

# Welcome to Micro 22

Principles of Microbiology

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2020

## THE FAR SIDE

By GARY LARSON

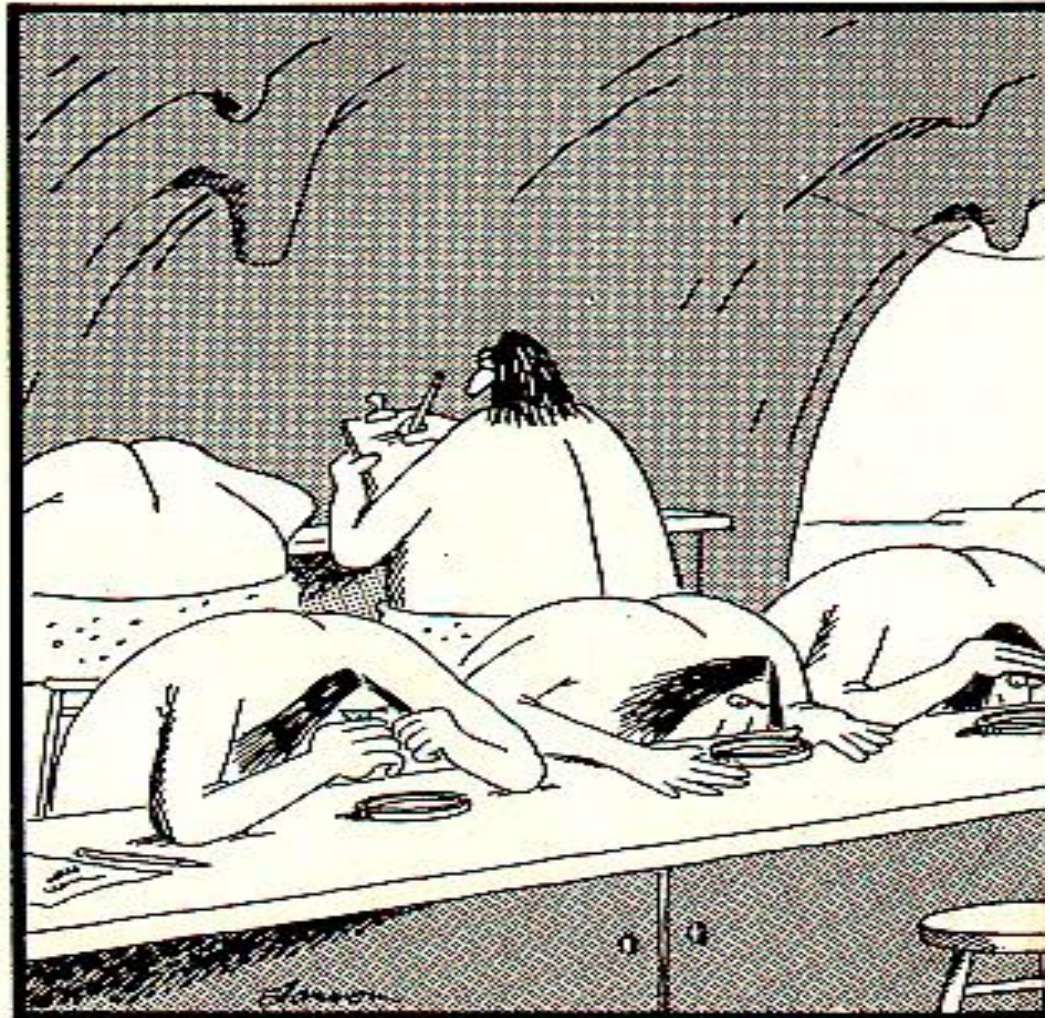
### What is Microbiology?

Root words:

Micro = small

Bio = life

Logy = study of



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Early microbiologists

## **Microorganisms (or Microbes)**

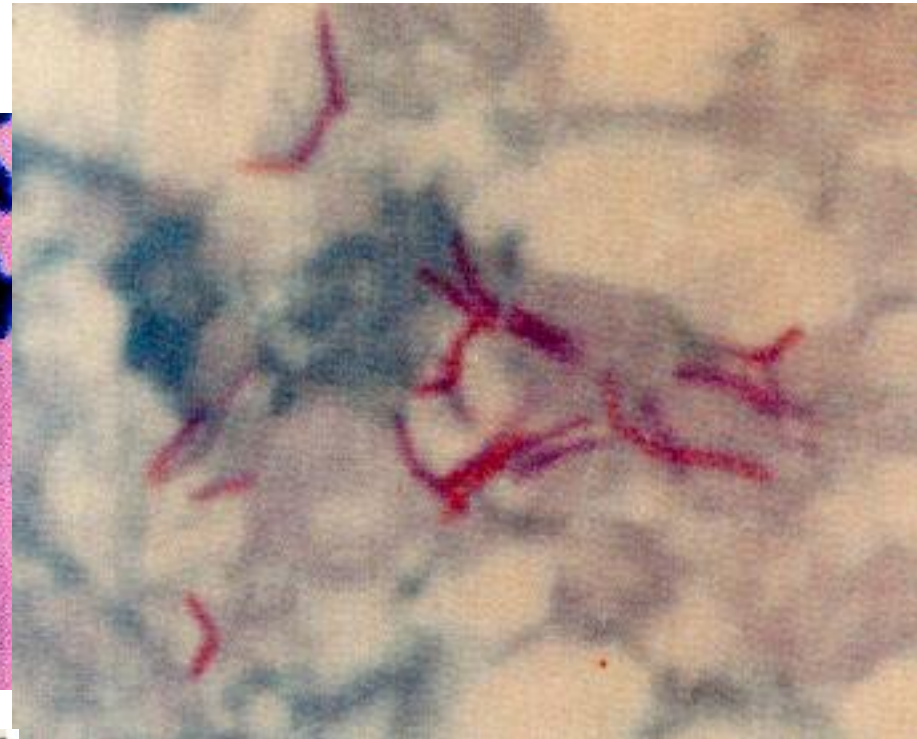
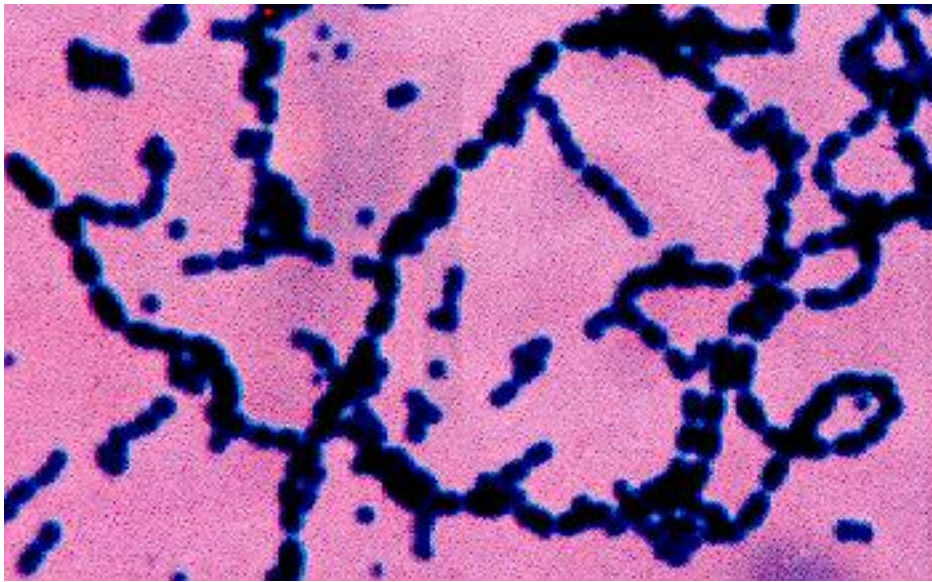
Organisms (living things) too small to  
be seen with the naked eye

OR

Organisms too small to be seen  
without a microscope

# Types of Microbes

- 1) Bacteria





# Types of Microbes

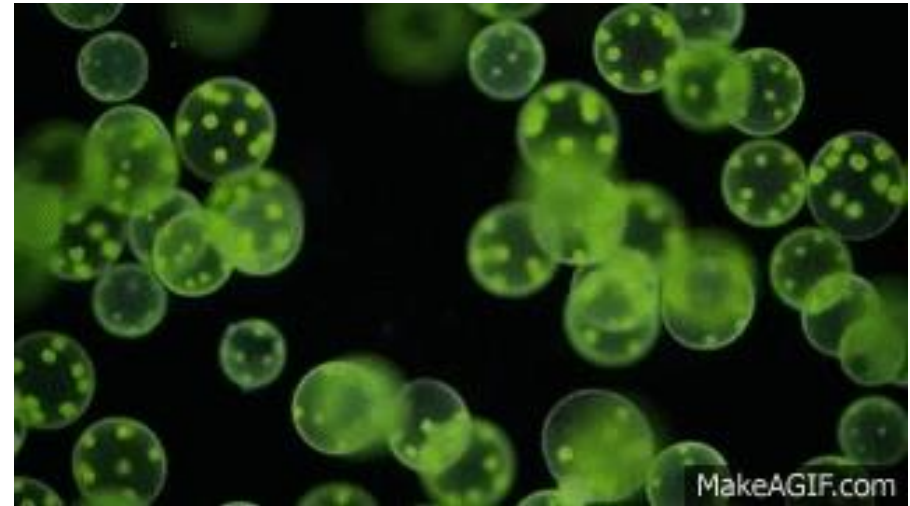
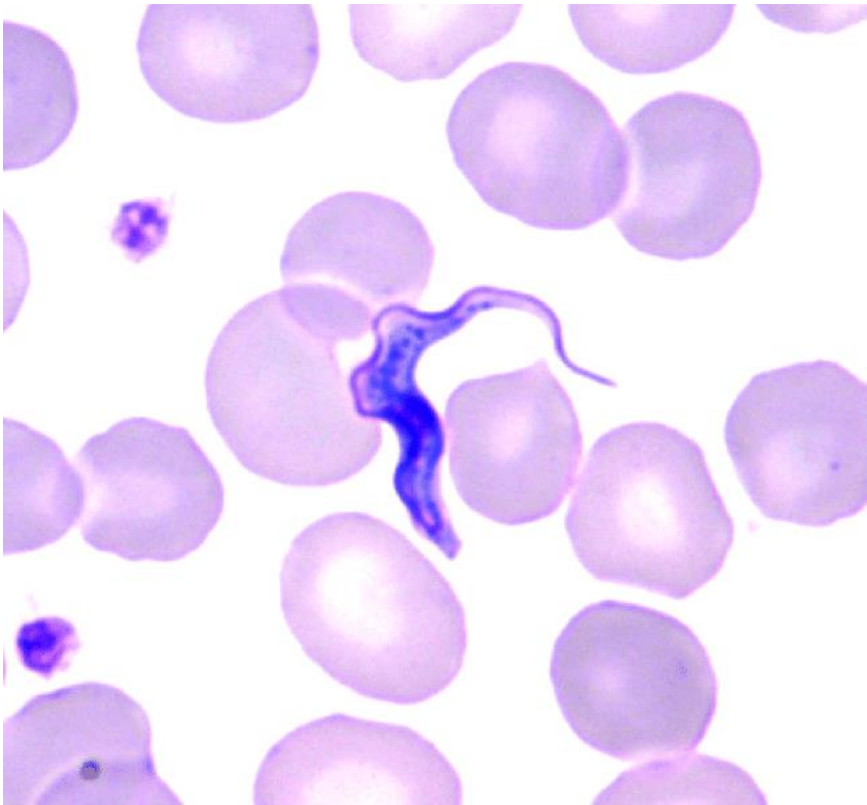
- 2) Archaea
- Like bacteria, but different (more to come!)
- Life's extremes (Hydrothermal vents)
- Not known to cause disease



