Metrex has been Protecting People across healthcare for over 20 years.

Evidence-based prevention of infectious diseases in schools

-Part I: Fundamentals of infections in schools

-Part II: The importance of surface hygiene

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Outlines

- ✓ Overview of infectious diseases at school

- ✓ Fundamental principles of infectious diseases
  - Basic and clinical microbiology
  - Microbial pathogenesis
  - Common pathogens and transmission pathways

- ✓ Evidence-based role of surface disinfection
  - Hand hygiene
  - Surface disinfection

Overview of infectious diseases at school

- Infectious diseases account for millions of school days lost each year for kindergarten through 12th-grade public school students in the United States[1]
- 40% of children aged 5–17 years missed 3 or more school days in the past year because of illness or injury[2]
- Nearly 22 million school days are lost each year due to colds alone[3]
- 38 million school days are lost each year due to the influenza virus[3]

1. CDC. Infectious diseases at school
2. CDC. Summary Health Statistics for U.S. Children: National Health Interview Survey, 2007.
3. CDC. Vital Health and Statistics. Current Estimates from the National Health Interview Survey, 1996.

Basic and clinical microbiology

Classification

- Virus (Smallest infectious agent-DNA or RNA in a protein coat)
- Bacteria (single-cell prokaryotes)
- Fungi (Eukaryotic organisms with cell walls that lack photosynthetic capability)
  - Yeast
  - Mold
- Prions (Infectious agent composed of protein)
- Parasites
  - Bedbugs, lice
  - Protozoa (unicellular, free-living eukaryotic organisms)

Scientific Names of Microbial Species

Species name	Source of Genus Name	Source of Specific Epithet
Klebsiella pneumoniae	Honors Edwin Klebs	The disease
Escherichia coli	Honors Theodor Escherich	Derived from the colon, an inhabitant in gastro-intestinal tract
Salmonella typhimurium	Honors Daniel Salmon	Stupor (*typh*-) in mice (*muri*-)
Staphylococcus aureus	Greek staphyle, *meaning* a bunch of grapes, and kokkos, *meaning* berry	Gold-colored (aureus) colonies

Genus name: May be descriptive or honor a scientist.

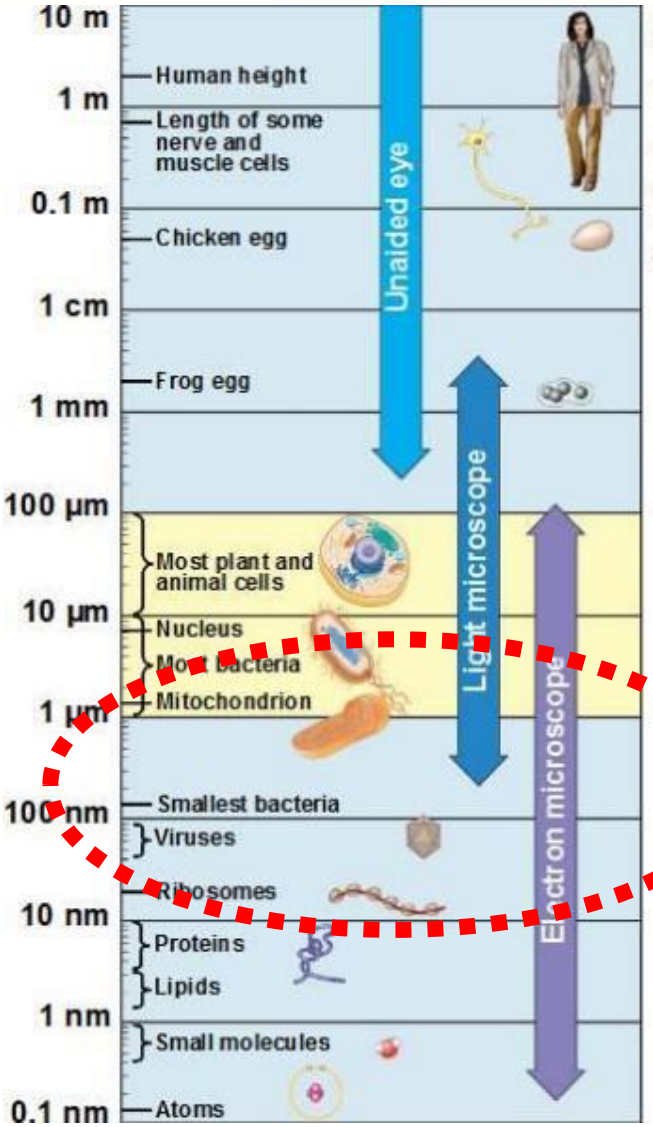
The species name includes the genus as well as the specific epithet.

- Italicized or underlined
- Genus name is capitalized and may be abbreviated
- A genus name may be used alone to indicate a genus group; a species name is never used alone

eg: *Bacillus subtilis*

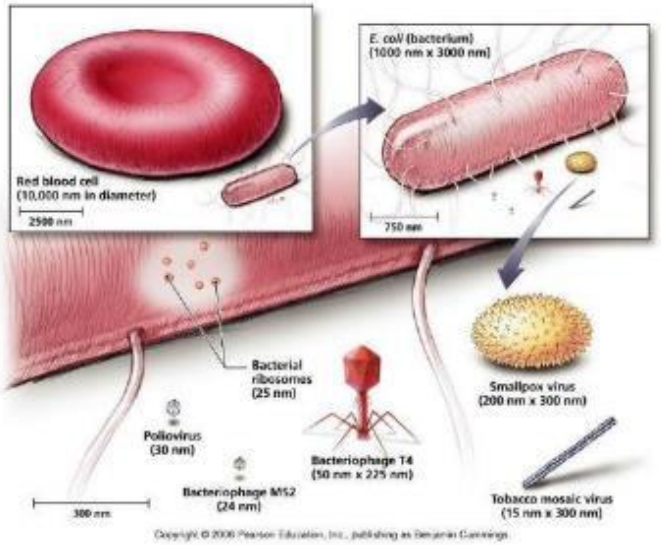
B. subtilis

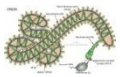
Culprits of Infectious Diseases



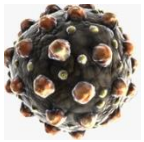
http://www.slideshare.net/5alod/campbell-biology-9th-edition-slides

