The Immune System and Disease

• **pre 1600s** - cause of disease not known
  – Punishment from God, bad luck, bad air, witchcraft, curses, maternal impressions etc.…

• **After 1600s**, microscopy and germ theory of disease
  – Scientific basis for disease, BUT doctors did not wear gloves, no anesthesia, no sterile technique

• **antibiotics** - penicillin, **1940s**. Revolutionized medicine
Pathogen = A biological unit that causes disease

- prion – protein – no DNA AND not alive!!
- virus - non living, needs host cell to replicate
- bacteria - single celled microbe
- protozoa
  - single celled eukaryote microbe
- parasite - multicellular

- Most microbes are NOT pathogens
Scale diagram — showing relative sizes of pathogens

Multicellular Parasite

Virus

Bacterium

Single-celled Parasite

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Disease Terms

1. *Infectious*
   – Can be transmitted from person (or animal) to person

   **Body fluids** – example:
   **Vectors** – example:
   **Ingestion** – example:
   **Inhalation** – example:
2. **Epidemic**
   - Contagious disease that spreads rapidly and uncontrollably affected large numbers of people

3. **Plague**
   epidemic that kills large numbers of people
~23% die of diarrhea (10 million children per year)- why/how?

Life straw nyt video lifestrawaustralia
**Prions** = (rare) spongiform encephalopathy disease

CJD in humans
- Always fatal, no treatment
- Most cases sporadic (arise spontaneously) or inherited
- Can be acquired from exposure to infected brains
- Example: Kuru

*Sponge-like brain*
Outbreak in England 1980s

• Cows stagger, shake, fall down (“mad cow”)
• Transmitted to ~18 humans via contaminated hamburger meat
• Caused by an infectious agent that is NOT alive and has no DNA!
How does a prion cause disease?

• Normal prp protein undergoes a shape change

• Brain cells lyse $\rightarrow$ spongy brain
• Don’t eat brains or meat from contaminated people or cows.
VIRUSES

• Antiviral drugs or wait it out
  – consist of protein + genetic material
  – infect cells and reproduce

– Smallpox virus (not in textbook)
  • pustules disfigure, blind, kill
  • eradicated in 1977
Other viruses

• Rhinovirus (50) colds

• Influenza - the flu (not in textbook)

• changes genetic makeup every year
  40 million deaths in 1920 in 4 months!
  >30,000 die in US each year!

• new vaccine needed every year because it changes so rapidly
Smallpox (variola virus)

- Vaccination available, if you’re under 30, you probably are not vaccinated.

1977 last case
• **Herpes** viruses sores on skin
  – Lies dormant in nervous system, activated by stress, sunlight
  – transmitted by direct contact with lesion

1. oral = 225 million in US (90% of us)
2. genital = 45 million in US
3. Chicken pox (a herpes virus) and shingles (not in textbook)

• Millions of new virus in pustules

• After infection, virus remains dormant near spinal cord

• If reactivated in later life → shingles
Poliomyelitis virus

- attacks the nervous system -> paralysis
- virus shed in feces (improved sanitation and hygiene helps to prevent transmission but it’s easily transmissible!)
- 1916 New York, 27,000 infected, 9000 died
Effects of polio
Bacteria

• single celled, prokaryotic
• May be killed by antibiotics
  – penicillin, tetracycline etc...
  – antibiotic resistance problem
• Lyme disease caused by B. burgdorferi bacteria

• Tick vector
• Tick feeds on blood -> bacteria migrate to mouthparts
• Bulls-eye rash
• treat early with antibiotics or joint/nervous system problems

Look at the size of this tick!
Incidence of lyme disease .....
• **Salmonella** (not in textbook) (Daniel Salmon)
  • From contaminated chicken, eggs
  • Must heat to 160 F to destroy, or wash off
  • Diarrhea, nausea, can be fatal in some
MRSA

• Methicillin- **resistant** Staphylococcus aureus (MRSA) infection
  – Staphylococcus aureus bacteria —"staph."
  – normally found on the skin of about 1/3 people.
  – "colonized" but not infected can pass it on
  – Usually does not cause problems – unless it gets into the bloodstream, heart, lungs
  – **Can’t** be treated with normal antibiotics (vancomycin still works)
How do bacteria develop antibiotic resistance?

1. Unnecessary antibiotic use in humans
2. Routine antibiotics in food and water
3. Mutation rate + bacteria that survive treatment with one antibiotic soon can resist others.

