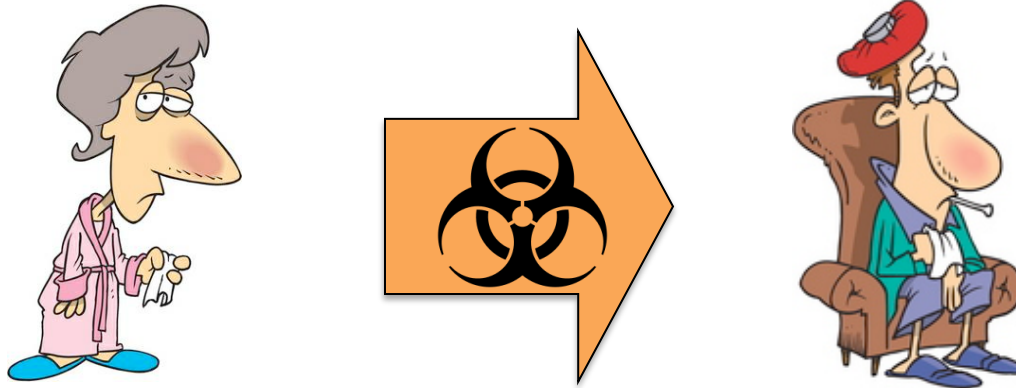


Infectious Disease and the Environment



Jessica Brownell
Ph.D. Candidate
Pathobiology/Global Health; UW

Infectious (Communicable) Disease:

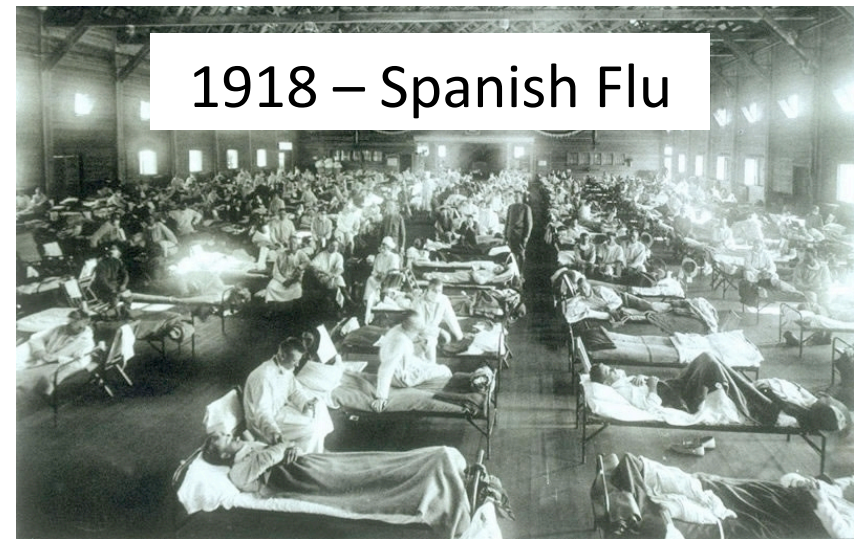


Diseases caused by **pathogenic microorganisms** (bacteria, viruses, parasites, fungi, prions) that can be **spread, directly or indirectly, from one person to another.**

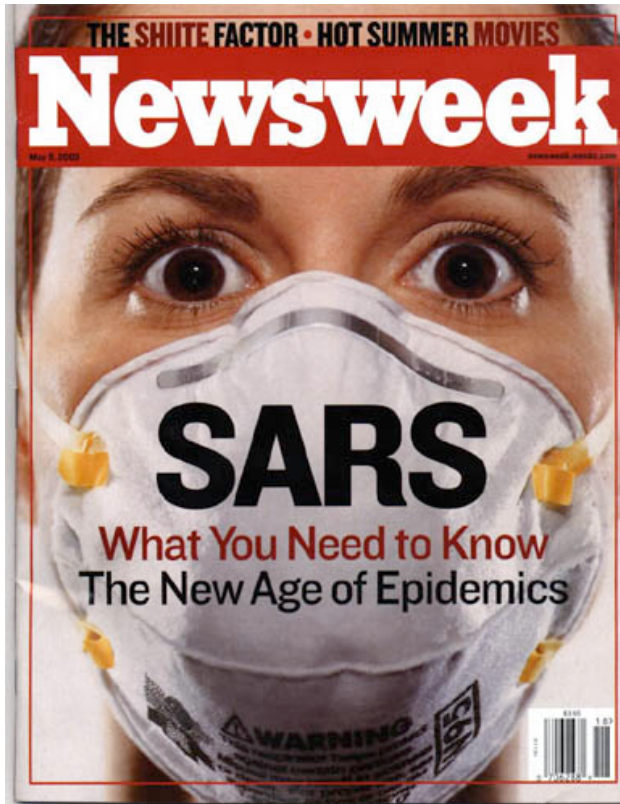


Zoonotic diseases are infectious diseases of animals that can spread and cause disease in humans.

Infectious Diseases Impacted History...



...and Still Impact Our World Today



Cholera in Haiti -2010



Beyond the Headlines



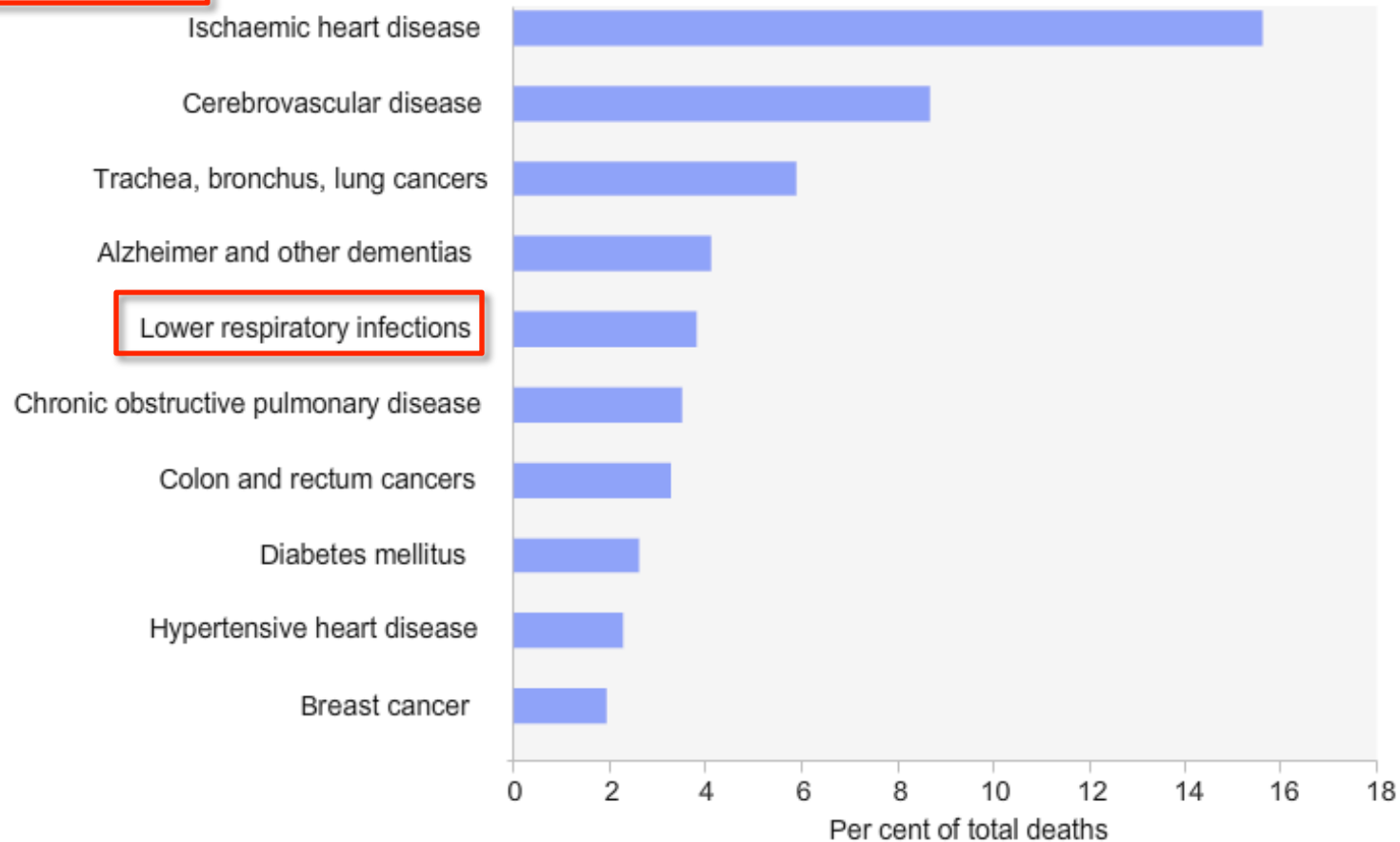
World Health Organization

Ten leading causes of deaths in 2008

Click on the country income groups below to view the related graphs

High-income countries

Low- and middle-income countries



Beyond the Headlines



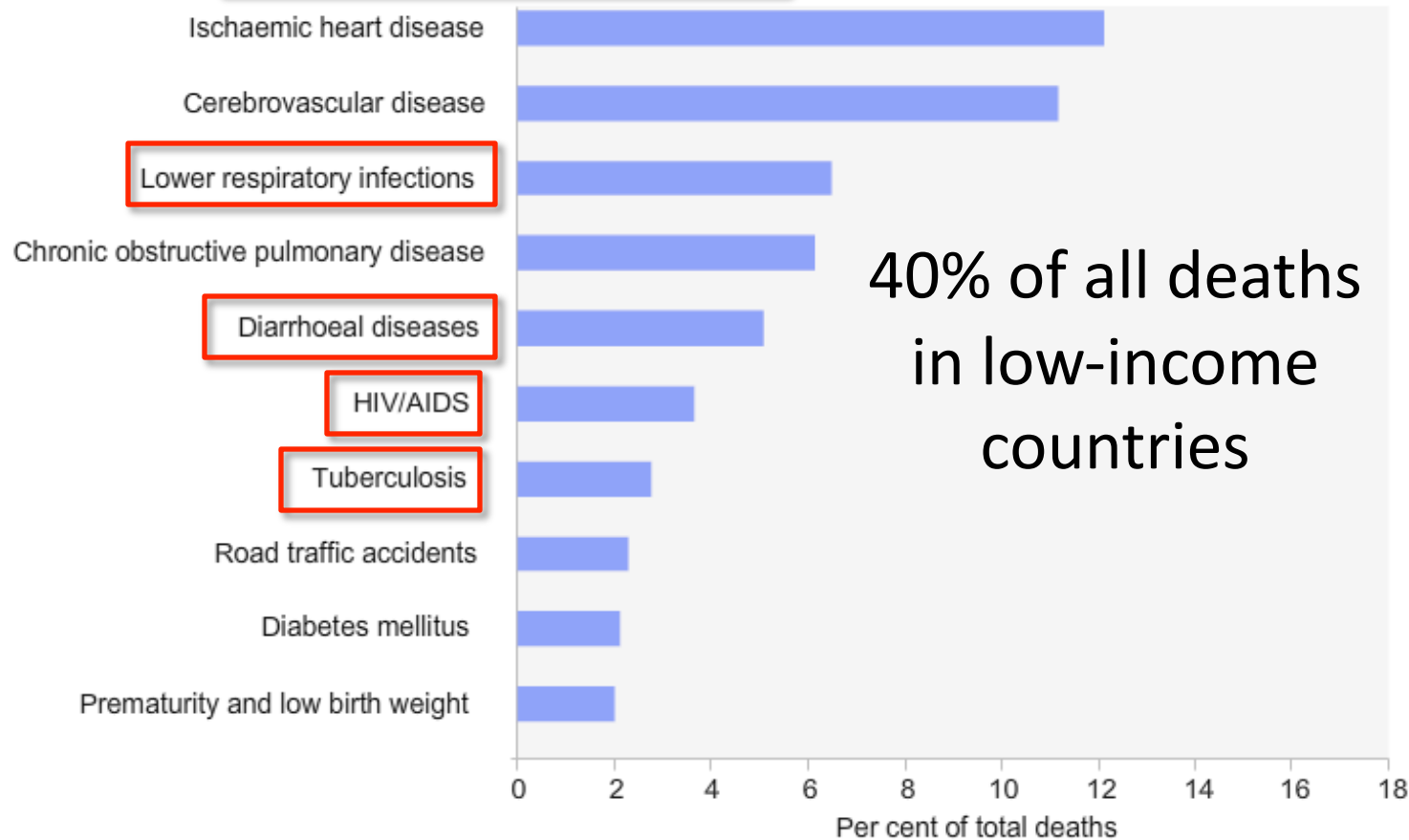
World Health Organization

Ten leading causes of deaths in 2008

Click on the country income groups below to view the related graphs

High-income countries

Low- and middle-income countries



Global Burden of Infectious Disease

Annual Mortality and Morbidity Due to Selected Infectious Diseases ¹⁻⁶		
Disease(s)	Deaths	DALYs ^a
Lower Respiratory Infections	4.2 million	94.5 million
Diarrheal Diseases	2.2 million	72.8 million
HIV/AIDS	1.8 million	58.5 million
Tuberculosis	1.3 million	34.2 million
Malaria	781 thousand	34.0 million
Measles	164 thousand	14.8 million
Neglected Diseases ^b	173-547 thousand	18.1-57.1 million
Sexually Transmitted Infections ^c	128 thousand	10.4 million
Polio	1 thousand	34 thousand
Other Infectious Diseases ^d	1.9 million	69 million

^a Disability-adjusted life years, the years of healthy life lost due to disability, sickness or premature mortality. Estimates are for 2004.
^b Includes: African trypanosomiasis, Chagas disease, schistosomiasis, leishmaniasis, lymphatic filariasis, onchocerciasis, dengue, ascariasis, trichuriasis, and hookworm.
^c Excludes HIV/AIDS.
^d Includes: pertussis, diphtheria, tetanus, meningitis, hepatitis B, hepatitis C, Japanese encephalitis, maternal sepsis, and neonatal infections.

