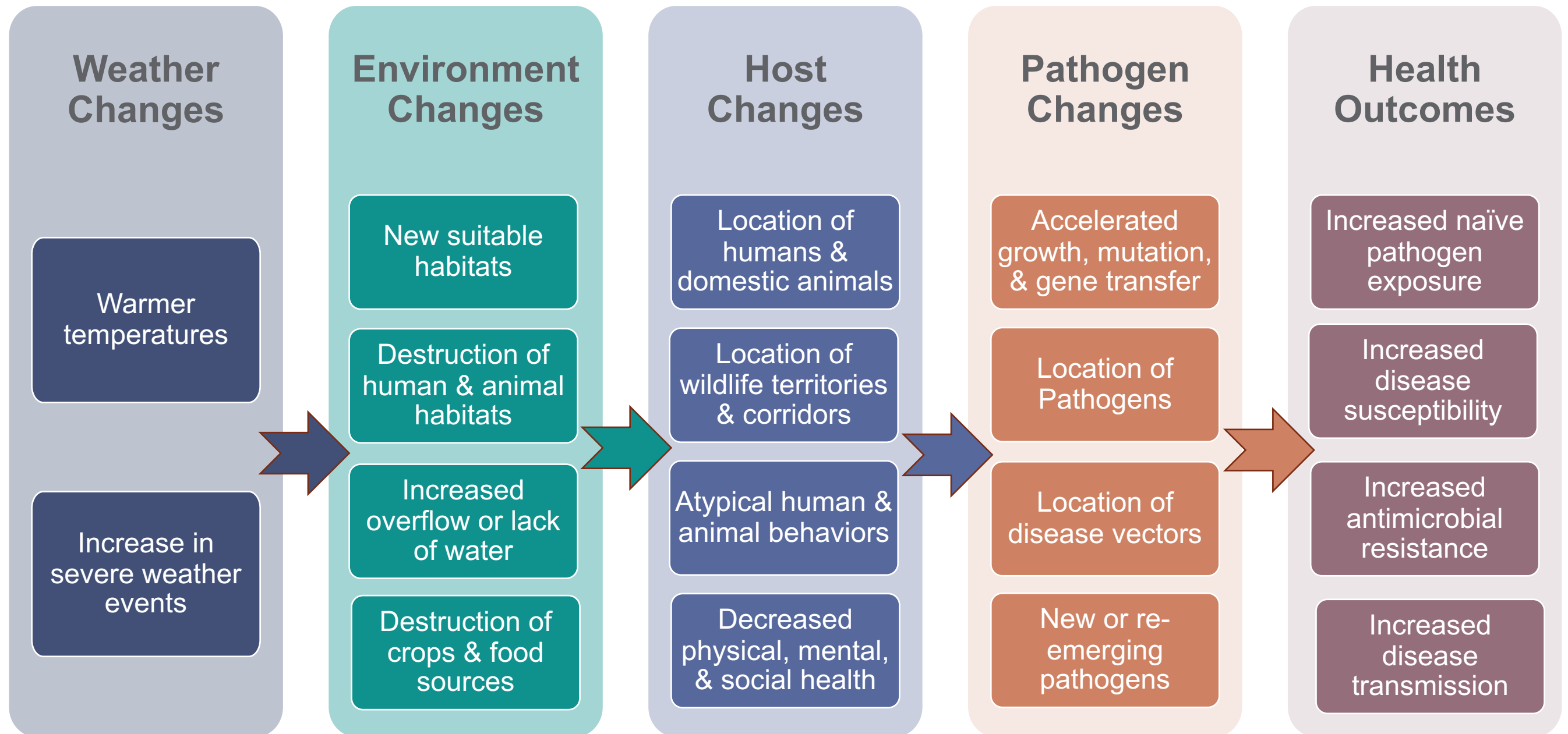**Traditional Disease Triangle**

- Disease
  - *Requires* susceptible host, virulent pathogen, & favorable environment (i.e., components)
    - ✓ Host = animal, human, or plant
    - ✓ Time = occurrence & intensity alignment
  - Normal low background rate
    - ✓ Helps maintain ecosystem balance
    - ✓ Facultative (opportunistic) or obligate (require 1+ host)

- Disease Outbreaks
  - *Occurs* with a great shift in component(s)
  - *Prevented* by eliminating ≥ 1 components
  - *Mitigated* by manipulating factors, e.g.,
    - ✓ Human activity
    - ✓ Vector control

