Breaking the Chain of Infection

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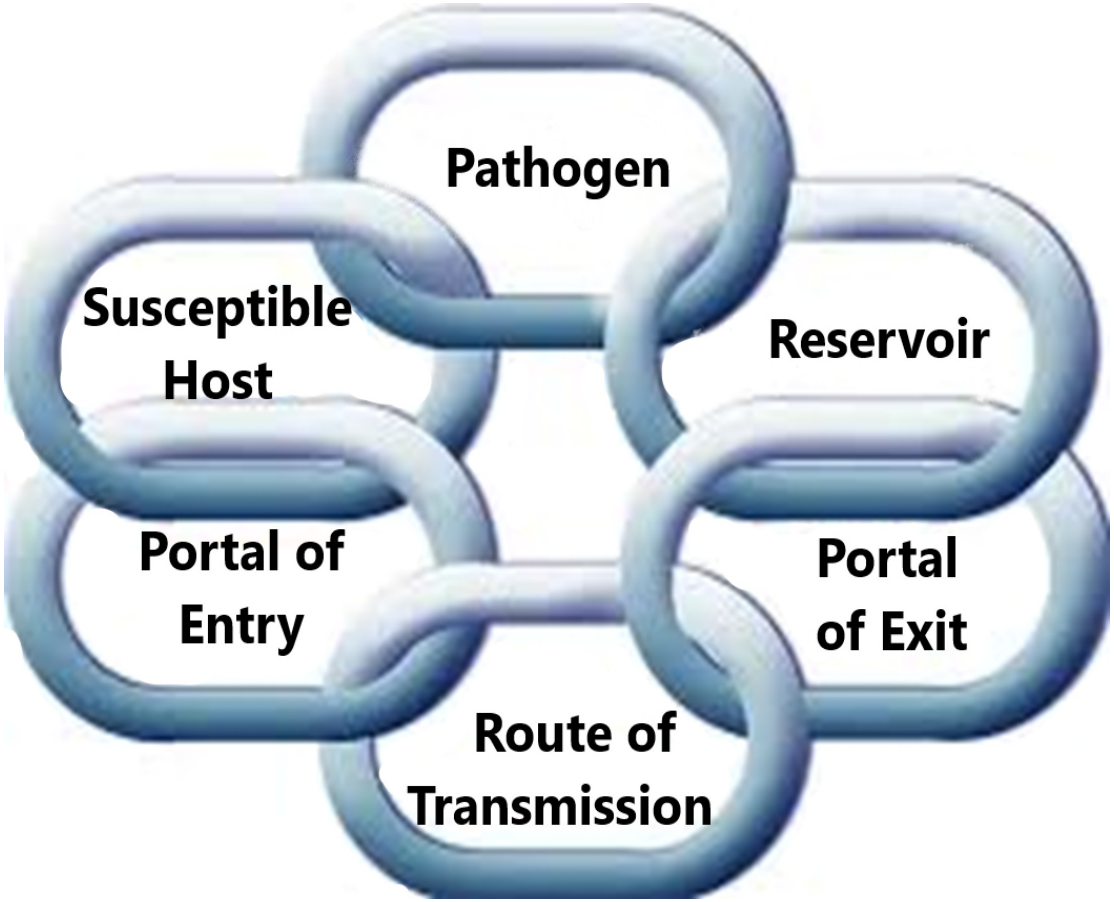
MRC Volunteer

The Chain of Infection



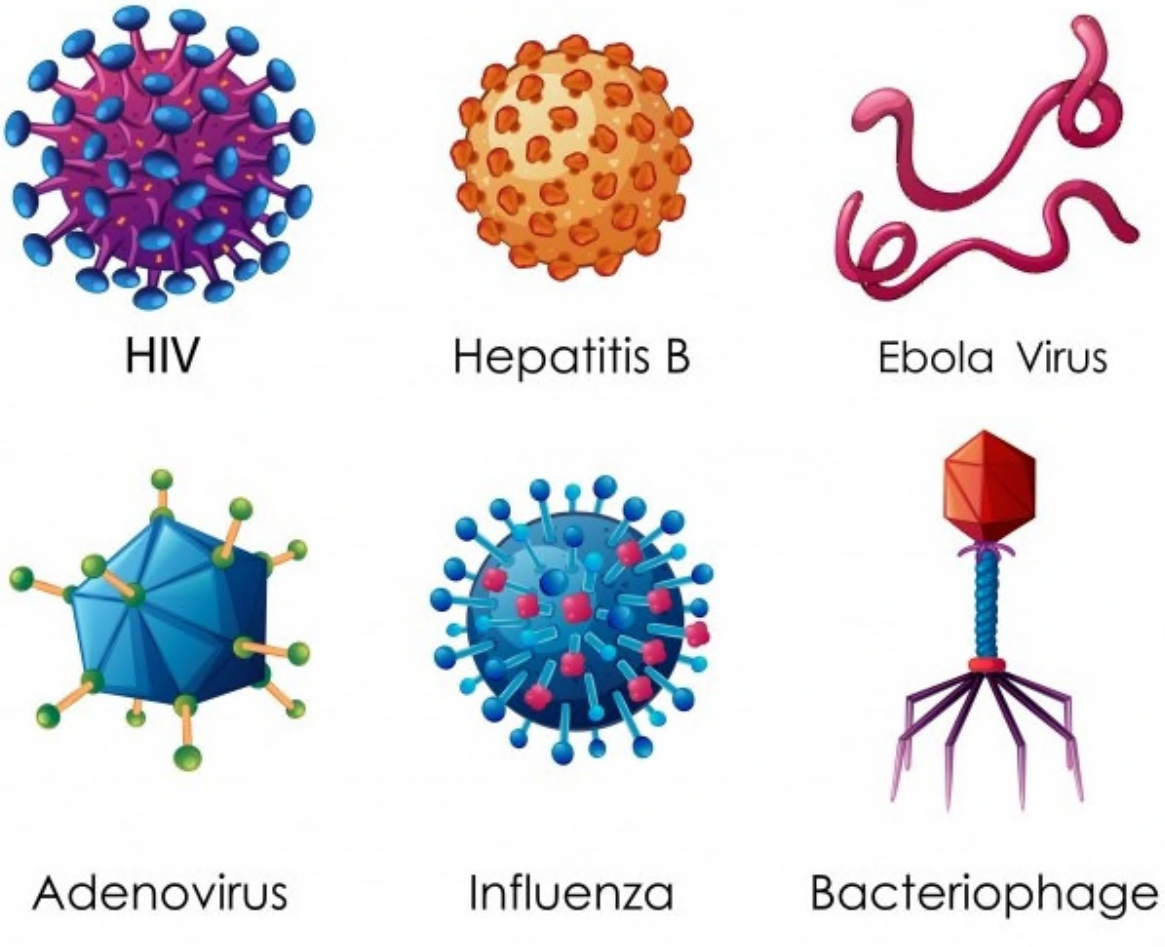
To stop the spread of infection, break any link in the chain!