Other Impacts of Infectious Disease

Agricultural Impacts

– Plant diseases

- Tobacco Mosaic Virus
- Grey vs. Noble rot (*Botrytis cinerea*)



– Animal Diseases

- Mad Cow Disease
- Colony Collapse Disorder?



Terminology

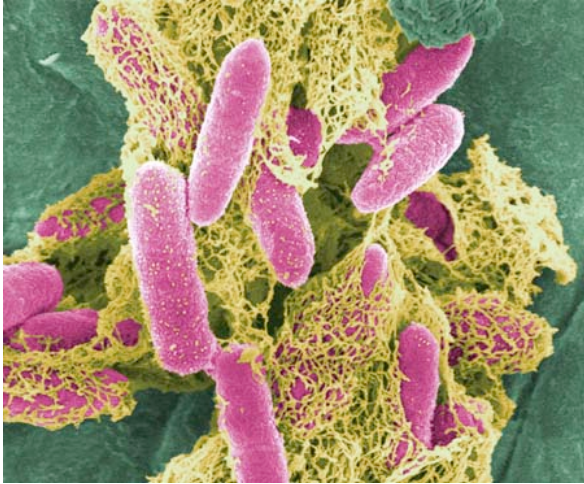
Pathogen: A pathogenic microorganism

- Primary Pathogen: Causes disease within a normal, healthy host
- Opportunistic Pathogen: Only causes disease in hosts with compromised immune systems

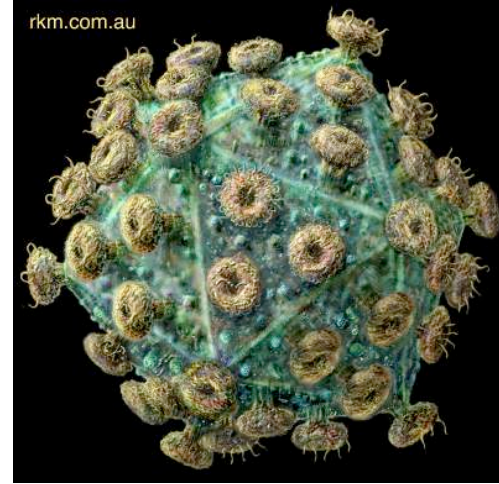
Infection: Growth of the agent within a host

Disease: Cell/tissue damage and loss of health

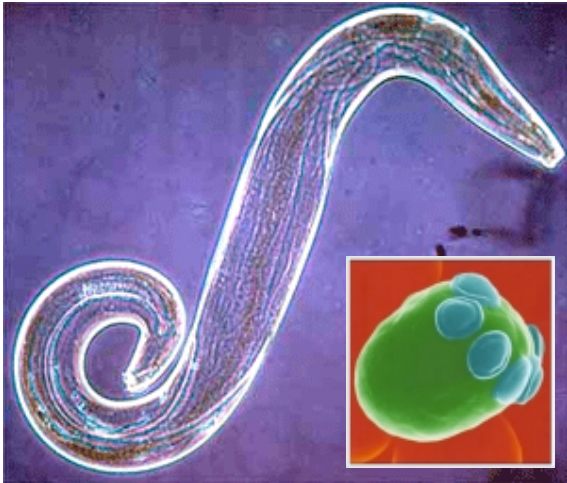
Types of Infectious Pathogens



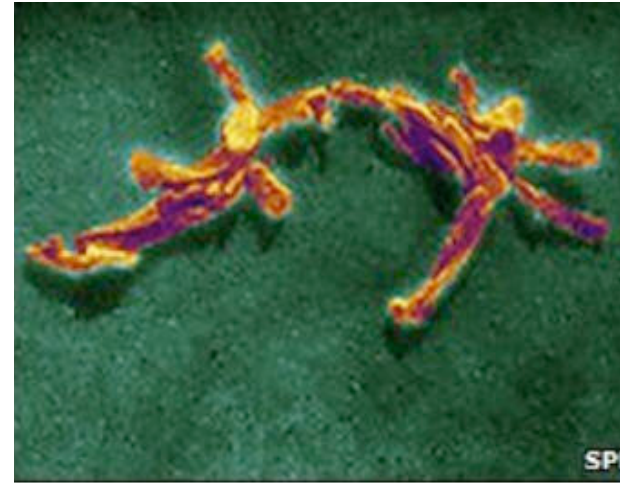
Bacteria



Viruses



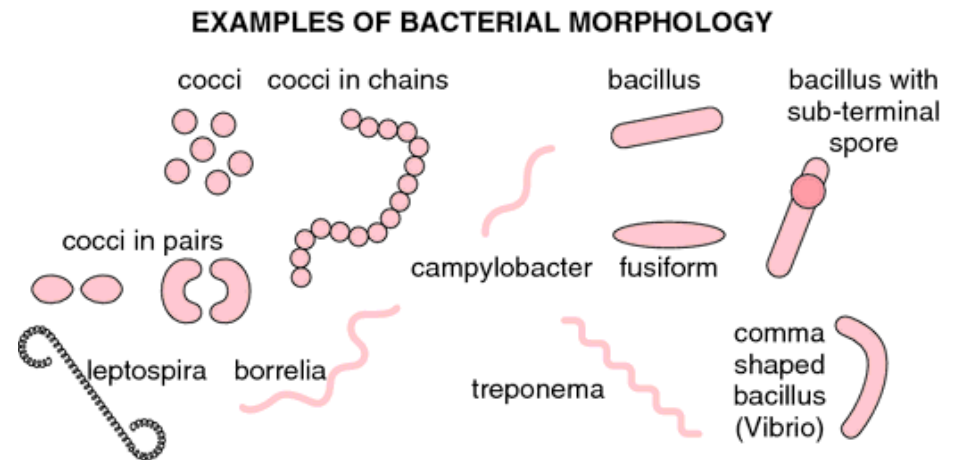
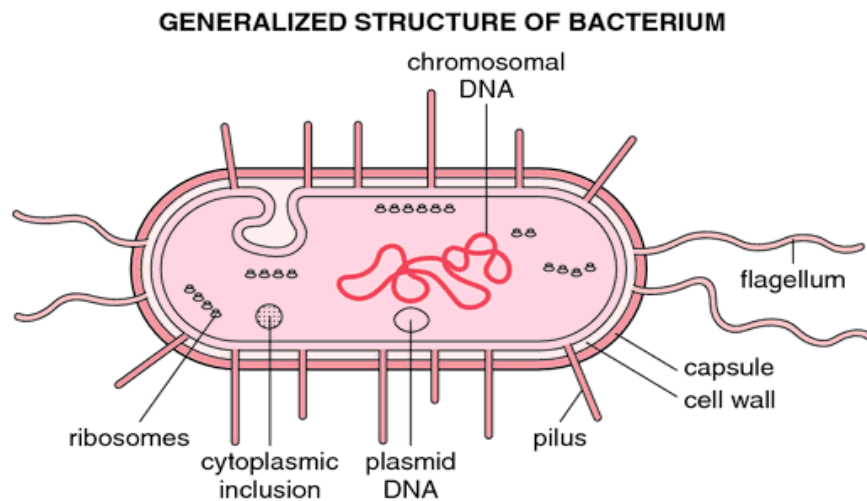
Eukaryotic



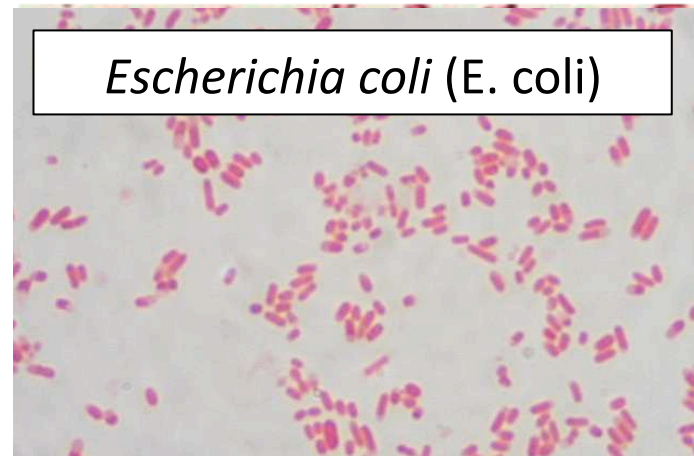
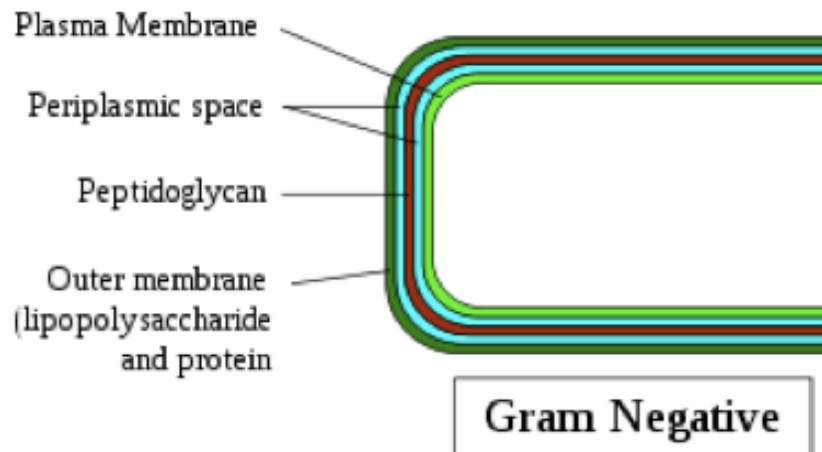
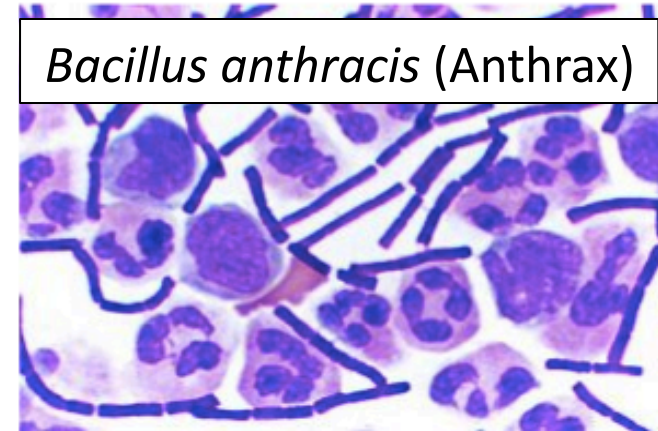
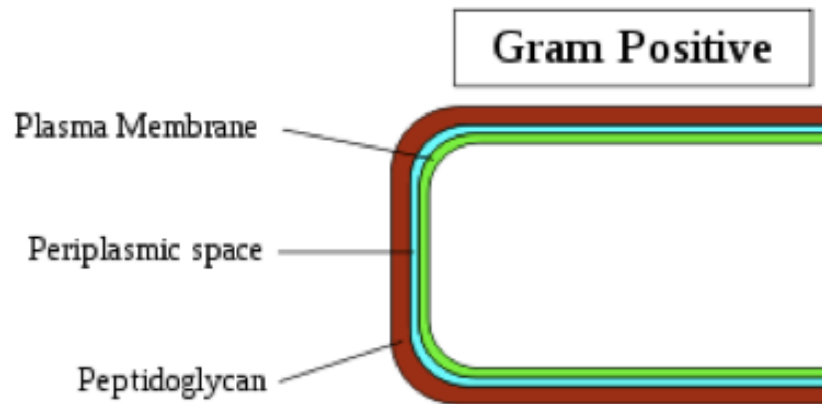
Other?