@Pearson Education/Benjamin Cummings





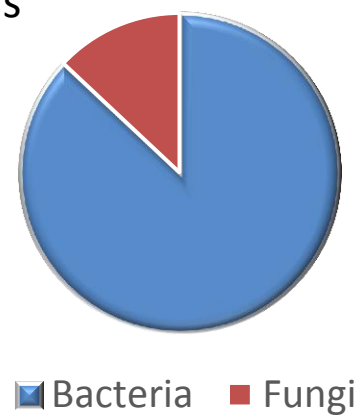
Ebola



Measles virus

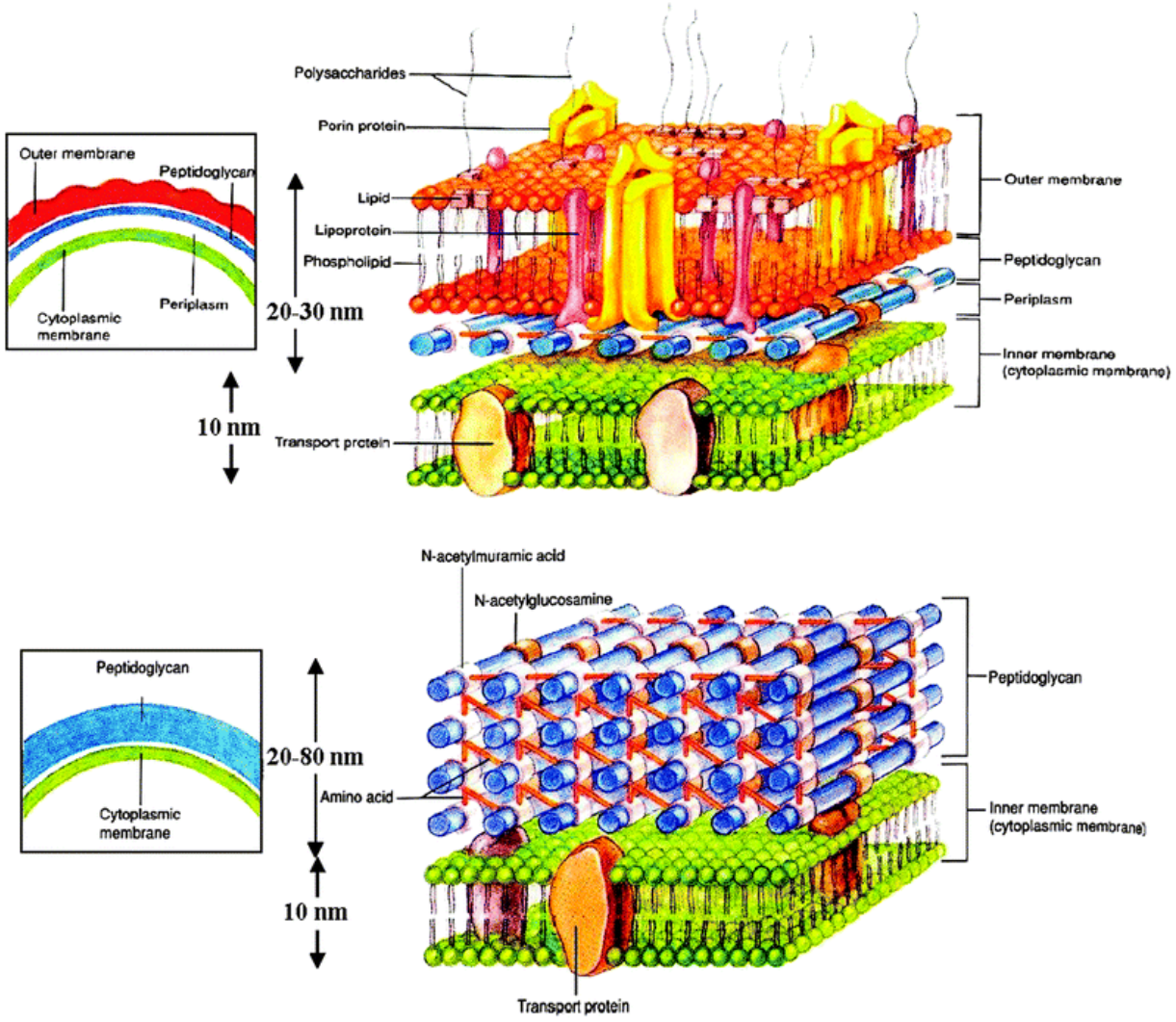
Epidemiologically Significant Pathogens

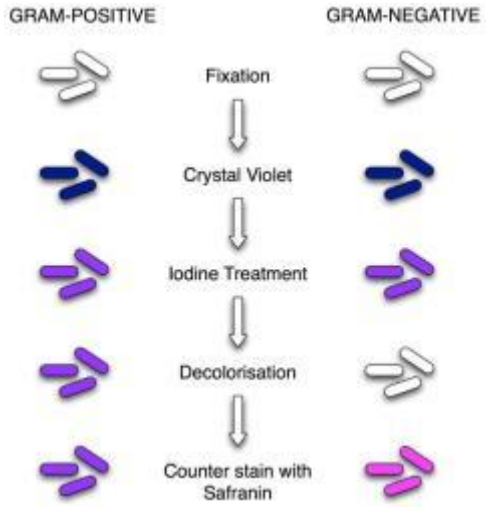
- 28,502 HAIs reported to NHSN b/w Jan 2006-Oct. 2007
- 621 U.S. hospitals

