

# One Health: Humans, Animals, and the Environment

Stanley Maloy

Center for Microbial Sciences  
San Diego State University

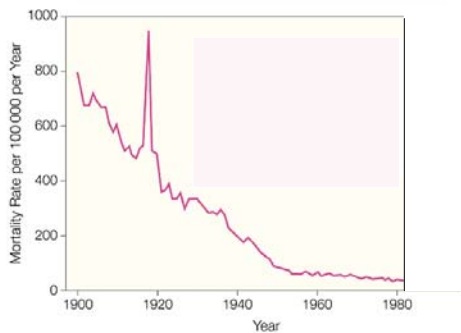


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## Preview

- **Emerging Infectious Diseases**
- **Where do they come from?**
  - Zoonotic diseases
  - New environmental niches
- **Examples**
  - Trypanosoma cruzii
  - Nipah virus
  - Salmonella
  - Exotoxin reservoir
- **One Health**
- **Challenges**

## Infectious disease mortality in the United States from 1900 to 1980



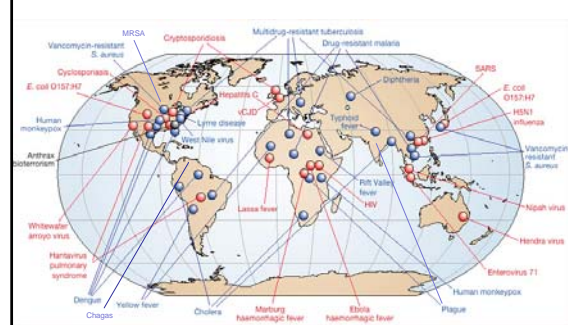
"...time to close the book on  
infectious diseases, declare the  
war against pestilence won, and  
shift national resources to such  
chronic problems as cancer and  
heart disease."

William Stewart  
US Surgeon  
General (1967)

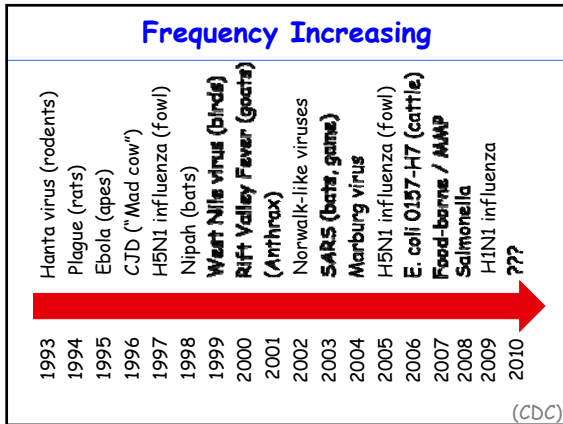
## Instead ...

- New and re-emerging diseases
- **Antibiotic-resistance rapidly increasing**
- Annual death rates due to infectious disease doubled in the last 2 decades
- **Leading cause of death worldwide**
- No geographic boundaries
- **Also cause chronic human diseases**

## Emerging Infectious Diseases

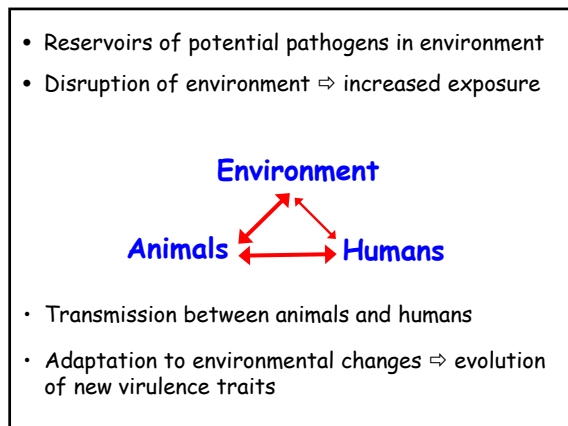


From Morens et al. (2004) Nature 430: 242-249



- ### Why is the rate increasing?
- Environment disruption (Lyme disease)
  - Technology (*Legionella*)
  - Demographics (Dengue fever, Nipah virus)
  - Increased travel (SARS)
  - Changes in agriculture and food distribution (*Salmonella*, *E. coli* O157-H7)
  - Disruption of public health (Rabies)
  - Climate change (Chagas Disease, Cholera, Plague)

- ### Where are they coming from?
- Human infections:**
- <100 pathogens are human specific
  - Many = commensals / environmental
  - >60% caused by zoonotic pathogens
  - Most emerging/re-emerging diseases caused by zoonotic pathogens
- Woolhouse, Gowtage-Sequeira (2005) *Emerg. Inf. Dis.*