Bacteria (Prokaryotes)

- Single-celled, free-living organisms
- 0.2 to 2.0 μm \rightarrow Can be seen in a microscope
- Can be *intracellular* (live within a host cell) or *extracellular* (live outside a host cell)
- Circular DNA genome
- No organelles (nuclei, Golgi, etc).



Identifying Bacteria - The Gram Stain



Some “non-staining” bacteria – Spirochetes (Syphilis) and Mycobacteria (Tuberculosis)

Viruses

- RNA or DNA packaged in a protein coat.
- Small - 20 to 300 nm (Cells = 10 - 100x bigger)
- Obligate intracellular pathogens
 - Takes over the machinery of the host cell
 - Generates new viruses from information in viral DNA or RNA.
- Not alive - no metabolic activity.

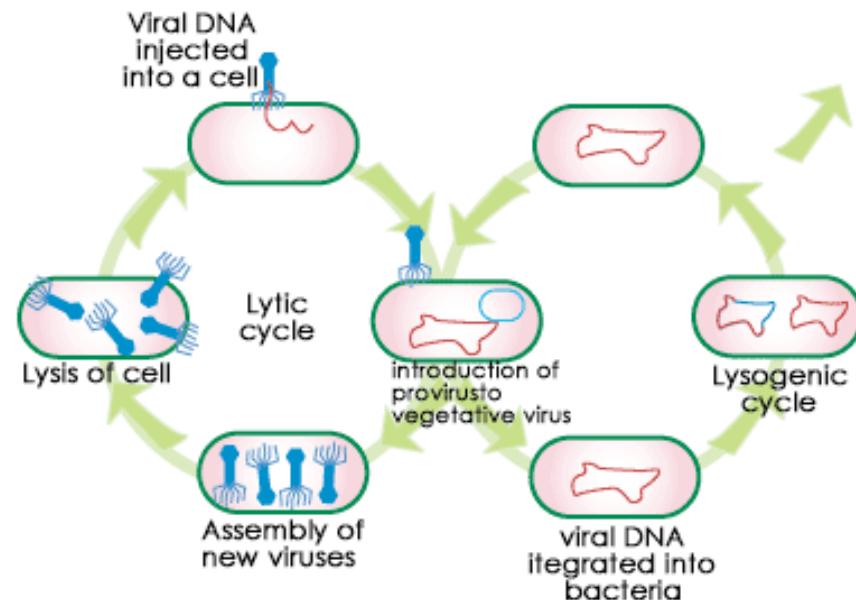
Generalized Virus Life Cycle:

Lytic Cycle:

Replication/Cell Death

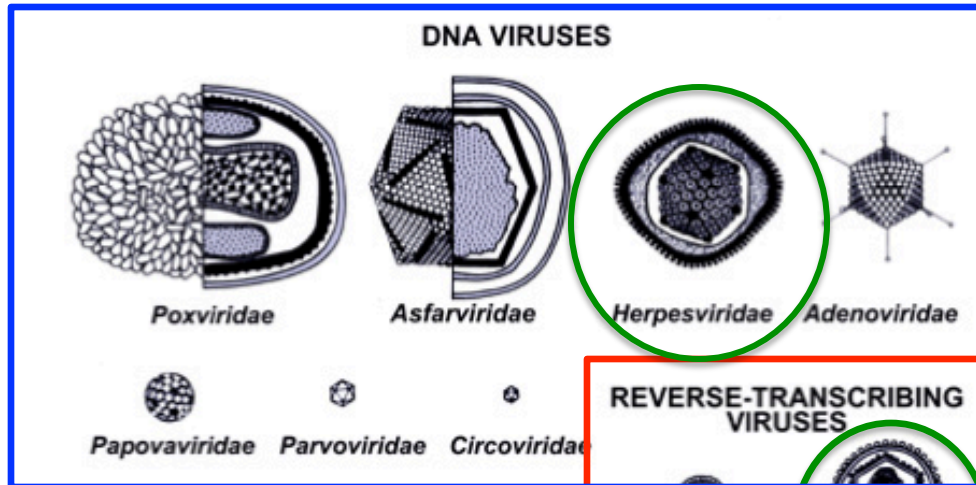
Lysogenic Cycle:

Integration/Dormancy



DNA → DNA

Example:
Herpes

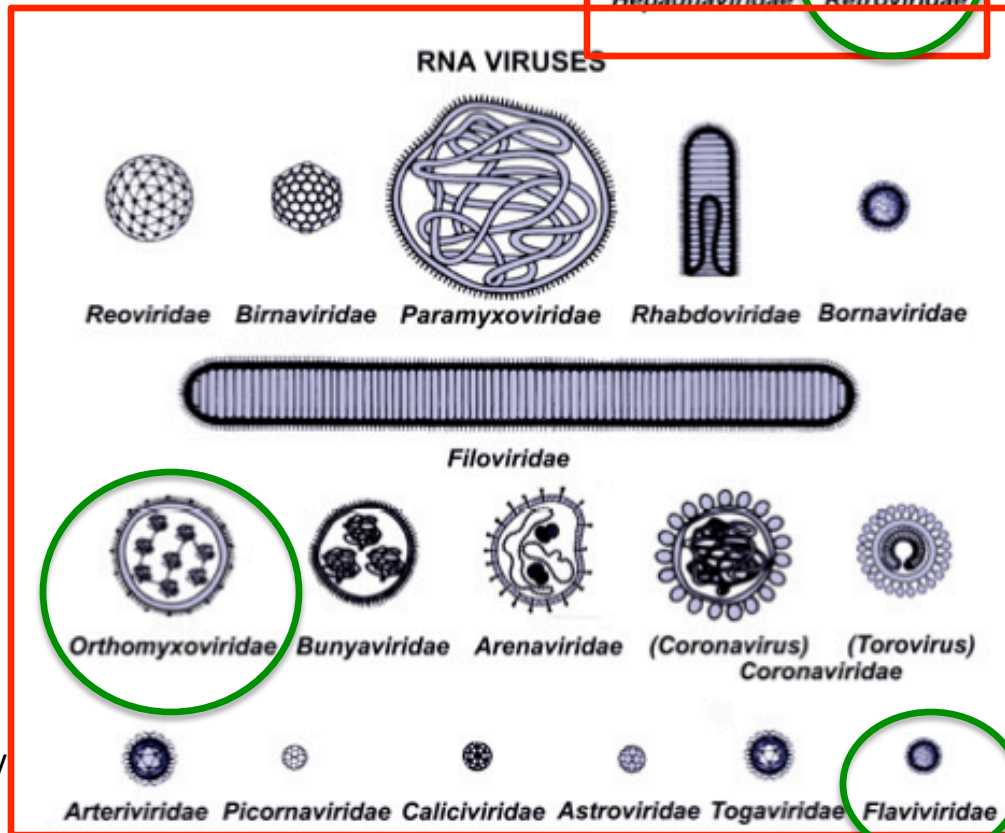


RNA → DNA →
RNA

Example: HIV

RNA → RNA

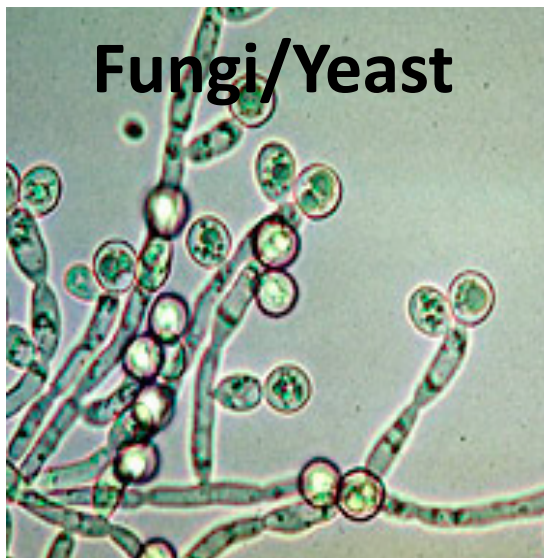
Examples:
Influenza
Hepatitis C



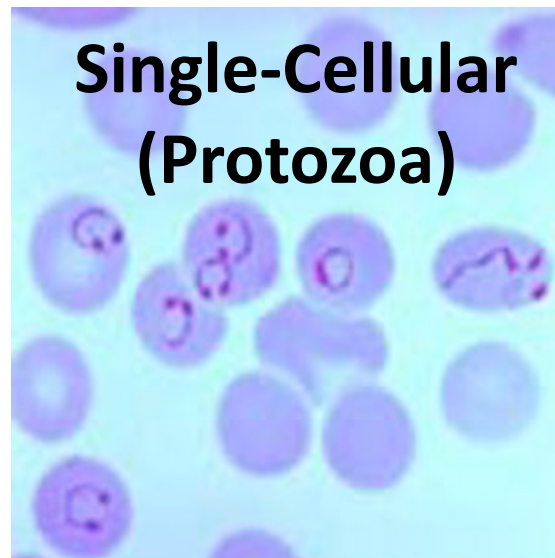
Adapted from website of FA
Murphy, School of Veterinary
Medicine, UC Davis

Eukaryotic Pathogens

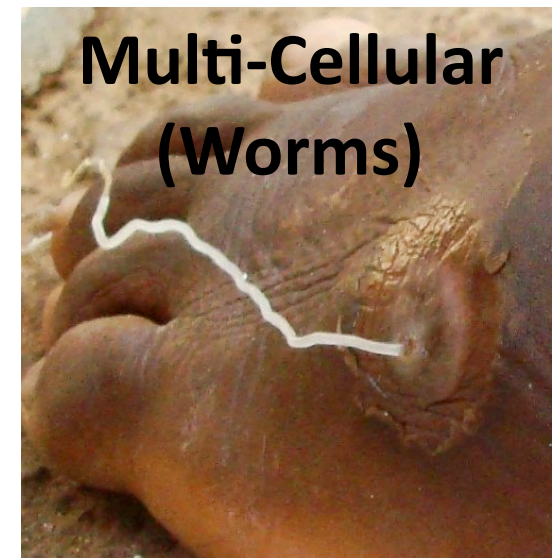
- Single-celled or multi-celled
- Intracellular or extracellular
- Similar to our cells - have a nucleus and other organelles (mitochondria, etc)



Candida albicans



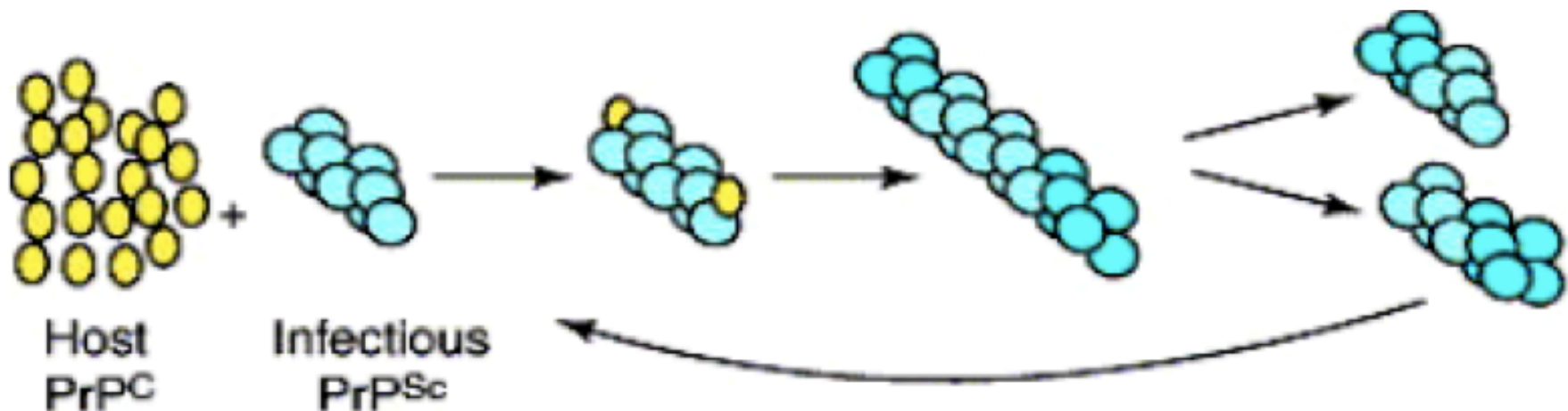
Plasmodium
(Malaria)