# Types of Microbes

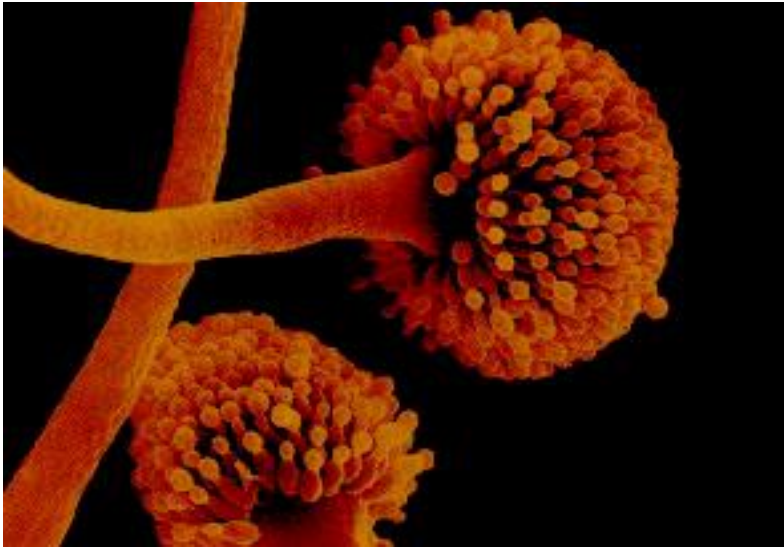


- 3) “Protozoa”
- Mostly single-celled organisms with a nucleus



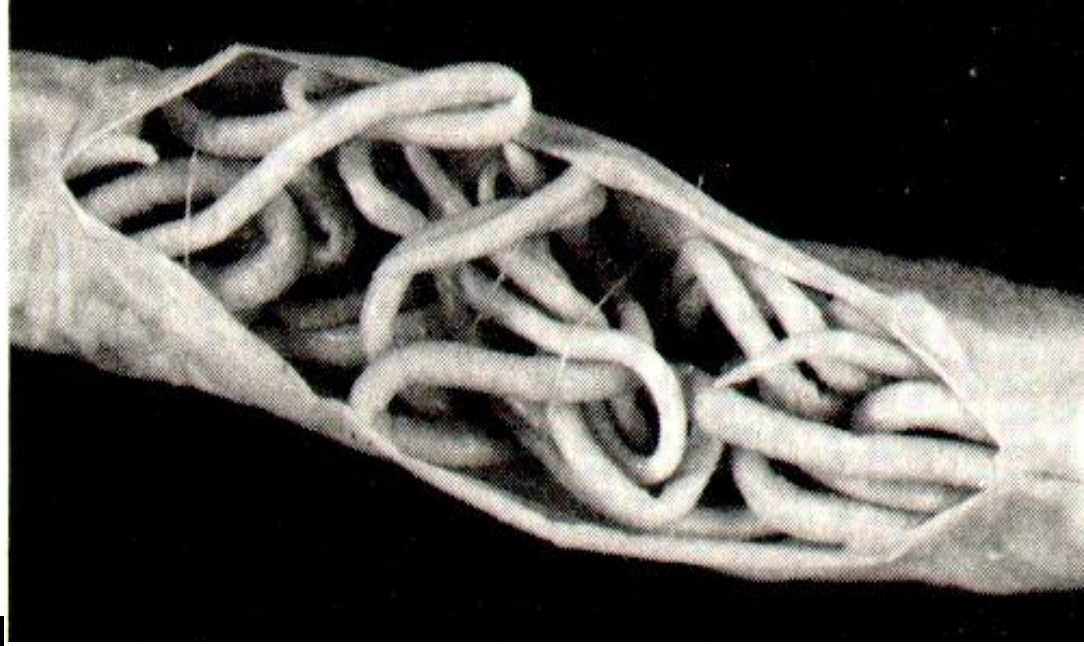
# Types of Microbes

- 4) Fungi (molds & yeast)

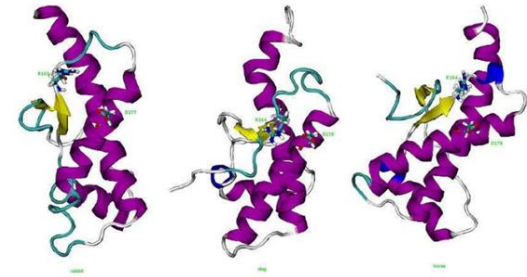


# Types of Microbes

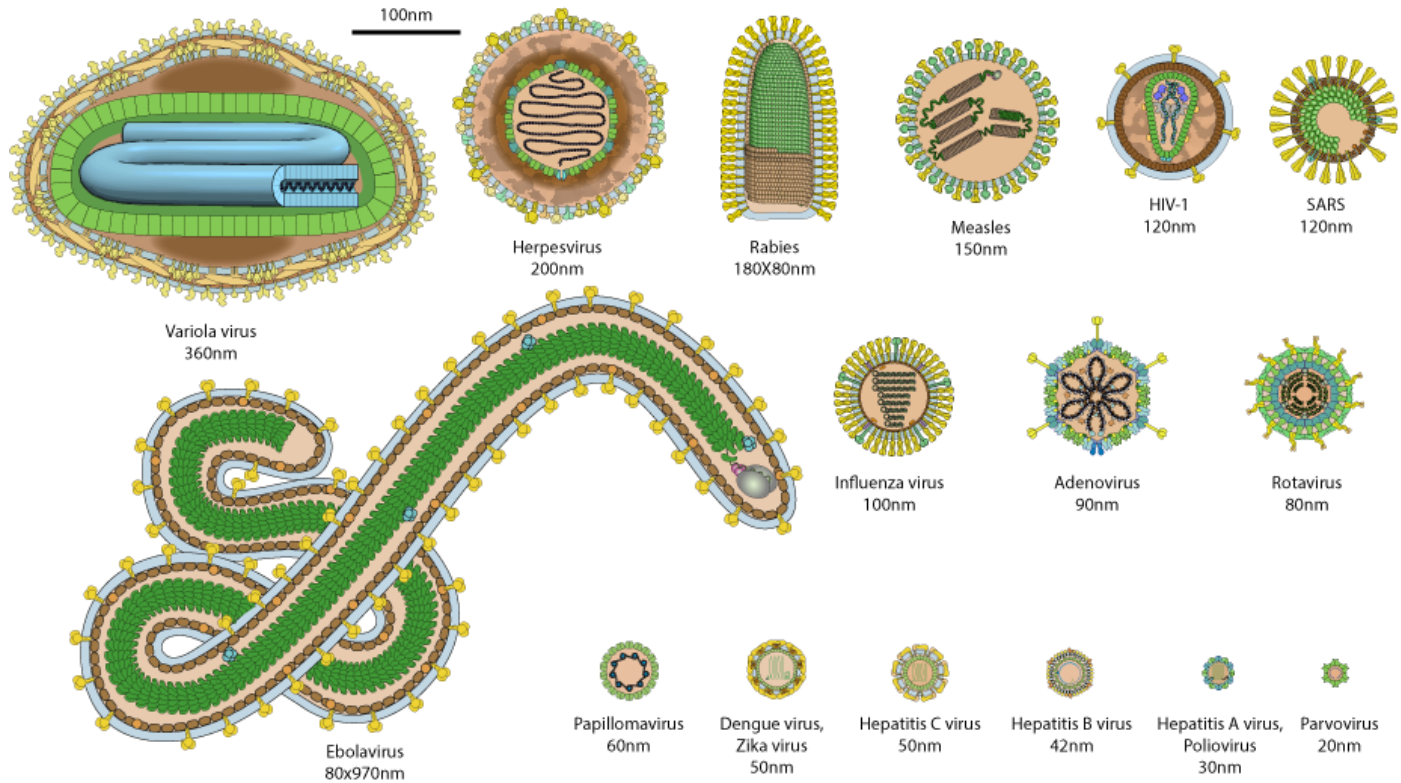
- 4) Parasitic worms







- 5) Viruses & Prions (not really living)



# But are microbes good or bad?

## Bad:

Can cause illness

Can damage  
food crops

## Good:

Good microbes can  
defend against bad  
microbes

Used in making yogurt,  
birth control pills, meat  
tenderizers

9 out of 10!

# Field of Microbiology

- A) Parasitology
- B) Immunology
- C) Bacteriology
- D) Mycology
- E) Virology
- F) Our emphasis will be on Medical Microbiology

# Some terms we use...

- **Organisms:** Any living thing
- **Microorganism:** Any living thing that is generally microscopic in form
- \_\_\_\_\_: Disease Causing organism or agent.
- Words in **RED** are **GREAT** options for “fill-in-the-blank” types of questions!





# And yet, even more terms!

- \_\_\_\_\_: Degree of pathogenicity or the degree to which a pathogen causes a disease.