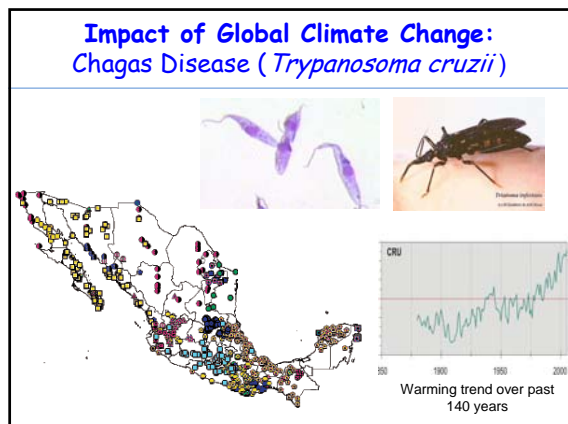
### Examples

Impact of global climate change

Animal agriculture

Evolution of new virulence traits

Reservoir of virulence genes



## Acai Berries



Nobrega et al. 2009. EID 15: 653-655

## Human Impact on the Environment (*Nipah virus*)



Reviewed in: Parrish et al. 2008. Microbiol. Mol. Biol. Rev. 72: 457-470.

## Evolution of new virulence traits: Sources of recent *Salmonella* outbreaks

### Animal products:

- Poultry
- Beef
- Pork
- Eggs
- Fish
- Milk
- Cheese
- Chocolate

### Pets:

- Turtles
- Reptiles
- Dogs
- Cats
- Birds
- Pet food
- Treats

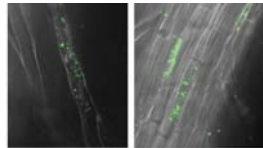
### Plant products:

- Alfalfa sprouts
- Bean sprouts
- Melons
- Marijuana
- Lettuce
- Onions
- Tomatoes
- Peppers
- Cilantro
- Cereal
- Rice
- Flour
- Nuts (peanut butter)

## Ability to grow in plants



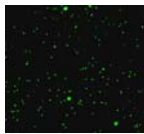
Scanning EM of *E. coli* on stomata of lettuce leaf (3250x)



3 hr      20 hr

GFP labeled *Salmonella* Typhimurium growing inside *Arabidopsis* tissue

## Reservoir of Virulence Genes: Environmental Metagenomics (Forest Rohwer)



> 10<sup>6</sup> viruses/ml seawater

- Isolated viral fraction from seawater
- Constructed clone banks from purified DNA
- Determined DNA sequence of cloned viruses

Found sequences = exotoxin genes

Casas et al. (2006) FEMS Microbiol. Lett. 216: 141

## Phage encoded Exotoxins

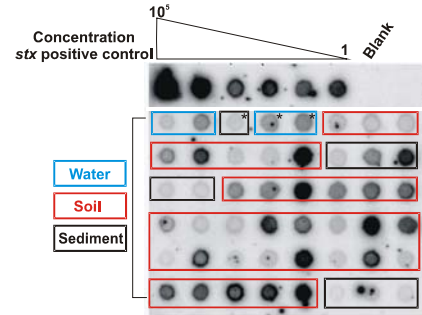
Bacterium	Phage	Gene product	Disease
<i>Vibrio cholerae</i>	Ctx	Cholerae toxin	Cholera
<i>Clostridium botulinum</i>	Btx	Botulinum toxin	Botulism
<i>Corynebacterium diphtheriae</i>	β	Diphtheria toxin	Diphtheria
<i>Streptococcus pyogenes</i>	T12	Erythrogenic toxin	Scarlet fever
<i>E. coli</i>	Stx	Shiga-like toxin	Hemorrhagic diarrhea

## How common are exotoxin genes in natural environments?

- Collect environmental samples
- Isolate bacteria and phage via size fractionation
- Extract total DNA from bacteria and phage
- Southern dot blots and PCR with exotoxin gene probes

Casas et al. (2009)