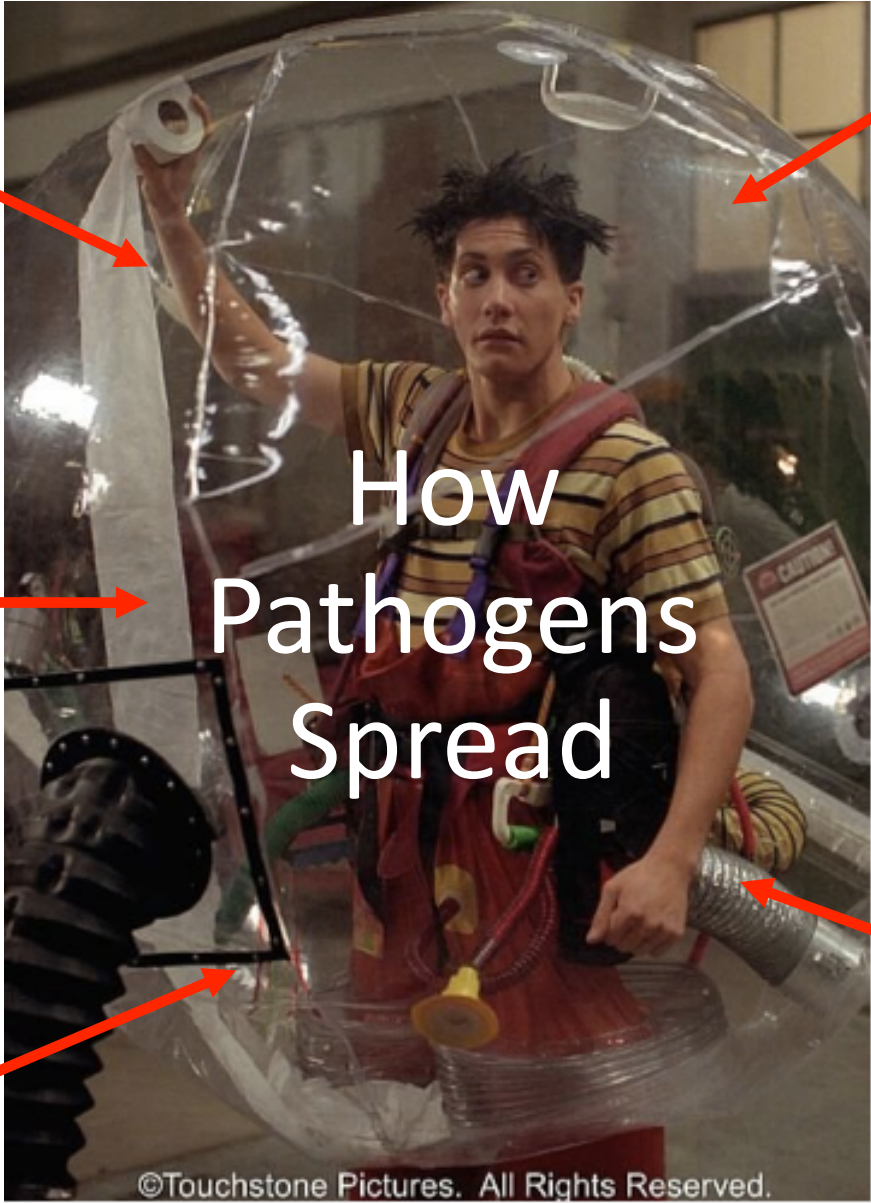
Guinea Worm

Other

- Prions
 - Proteinaceous infectious particles without nucleic acids
 - Malformed version of the neural protein **PrP**
 - Can convert normal protein to abnormal form
 - Malformed proteins form aggregates (“plaques”)
 - Neuron death → Symptoms



Examples: Mad Cow, variant Creutzfeldt-Jacob Disease (vCJD)



Airborne

Foodborne/
Waterborne

Sexually-
Transmitted

How Pathogens Spread

Insects
(Vectors)

Bloodborne

©Touchstone Pictures. All Rights Reserved.

Bubble Boy, 2001

Airborne

Pathogens spread via droplets in the air

Infection occurs through mucous membranes

- 1) Inhalation
- 2) Surface-to-Face

Examples: **Influenza, Common Cold, Smallpox, Tuberculosis**



Sexually-Transmitted

Pathogens spread during sexual activity (vaginal, oral, or anal)

Some also considered bloodborne (**HIV, Hepatitis B**)

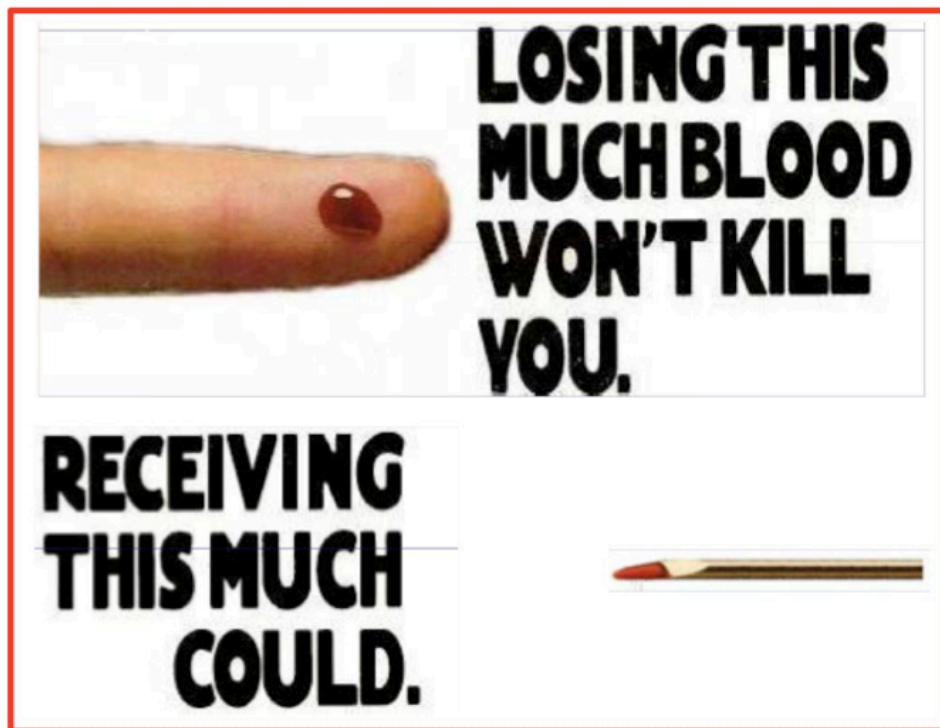
Other examples:
Syphilis, Gonorrhea, HPV



Bloodborne

Pathogens spread through contaminated blood

Routes of exposure: Shared needles, transfusions (pre-screening), open wounds/needlesticks



Examples:

HIV

Hepatitis B

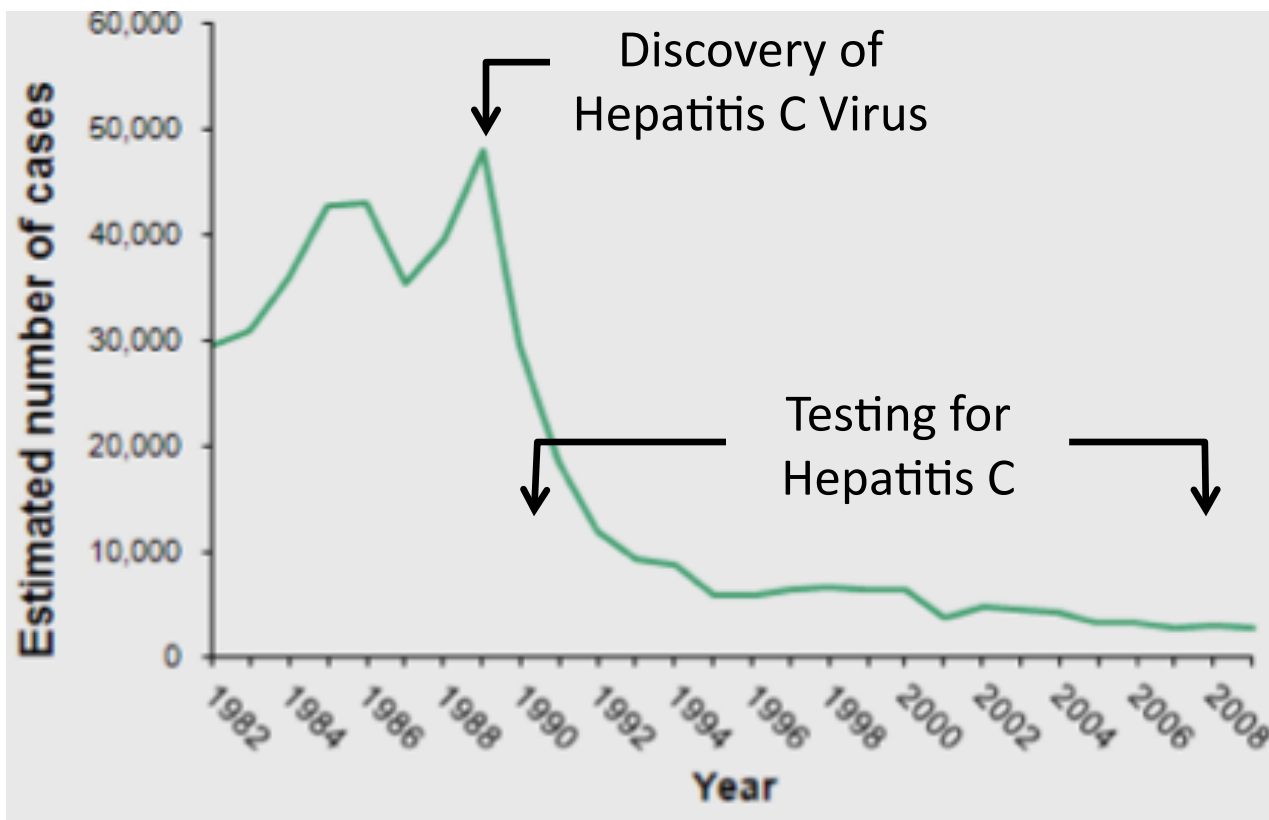
Hepatitis C

Hepatitis C: Screening the Blood Supply

Blood collection begins in the 1940's in USA

Large demand for blood for heart surgery etc.

1970's: Recognition of non-A non-B hepatitis (Hepatitis C)



Incidence of acute Hepatitis C USA, 1982-2009

Foodborne/Waterborne

Food or water contaminated by pathogens

Generally gastrointestinal symptoms

Food Contaminants	Water Contaminants
<i>E. Coli</i> Hepatitis A Virus <i>Salmonella</i>	Ghiardia Cholera Hepatitis E Virus

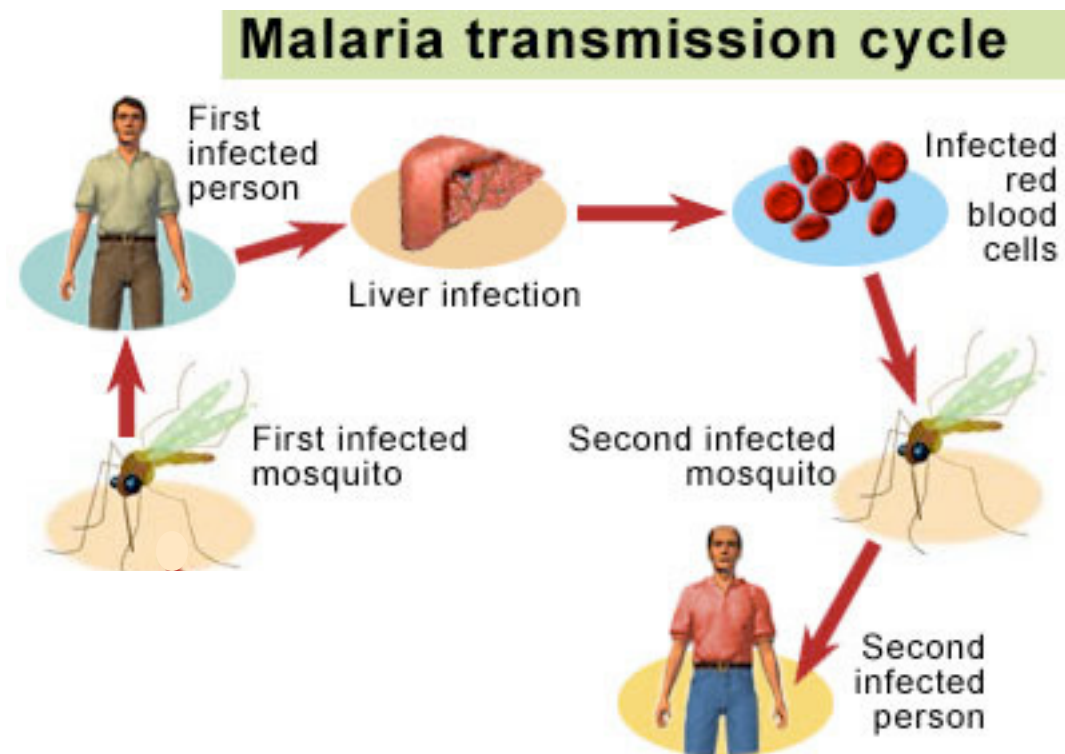
Recent Outbreaks:

- Oct 2010: Haiti (Cholera)
- Sept 2011: Cantaloupe (*Listeria*)

Insects (Vectors)

Transmitted between humans or from a reservoir to a human via an infected insect (fly, mosquito etc)

Examples: **Malaria, Lyme Disease, West Nile Virus**



Global Patterns of Disease

Infectious disease outbreaks are dynamic

Outbreaks of disease occur at different and changing frequencies

- Endemic: A common infection in a given region (Ex. Malaria in Tanzania, Africa)
- Epidemic: An increase in the number of cases of a disease over that rate usually found. A rapidly spreading new disease.
- Pandemic: Worldwide epidemic

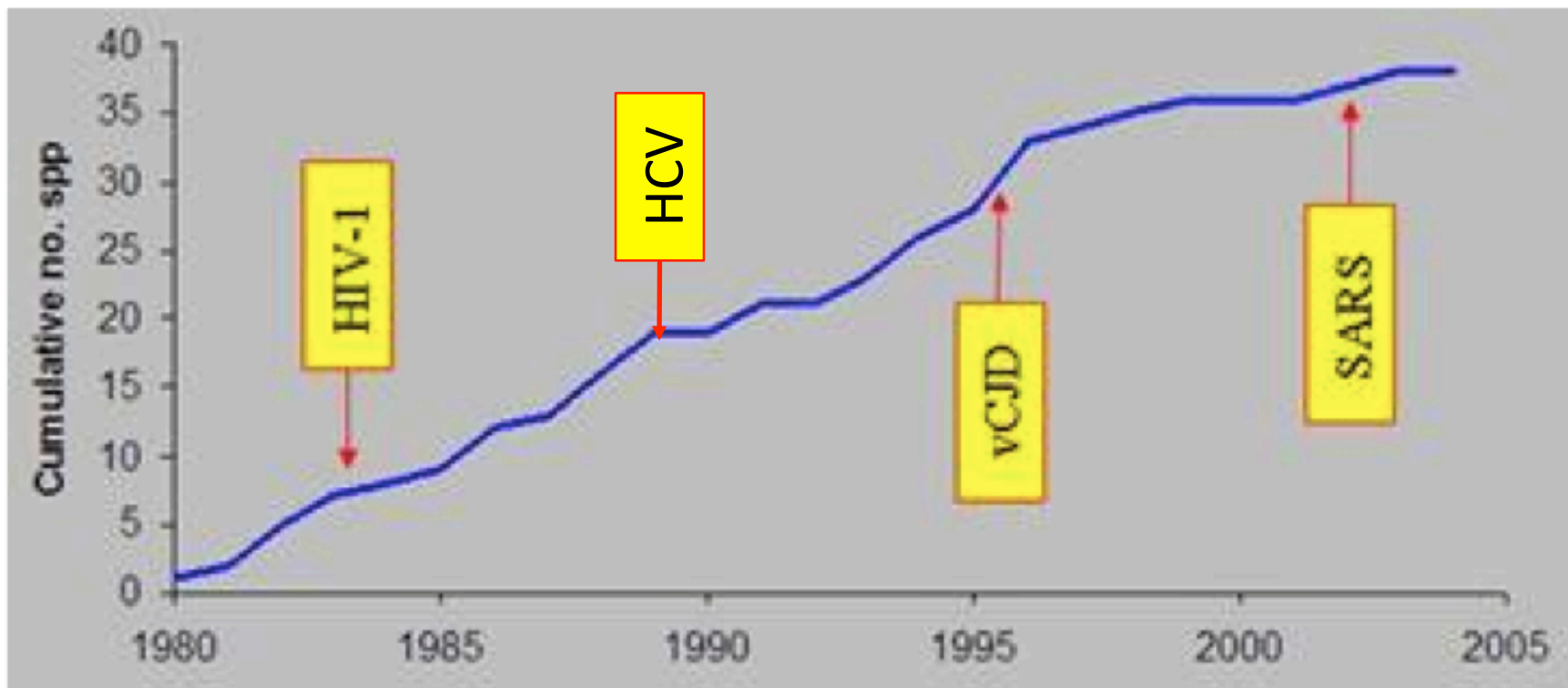
Pathogens are constantly evolving

- New pathogens emerge
- Old pathogens acquire resistance to therapies

New Pathogens are Continually Emerging

Total Known Pathogens Infecting Humans: 1415

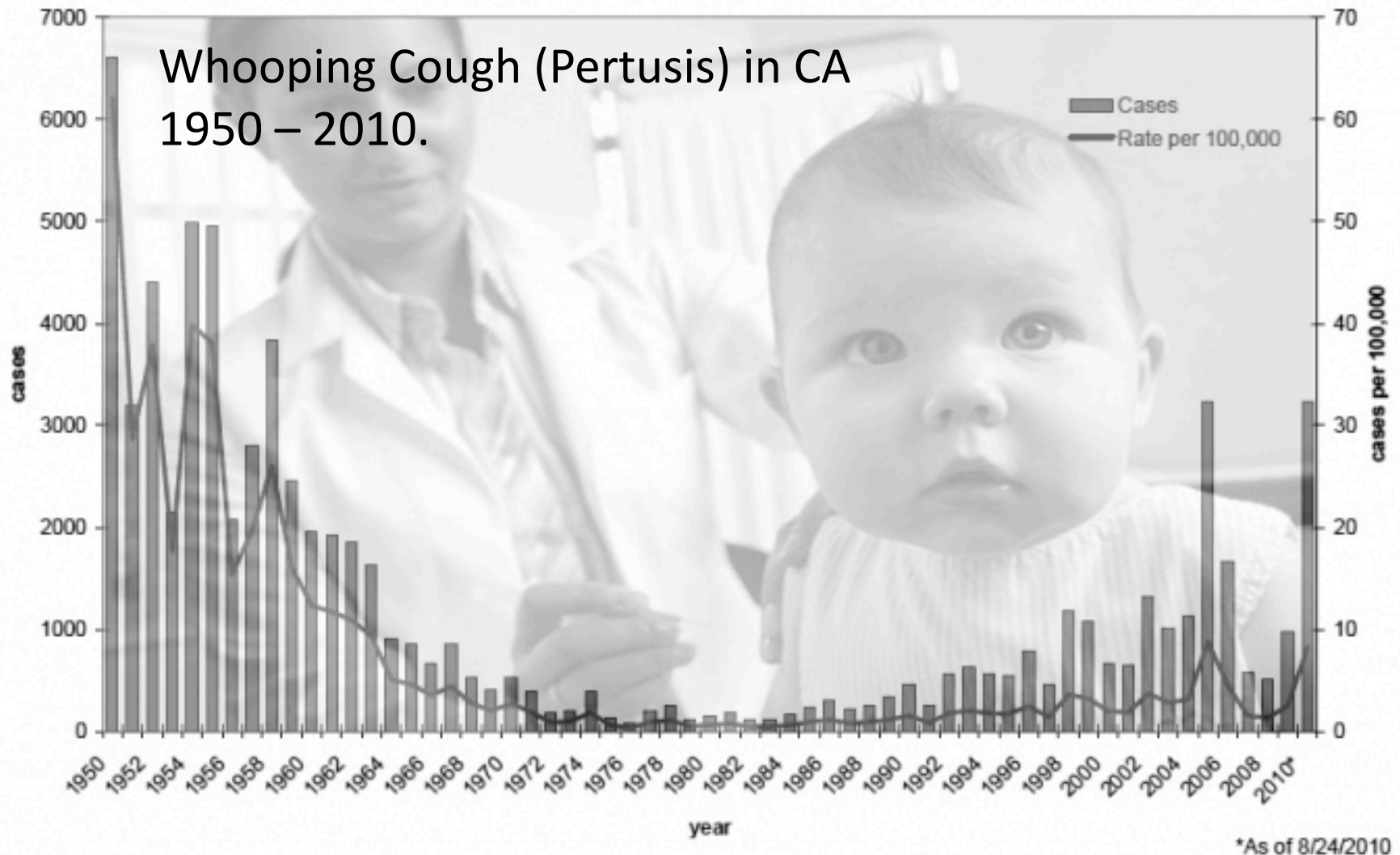
48 have been discovered since 1975



Existing pathogens are also continually evolving and expanding to new areas

“Re-emerging” Pathogens

Known pathogens turning up in increased frequency despite previously successful control

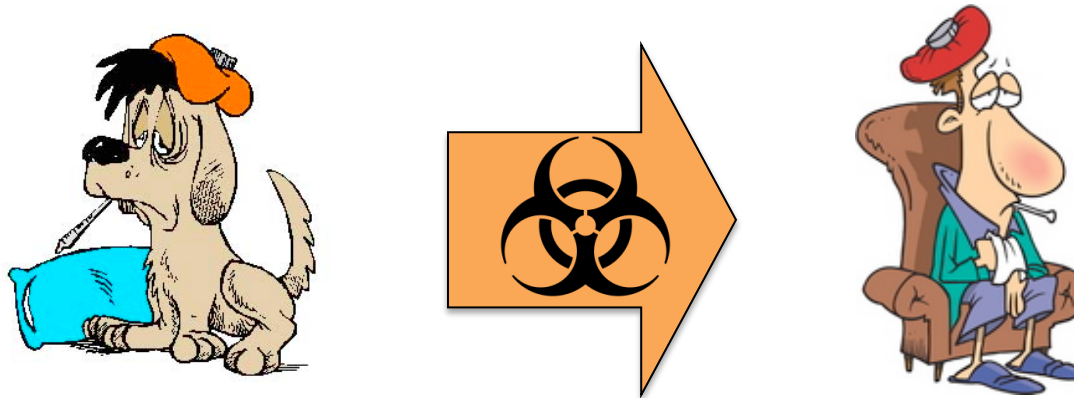


Reasons Behind Emerging and Re-emerging Pathogens

- Animal reservoirs
- Climate change
- Microbial resistance and host susceptibility
- Human behavior and migration

Animal Reservoirs

Zoonotic diseases are infectious diseases of animals that can spread and cause disease in humans.



Animals can also serve as “mixing vessels” between strains of a pathogen → Generates new strains of existing pathogens