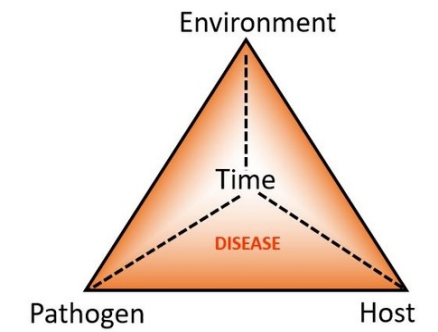# One Health (OH) Perspective on Disease

- Integrated, unifying approach to balance and optimize health

- Closely linked & interdependent health of
  - ✓ People, animals, plants, and
  - ✓ Shared environment & ecosystem

One Health Pyramid

Environmental Health

Pathogens & Vectors

Plant Health

Human Health

Animal Health

Climate Change Effects on Disease Emergence

Weather Changes
- Warmer temperatures
- Increase in severe weather events

Environment Changes
- New suitable habitats
- Destruction of human & animal habitats
- Increased overflow or lack of water
- Destruction of crops & food sources

Host Changes
- Location of humans & domestic animals
- Location of wildlife territories & corridors
- Atypical human & animal behaviors
- Decreased physical, mental, & social health

Pathogen Changes
- Accelerated growth, mutation, & gene transfer
- Location of Pathogens
- Location of disease vectors
- New or re-emerging pathogens

Health Outcomes
- Increased naïve pathogen exposure
- Increased disease susceptibility
- Increased antimicrobial resistance
- Increased disease transmission

6

Traditional Approach to Climate-driven Emerging Infectious Diseases

Identify **sick** human

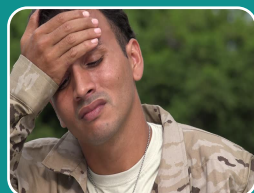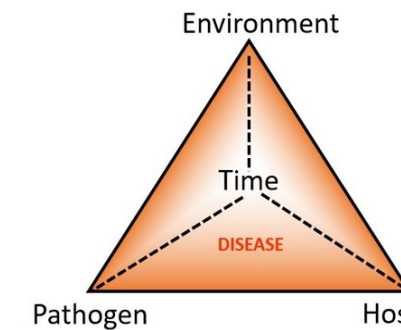Run tests to identify if threat is on the **list of known agents**

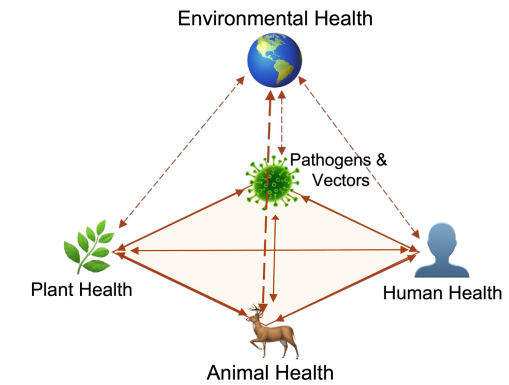**Develop**, test, and verify countermeasures specific to the threat **agent**

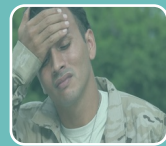Enact measures to **mitigate** spread through human population

Traditional Approach to Climate-driven Emerging Infectious Diseases
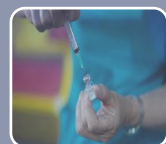
Identify **sick** human

Run tests to identify if threat is on the **list of known agents**

Develop, test, and verify countermeasures specific to the threat **agent**

Enact measures to **mitigate** spread through human population

→ **Long time, Mitigation**

OH Approach to Climate-driven Emerging Infectious Diseases

Current Traditional Approach

Identify **sick** human

Run tests to identify if threat is on the **list of known agents**

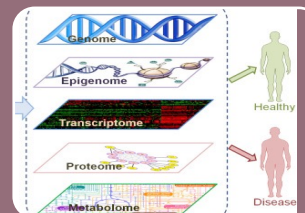**Develop**, test, and verify countermeasures specific to the threat **agent**

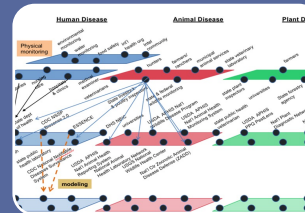Enact measures to **mitigate** spread through human population

➡ Long time, Mitigation

Identify **signatures** in animals, environment, or event lifecycle *before* it affects humans