The First Link: The Pathogen

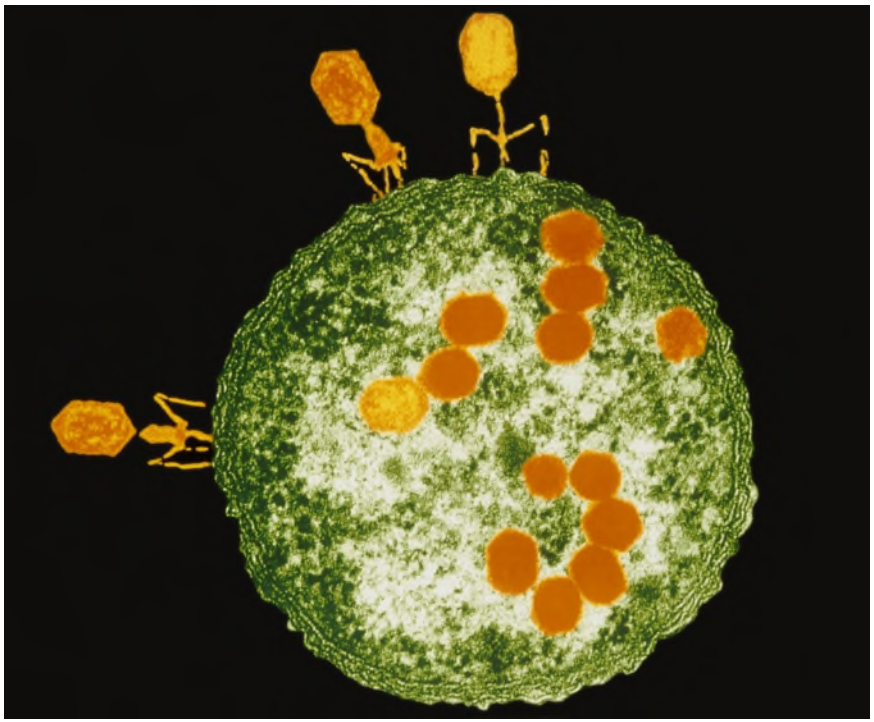
-  Viruses
-  Bacteria
-  Rickettsiae
-  Fungi
-  Parasites
-  Prions

Viruses

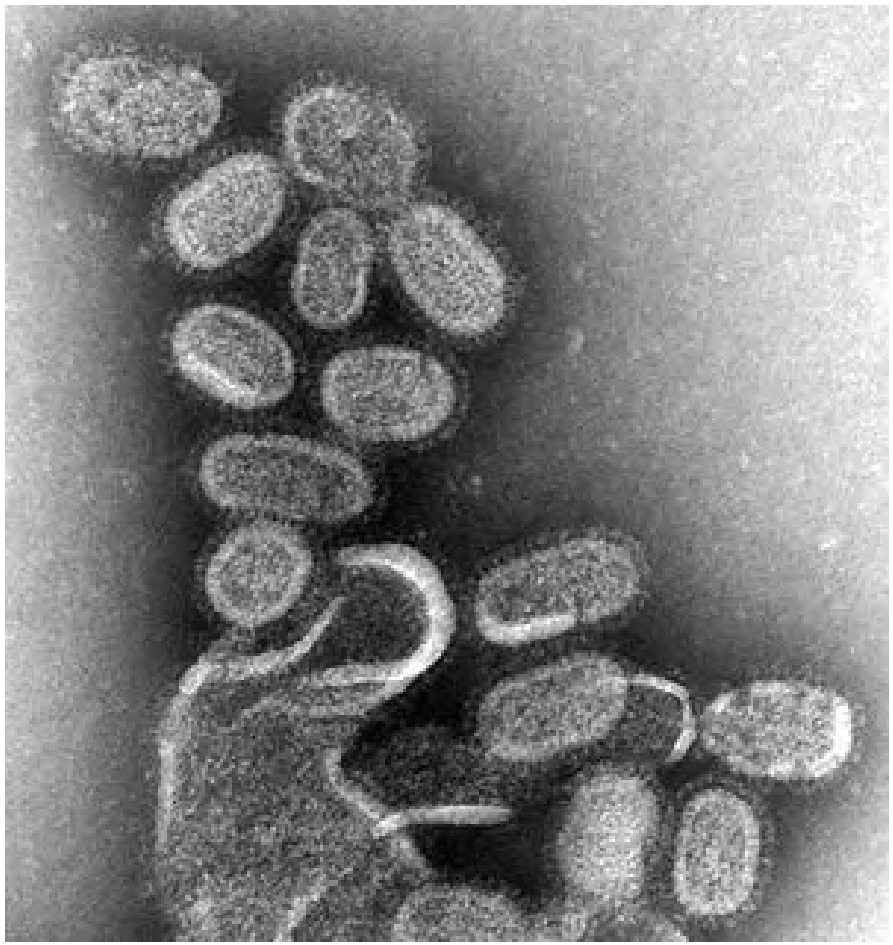
- Genetic material in a protein sheath
- Not a cell; not really alive
- Viruses hijack host cells and inject their genetic material
- The host cell is converted into a virus replicator
- Eventually the host cell bursts, releasing countless new virus particles



The Virus in Action



Viruses injecting their genetic material into bacteria
(Microbiology Online)



A host cell ruptures, releasing replicated influenza viruses
(Wikipedia)

Examples of viral diseases

- Smallpox
- Viral Hemorrhagic Fevers
- Measles, Mumps, Rubella
- SARS and MERS
- HIV
- The Hepatitides
- RSV
- Poliomyelitis
- Rabies

More about viruses

Antibiotics don’t work

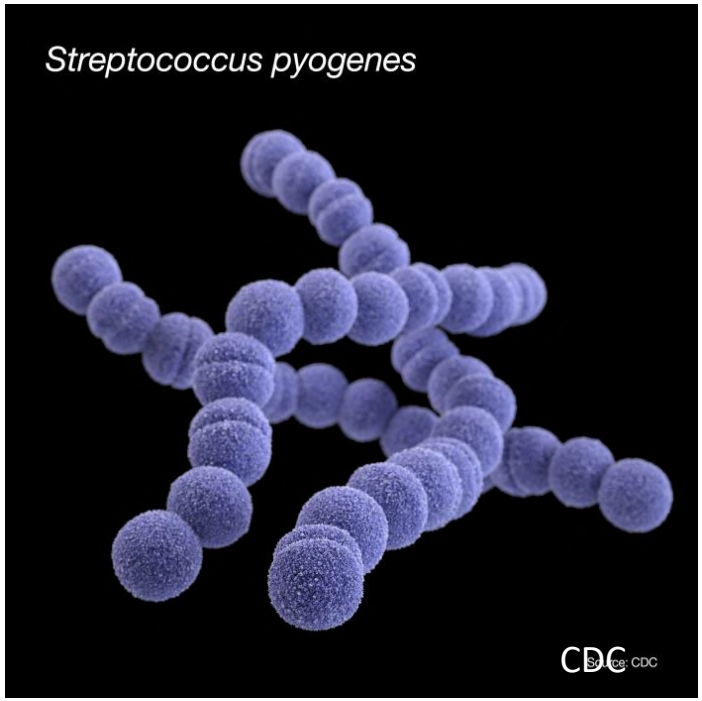
Some viruses respond to antiviral medications like oseltamivir, ribavirin, or AZT

Some viruses persist in the environment for a very long time

The most likely MCM we will dispense at an EDS for a viral disease is…

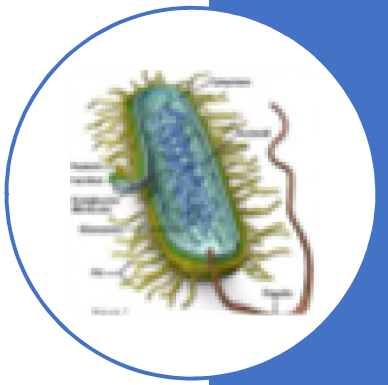
Vaccine

Bacteria



Bacteria

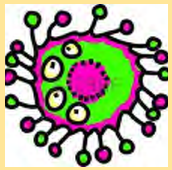
- Single-celled life forms with cell walls and DNA but no nucleus
- Wide range of sizes, shapes, and behavior
- Can sometimes be eliminated with antibiotics
  - Bactericidal – kills the bacteria
  - Bacteriostatic – keeps the bacteria from reproducing
  - The antibiotic must be effective against the particular bacteria
  - Bacteria replicate and evolve very quickly, easily developing antibiotic resistance
- Some bacteria form spores so that they can survive in hostile environments