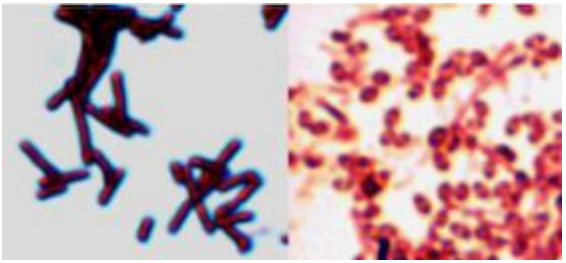


CDC 2010 report

Culprits of Infectious Diseases





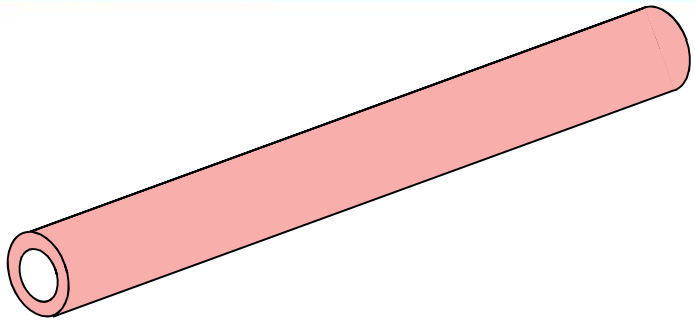


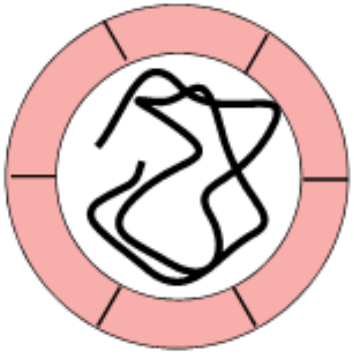
Teresa Cardoso, et. al. *BMC Infectious Diseases* 2012, **12**:375 doi:10.1186/1471-2334-12-375

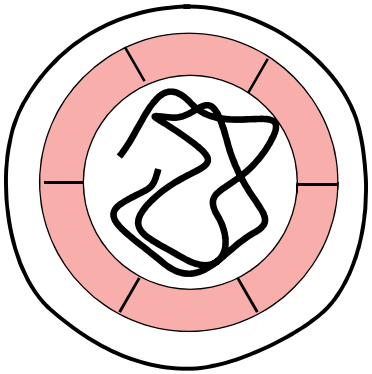
Cattaneo *et. al.* **Nature Reviews Microbiology** 6, 529-540 (July 2008) | doi:10.1038/nrmicro1927

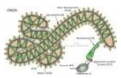
Culprits of Infectious Diseases

- Virus size
  - 17 nm – 3000 nm diameter
- Basic shape
  - Rod-like
  - "Spherical"
- Protective Shell - Capsid
  - Made of many identical protein subunits
  - Symmetrically organized
  - 50% of weight
  - **Enveloped or non-enveloped**
- Genomic material
  - DNA or RNA
  - Single- or double-stranded