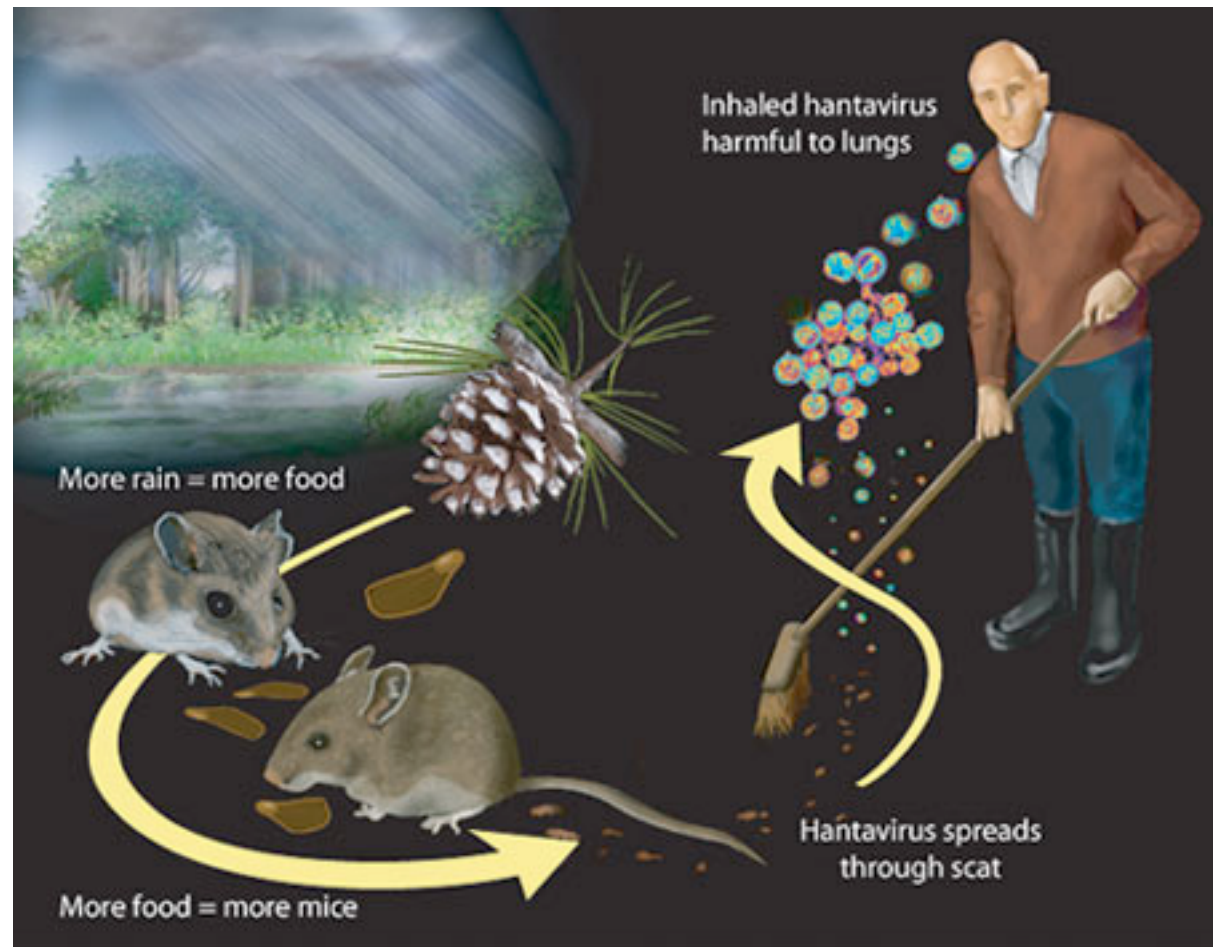
Hantavirus Spread by Deer Mice

RNA Virus

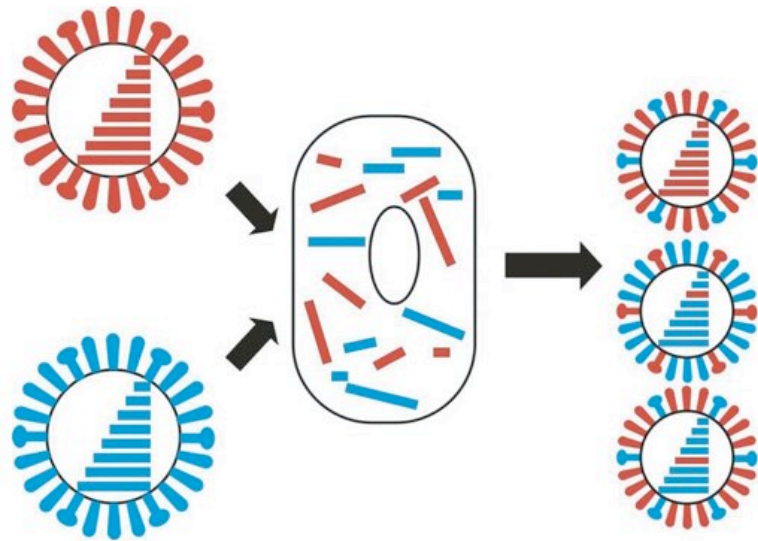
Cannot be spread between humans

Korean War:
Hemorrhagic
Fever with Renal
Syndrome (HFRS)

1993 Four Corners:
Hantavirus
Pulmonary
Syndrome (HPS)



Birds, Pigs, Influenza, Oh My!



Influenza A
RNA Virus - 7 genomic segments

Recombination of segments
between viruses leads
to new strains

Pigs can carry **Swine**
Influenza (H1N1),
Bird Influenza
(H5N1), and **Human**
Influenza viruses

Avian Flu Virus



Human Flu Virus



Mixing
Vessel



Novel
Pandemic
Virus

2009 Swine Flu Pandemic

Trifonov et al. NEJM. 2009

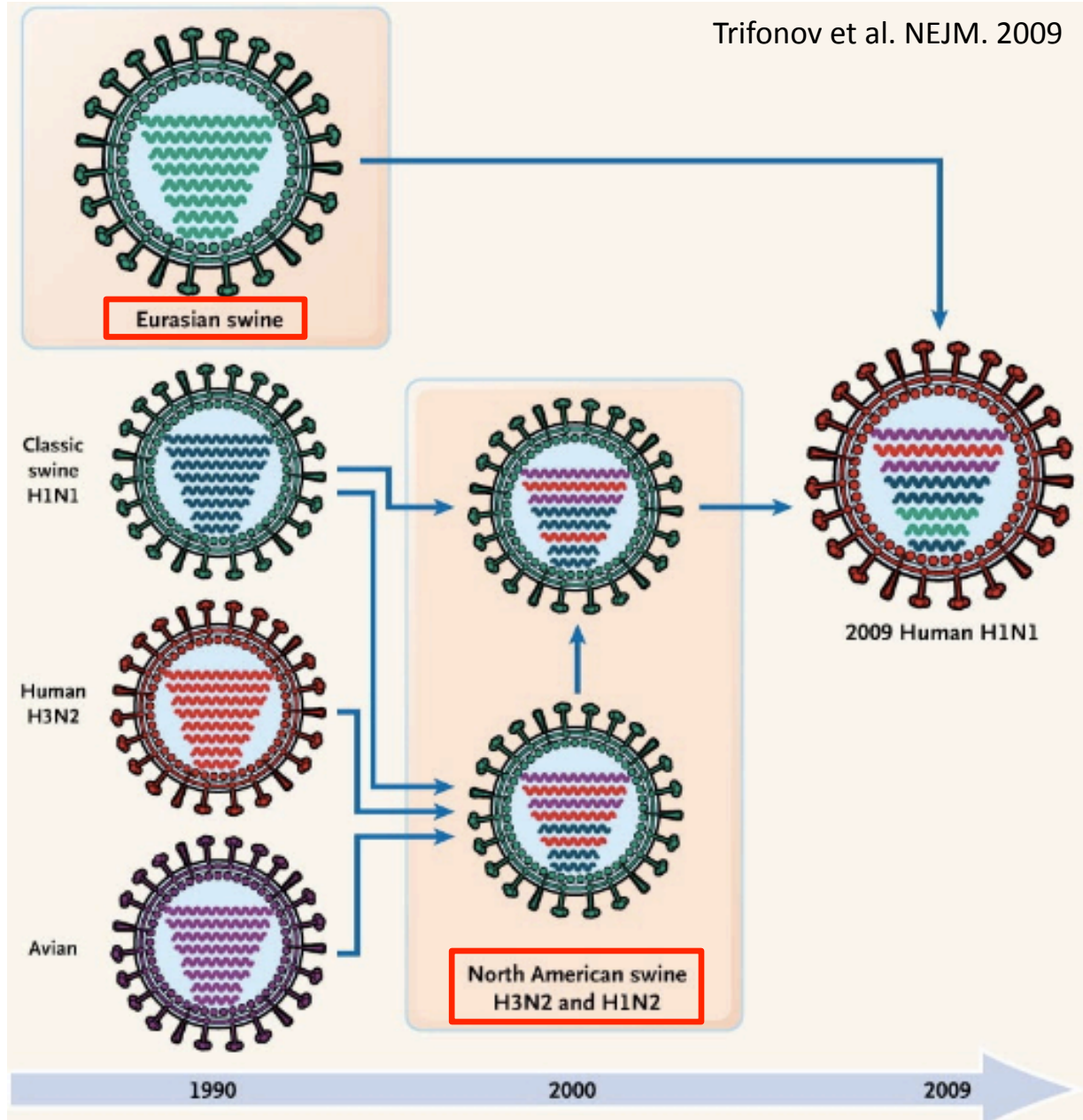
April 2009:

New human H1N1
Influenza found
in Mexico

Combination of NA
and Eurasian swine
influenzas



Likely circulated for
years in domestic pigs
being transported
between continents



Contagion Pandemic – A Real Virus!



Nipah Virus (RNA Virus, Paramyovirus family)

- Discovered in 1999 → Only 13 documented outbreaks
- Animal-to-human and (rarer) human-to-human transmission
- Effects range from asymptomatic infection to fatal encephalitis



Known
Natural
Hosts

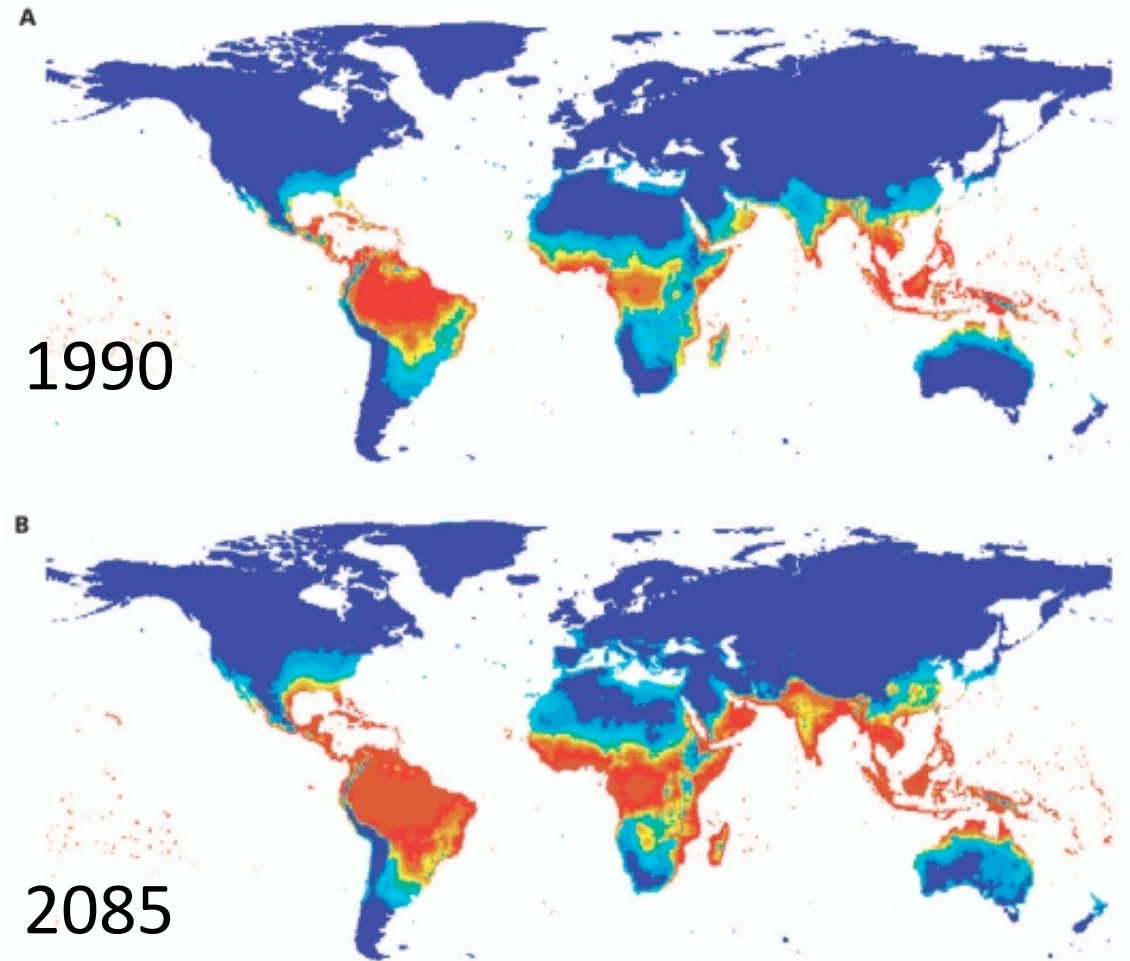


Climate Change and Vector Range

Dengue Fever

- RNA Virus
- Fever, headache, rash
- Subsequent infections often more serious

Spread by *Aedes* mosquitoes in tropical areas



Hales et al. 2002

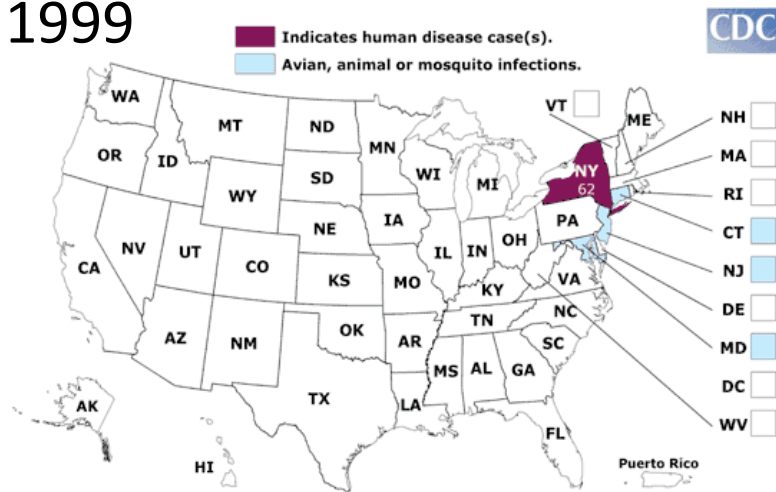
Global warming → Expanded tropical climates → Expanded mosquito range