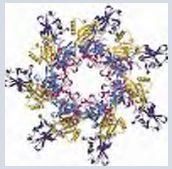
Examples of Bacterial Diseases

- Plague
- Bacterial meningitis
- Anthrax
- Tuberculosis
- Listeriosis
- Glanders, Melioidosis, Brucellosis
- Pertussis
- Tetanus

More about bacteria

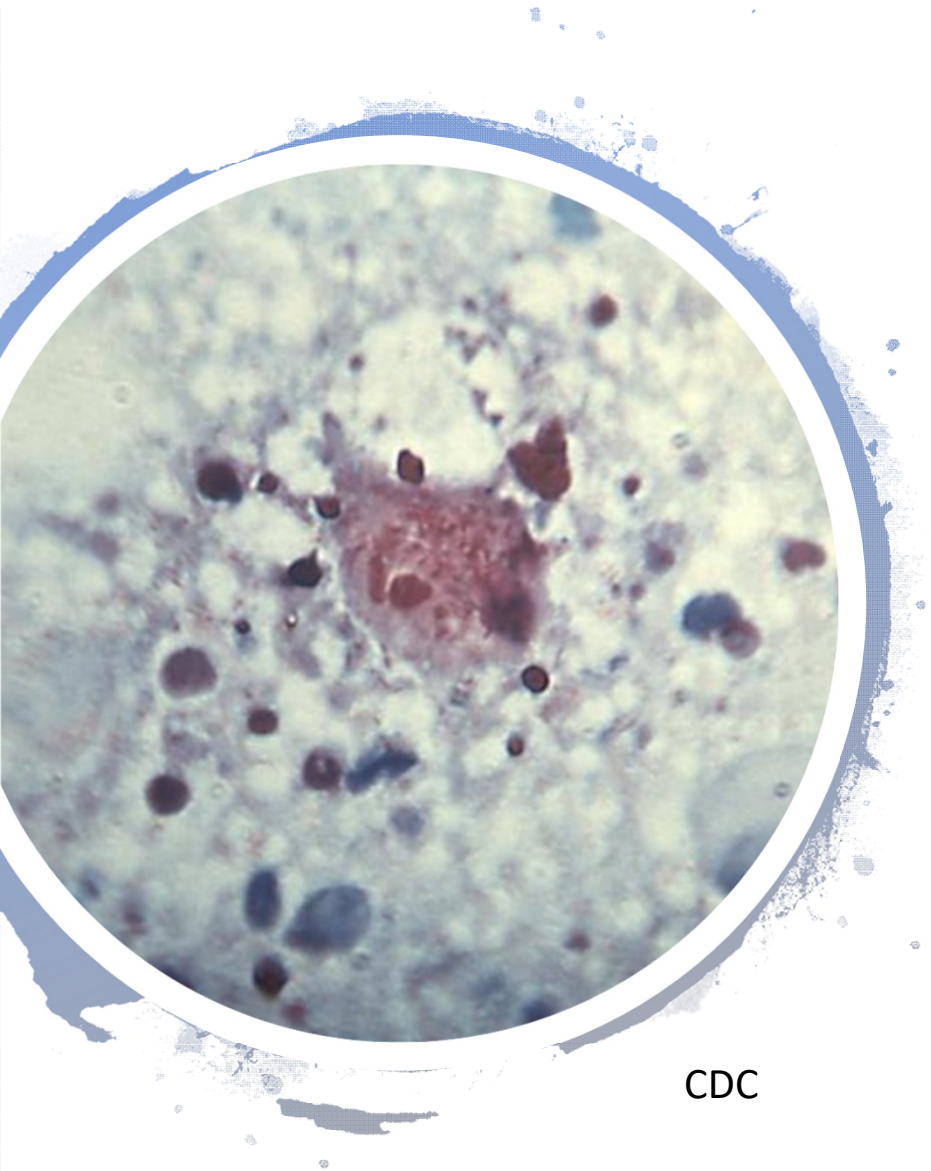


Bacterial spores are very hardy



Some bacteria produce toxins

We would most likely dispense antibiotics and vaccines at our EDSs

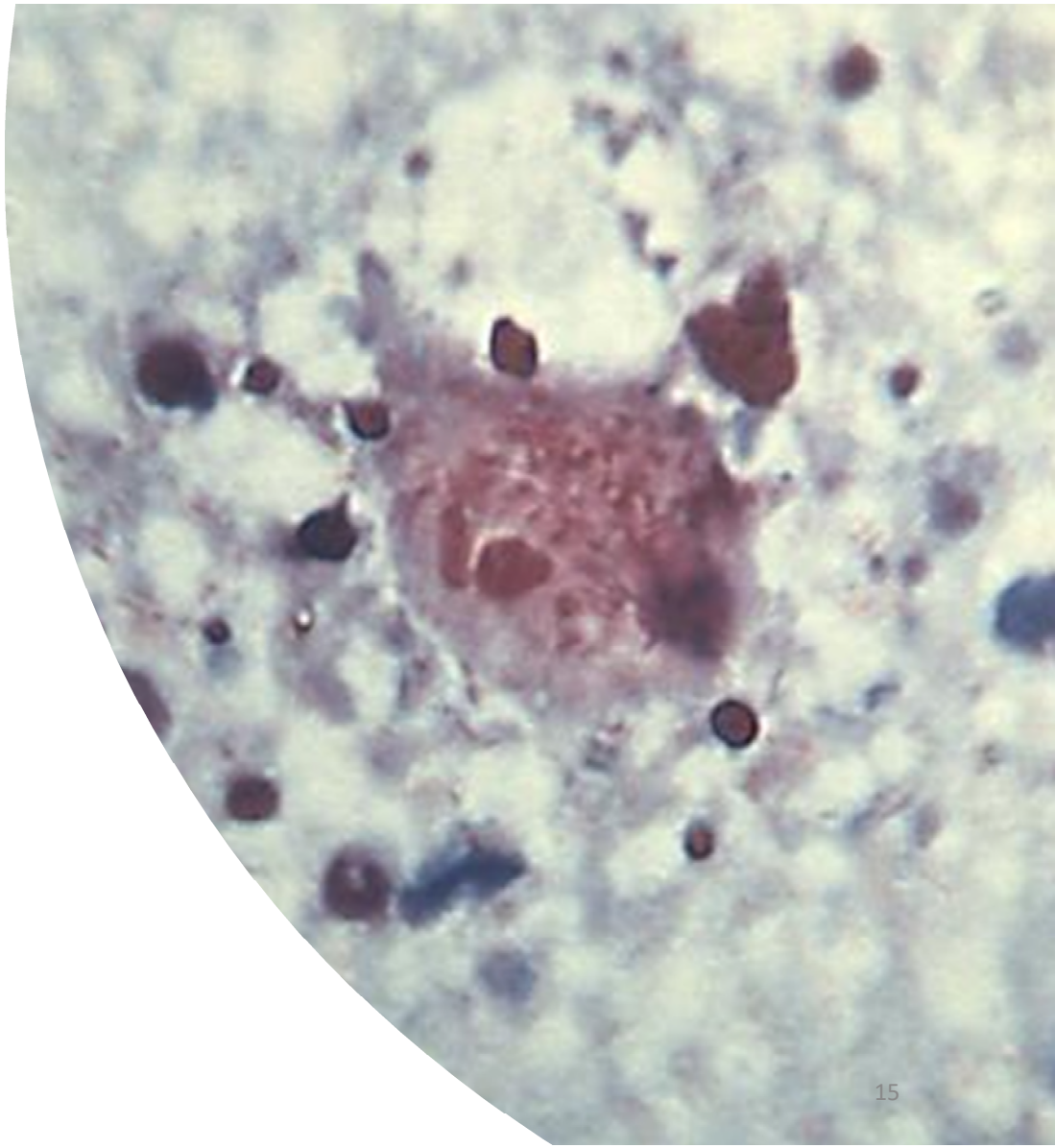


CDC

Rickettsiae

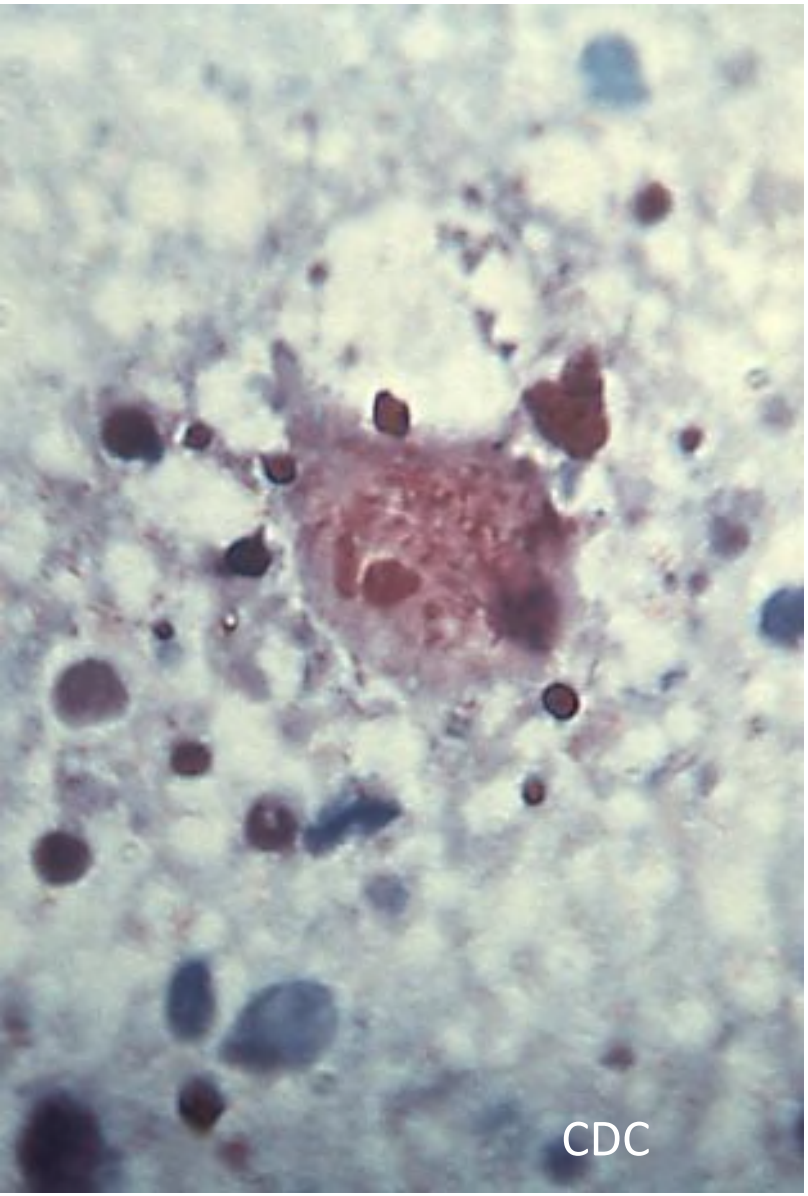
Rickettsiae

- Tiny intracellular organisms
- Most rickettsial diseases are zoonotic and are transmitted to humans via arthropod vectors
- Diagnosis may be very complex and difficult; treatment may be long



Examples of rickettsial diseases

- Lyme disease
- Babesiosis, Ehrlichiosis, Anaplasmosis
- Rocky Mountain Spotted Fever
- Typhus
- Q fever



More about Rickettsiae

- Rickettsiae don't make their own ATP like other "cells" do. They steal ATP parasitically from the cells in which they live.
- They can't be grown in culture medium like bacteria – that's one of the reasons rickettsial disease is hard to diagnose.
- Almost all rickettsial disease causes rash in affected humans, except for Q fever
- First-line treatment = DOXYCYCLINE

Fungi, yeasts and molds

Fungi

- Simple, ubiquitous organisms that produce spores
- Feed on organic matter in their environment
  - Fungi are necessary for decomposition
  - Fungi often compete with bacteria for local resources
- Superficial fungal infections = usually not dangerous
- Systemic/internal fungal infections = sometimes deadly

Examples of Fungal Diseases

- Candidiasis
- Histoplasmosis
- Mucormycosis
- Coccidioidomycosis
- Cryptococcus neoformans
- Pneumocystis carinii
- Aspergillosis
- Other diseases ending in “mycosis”

More about Fungi

Many fungi produce toxins that are deadly to humans

Immuno-compro-mised people are at greater risk for fungal disease

Anything that eliminates bacteria gives the fungi a chance to flourish

Some bioweapons are derived from fungi, especially those designed to impact the food supply

Parasites

- WIDE RANGE of size, complexity, habits
- Parasites live by taking what they need from their host
- Most parasites don’t benefit by killing their hosts
- Parasites are often species-specific –
  - inside members of other species, they get lost
  - Brain tissue and eye tissue make popular destinations for animal parasites inside humans