Example: *Salmonella*

Estimated **1.3 million** cases/yr in U.S. (**420 deaths**)

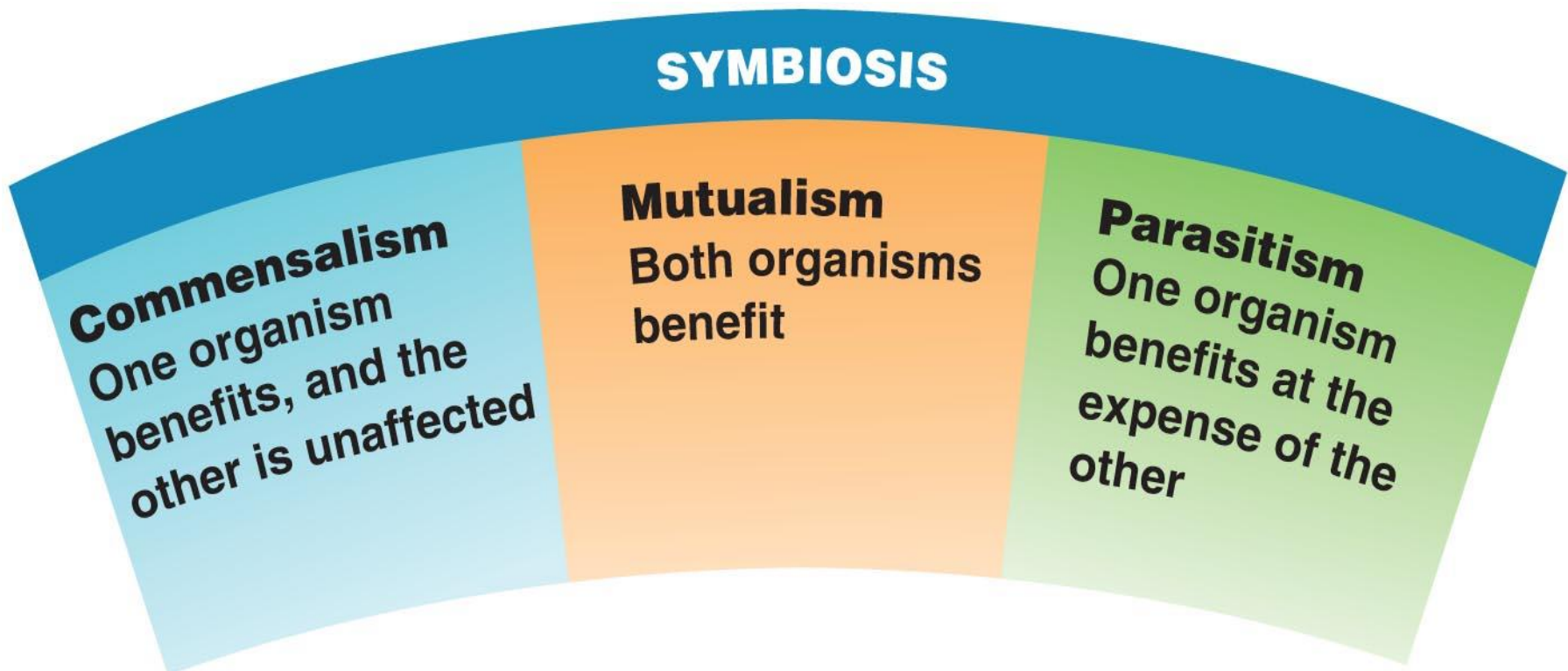
Associated with raw meat, poultry, milk, dairy products, fish, eggs, coconut, frog legs, peanut butter, cocoa and chocolate, Pets! (such as turtles, other reptiles, dogs, cats, birds, pet food, treats)!

# Changes in our understanding....

- \_\_\_\_\_ - clusters of genes (genetic information) responsible for virulence can move a pathogenic strain into **avirulent** organism converting it into a pathogen!

# Symbiosis

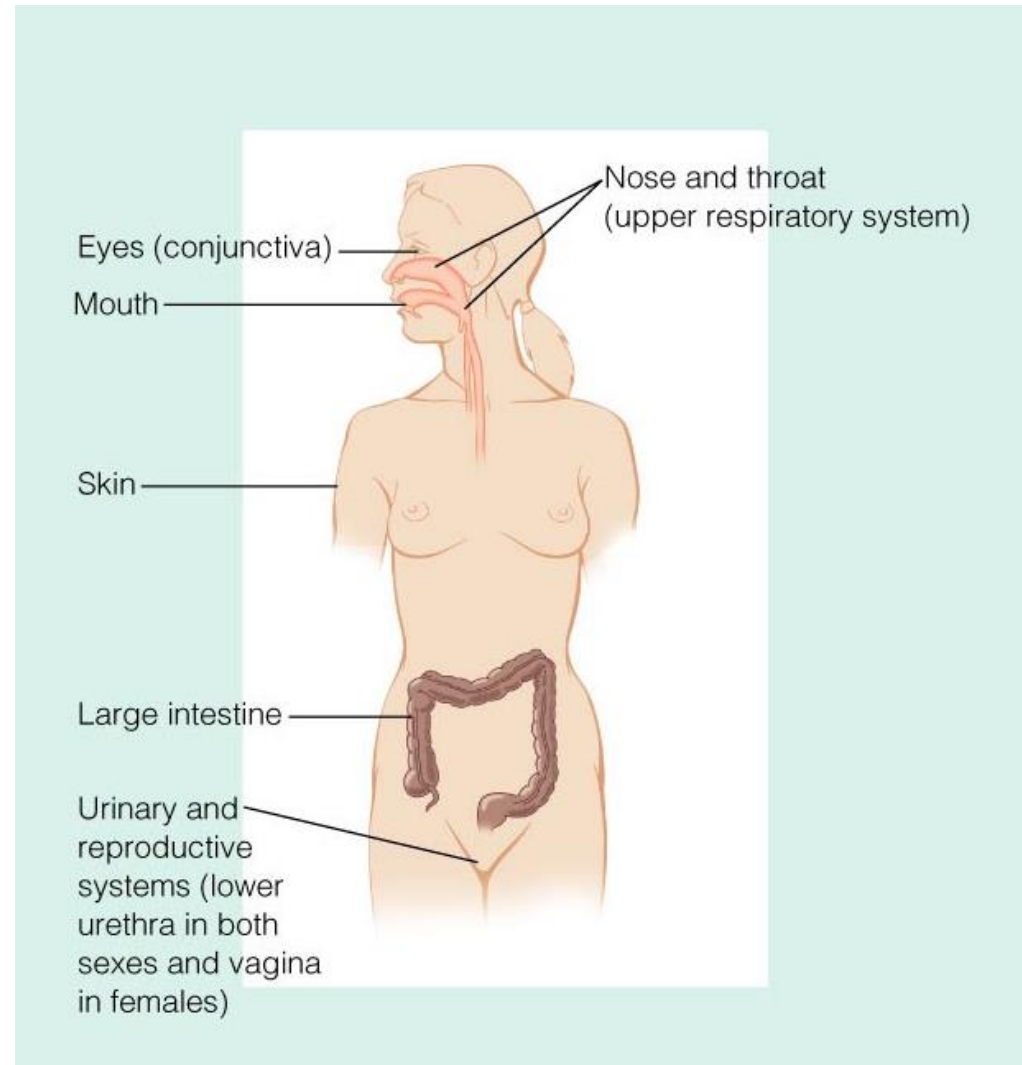
- When two organisms live together





# Normal Flora

- Locations of normal microbiota on and in the human body.
- Over 1000 species in the mouth!
- 99% of the cells on our body are not ours!



# Normal Microbiota and the host (you!)

- Microbial antagonism is a competition between microbes
- **Normal microbiota** protect you by:
  - Occupying niches that pathogens might occupy
  - Producing acids
  - Producing \_\_\_\_\_ (bacterial toxins that prevent the growth of other bacteria!)
- \_\_\_\_\_ – live microbes applied to or ingested into the body
- \_\_\_\_\_ – chemicals that promote bacterial growth.
  - “feces sample” – mixed results



# Opportunistic Microbes

- Normally do not cause disease...
- But!...
  - Host becomes weakened
    - AIDS and *Pneumocystis* pneumonia
  - Microbes in a different environment
    - *E. coli* in food...
  - Cooperation among microbes
    - \_\_\_\_\_ a disease caused by more than one organism (often are synergistic – one alters the environment for the other!)

# Classifying Infectious Diseases

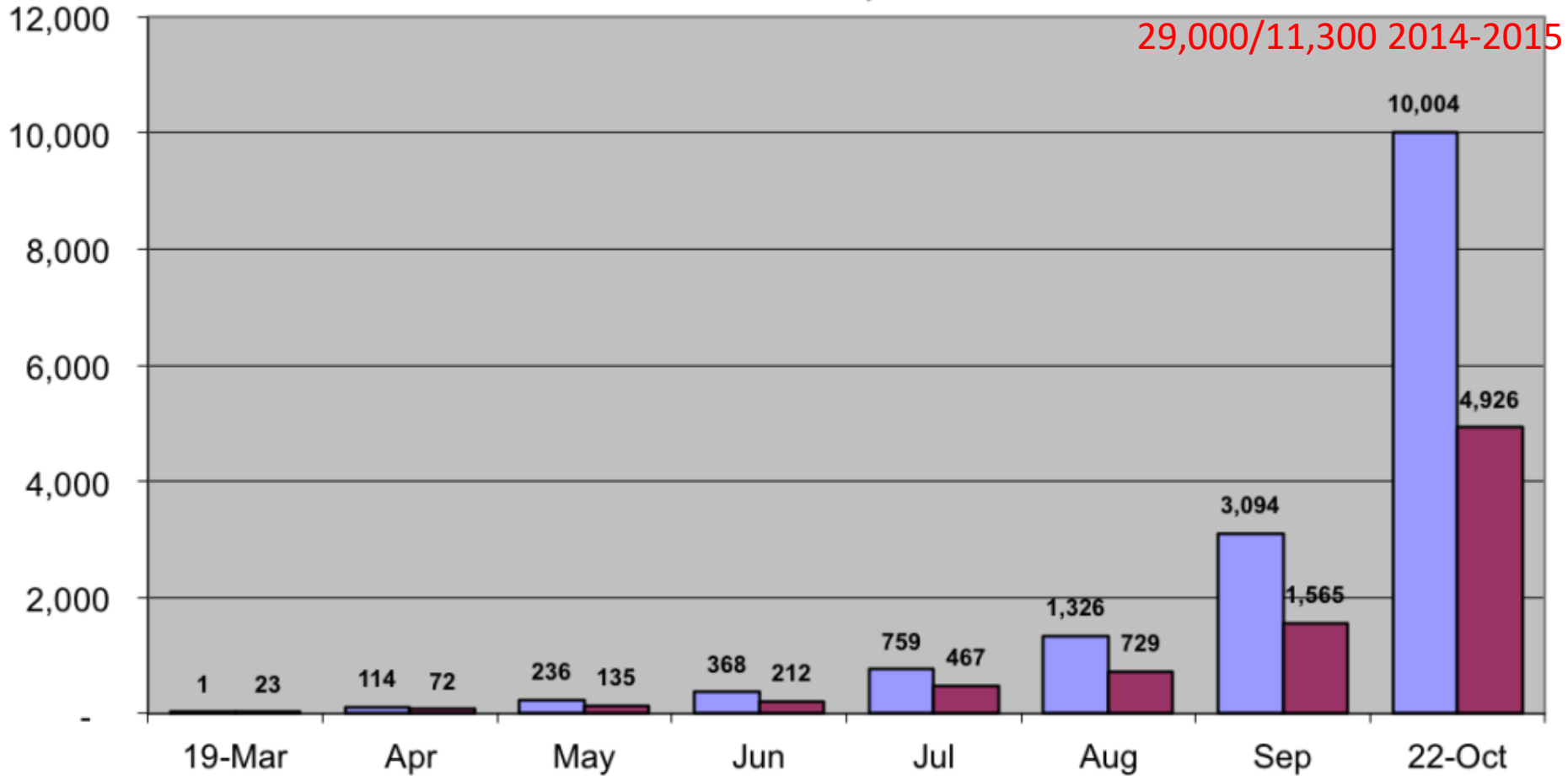
- \_\_\_\_\_ a change in body function that is felt by a patient as a result of disease.  
(pain, itchy skin)
- \_\_\_\_\_ a change in a body that can be measured or observed as a result of disease.  
(blood pressure, painless/non-itchy rash)
- \_\_\_\_\_: A specific group of signs and symptoms that accompany a disease.