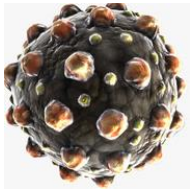




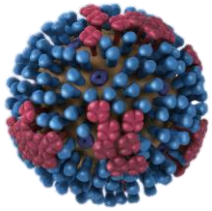




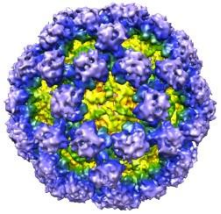
Ebola



Measles virus



Influenza



Norovirus

Jonathan King, *et al*. Introduction to Virus Structure. MIT Tutorial. 2008

Microbial Resistance Profile to Disinfectants and Sterilants

More resistant

Prions

Endospores of bacteria

Mycobacteria

Cysts of protozoa

Vegetative protozoa

Gram-negative bacteria

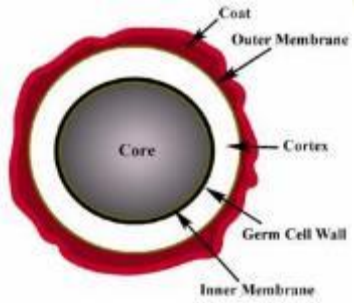
Fungi, including most fungal spores

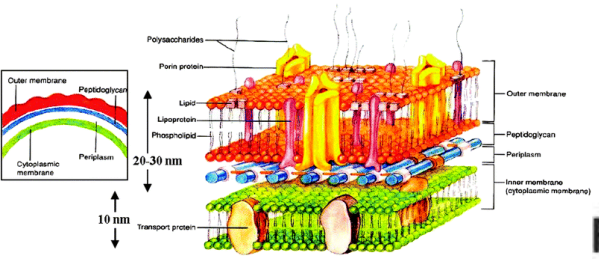
Viruses without envelopes

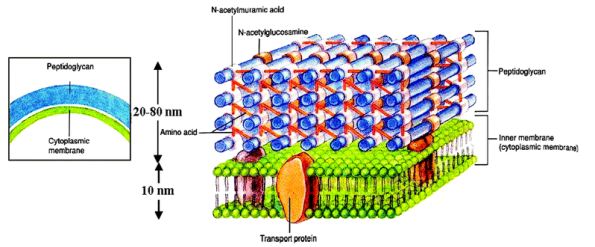
Gram-positive bacteria

Viruses with lipid envelopes

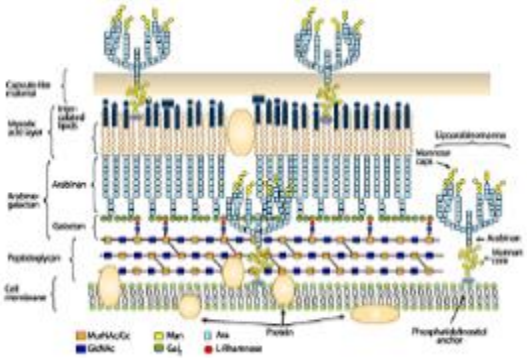
Less resistant

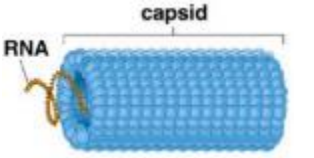


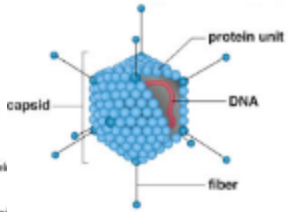


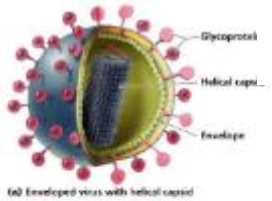


Peptidoglycan

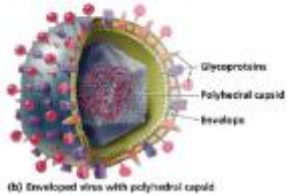








(a) Enveloped virus with helical capsid

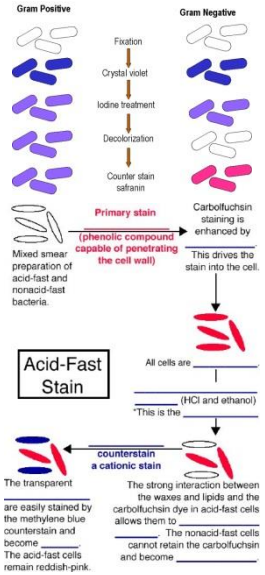


(b) Enveloped virus with polyhedral capsid

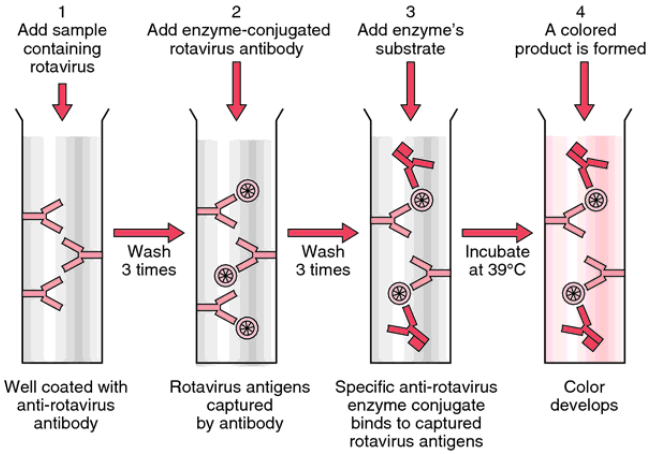
Reference: Gerald E. McDonnell.
"Antisepsis, Disinfection, and Sterilization: Types, Action, and Resistance" American Society for Microbiology (ASM)Press, Washington, D.C., 2007

Basic and clinical microbiology

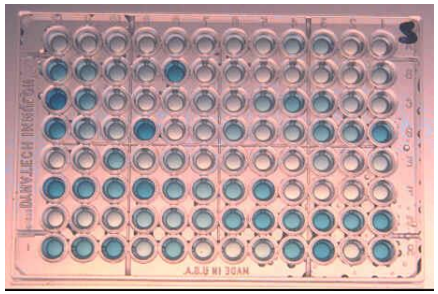
- Techniques used to identify microbes
  - Direct on microbes
    - ✓ Biochemistry
      - Gram staining, acid-fast staining
      - Culture (Growth media, incubation parameters)
      - Differential testing (biochemical responses, carbohydrate fermentation, enzyme testing)
      - Antigen detection (ELISA, serological testing, latex agglutination, MIP)



Specific color reactions of microorganisms on CHROMagar Orientation.
1, *P. mirabilis*;
2, *E. faecalis*;
3, *K. pneumoniae*;
4, *P. aeruginosa*;
5, *E. coli*;
6, *S. aureus*.



Samra Z *et al*. **J. Clin. Microbiol.** 1998;36:990-994



Chromogenic media

-Contains chromogenic substrate such as ONPG, X-Gal, X-Glu
-The substrate can only be metabolized by certain enzymes
-The enzymes are specific to target microbes
-Direct observation of a distinct color change in the medium

Overview of Microbial Diagnostics

Catch me if you can!