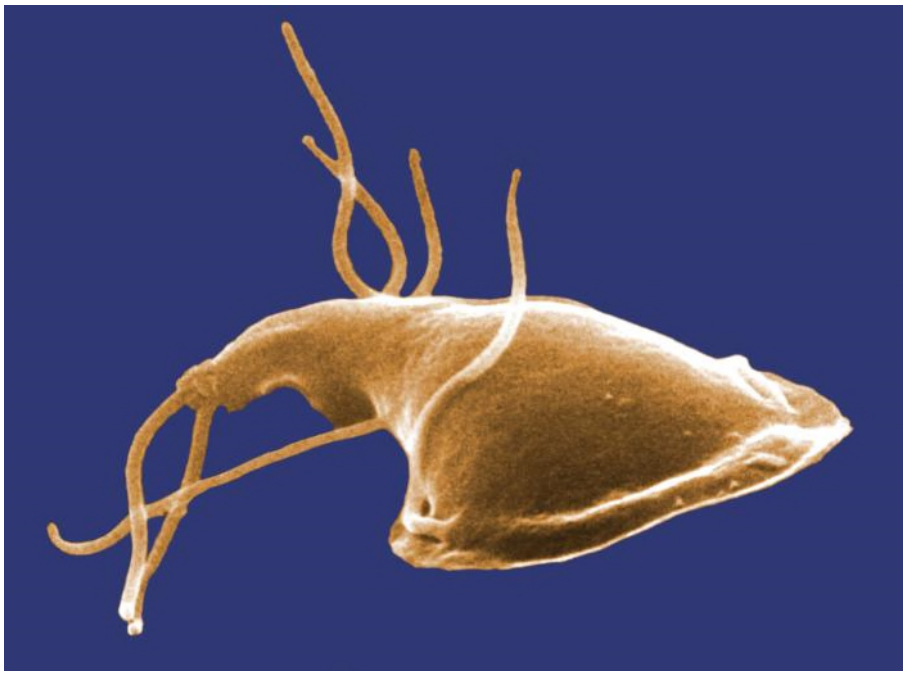
Nutritionfacts.org

Neurocysticercosis

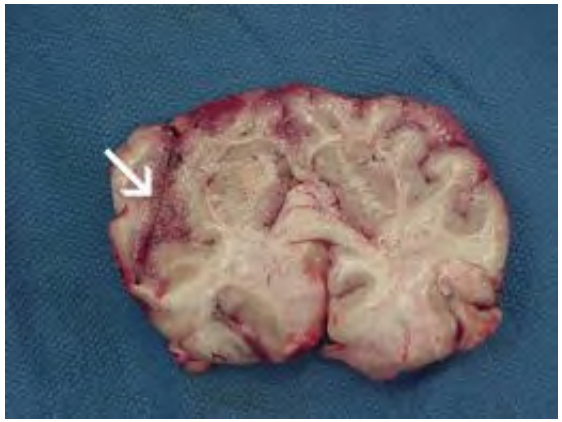
Live pork tapeworms ingested by humans often wind up in the brain

Neurocysticercosis is the most common cause of acquired epilepsy in developing countries

Endoparasites – Protozoans

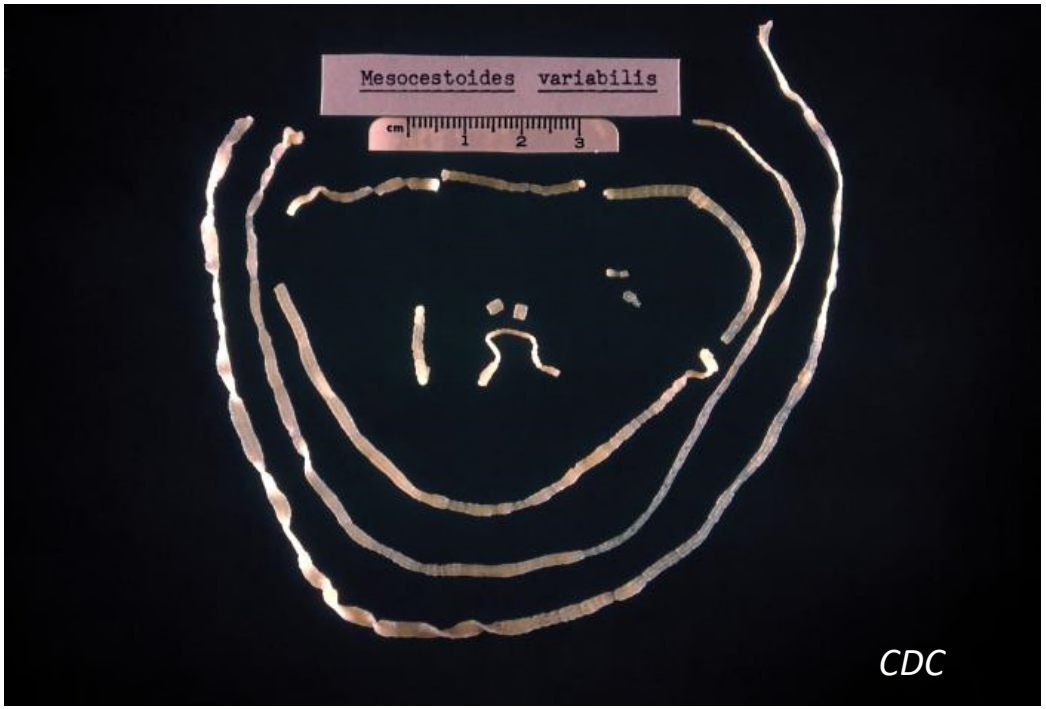


G. Lamblia – protozoan causing Giardiasis
CDC



Naegleria fowleri, “the brain-eating amoeba”
Primary amoebic meningoencephalitis -- CDC

Entamoeba histolytica, eating the lining of a small intestine CDC



Multi-celled endoparasites

New World Screwworm “maneater” CDC

Some ectoparasites are harmless nuisances…

CDC

CDC

and some are vectors of deadly diseases.

Parasites

Often have complex life cycles requiring several different hosts

Generally do not kill their host on purpose (c.f. “parasitoid” or “predator”)

Often bring us other pathogens

Extra credit: do you have to be a parasite to be a vector?

Prions

- Little scraps of protein that can recode genetic material
- Causative agent of
  - BSE – Mad Cow Disease
  - CJD – Creutzfeldt-Jakob Disease
  - Scrapie – animal brain disease
  - Kuru – human brain disease

- Prion diseases are contracted by eating infected CNS tissue
- Prion disease may take decades to manifest
- You can't kill prions by cooking, even at high temps for long periods
- Prions may someday make diabolical bioweapons

So how do we break the pathogen link?

Kill	Incapacitate	Remove or sequester
Kill the pathogen – antibiotics, antivirals, disinfectants, heat	**Incapacitate the pathogen/stop replication – bacteriostatic agents, fever**	**Remove or sequester the pathogen – biohazard waste, burning, burial**

The Second Link: The Reservoir

The Reservoir

- Where pathogens hang out
- Can be a location, an environment, a population of animals
- In the case of some EIDs, the reservoir can be a human or a group of humans (e.g., smallpox)

Milwaukee, 1993

- Outbreak of cryptosporidiosis
- Failure of water treatment system to remove oocysts in water from Lake Michigan
- Over 100 fatalities; thousands of people with symptoms
- Reservoirs:
  - Lake Michigan
  - City drinking water supply

Mary Mallen – asymptomatic carrier of S. typhi

Fig. 5.1. *"Typhoid Mary" breaking skulls into skillet, 1909.*

So how do we break the reservoir link?

Eliminate	Isolate	Treat
Eliminate the reservoir altogether – "cats to eat the rats," reservoir for VHFs in South America	Isolate the reservoir from the at-risk population – Mary Mallen	Treat the reservoir – vaccine baiting for raccoons; filtration of water supplies

The Third Link: The Portal of Exit

(How the pathogen gets out of the reservoir)

Portals of Exit

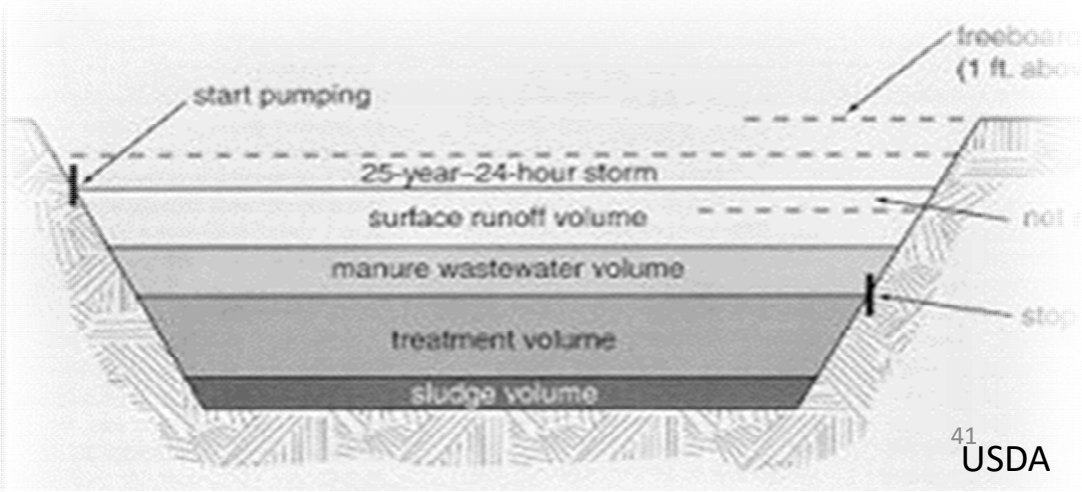
- Specific to the reservoir
  - Coughing, sneezing, bleeding, breathing, defecating/urinating etc.
  - The bite of a vector species
  - Humans intentionally tapping the reservoir for resources
  - Mechanical failure (e.g., faulty filtration; wet mask; ruptured can)
- “Acts of God”
  - Harvey and the lagoons