West Nile Virus Expansion in USA

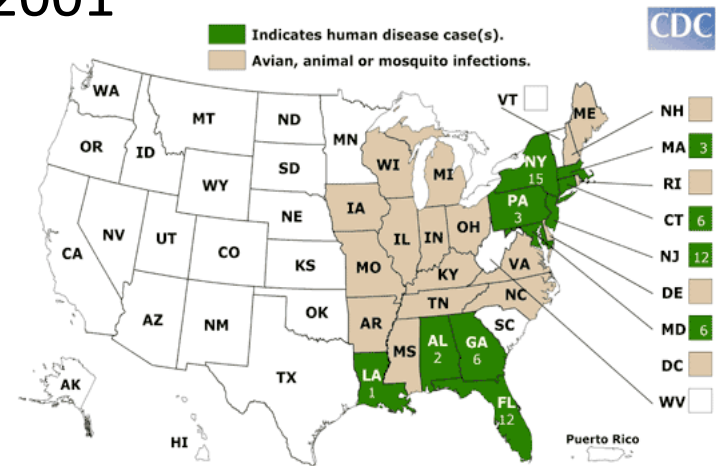
Primarily a bird disease but can infect humans

Spread by mosquitoes

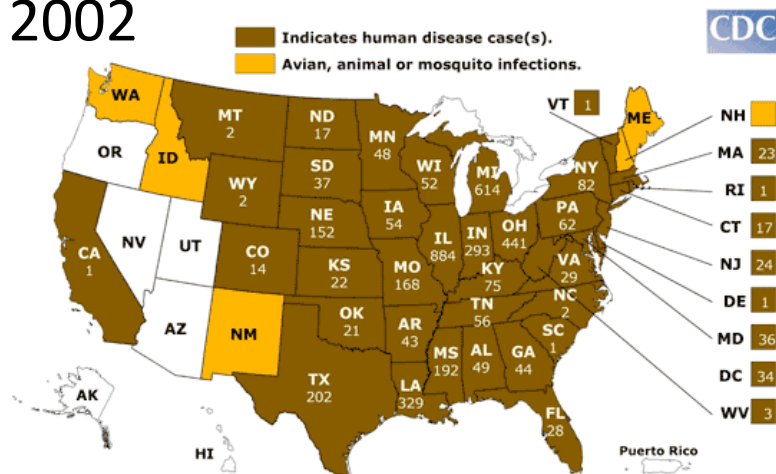
1999



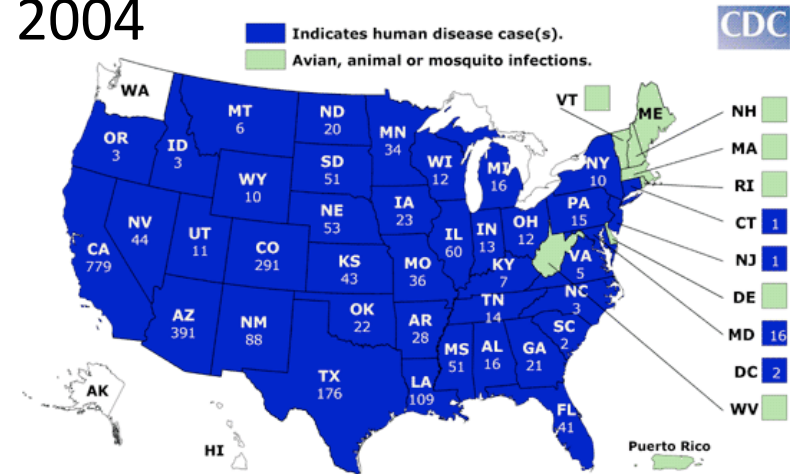
2001



2002



2004



Microbial Resistance vs. Human Susceptibility

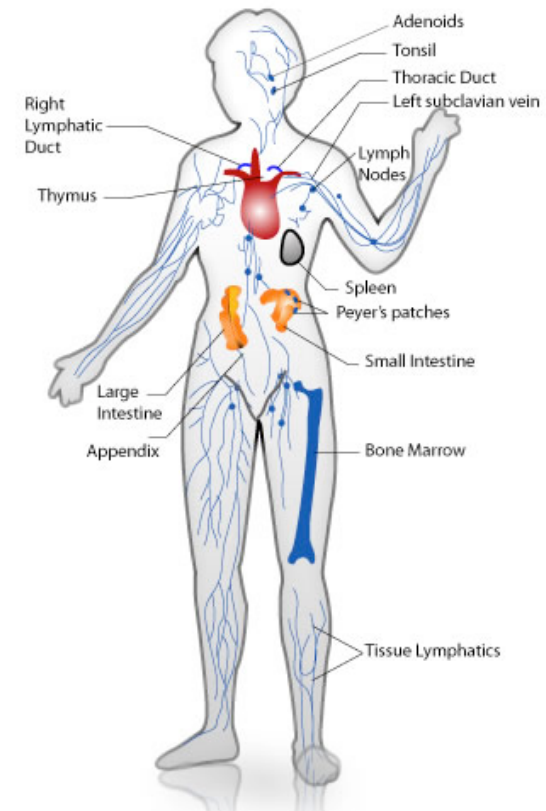
Microbial Evolution



It was on a short-cut through the hospital kitchens that Albert was first approached by a member of the Antibiotic Resistance.

Drug resistance makes pathogens more virulent

Human Immune System



Compromised immunity increases infection risk

Opportunistic Infections in HIV/AIDS

HIV infection causes a decline in CD4+ T cells →
Main “director” cell of the immune system

Depletion leads to opportunistic infections and death

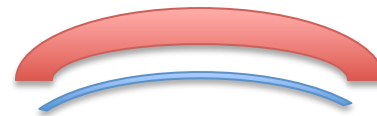
AIDS Stage	Opportunistic Infection
Pre-AIDS	<i>Candida</i> (Yeast) Shingles (Virus)
AIDS CD4+ < 200 cells/ul blood	Tuberculosis (Bacteria) Pneumocystis (Yeast)
CD4+ < 100 cells/ ul blood	CMV Infection (Virus) Dimorphic fungi infection
CD4+ < 50 cells/ul blood	MAC (Bacteria) Toxoplasmosis (Parasite)

Drug Resistance

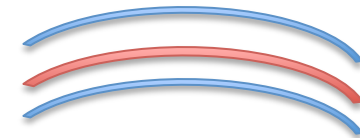
Primary (Intrinsic)

Characteristic of the pathogen

Penicillin attacks bacterial cell wall synthesis – gram (-) less susceptible



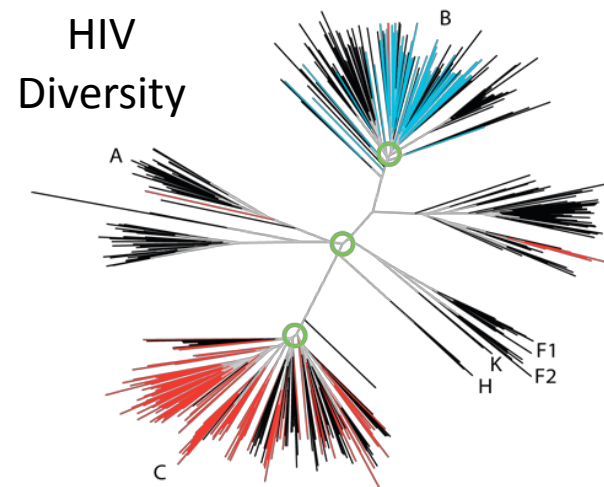
Gram (+)



Gram (-)

Secondary (Acquired)

Stable (mutation) or Transient (plasmids)



HIV rapidly mutates



Drug no longer recognizes target

Drugs DO NOT cause resistance mutations – they select already resistant strains for survival

Practices That Promote Resistance

Drugs in animal feed for growth and disease prevention

- 70% of antibiotics are used in animals

Failure to complete full treatment

- Side effects → Tuberculosis, Hepatitis C
- Because patient “feels better”

Inappropriate use of drugs

- Antibiotic for cold or influenza viruses

Hospital transmission (MRSA)

Over the counter use in developing countries

International travel

Human Behavior and Migration

Social factors greatly impact pathogen spread/emergence

International Travel



War



Poverty

VOICE OF THE ENVIRONMENT

**INVESTIGATING THE
AUTISM EPIDEMIC**

Misinformation
& Fear



Natural Disasters Also Lead to Breakdown of Public Health Resources

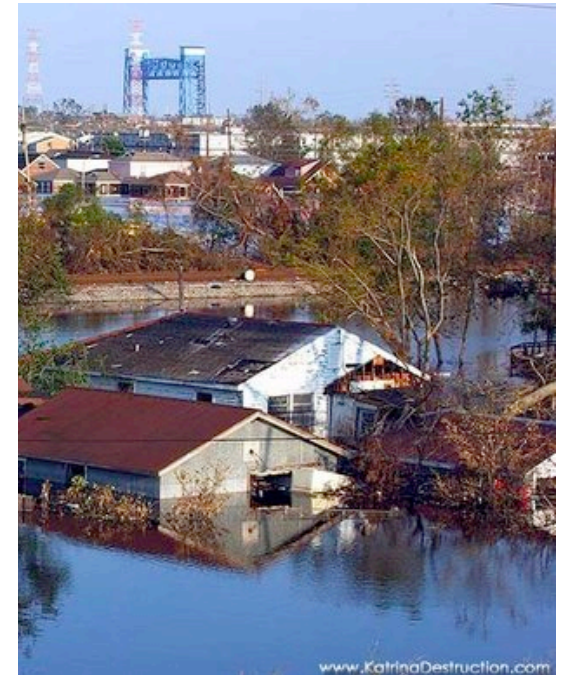
Famine –
Somalia, 2011



Earthquake –
Haiti, 2010



Hurricane Katrina –
New Orleans, 2005



Lack of available resources (medicine, trained personnel, emergency plans, proper sanitation, etc) make fighting epidemic disease that much harder

Combating Infectious Disease

Major advances over the past 100 years help control the impact of pathogens worldwide

Drugs

- Penicillin → First antibiotic, mass-produced in 1944

Vaccines

- First vaccine: Smallpox → Edward Jenner, 1796 (Eradicated 1979)
- Salk (1955) and Sabin (1962) Polio vaccines

Non-medicinal interventions

- Bednets for malaria prevention
- Promotion of condom use in areas of high HIV/AIDS
- Municipal water chlorination

Surveillance

Monitoring Increases the Chance of Early Outbreak Detection and Intervention

Incidence: Number of *new* cases
of a disease

Prevalence: *Total number* of cases
of a disease

Morbidity: Illness/Disability

Mortality: Death

DALY: Disability Adjusted Life Years -
measure of total morbidity and
mortality for a disease

Global



World Health
Organization

National



CENTERS FOR DISEASE™
CONTROL AND PREVENTION

Local



Notifiable Conditions and the Health Care Provider



The following conditions are notifiable to local public health authorities in Washington in accordance with WAC 246-101. Timeframes for notification are indicated in footnotes. **Immediately notifiable conditions are indicated in bold** and should be reported when suspected or confirmed.

- Acquired immunodeficiency syndrome (AIDS)³ (including AIDS in persons previously reported with HIV infection)
- Animal bites**¹
- Arboviral disease³ (West Nile virus disease, dengue, Eastern & Western equine encephalitis, etc.)
- Botulism**¹ (foodborne, wound and infant)
- Brucellosis**¹
- Campylobacteriosis³
- Chancroid³
- Chlamydia trachomatis*³
- Cholera**¹
- Cryptosporidiosis³
- Cyclosporiasis³
- Diphtheria**¹
- Disease of suspected bioterrorism origin**¹ (including Anthrax and Smallpox)
- Disease of suspected foodborne origin**¹ (clusters only)
- Disease of suspected waterborne origin**¹ (clusters only)
- Enterohemorrhagic *E. coli*, including *E. coli* O157:H7 infection**¹
- Giardiasis³
- Gonorrhea³
- Granuloma inguinale³
- Haemophilus influenzae* invasive disease**¹ (under age five years, excluding otitis media)
- Hantavirus pulmonary syndrome³
- Hemolytic uremic syndrome (HUS)**¹
- Hepatitis A, acute**¹
- Hepatitis B, acute³; chronic^M (initial diagnosis only)
- Hepatitis B, surface antigen positive pregnant women³
- Hepatitis C, acute and chronic^M (initial diagnosis only)
- Hepatitis, unspecified (infectious)³
- Herpes simplex, genital (initial infection only) and neonatal³
- HIV infection³
- Immunization reactions³ (severe, adverse)
- Legionellosis³
- Leptospirosis³
- Listeriosis**¹
- Lyme disease³
- Lymphogranuloma venereum³
- Malaria³
- Measles (rubeola)**¹
- Meningococcal disease**¹
- Mumps³
- Paralytic shellfish poisoning**¹
- Pertussis**¹
- Plague**¹
- Poliomyelitis**¹
- Psittacosis³
- Q fever³
- Rabies**¹
- Rabies post-exposure prophylaxis³
- Relapsing fever (borreliosis)**¹
- Rubella**¹ (including congenital)
- Salmonellosis**¹
- Shigellosis**¹
- Syphilis³ (including congenital)
- Tetanus³
- Trichinosis³
- Tuberculosis**¹
- Tularemia³
- Typhus**¹
- Vibriosis³
- Yellow fever**¹
- Yersiniosis³
- Unexplained critical illness or death**¹
- Rare diseases of public health significance**¹