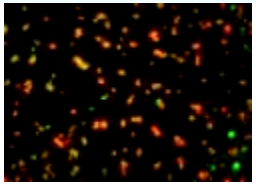
Pathogenic organisms, e.g. bacteria, virus
(AFM image of pathogenic *E. coli*)

Phenotypic diagnosis

Significant delay and inaccuracy

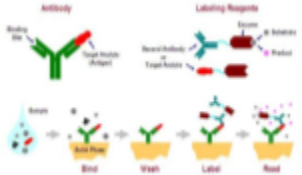
Biochemical diagnosis

Too specific and costly



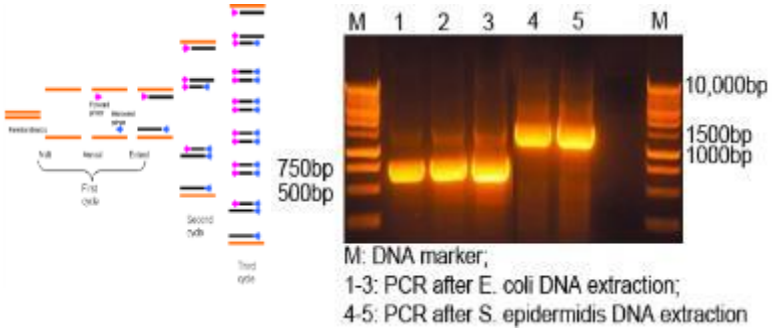
Fluorescent diagnosis

Complex steps (stain, wash, image….)



Immunological diagnosis

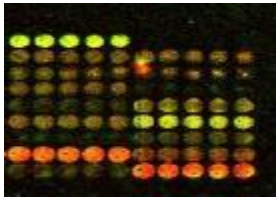
Hard to determine the "cut-off" point between a positive and negative result



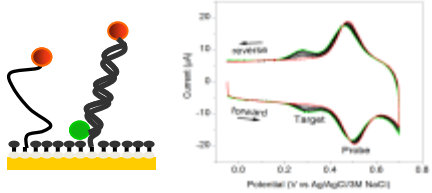
Nucleic acid amplification based diagnosis, e.g. PCR

Difficulty in primer design for unknown samples, amplification fidelity and cost

Polymerase Chain Reaction (PCR)