Stop the spread of germs that make you and others sick!
Cover your Cough
Cover your mouth and nose with a tissue when you cough or sneeze
or
cough or sneeze into your upper sleeve, not your hands.
Put your used tissue in the waste basket.
You may be asked to put on a surgical mask to protect others.
Clean your Hands
after coughing or sneezing.
Wash with soap and water
or
clean with alcohol-based hand cleaner.
CDC
MDH
APIC

Wikipedia

John Snow and Cholera – London, 1854

Engineering Controls to prevent E. coli from sloshing out of the lagoon



USDA

So how do we break the Portal of Exit link?

Block/Contain	Remove Access	Eliminate
Block the pathogen as it leaves the reservoir – cough etiquette	Prevent humans from accessing contents of reservoir – pump handle	Eliminate egress of pathogen from reservoir – spill prevention

The Fourth (and most critical) Link: Routes of Transmission

(how the pathogen gets to its next victim)

Routes of Transmission

- Direct Contact
- Indirect Contact
- Droplet
- Waterborne
- Foodborne
- Bloodborne
- Airborne
- Vectorborne

Direct Contact

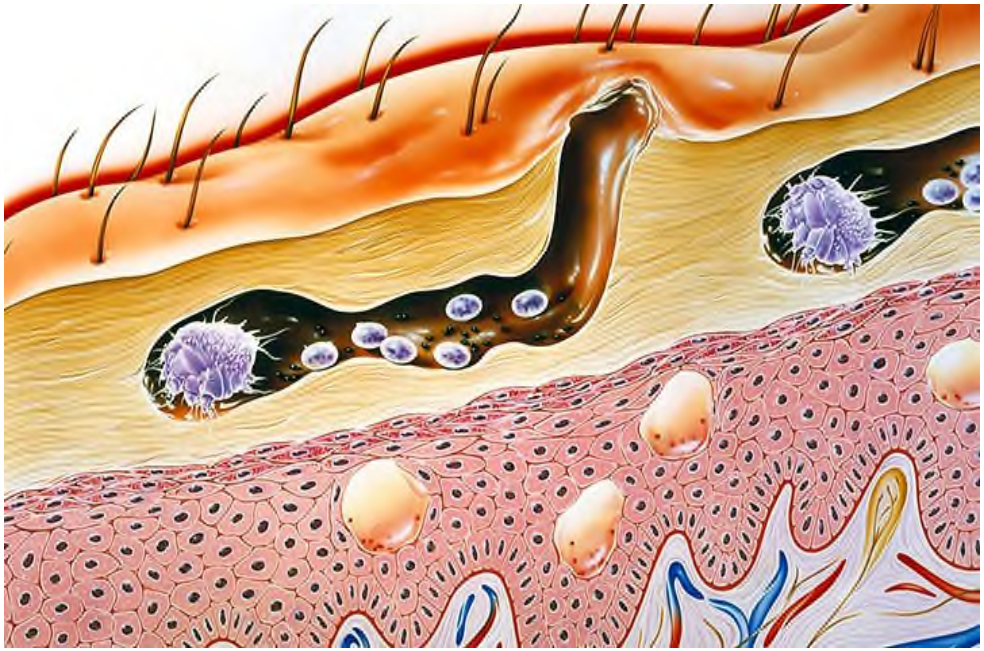
openclipart.com

You physically contact the infected person:

- Touching
- Kissing
- Sexual contact

…and the pathogens move from the infected person to you

Sample “Direct Contact” Infection: Scabies



Preventing Direct Contact Transmission

Avoid Contact	Use Barriers (PPE)
No handshaking No hugging No skin-to-skin contact of any kind!	Used PPE is contaminated and must be discarded before it contaminates you or anyone else DOFF PPE WITH GREAT CARE!

Indirect Contact

You touch something that the infected person has touched

Objects that can harbor pathogens are called FOMITES

Many pathogens can persist for hours or days on fomites

ALMOST EVERY PATHOGEN CAN BE TRANSMITTED BY INDIRECT CONTACT!

Examples of Fomites

- Pens and pencils
- Door and faucet handles
- Keyboards
- Toys and furniture
- Cell phones
- Cutting boards
- Litterboxes
- Used tissues

Preventing Indirect Contact Transmission

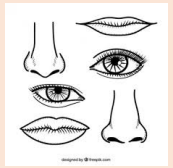
Avoid fomites	Disinfect fomites	Offer sanitizer
Avoid touching potential fomites to the extent possible	Clean and disinfect fomites frequently	Provide hand sanitizer for people using fomites (e.g., pens)

Droplet Transmission

The pathogen reaches you through a spray of droplets

Coughing
Sneezing
Vomiting, etc.
Splashing

You inhale the droplets



The droplets land on your mucous membranes

Preventing Droplet Transmission

Block spray	Keep clear	Avoid splashing
Use masks, tissues, cough etiquette techniques	Stay at least 6 feet away from people who are coughing or sneezing	Perform procedures carefully

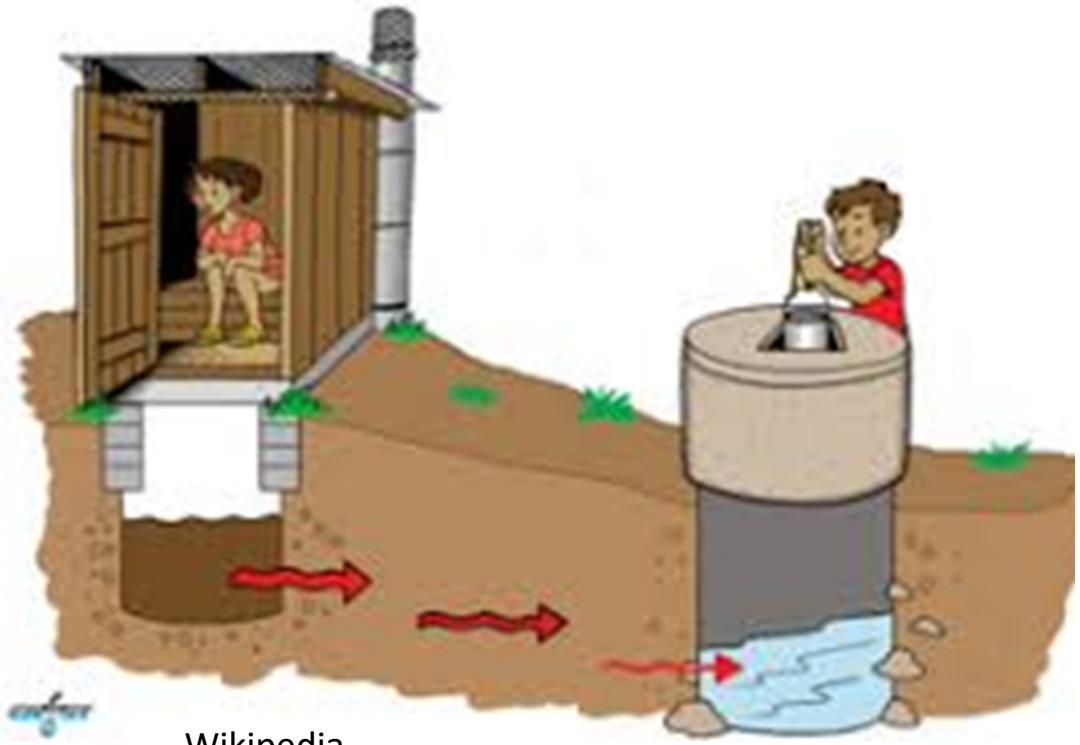
NB: Droplet Transmission is tricky!