# Occurrence of Disease

- Incidence The fraction of a population that contracts a disease during a specific time.
    - An indicator of the spread of a disease (RATE).  
120 new cases per month for the past year
  - Prevalence The fraction of a population having a specific disease at a given time.
    - Regardless of when it first appeared
    - Takes into account both old and new cases (SNAPSHOT). (12% of the population of Los Angeles)
- INCIDENCE is a RATE at which a disease is spreading over a period of time....PREVALENCE is a measure of how widespread a disease is at specific time**

**Chart 1. Reported Ebola Cases and Deaths  
As of October 22, 2014**



As of Sep 2019 3,000 cases / 2,000 deaths (Democratic Republic of Congo) **0%** = Trump impeachment!) – Dec 18<sup>th</sup> 2019

Source: World Health Organization

■ Cases ■ Deaths

# Occurrence of Disease

- \_\_\_\_\_ Diseases that occur occasionally in a population.
  - Most days, no cases (Plague, Rabies, Ebola 2014, 2019-2020???)
- \_\_\_\_\_ Disease constantly present in a population.
  - Can be endemic from very low level (Syphilis) to nearly universal (Oral Herpes)

# Occurrence....

- \_\_\_\_\_ Disease acquired by many hosts (people) in a given area in a short period of time.
  - Disease could normally be either sporadic or endemic (Example, Hepatitis A at certain times).
- \_\_\_\_\_ Worldwide epidemic
- \_\_\_\_\_ – Immunity in most of a population (80%)



# Severity or Duration of a Disease

- \_\_\_\_\_ Symptoms develop rapidly.
- \_\_\_\_\_ Disease develops slowly.
  - These terms are **NOT** necessarily tied to how “bad” a disease is!
    - A Cold and Ebola are both Acute
    - Arthritis and Alzheimer’s are both Chronic
  - **Latent Diseases** – Diseases that appear to disappear and reappear (TB)

# Extent of Host Involvement

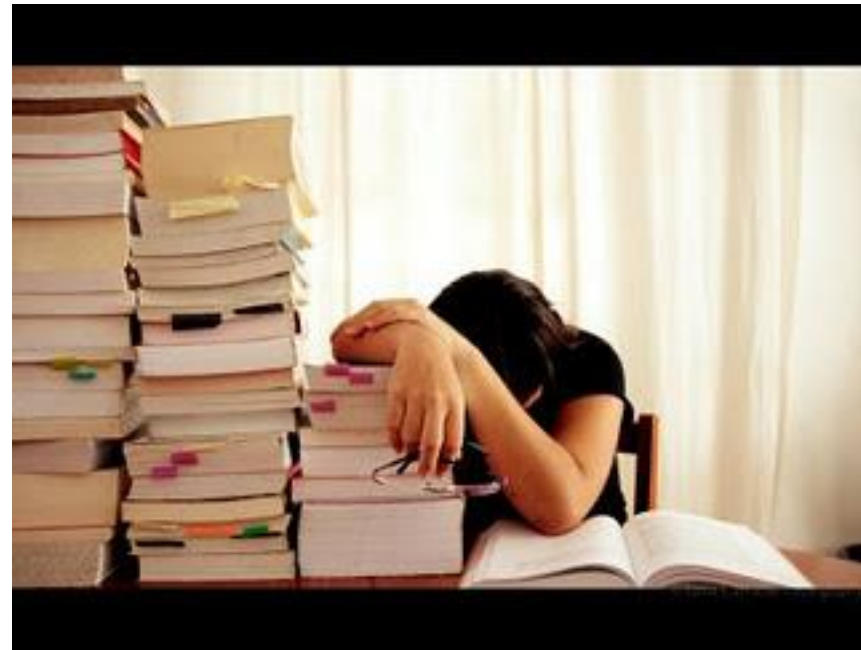
- \_\_\_\_\_ Pathogens are limited to a small area of the body.
- \_\_\_\_\_ An infection throughout the body.
- \_\_\_\_\_ Systemic infections that began as local infection
- \_\_\_\_\_ Bacteria in the blood
- \_\_\_\_\_ Growth of bacteria in the blood.

# Extent of Host Involvement

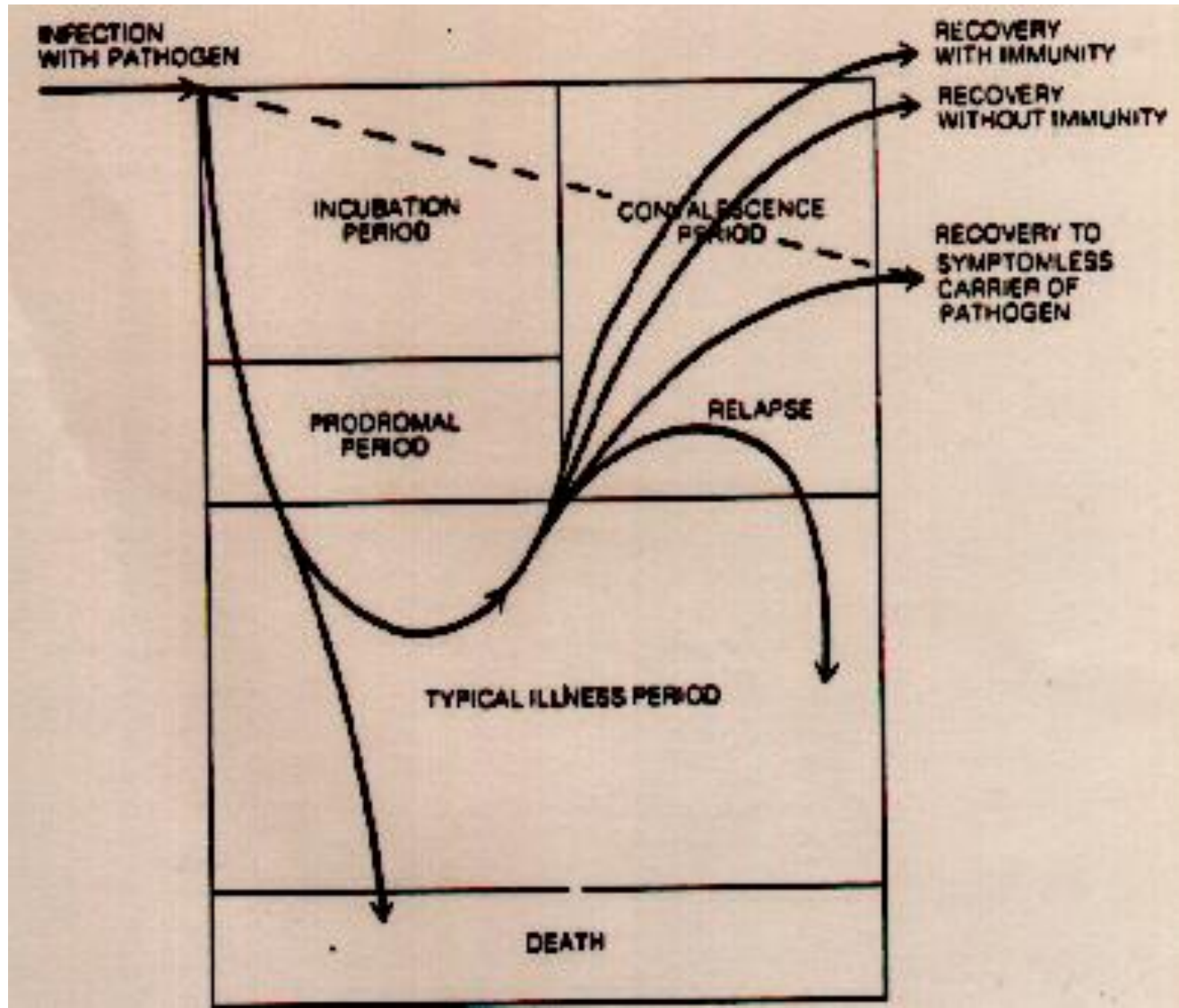
- \_\_\_\_\_ Toxins in the blood
- \_\_\_\_\_ Viruses in the blood
- \_\_\_\_\_ Acute infection that causes the initial illness
- \_\_\_\_\_ Opportunistic infection after a primary (or predisposing) infection.
- \_\_\_\_\_ No noticeable signs or symptoms (inapparent infection).

# Predisposing Factors

- Make the body more susceptible to disease:
  - Short urethra in females (UTI's)
  - Genetics
  - Climate and weather
  - Fatigue
  - Age
  - Lifestyle (stress!)
  - Chemotherapy
  - 2013 Study - Sleep Removes brain toxins...