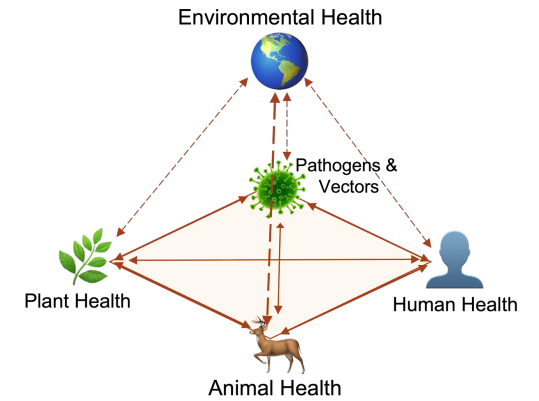Run tests for **level of threat** to humans, animals, plants, environment

Run models to **identify** best steps to stop the threat **event** lifecycle given what is known
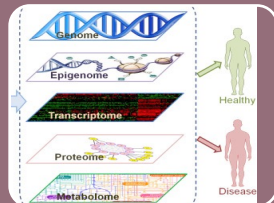
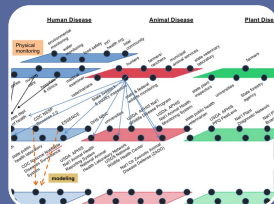Enact measures to **prevent** human exposure to the threat

OH Approach to Climate-driven Emerging Infectious Diseases

Identify **signatures** in animals, plants, environment, or event lifecycle *before* it affects humans

Run tests for **level of threat** to humans, animals, plants, and environment

Run models to **identify** best steps to stop the threat **event** lifecycle given what is known

Enact measures to **prevent** human exposure to the threat

Short time, Prevention

Incorporating the One Health Lens

- Humans, animals, plants, and environmental health are all linked

- All living beings/systems react to any ecosystem change

- Animals, plants, and environment can be *early warning sensors* for human health threats
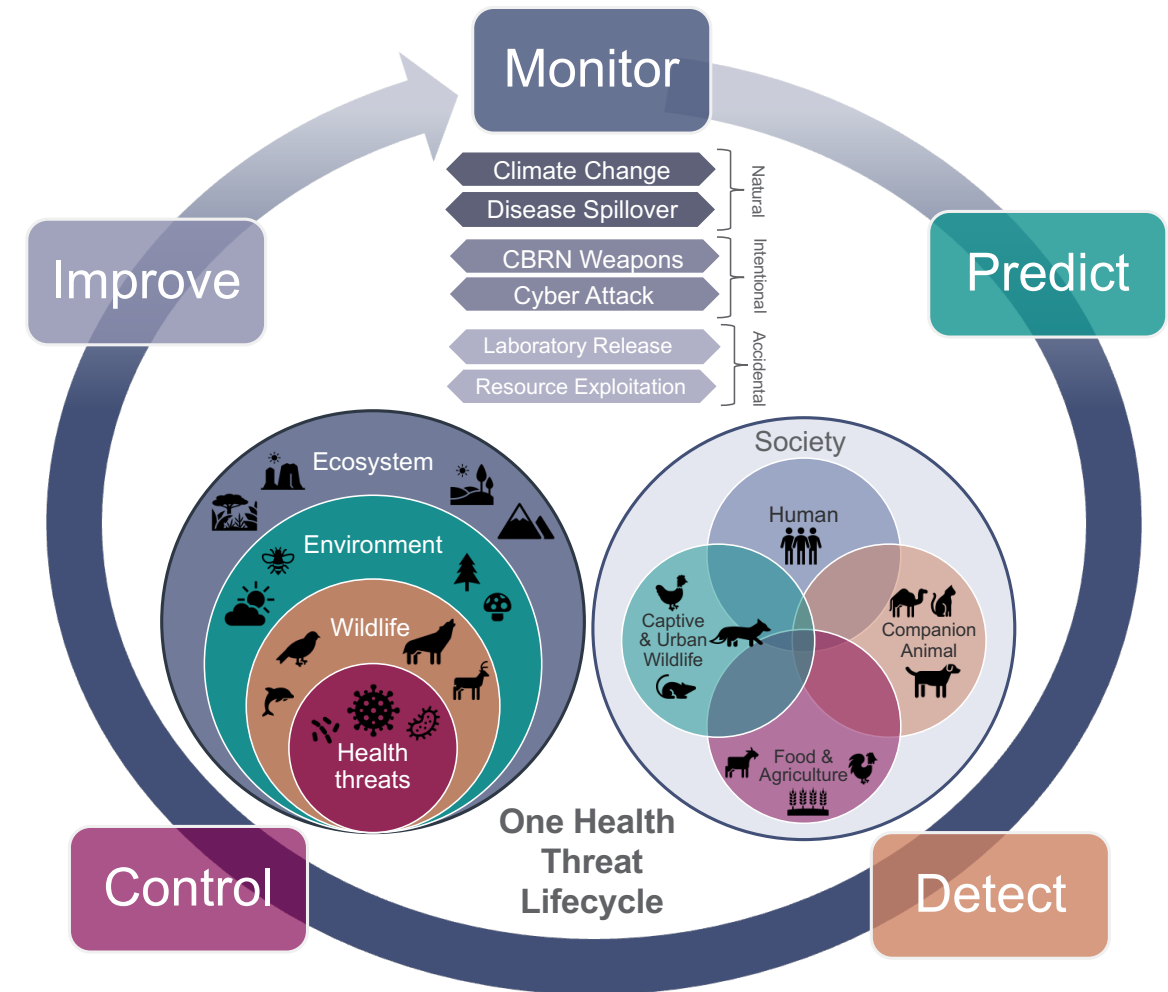
Zoonotic Diseases