What can you do? Wash hands, don’t share towels, shower, use antibiotics appropriately!
Protozoa

Malaria

- mosquito vector contains protozoa (single-celled eukaryote)
  - Periodic bursting of protozoa from red blood cells
  - Fever, weakness, death
  
  - 300 million infected, millions die each year
Parasites

Multicellular animals
  – hookworm, tapeworm, pinworm, heartworm (dogs)
  – diarrhea, weakness, weight loss

Roundworm infects millions of people
Up to 12 inches in length

Note: you may not want to see next....
Organs of the immune (lymphatic) system

- Tonsils
- Lymph nodes
- Thymus
- Spleen
- Also, bone marrow
• Lymph nodes in groin, armpit, neck, intestines
• Tonsils
• Spleen
• Thymus
• Bone marrow
How do we fight disease? How can we ever win in this sea of pathogens?

• Non specific immunity
  – Skin, sweat, mucus, tears, stomach HCl, some types of white blood cells, ear wax, pH….
Specific immunity

• Recognizing **self** from **non-self**
  – each foreign cell, protein, DNA has a unique identity that can be recognized as foreign by the body’s immune system
  – Self antigens
    • Mark your cells as “you”
  – Foreign antigens
    • Are not yours …..

• Your immune system should be able to attack and destroy specific pathogens
white blood cells active in specific immunity

• **B cells** (lymphocytes)
  – Make antibodies
  – Antibodies bind to foreign antigens (pathogens)

• **T cells** (lymphocytes)
  – coordinate immune response
  – Kill infected cells
Vaccination/Immunization

- Vaccine = antigen
- Types
  - Killed microorganism or virus
  - attenuated (disabled)
  - Toxoids (the toxin)
  - Fragment (piece)
Expose individual to vaccine and.....
B cells make antibodies to the vaccine
• B cells have “memory”
  – When body is exposed to foreign antigen (pathogen) years later, B cells rapidly produce large amounts of the correct antibody

• Enough B cells to recognize every foreign antigen in nature!

• Note: you can gain immunity by contracting disease itself

• Some vaccines require boosters (example: tetanus)
Poliovirus vaccination in the USA

- Inactivated vaccine (IPV) introduced
- Oral, live-attenuated vaccine (OPV) introduced

Cases per 100,000: 20.0, 10.0, 1.0, 0.5, 0.1, 0.05, 0.01, 0.005, 0.001

Vaccines

• Diphtheria, whooping cough, tetanus (DPT) - bacteria
• Chicken pox - virus
• Polio - virus
• Measles, mumps, rubella (MMR) - virus
• The flu (influenza) - virus
• Hib - bacteria
• Hepatitis B - virus
Why vaccinate?

- Diptheria 1920s 100,000 to 200,000 cases per year in the United States, 13,000 to 15,000 deaths.
- Pertussis Worldwide, 30–50 million pertussis cases, 300,000 deaths
- Before polio vaccine was available, 13,000 to 20,000 cases of paralytic polio were reported each year in the United States.
- Before measles immunization was available, nearly everyone in the U.S. got measles. 1/100 – 1/1000 die
- Hib Before the vaccine, approximately 20,000 invasive Hib cases annually. Approximately two thirds of the 20,000 cases were meningitis, and one-third were other life-threatening invasive
- In 1964-1965, before rubella immunization was used routinely in the U.S., there was an epidemic of rubella that resulted in an estimated 20,000 infants born with CRS, as well as 2,100 neonatal deaths and 11,250 miscarriages. Of the 20,000 infants born with CRS, 11,600 were deaf, 3,580 were blind, and 1,800 were mentally retarded.
- 2 billion persons worldwide have been infected with the hepatitis B virus at some time in their lives. 1 million will die from liver disease
- An estimated 212,000 cases of mumps occurred in the U.S. in 1964. Was a leading cause of childhood deafness, can be fatal
Measles outbreak 2008

- Unvaccinated 7 yr old child visited Europe 1/08 (PBE)
- Unvaccinated children in US contracted measles
  - His siblings
  - 5 kids from school
  - 4 kids in the waiting room at the Dr.’s office
- 21 were quarantined
- Can cause encephalitis, pneumonia, even death
Before vaccination program for measles

• Millions of cases per year, 28,000 hospitalizations, 1000’s with chronic disabilities (encephalitis effects)

• One case costs >$100,000 to control
Vaccine concerns

- Autism (???)
- SIDS (???)
- Side effects – fever, soreness, aches, nausea, allergy
- Disease (attenuated vaccine) – low (!!!) risk
Quick Immunization Facts:

• 3 million children die every year from diseases that are entirely preventable.
• 30 million infants have no access to basic immunization each year.
• One child can be fully immunized for $17.
In the future…….

- Malaria
- HIV
- Lyme disease
- Herpes
Available but not given to general population, why??

- Smallpox
- Anthrax