# Course of disease

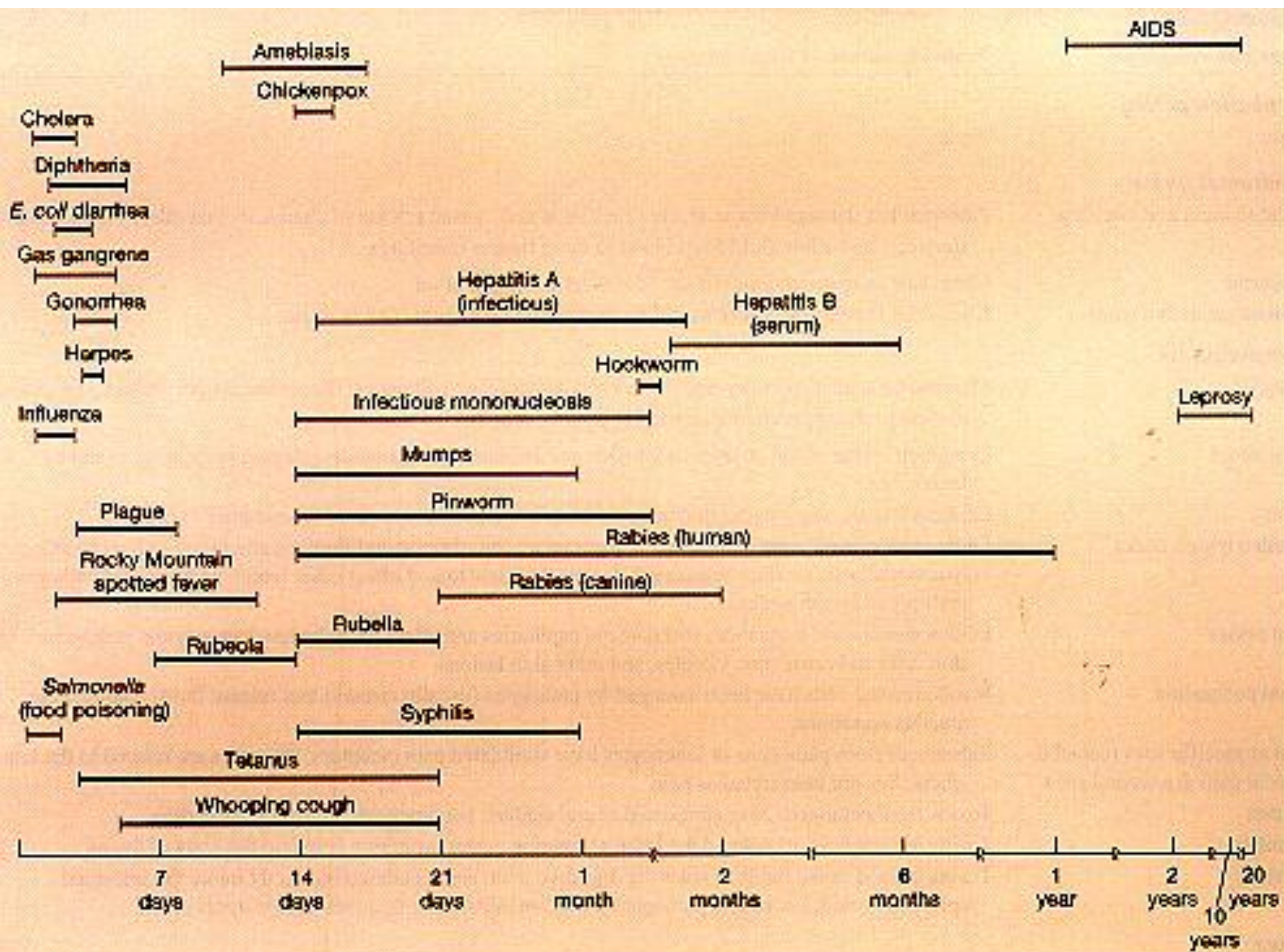




# Course of Disease

- 1) \_\_\_\_\_ Pathogen enters host body, overcomes host defenses, and initiates parasitism.
- 2) \_\_\_\_\_ time between infection and appearance of first symptoms
  - Hours to years
  - Pathogen may be multiplying, adapting to new host, migrating through host body. **This is OFTEN when pathogen is most contagious!**





# Course of Disease

- 3) \_\_\_\_\_ Appearance of nonspecific symptoms (often fever, headache, malaise
  - Usually can not diagnose by prodromal symptoms
    - Contagious period: for many diseases, most contagious time is last half of incubation period and prodromal period.

# Course of Disease

DISEASE vs.  
Infection

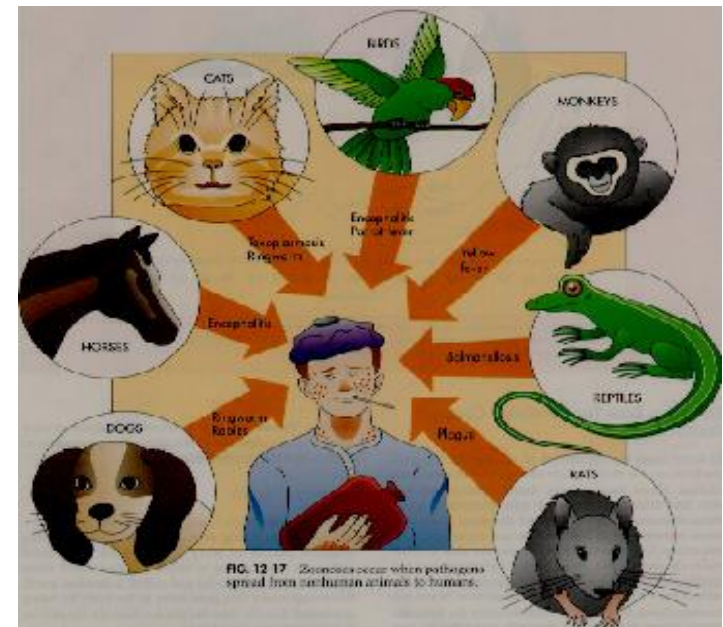
- 4) \_\_\_\_\_ appearance of specific symptoms
  - May be specific enough to allow symptomatic diagnosis
  - Period of illness and period of decline
- 5) \_\_\_\_\_ Period of recovery from illness
  - Some pathogens remain alive in body
  - Possibility of relapse (return of symptoms)

# Course of disease

- Level of recovery:
- Recovery with immunity: will probably not have disease again (Chicken Pox)
- Recovery without immunity: may have same disease again
- Recovery as a carrier of pathogen
  - No symptoms, but shedding pathogen and able to infect other people
  - Carrier state may last from days to lifetime
  - May go directly from infection to carrier state!

# Spread of infection

- Reservoirs of infection are continual sources of infection.
  - Human – HIV, Gonorrhoea
    - Carriers may have in apparent infections or latent infections.
  - Animal – Rabies, Lyme Disease
  - Abiotic (nonliving)
    - Water – Cholera, Typhoid Fever.
    - Soil – Botulism, Tetanus





## Why take precautions?



Because 10,000 people will get roundworms this year.<sup>1</sup>

**Zoonosis** [zoh-uh-noh-sis]  
A disease or parasite that can be transmitted from animals to humans.

**1 TO 3 MILLION**  
PEOPLE ARE INFECTED WITH ZOOBOTIC  
PARASITES EVERY YEAR IN THE U.S.<sup>2</sup>

**700+**  
EXPERIENCE PERMANENT OR PARTIAL LOSS  
OF VISION FROM ROUNDWORMS (*TOXOCARA*).<sup>2</sup>

Children are at high risk because they have a tendency to put dirty fingers and objects in their mouths.

### TIPS FOR PROTECTING YOUR FAMILY:

- Use a broad-spectrum heartworm product that also protects year-round against zoonotic parasites.
- Promptly collect animal feces in your environment and dispose of them.
- Instruct children to wash their hands often.
- Always wear shoes when outside.
- Make unprotected sandboxes off-limits to pets and children.
- Sign up for monthly protection e-mail reminders.

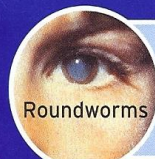


<sup>1</sup>The Center for Food Security & Public Health. "Roundworm Infection, Toxocariasis." Fast Facts. [http://www.cfsph.iastate.edu/fastfacts/pdfs/toxocariasis\\_1.pdf](http://www.cfsph.iastate.edu/fastfacts/pdfs/toxocariasis_1.pdf) (accessed September 26, 2008)

<sup>2</sup>[www.cdc.gov](http://www.cdc.gov)

<sup>3</sup>*A. caninum*

| ZOOBOTIC PARASITE | HOW PEOPLE CAN BECOME INFECTED | AREAS INFECTED |
|-------------------|--------------------------------|----------------|
|-------------------|--------------------------------|----------------|



Roundworms

Licking dirty fingers, eating without washing hands, etc.

Eyes, liver, and lungs<sup>2</sup>



Hookworms<sup>3</sup>

Walking barefoot outside, licking dirty fingers, eating without washing hands, etc.

Skin, internal organs, and intestinal tract<sup>2</sup>

# Transmission of Pathogens

- Transmission is *How* a pathogen is carried to a new host.
- 1) **Direct Contact** (with infected host)
  - Kissing, sex, petting an animal, animal bite (including human!)





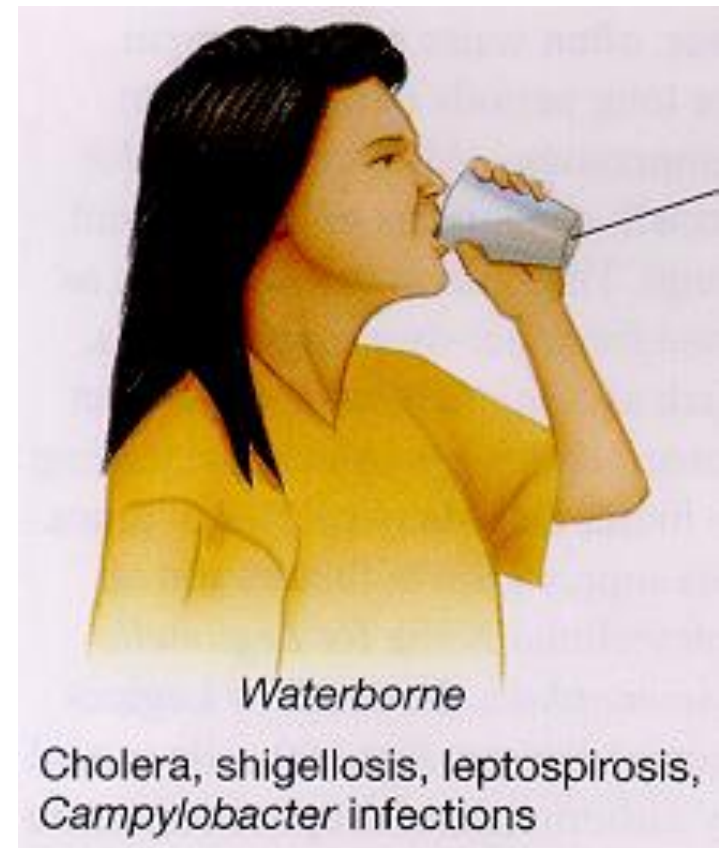


- 3) **Droplet infection**: Saliva or respiratory discharges traveling through the air (for <1 meter)