Table 2. Foodborne Outbreaks Reported to Washington State Department of Health, 2009

No.	Month	County	Illness Agent	Total # ill	# Ill lab confirmed	Food Source	Setting	Contributing Factors
1	Jan	{ Multiple }	<i>Salmonella</i> Typhimurium	25	25	Peanut butter	Commercial product	Unknown
2	Jan	{ Multiple }	<i>Salmonella</i> Rissen	3	3	White pepper	Commercial product	Contaminated raw product
3	Feb	Snohomish	Virus*	13	--	Pea salad	Church	Unknown
4	March	King	Hepatitis A	6	6	Restaurant meal	Restaurant	Infected food handler
5	April	Jefferson	Virus*	10	--	Restaurant meal	Restaurant	Insufficient handwashing
6	May	{ Multiple }	<i>E. coli</i> O157:H7	5	5	Cookie dough	Commercial product	Contaminated raw product; insufficient initial cooking time/temperature
7	June	Stevens	Norovirus	13	6	Ill food worker	Restaurant	Bare-handed contact
8	June	Clallam	Virus*	56	--	Potato salad	Group camp	Unknown
9	June	{ Multiple }	<i>Salmonella</i> Muenchen	4	4	Sandwiches	Cafeteria/Deli	Unknown
10	June	King	Virus*	2	--	Salad	Restaurant	Infected worker
11	June	{ Multiple }	<i>Salmonella</i> Newport	6	6	Burritos	Restaurant	Unknown
12	June	King	Virus*	4	--	Restaurant meal	Restaurant	Bare-handed contact; infected worker; storage in contaminated environment
13	June	Clark	Scombroid poisoning	3	--	Fish	Food Market	Toxic substance part of tissue
14	July	Clark	<i>Salmonella</i> Enteritidis	54	15	Eggs	Camp	Contaminated raw product; process failures that permit pathogen survival
15	July	Chelan	Norovirus	7	2	Take out meal	Workplace	Ill food worker
16	July	King	<i>Bacillus cereus</i>	15	1	Pasta	Catered event	Food preparation practices that support proliferation of pathogens; improper cold holding; slow cooling
17	July	{ Multiple }	<i>Salmonella</i> Typhimurium	26	26	Lettuce	Commercial product	Contaminated raw product
18	July	King	<i>Salmonella</i>	17	9	Restaurant meal	Restaurant	Contaminated raw product; cross-contamination of ingredients; bare-handed contact; contaminated storage environment
19	July	King	Chemical ingestion	2	--	Unidentified chemical	Restaurant	Poisonous substance inadvertently added
20	August	King	<i>Salmonella</i> Enteritidis	2	2	Eggs	Restaurant	Cross-contamination of ingredients; improper cold holding
21	Sept	Jefferson	Bacterial toxin	5	--	Pizza	Home delivery	Unknown
22	Sept	King	<i>E. coli</i> O157:H7	2	2	Unidentified	Restaurant	Unknown
23	Sept	King	Virus*	4	--	Ill food worker	Restaurant	Cross-contamination of ingredients; glove-handed contact by an infected food handler
24	Sept	{ Multiple }	Shiga toxin-producing <i>E. coli</i>	3	3	Raw milk	Dairy product	Contaminated raw product
25	Sept	King	<i>E. coli</i> O157:H7	4	3	Unidentified	Restaurant	Unknown
26	Oct	Benton	<i>Salmonella</i> Enteritidis	6	6	Pork	Restaurant	Unknown
27	Nov	King	Virus*	10	--	Ill food worker	Restaurant	Bare-handed contact; glove-handed contact by an infected food handler

* Agent not lab confirmed

Full 2009 Report: <http://www.doh.wa.gov/notify/annlrpt/cdr2009.pdf>

ProMed Alerts

International
Society for
Infectious
Diseases
(www.isid.org)

Daily tracking
of current
outbreaks
worldwide

PROMED-MAIL DAILY UPDATE 08-NOV-2011

A ProMED-mail post

<http://www.promedmail.org>

ProMED-mail is a program of the
International Society for Infectious Diseases

<http://www.isid.org>

08-Nov-2011

Dengue/DHF update 2011 (44)

<http://apex.oracle.com/pls/otn/pm?an=20111108.3320>

Infectious salmon anemia - Canada (02): (BC)

<http://apex.oracle.com/pls/otn/pm?an=20111108.3321>

Anthrax, human, bovine - Uganda (02): (Western)

<http://apex.oracle.com/pls/otn/pm?an=20111108.3322>

Avian influenza (68): H5N1 transmissibility to ferrets

<http://apex.oracle.com/pls/otn/pm?an=20111108.3323>

Tularemia, human, possum - Australia (02): (TS), RFI

<http://apex.oracle.com/pls/otn/pm?an=20111108.3324>

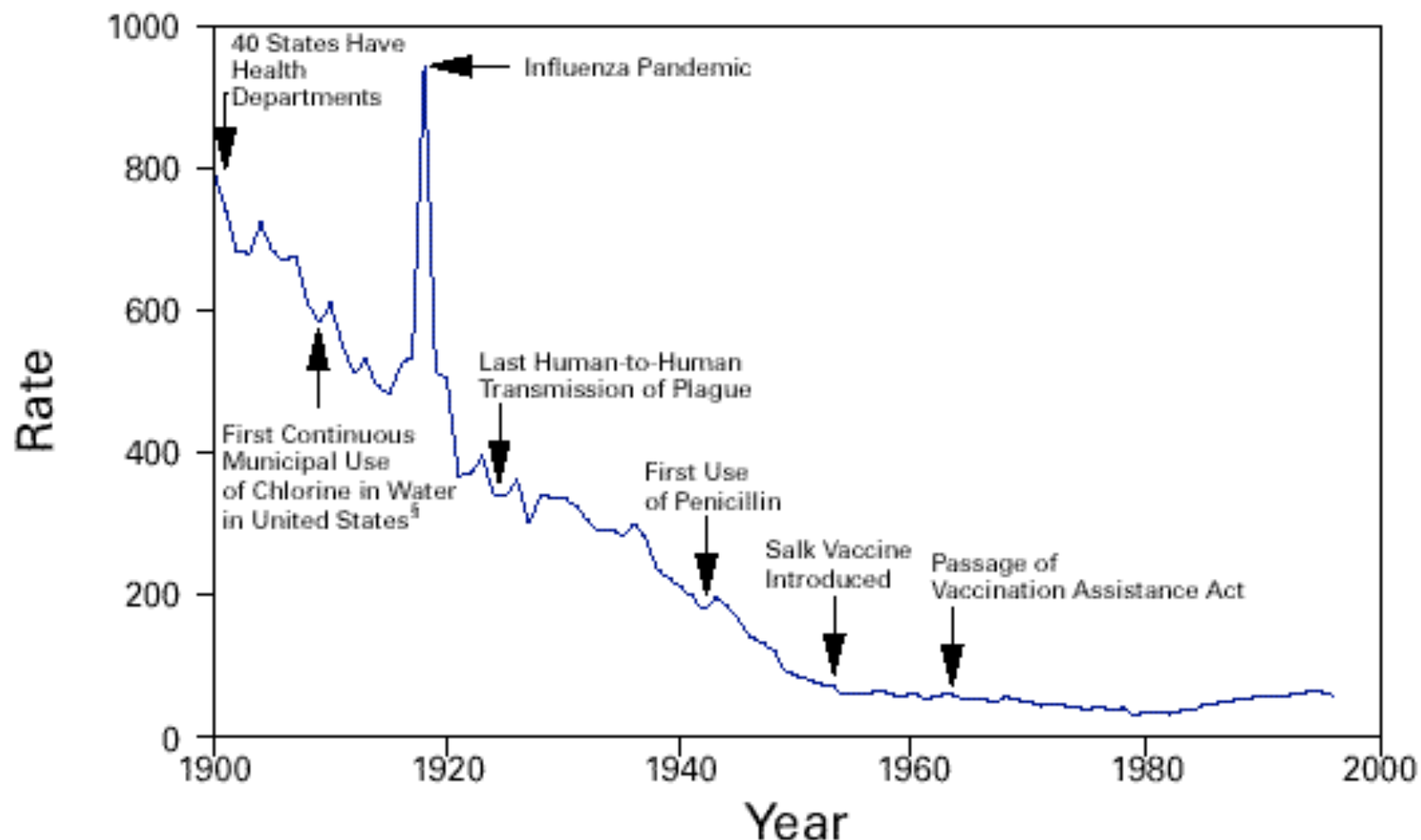
Global Incident Map

(For those who enjoy paranoia!)



<http://outbreaks.globalincidentmap.com/home.php>

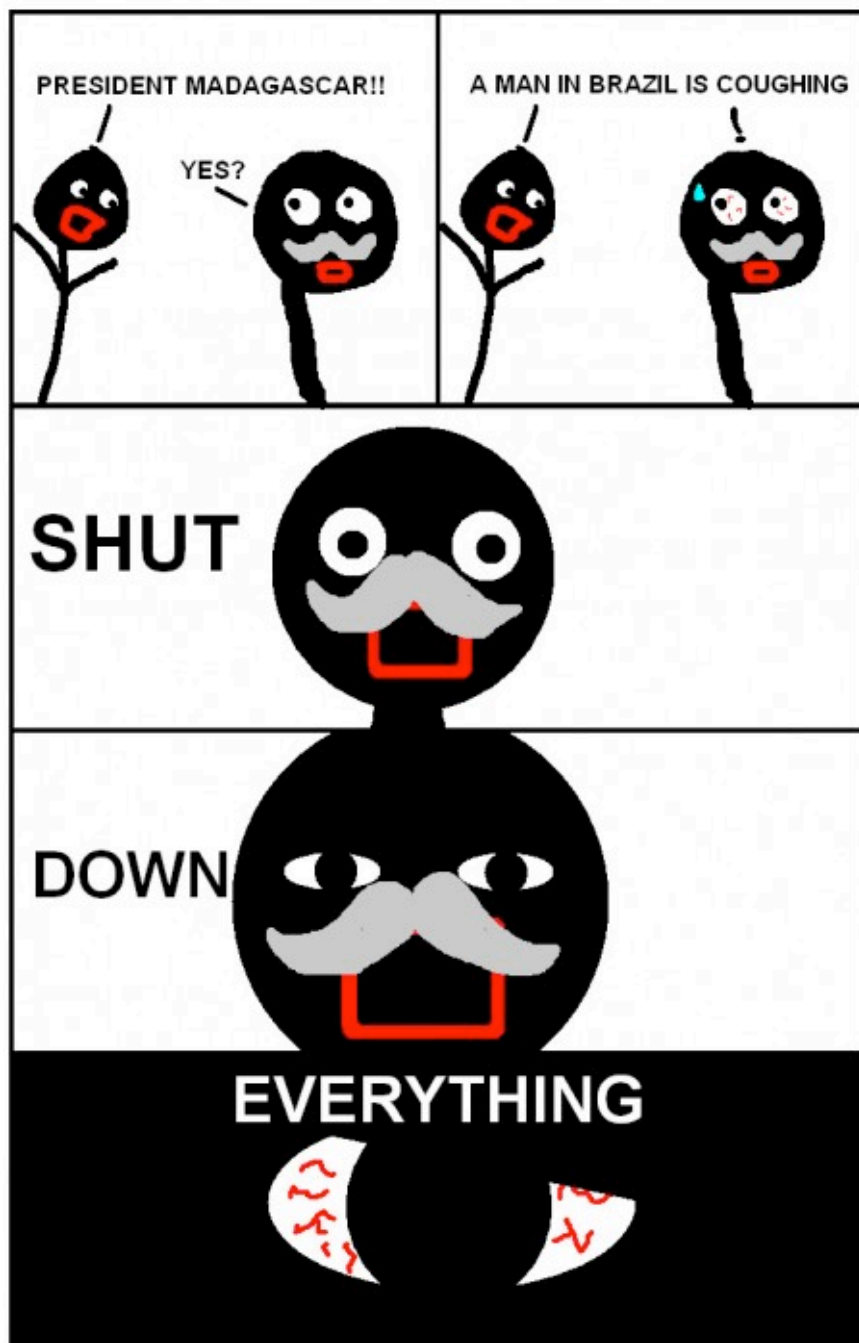
FIGURE 1. Crude death rate* for infectious diseases — United States, 1900–1996†



*Per 100,000 population per year.

†Adapted from Armstrong GL, Conn LA, Pinner RW. Trends in infectious disease mortality in the United States during the 20th century. *JAMA* 1999;281:61–6.

§American Water Works Association. Water chlorination principles and practices: AWWA manual M20. Denver, Colorado: American Water Works Association, 1973.



Questions?

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