✓ 60% all human pathogens are zoonotic

✓ 75% new emerging infectious diseases are zoonotic

✓ 80% potential bioterrorism agents are zoonotic

✓ 85% of all pandemics are zoonotic

✓ 100% of pandemics since 1970s are zoonotic

e.g., HIV, West Nile, SARS, Influenza H1N1, Ebola, MERS, COVID, Anthrax, Plague, Tularemia, VHF

Exploiting the OH Threat Event Lifecycle

- Holistic view of health threats
- Threat events are *only* part of a life cycle
- Detectable signatures throughout lifecycle
  - Independent of threat type
  - Humans (and human systems), animals, plants, and environment
- Goal to disrupt the cycle

Event Initiator
- Natural
- Intentional
- Accidental

Threat Event
- Precursors
- Release
- Development

One Health Threat Event Lifecycle

Other Impacts
- Social
- Political
- Economic
- Infrastructure

Health Impacts
- Human
- Animal
- Plant
- Environmental

Climate Change Example

- Initiator: Natural Disaster

- Detectable signatures
  - Event
    - ✓ Weather forecasting
    - ✓ Wildlife disease situational awareness
    - ✓ Disease modeling & forecasting
  - Health Impacts
    - ✓ Abnormal wildlife behavior
    - ✓ Increasing medical demands
  - Other Impacts
    - ✓ Social chatter
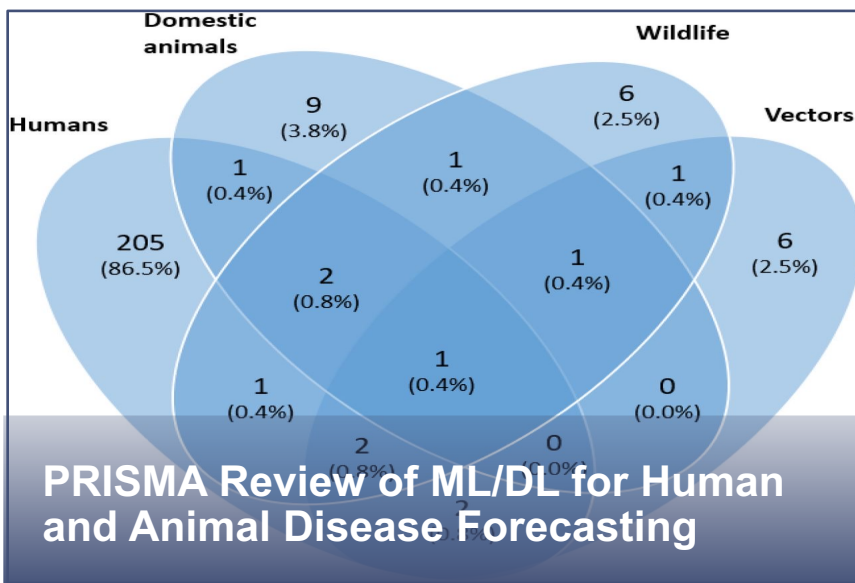   - ✓ Missing work and school
    - ✓ News reports

Initiator
1. Natural Disaster
2. *Intentional Protest*

Event
- *Pre*: Weather Indicators
- *Release*: Displacement of Wildlife
- *Dev*: Increased human-wildlife contact

One Health Threat Event Lifecycle

Other Impacts
- Social unrest
- Political actions
- Economic losses
- Infrastructure strain

OH Impacts
- Habitat loss
- Food source loss
- Increase disease contact
- Decreased physical & mental

Combating climate-driven emergence of infectious diseases through a One Health lens

PNNL uses a OH approach for situational awareness, early warning, and disease forecasting.