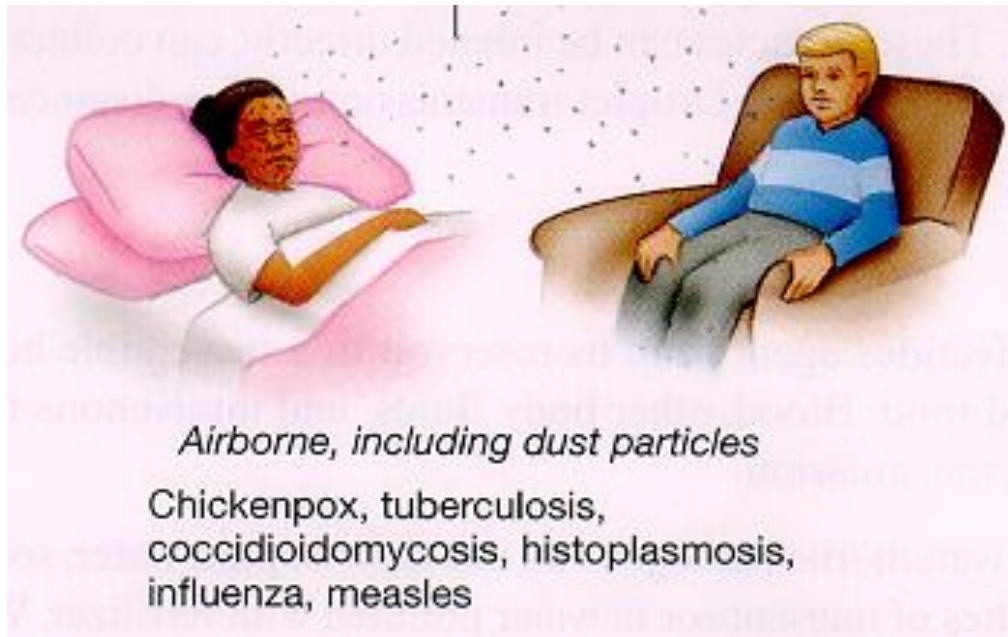




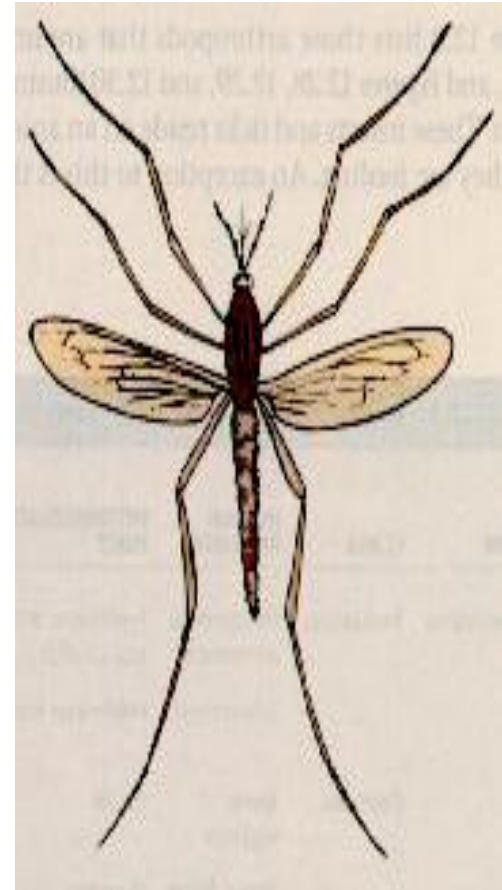
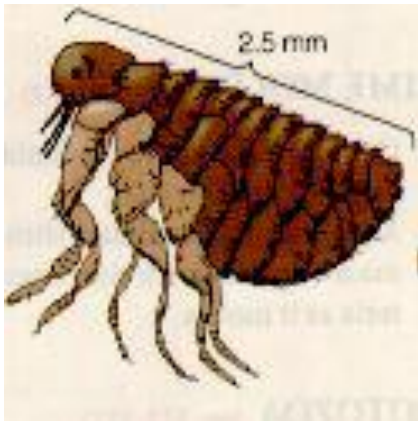
- 4) **Vehicle**: Transmission by an inanimate reservoir (food, water).



- 5) **Airborne**
  - Pathogen carried by air for  $> 1$  meter
    - Measles virus, fungus spores

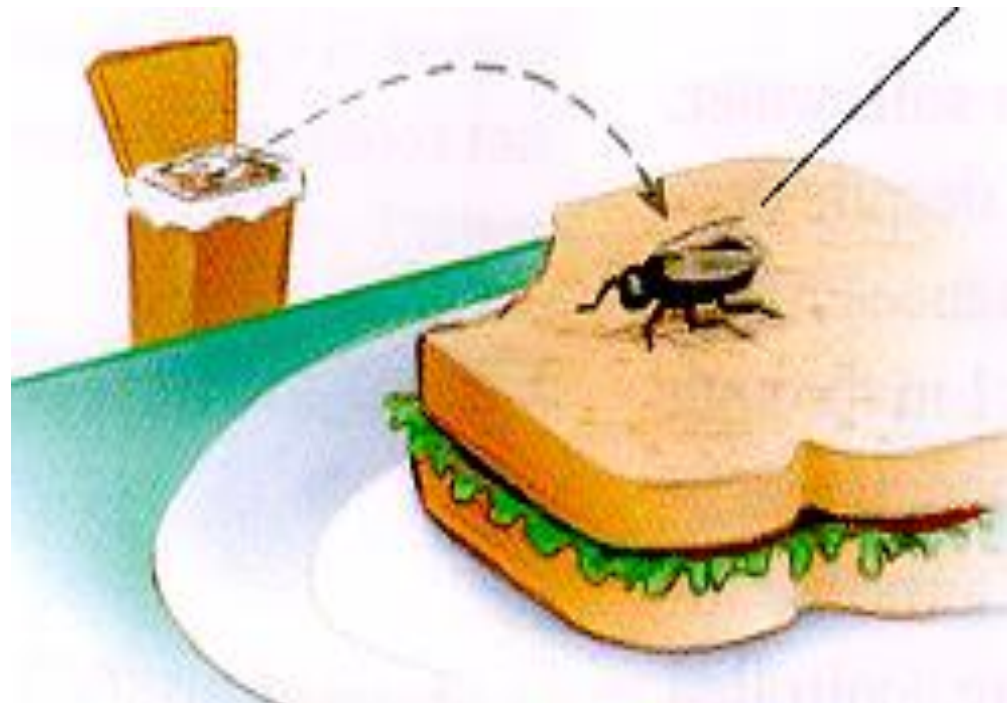


- 6) **Vectors: Arthropods** (fleas, ticks, mosquitoes)
  - Mechanical or Biological





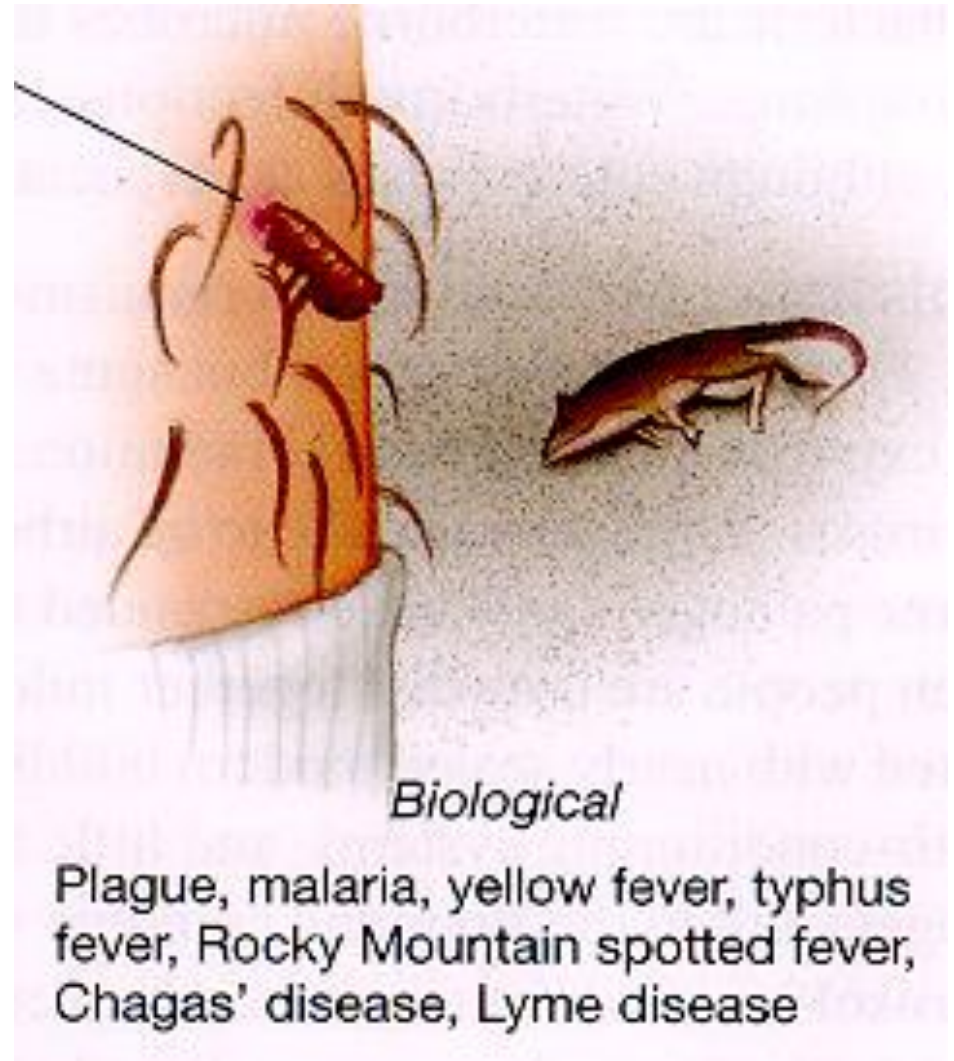
- 6a) **Mechanical Vector Transmission**



*Mechanical (on insect bodies)*

*E. coli* diarrhea, salmonellosis,  
trachoma

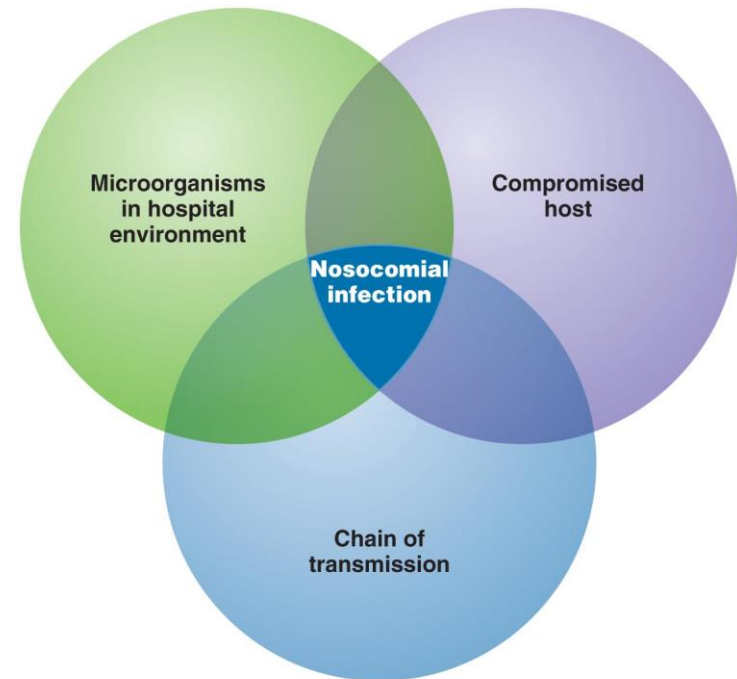
- 6b) **Biological vector transmission**
  - Pathogen reproduces in vector