- Scientists debate about the classification of some respiratory illnesses
  - Influenza – droplet or airborne???
- Anything that creates an aerosol can create a droplet pathogen
  - Suctioning, irrigating wounds, blowback, hand dryers, flushing
- Droplets that land on surfaces/fomites can spread germs via indirect contact

Waterborne Transmission

You are exposed to the pathogen by

- Drinking the water
- Using the water for personal care tasks such as bathing, brushing teeth
- Engaging in recreational activities – swimming, boating, hot tubbing etc.
- Using contaminated water to wash dishes, equipment
- Inhaling the water via Neti-Pot or humidifier



Wikipedia

Examples of Waterborne Diseases

- Cholera
- Giardiasis
- Dracunculiasis
- Legionnaires' disease
- Cryptosporidiosis
- Schistosomiasis
- Primary amoebic meningoencephalitis
- E. coli or other enteritis

Preventing Waterborne Transmission

Avoid	Treat at source	Treat before use
Don’t drink or otherwise use contaminated water	Assess and repair water supply purification	Boil, filter or chemically treat water for personal use as appropriate

Foodborne Transmission

- You eat something containing the pathogen
- The pathogen got into your food via
  - Cross-contamination
  - Intentional contamination
  - Inadequate, inappropriate preparation
  - Poor hygienic practices by food handlers
  - Food spoilage/inadequate food storage practices
  - Contamination of food before purchase
- Viruses, bacteria, fungi, parasites and prions can all be foodborne

Examples of Foodborne Diseases

- Enteritis – E. coli, C. jejuni, S. typhus
- Parasites – Trichinellosis, neurocysticercosis
- Ergot or trichothecene poisoning
- Clostridium toxin ingestion
- Norovirus, rotavirus, Hep A
- Anthrax, tularemia
- BSE

Preventing Foodborne Transmission

Proper handling	No Second Rule	Game = germs
Prepare and store food properly	Don’t eat food that hits the floor. Ever.	Treat game and all animal products as if they are contaminated

Bloodborne Transmission

CMS@montgomerycollege.edu

- You are exposed when infectious blood or body fluids get into your body
  - Unprotected sex
  - Prenatal exposure
  - Shared needles; needlesticks
  - Through breaks in skin or through mucous membranes
  - Transfusions

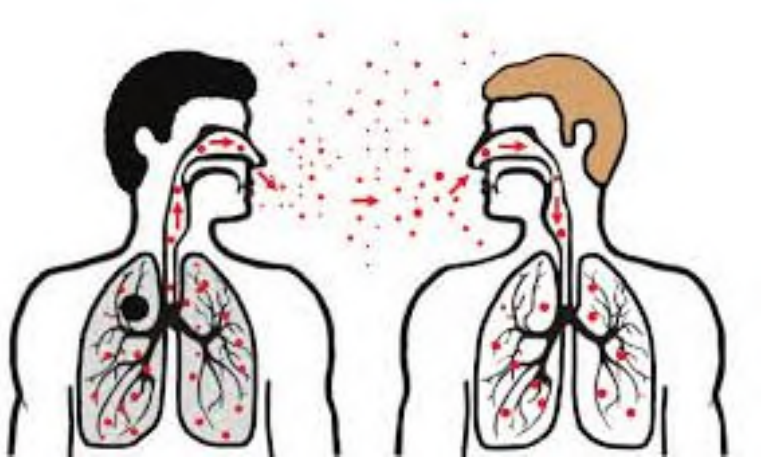
Examples of Bloodborne Diseases

- HIV
- Ebola and other VHFs
- Hepatitis B, C, etc.
- Malaria
- Syphilis
- Zika

Preventing Bloodborne Transmission

Barriers	Screening	No sharing
Bloodborne precautions as per OSHA and CDC	Screen blood supply, pregnant women etc.	needles secretions instruments

Airborne transmission



CDC

- The pathogen hangs in the air for extended periods
- Everyone in the area is exposed
- Airborne diseases:
  - Measles
  - Tuberculosis
  - Smallpox

Preventing Airborne Transmission

Isolate	Control air flow	High-level PPE
Isolate and cohort infected people Social distancing	Negative pressure rooms, HEPA filtration	Adequate, properly fitted PPE, safely removed

“POD” suitable for preventing airborne transmission

Vectorborne Transmission

- The pathogen is conveyed to you by another entity
  - Arthropods
  - Other animals
- Vectors can bring you
  - Viruses
  - Bacteria
  - Rickettsiae
  - Parasites/protozoans

Examples of Vectorborne Diseases

- Malaria
- Most rickettsial illness
- Dengue, Chikungunya
- West Nile Virus Disease, EEE
- Chagas disease
- Leishmaniasis
- Rabies
- Plague

Preventing Vectorborne Transmission

Eliminate	Prevent Bites	Treat
Rid the environment of the vector(s)	Prevent vectors from biting – nets, bug spray, in by dusk	Medicate vectors to incapacitate or kill the pathogen

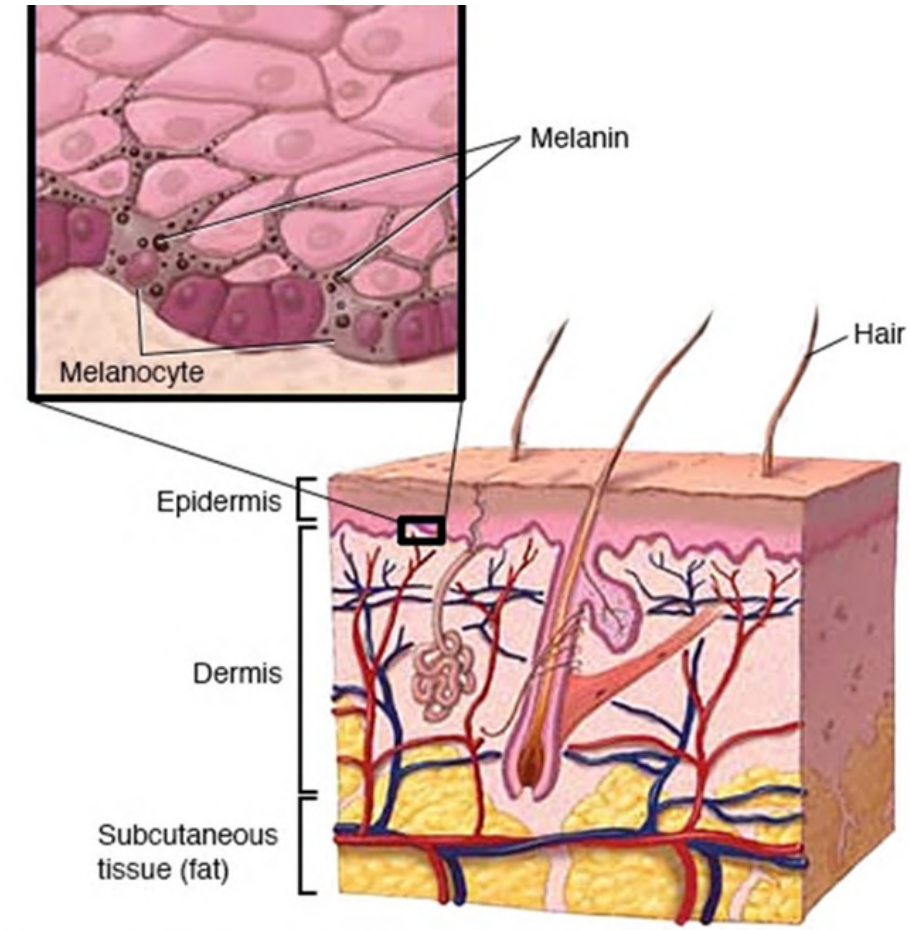
The Portal of Entry is the way the pathogen gets into your body

The Fifth Link: The Portal of Entry

Most of the time, pathogens DON'T get in…

We each have an efficient barrier that keeps any arriving pathogen from getting inside our bodies…

Our skin!