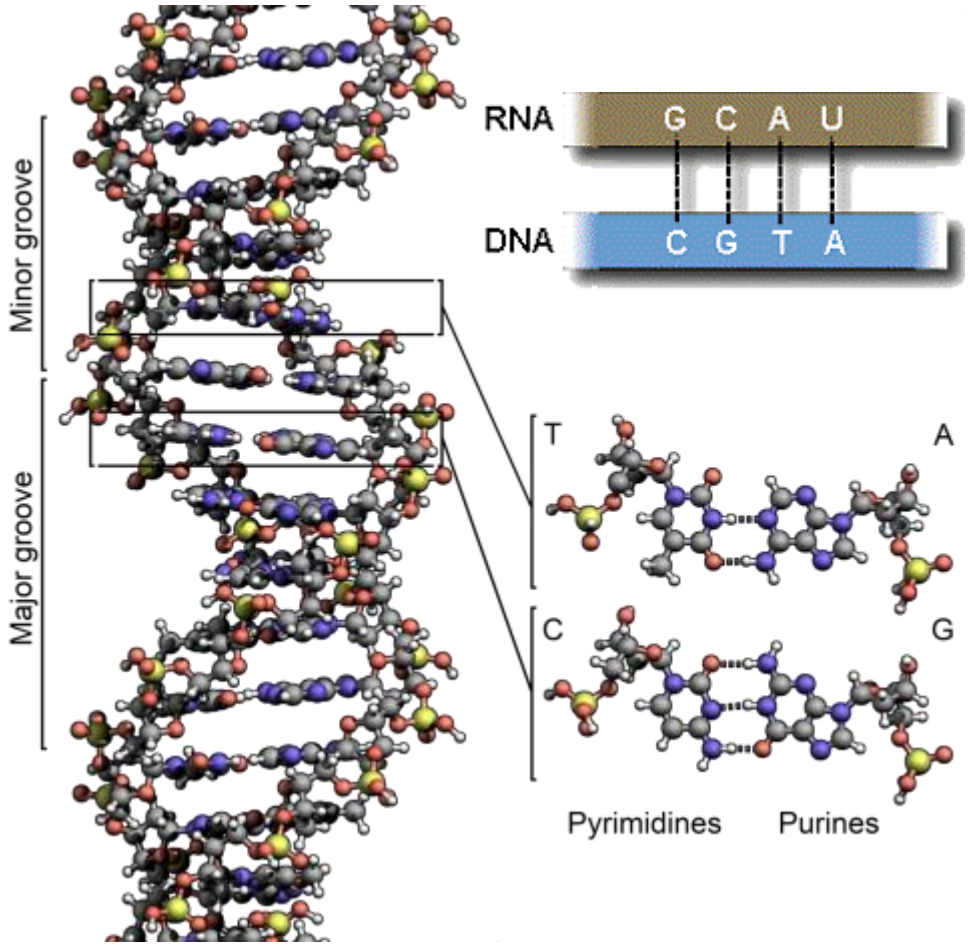
Surface based hybridization

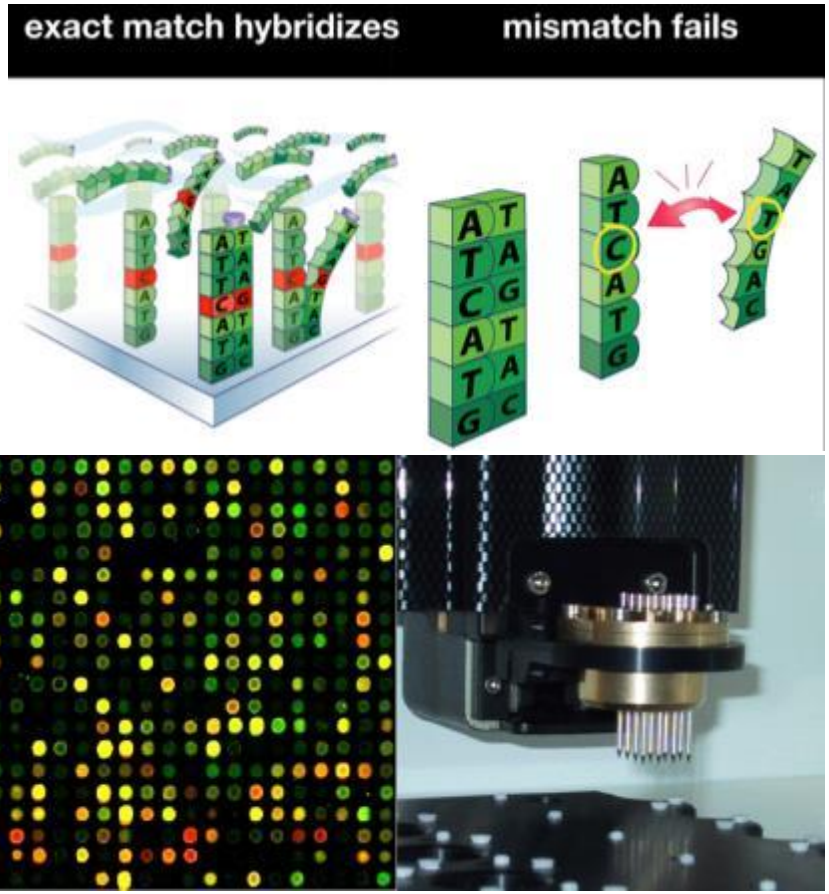


Surface hybridization based, e.g. microarray

Liu, Y., *et al.* **JACs** 132(28), 9663-9671, 2010.

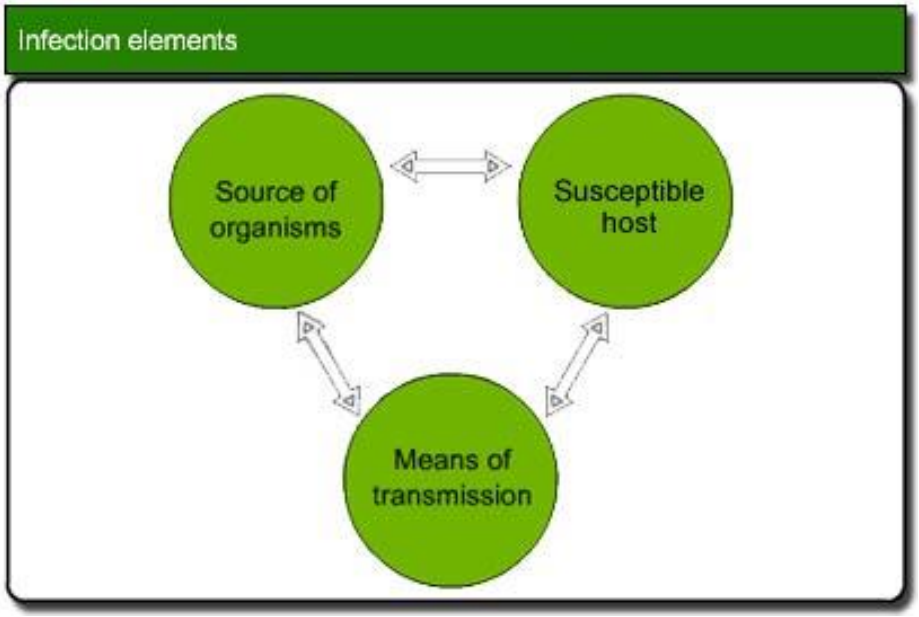
DNA/RNA hybridization based molecular diagnostics

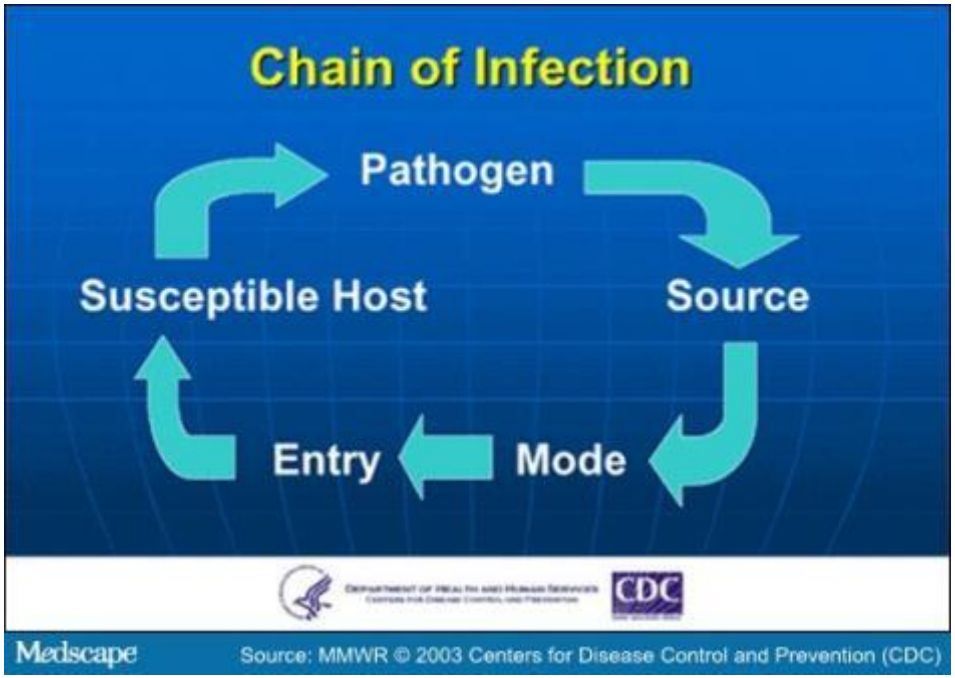




Liu, Y. *et al*., ***Analytical Biochemistry***. *Charge-neutral morpholino microarrays for nucleic acid analysis.* 2013, 434 (2) 207-214