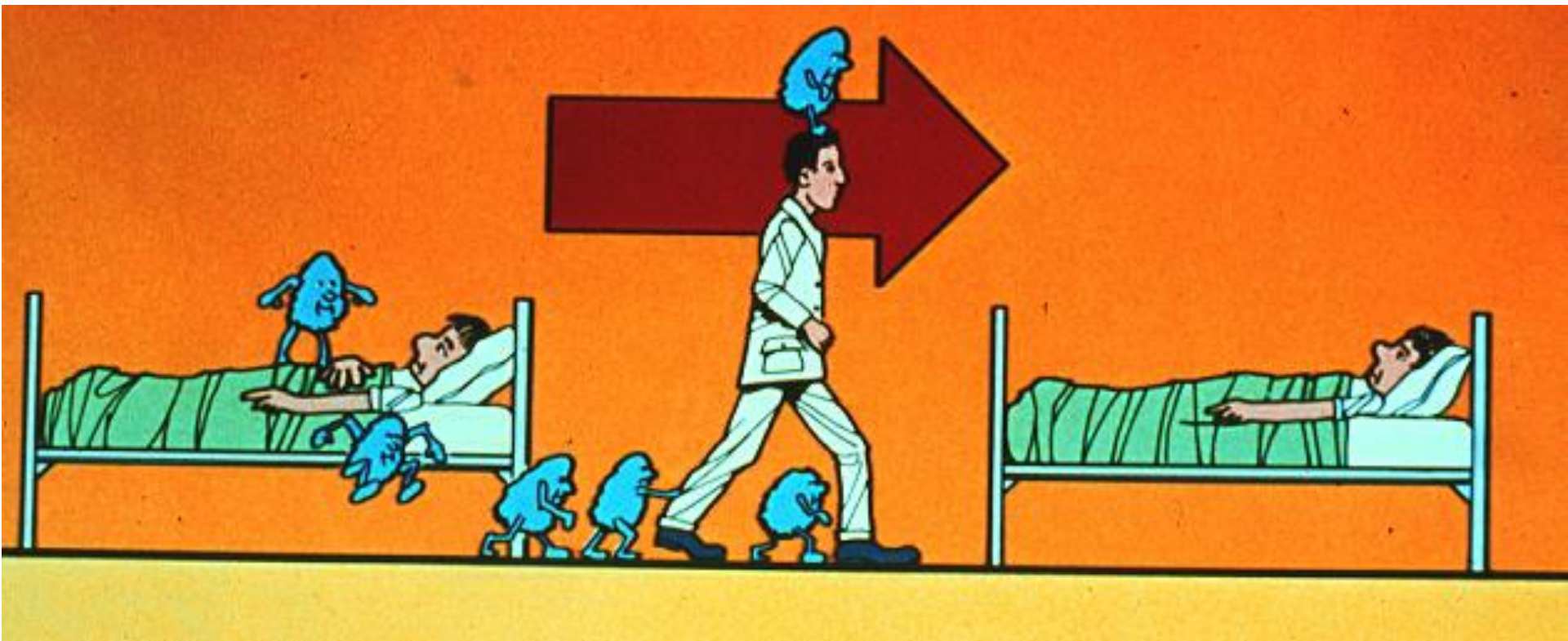


# \_\_\_\_\_ infections

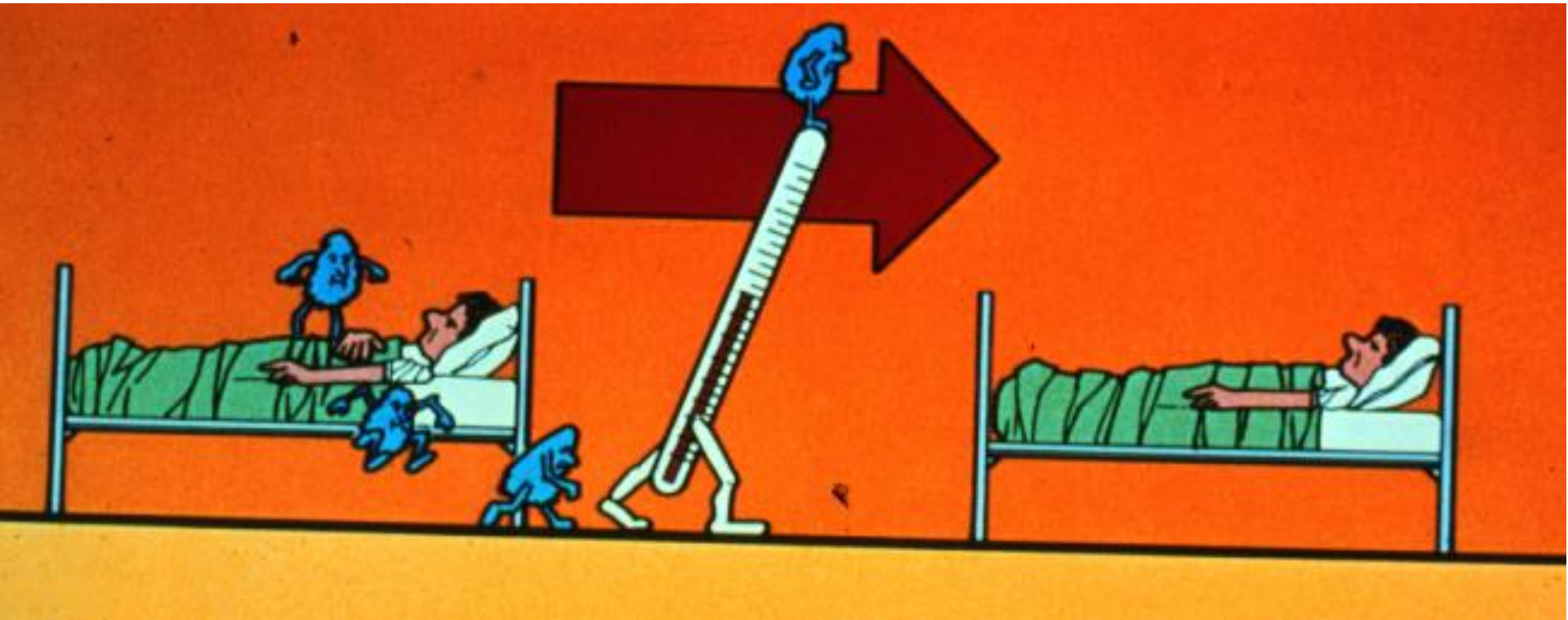
- Infections acquired as a result of a hospital stay.
- 5-15% of all hospital patients acquire nosocomial infections!



# Nosocomial



# Nosocomial

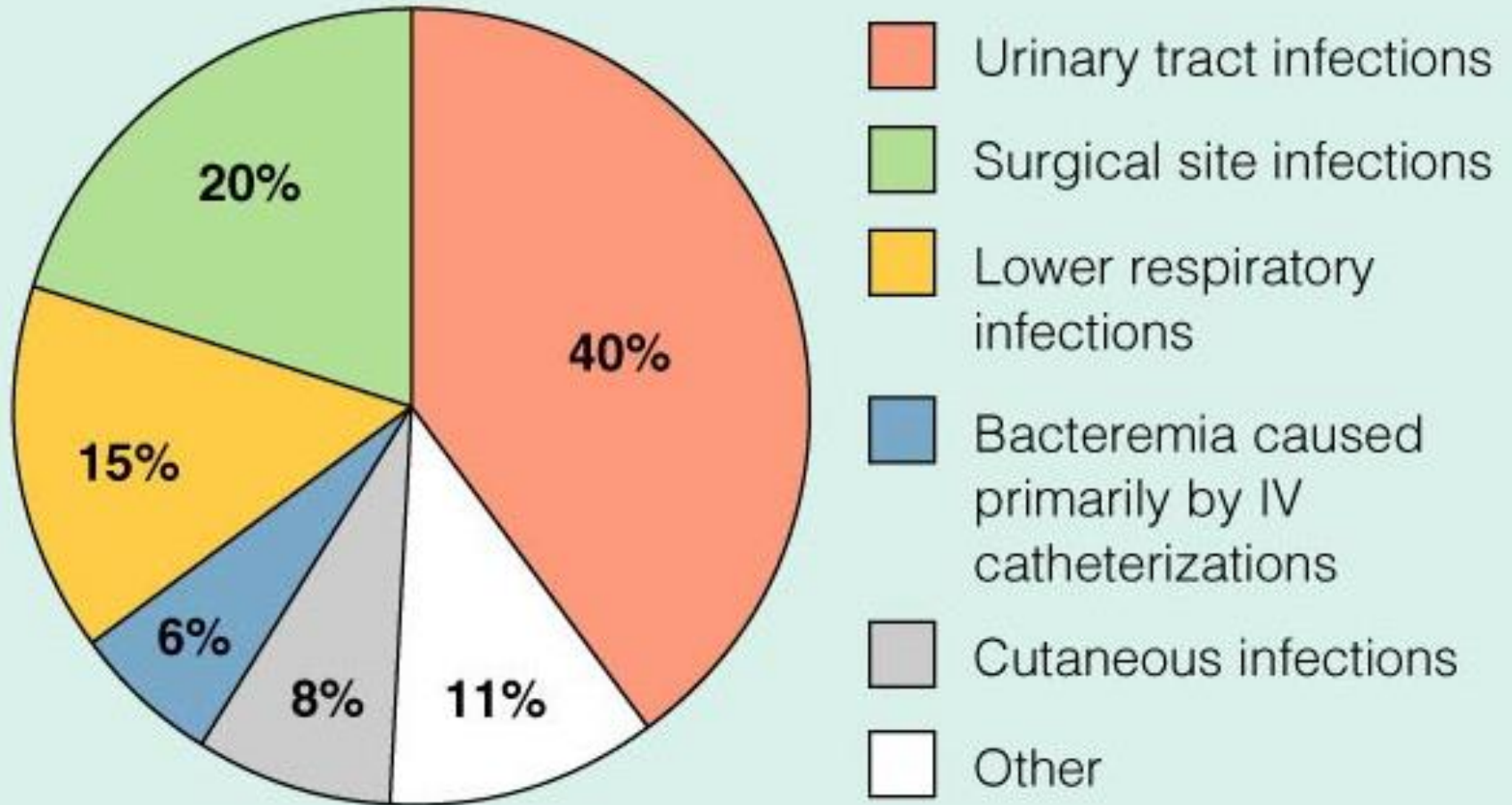




# Nosocomial



# Nosocomial Infections



# Common Causes of Nosocomial Infections

|                                     | Percentage of Nosocomial Infections | Percentage Resistant to Antibiotics |
|-------------------------------------|-------------------------------------|-------------------------------------|
| <b>Gram + cocci</b>                 | <b>51%</b>                          | <b>29%-89%</b>                      |
| <b>Gram – rods</b>                  | <b>30%</b>                          | <b>3-32%</b>                        |
| <b><i>Clostridium difficile</i></b> | <b>13%</b>                          | <b>Very HIGH!</b>                   |
| <b>Fungi</b>                        | <b>6%</b>                           |                                     |