Skin is a near-foolproof line of defense, *unless…*

- The skin is damaged or broken
  - Burns
  - Chapping
  - Dryness
  - Rashes
  - Abrasions or other breaks in the skin
  - Maceration (waterlogging)
- The skin is breached by a vector or fomite
- The pathogen lands on mucous membranes

To break the Portal of Entry link in the chain…

Care for your skin	Protect mucous membranes	DON'T TOUCH
Take good care of your skin! Keep it in tip-top condition! BEWARE OF SHARPS!	Use appropriate barrier PPE – face shields, goggles, masks, condoms etc.	your eyes, nose, mouth, or other mucous membranes unless you have JUST washed your hands thoroughly!

The pathogen must reach someone who is susceptible in order to produce disease

The Sixth Link: The Susceptible Host

Strategy #1 -- Immunity

- Genetic "Immunity" and Natural Selection
- Active or passive immunity – your body recognizes and destroys the pathogen
  - Active immunity – previous illness or vaccination
  - Passive immunity – receipt of someone else's antibodies
    - Prenatally or via colostrum
    - Via antitoxin administration or treatment with convalescent serum
- Herd Immunity – pathogen can't get a foothold in the population

Strategy #2 -- Resistance

OPTIMAL NUTRITION

ADEQUATE SLEEP/REST

STRESS MANAGEMENT

Strategy #3 -- Avoidance

- People with immune system disadvantages may need to avoid any exposure to pathogens
- They may be advised to employ social distancing during outbreaks
- Some people require protective or reverse precautions

Strategy #4 – “Cocooning”

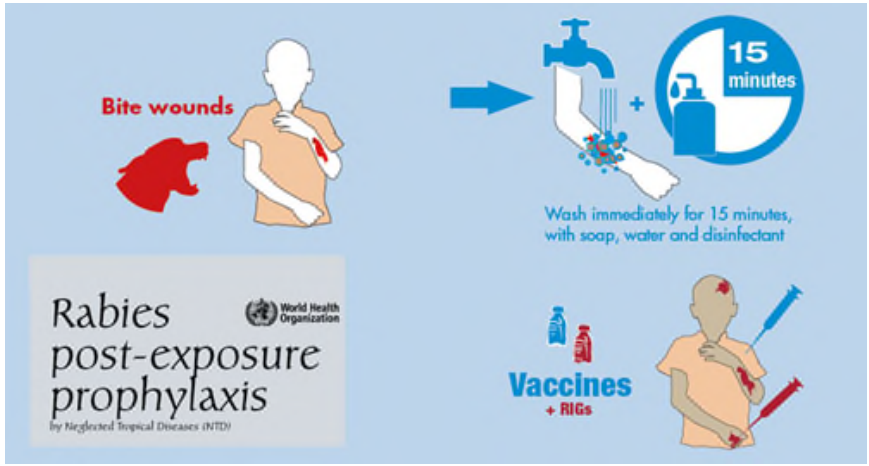
People with whom the vulnerable person must interact are all vaccinated (e.g., pertussis vaccine for infants’ family members)

Everythingsilkworm.com.au

Strategy #5 – Pre- or Post-Exposure Prophylaxis

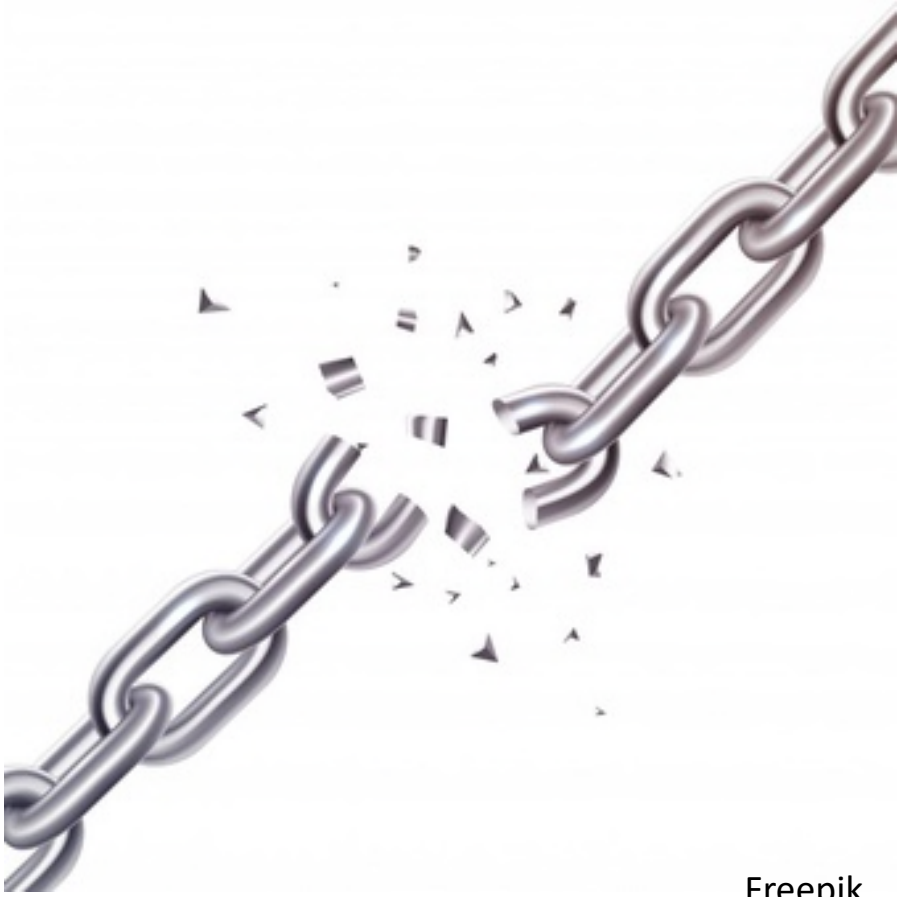
When a susceptible person may soon experience an exposure – Pre-Exposure Prophylaxis may prevent development of the disease

HIVplusmag.com



After a susceptible person has been exposed – Post-Exposure Prophylaxis may prevent development of the disease

When you administer post-exposure prophylaxis at an EDS, you are breaking the Chain of Infection!



Freepik

Special Bonus Slide: Zoonotic Diseases

- A zoonotic disease ("zoonosis") is one that came from animals.
- Humans may be accidental or incidental victims.
- Animal pathogens sometimes "get lost" inside human bodies…
  - They wind up in unexpected places (e.g., toxocariasis)
  - They often have multiple routes of transmission (e.g., tularemia)
- You and your pets can often share zoonotic diseases