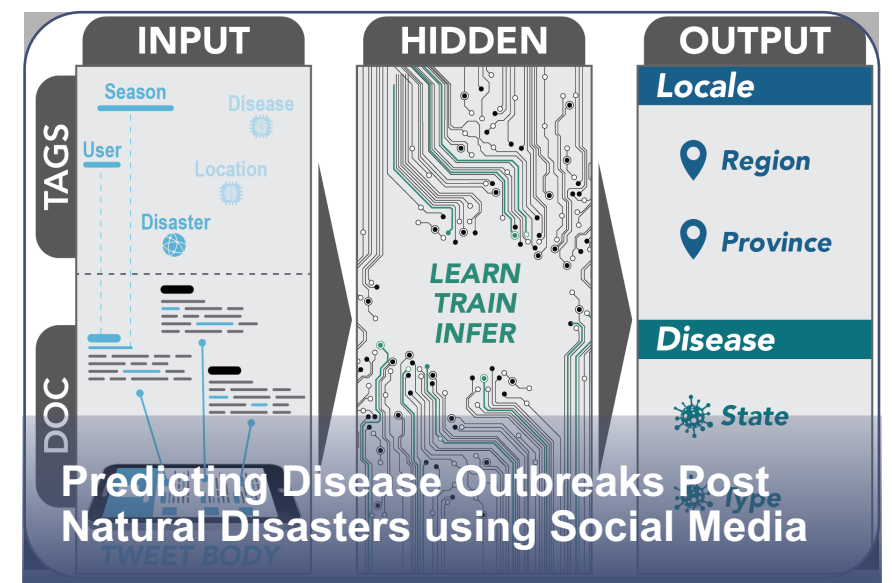Biofeeds (human, animal, plant global biosurveillance of open-source information)

MedINT (human, animal, plant, & environmental health-situational awareness, anomaly detection, investigation)
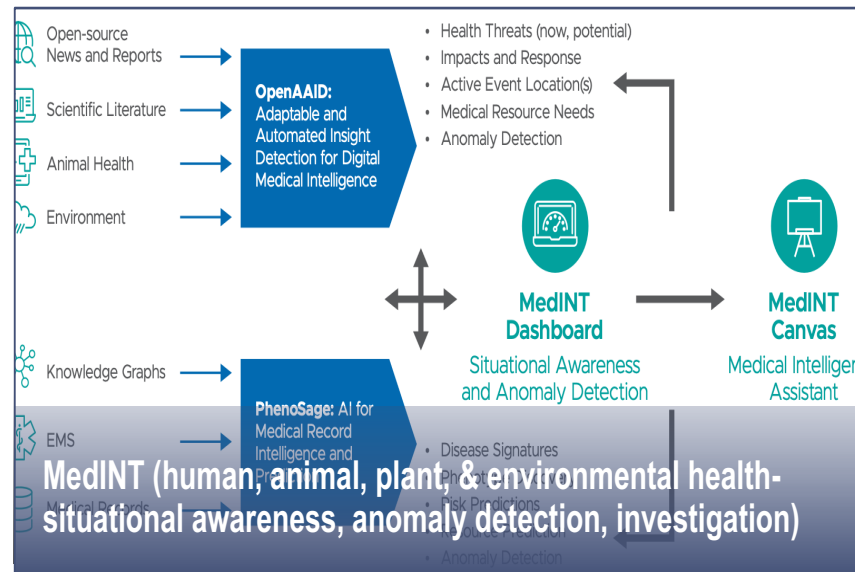
Zoonotic Spillover Risk (Open-source news, live-stock events, human and animal population)

PRISMA Review of ML/DL for Human and Animal Disease Forecasting

ML4Dz (AI-driven OH ensemble approach to disease forecasting)

Predicting Disease Outbreaks Post Natural Disasters using Social Media

Thank you

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