Infection elements





Source: CDC

Microbial pathogenesis

- Pathogenicity
  - Ability of a microorganism to cause disease by overcoming the defenses of a host
- Virulence
  - The degree or extent of pathogenicity

Microbial pathogenesis

- Transmission
  - Direct contact: close physical contact
  - Indirect contact: transmission by fomites
  - Droplet transmission: coughing or sneezing
  - Vehicle transmission: via a medium (water, food, air, etc.)

http://www.sciencephoto.com/

Portals of Entry

- Pathogens
  - Must gain access to host
  - Adhere to host tissue
  - Penetrate or evade host defenses
  - Damage host tissue

Portals of Entry

- Portal of Entry
  - Routes microorganisms can penetrate the body
    - 1- mucous membranes
    - 2- skin
    - 3- parenteral route

Mucous membrane entry

- Mucous membranes
  - Respiratory tract
    - Easiest and most frequent route of infection
    - Inhaled through nose or oral cavity
    - Duct particles, moisture droplets
    - Common cold, pneumonia, tuberculosis, influenza, smallpox and measles

Mucous Membrane Entry

- Mucous membrane
  - Gastrointestinal route
    - In food or water
    - Contaminated fingers
    - Most are inactivated by stomach acid, enzymes
    - *Norovirus*, *Salmonella*, hepatitis A, cholera

Mucous Membrane Entry

- Mucous membrane
  - Genitourinary tract
    - Contracted sexually
    - Intact or broken mucous membranes
    - STD (sexually transmitted diseases/infections)
    - HIV, genital warts, genital herpes, syphilis, and gonorrhea

Skin

- Skin
  - Unbroken skin – barrier to microorganisms
  - Abscesses, burns, wounds, bites
  - A reservoir

Preferred Portal of entry

- Some microbes must enter via preferred route to cause disease
  - *Streptococcus pneumoniae*
    - if inhaled can cause pneumonia
    - if enters the G.I. Tract, no disease
  - *Salmonella typhi*
    - if enters the G.I. Tract can cause Typhoid Fever
    - if on skin, no disease
- Some microbes may cause disease with many different route of entry
  - *Pseudomonas aeruginosa*

Transmission of Measles

- Measles is a highly contagious virus that lives in the nose and throat mucus of an infected person.
- It can spread to others through coughing and sneezing.
- Also, **measles virus can live for up to two hours on a surface** or in an airspace where the infected person coughed or sneezed.
- If other people **breathe** the contaminated air or **touch** the infected surface, then touch their **eyes**, **noses**, or **mouths**, they can become infected.
- Measles is so contagious that if one person has it, 90% of the people close to that person who are not immune will also become infected.
- Infected people can spread measles to others from four days before to four days after the rash appears.
- Measles is a disease of humans; measles virus is not spread by any other animal species.

Reference: CDC. Measles.

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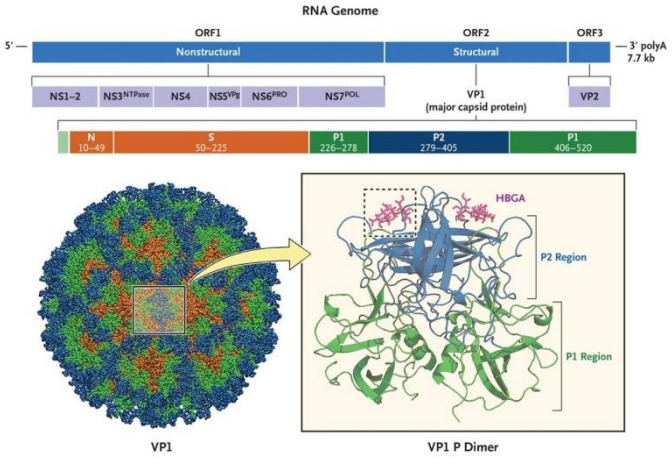
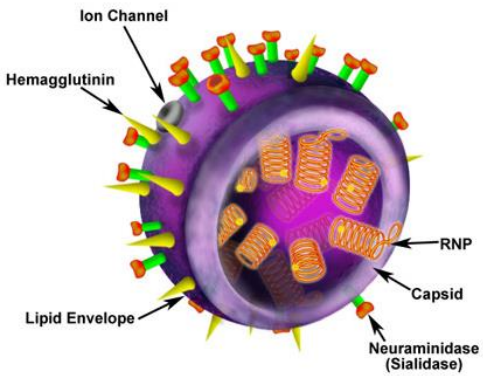
Adherence/Attachment

Specific adherence	Non-specific adherence
Ligand-receptor interactions	• Liftshitz-van der Waals • Electrostatic interactions • Lewis acid/base interactions • Hydrophobic/lipophilic-mediated adhesion • Hydrophobic structure on microbial cell envelope • Lipophilic area on host cell membrane