## DNA hybridization assay for Shiga toxin gene (*stx*) in environmental samples

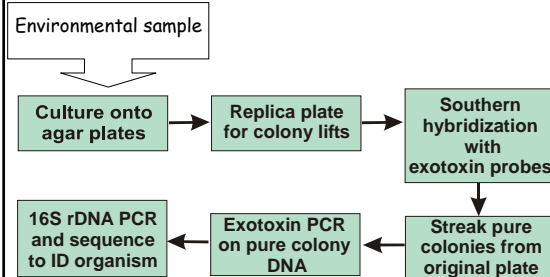


## Exotoxin genes widespread in environment

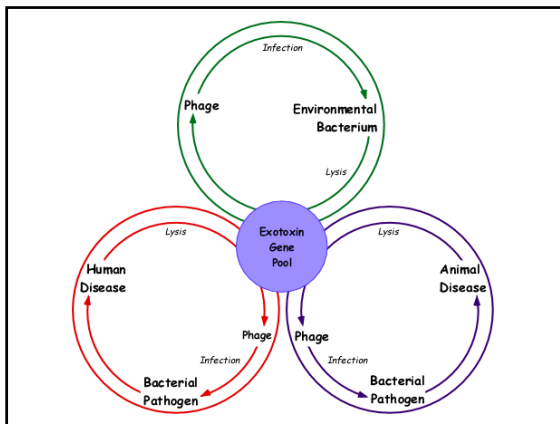
Environment	Toxins			
	STX	SEA	DTX	CTX
Soil	29% n=229	11% n=229	5% n=146	3% n=146
Sediment	15% n=66	14% n=66	11% n=61	31% n=61
Water	18% n=44	0% n=40	0% n=47	49% n=41
<b>Total positives</b>	<b>25%</b>	<b>10%</b>	<b>6%</b>	<b>18%</b>

Samples from multiple locations in San Diego region  
BUT cognate bacterial pathogen not detected

## Source of phage encoded exotoxin genes?

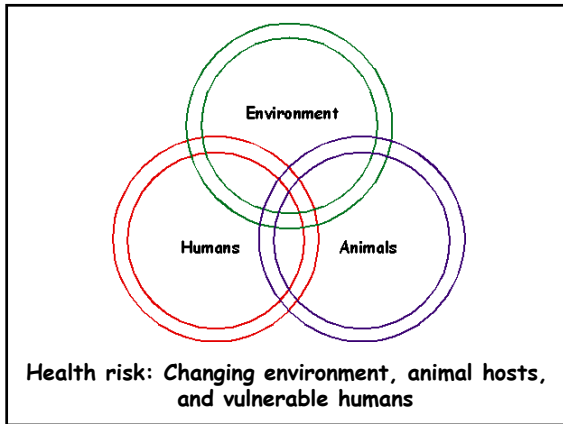


Environmental reservoir *Staphylococcus sea*  
enterotoxin gene = psychrophilic *Pseudomonas* sps.



## Environmental Reservoir

- Pool of virulence genes and population of potential pathogens
- Raw materials for evolution of new diseases
- Environmental change  $\Rightarrow$  selection for new phenotypes
- Detection via molecular approaches such as Metagenomics



## One Health Initiative

- Veterinary medicine, Human medicine, Environmental sciences, **Microbiology**
- New paradigm = prediction and upstream intervention

### Human Health paradigm:

Disease Surveillance → Investigation → Treatment

- Human disease

### One Health paradigm:

Environment Surveillance → Prediction → Prevention

- Environment
- Animals
- Human disease

### Statement by G8 Leaders

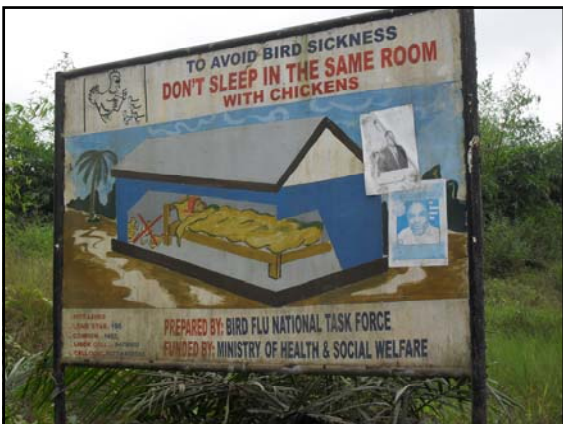
St. Petersburg, July 16, 2006

"A vigorous response to the threat of infectious diseases, a leading cause of death worldwide, is essential to global development and the well-being of the world's population."

- International communication and coordination
  - build laboratory capacity
  - timely sharing of clinical samples and information about disease outbreaks
- Awareness
  - Education = human medicine, veterinary, environment
  - Responsible environmental policy

Coming soon ... Hanta, Nipah, Plague, Cholera, and more:

One Health - Predicting and Preventing the Next Pandemic.  
 R. Atlas, C. Rubin, P. Daszak, R. Cowell, and S. Maloy.  
*Microbe* (2010)



## Microbial View



CDC