Adherence/Attachment

		Microbial adhesion	Host cell receptor
Bacteria	Fimbrial	Uropahogenic *E coli* **P pili (fimbriae)**	Epithelial cells **glycolipid receptor globobiose**
	Afimbrial	*Staphylococcus aureus* **fibronectin binding protein**	Epithelial, endothelial, fibroblastic cells **fibronectin receptor integrin**
Virus		*Norovirus* **P domain of the capsids**	Epithelial cells (food, direct contact, fomites) **human histo-blood group antigens (HBGAs)**
		Influenza **hemagglutinin (H) protein**	Upper respiratory tract **Sialic acid on host membrances**



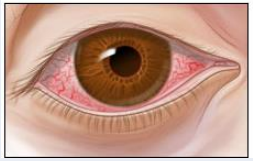
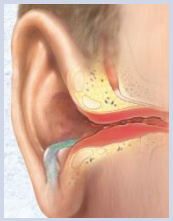


Hemagglutinin: >18 subtypes

Neuraminidase: > 11 subtypes

Bok, Karin, et al. **The New England Journal of Medicine**, 2012, 367: 2126-2132

Common infections and pathogens in schools

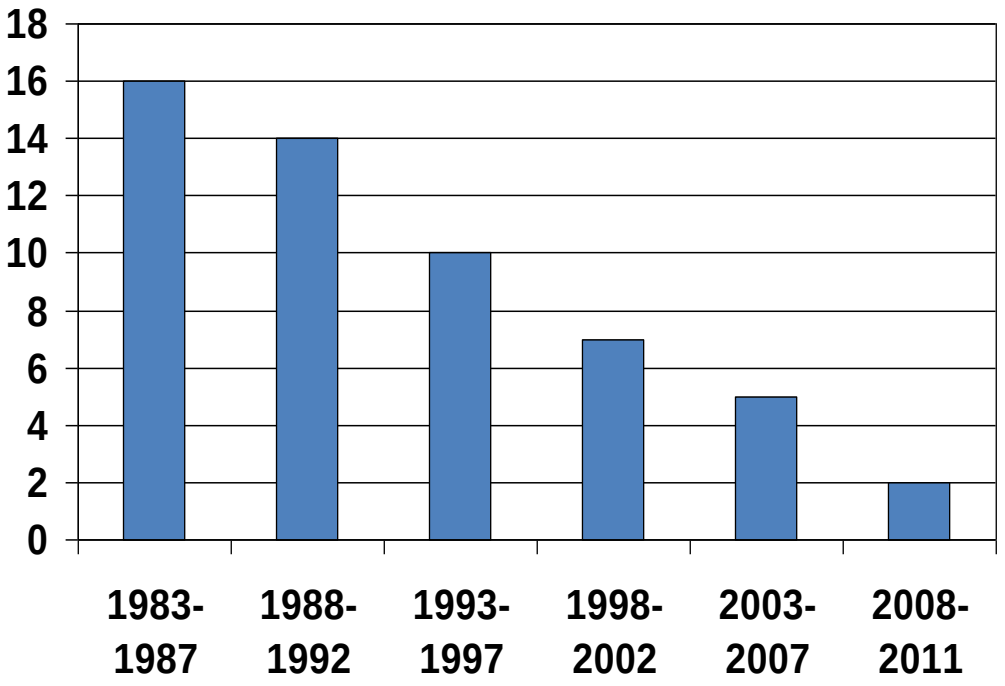
Infection category	Examples		Pathogens
Stomach & Intestinal Infections	Stomach flu vs. food poisoning	Diarrhea	*Salmonella*, *Norovirus*
Lung & Respiratory infections	Infection vs. asthma (inflammation of the airways)	Cold; flu	*Rhinovirus*, *coronavirus*, RSV; *Influenza* A, B; *Measles viruses*
Skin Infections & Rashes		Scarlet fever (strep throat with a rash)	*Streptococcus pyogenes*
Eye Infections		Conjunctivitis (pinkeye)	Viruses or bacteria *Staphylococcus*, *Pseudomonas*
Ear Infections	 	Middle Ear Infections	*Streptococcus*, Respiratory syncytial virus (RSV) *Influenza*

http://kidshealth.org/parent/infections/

Healthwise; Mayo Foundation for Medical Education and Research

Antimicrobial Therapy

Goal: Seek to suppress or kill pathogenic microorganisms with minimal toxicity and /or side effects to the patient.



Adapted from Spellberg B et al. *Clin Infect Dis*. 2004;38:1279-86.

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Summary

- ✓ Overview of infectious diseases at school

- ✓ Fundamental principles of infectious diseases
  - Basic and clinical microbiology
  - Microbial pathogenesis
  - Common pathogens and transmission pathways

- ✓ Evidence-based role of surface disinfection
  - Hand hygiene
  - **Surface disinfection**

Infectious diseases at school

Schools inherently foster the transmission of infections from person to person because they are a group setting in which people are in close contact and share supplies and equipment.

In order to cut the transmission pathways, good practices include:

- Encouraging sick students and staff to stay home and seek medical attention for severe illness.
- Facilitating hand hygiene by supplying soap and paper towels and teaching good hand hygiene practices.
- Being vigilant about cleaning and disinfecting classroom materials and surfaces.
- Providing messages in daily announcements about preventing infectious disease.
- Adopting healthy practices such as safe handling of food and use of standard precautions when handling body fluids and excretions.
- Encouraging students and staff to get annual influenza vaccinations, measles vaccine.

http://www.cdc.gov/healthyyouth/infectious/

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Thank you!