# Ways to prevent Nosocomial infections...

**FIGHT GERMS BY WASHING YOUR HANDS!**



**1** Wet your hands

**2** Soap

**3** Lather and scrub - 20 sec

**4** Rinse - 10 sec

**5** Turn off tap

**6** Dry your hands

**DONT FORGET TO WASH:**

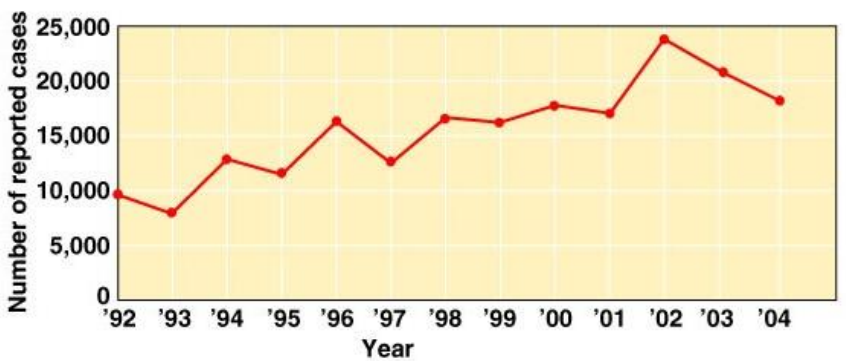
- between your fingers
- under your nails
- the tops of your hands

# Emerging Infectious Diseases

- Diseases that are new, increasing in incidence, or showing a potential to increase in the near future.
- Contributing factors
  - Genetic recombination
    - *E. coli* 0157, Avian influenza (H5N1), Swine Flu (H1N1)
  - Evolution of new strains
    - *V. cholerae* 0139
  - Inappropriate use of antibiotics and pesticides
    - Antibiotic resistant strains



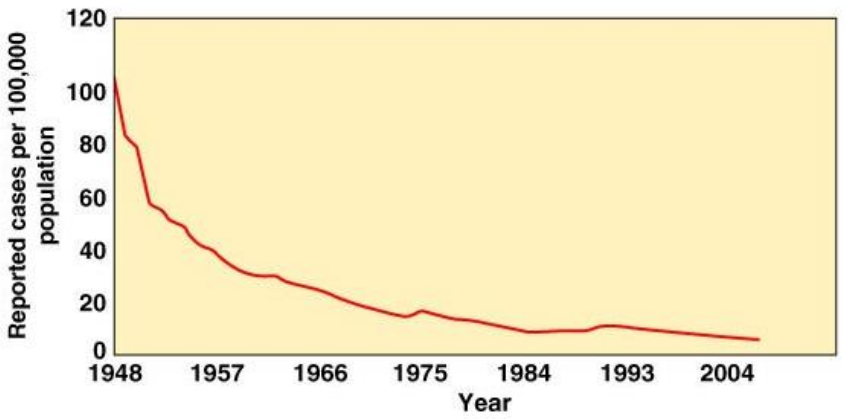
- The study of where and when diseases occur and how they are transmitted in populations



(a) Lyme disease cases, 1992 through 2004



(b) Lyme disease by month, 2004



(c) Reported tuberculosis cases, 1948 through 2004

# CDC (Centers for Disease Control and Prevention), Atlanta, GA

- 2014

\$6.6 billion

2017

\$7.2 billion

2018

**\$6.5 billion**

(9% cut)

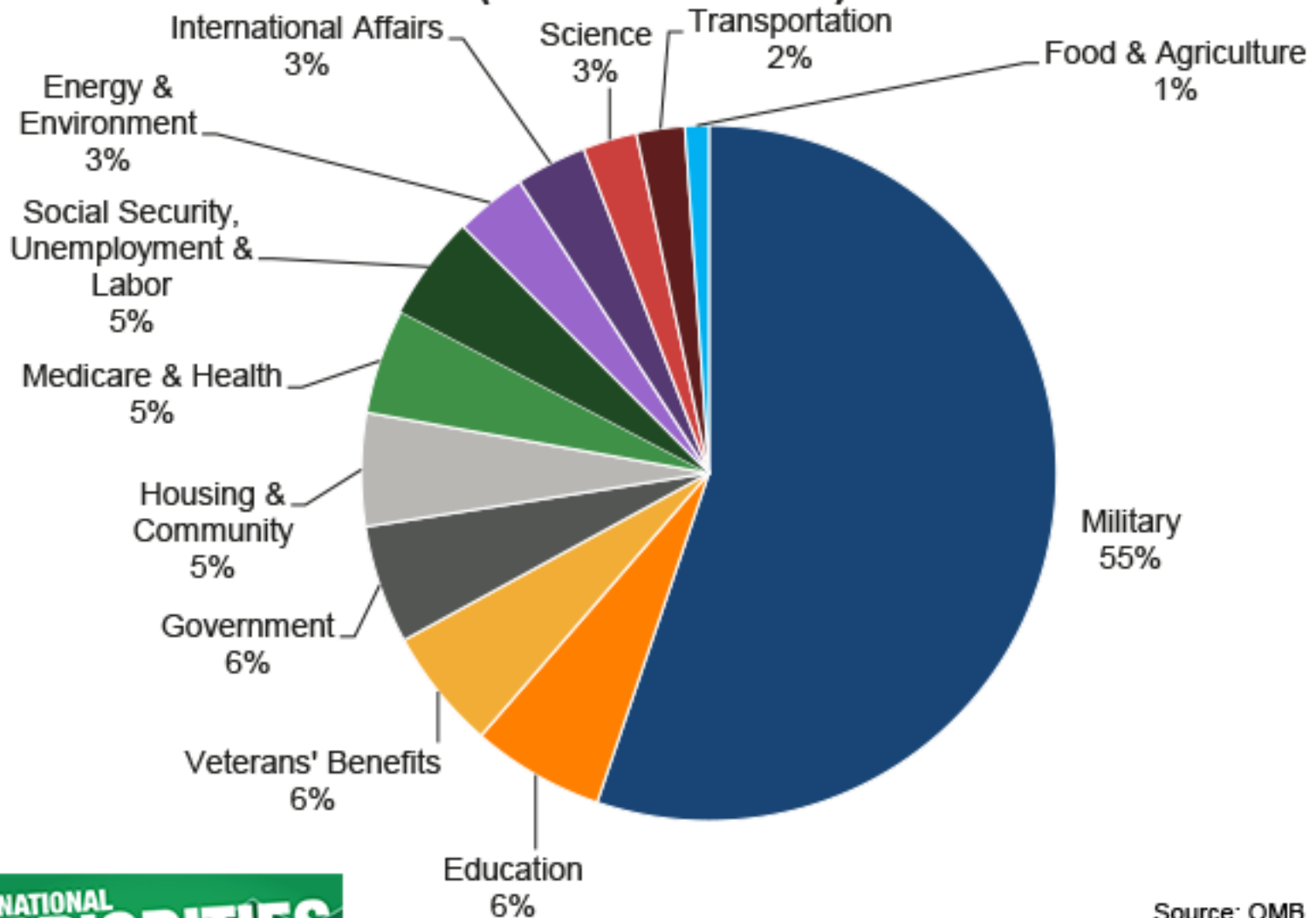
US spends

**\$2.5 billion**

On Halloween



# President's Proposed Discretionary Spending (Fiscal Year 2015)



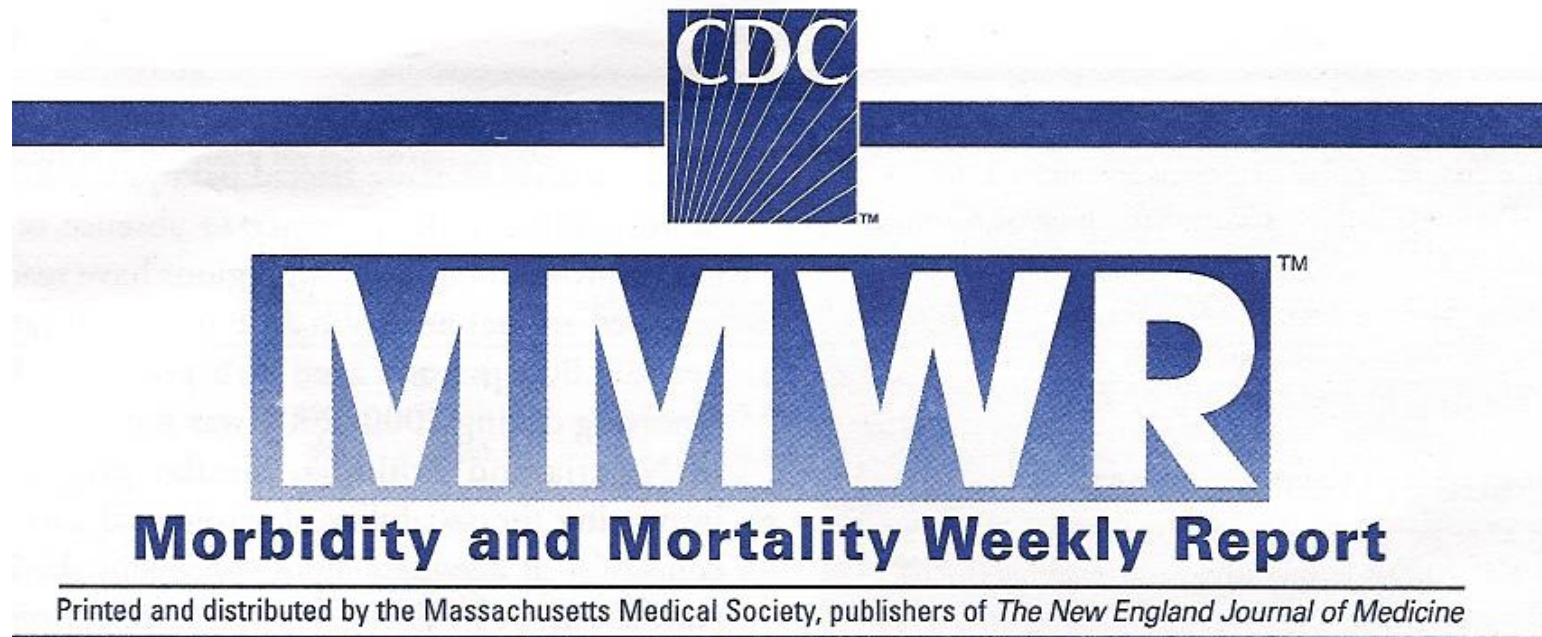
# Centers for Disease Control and Prevention (CDC)

- \_\_\_\_\_: Incidence of a specific notifiable disease.
- **Mortality**: Deaths from notifiable diseases.
- **Morbidity rate**: Number of people affected in relation to the total population in a given time period.
- **Mortality rate**: Number of deaths from a disease in relation to the population in a given time.



# Centers for Disease Control and Prevention (CDC)

- Collects and analyzes epidemiological information in the United States.
- Publishes *Morbidity and Mortality Weekly Report (MMWR)* [www.cdc.gov](http://www.cdc.gov)



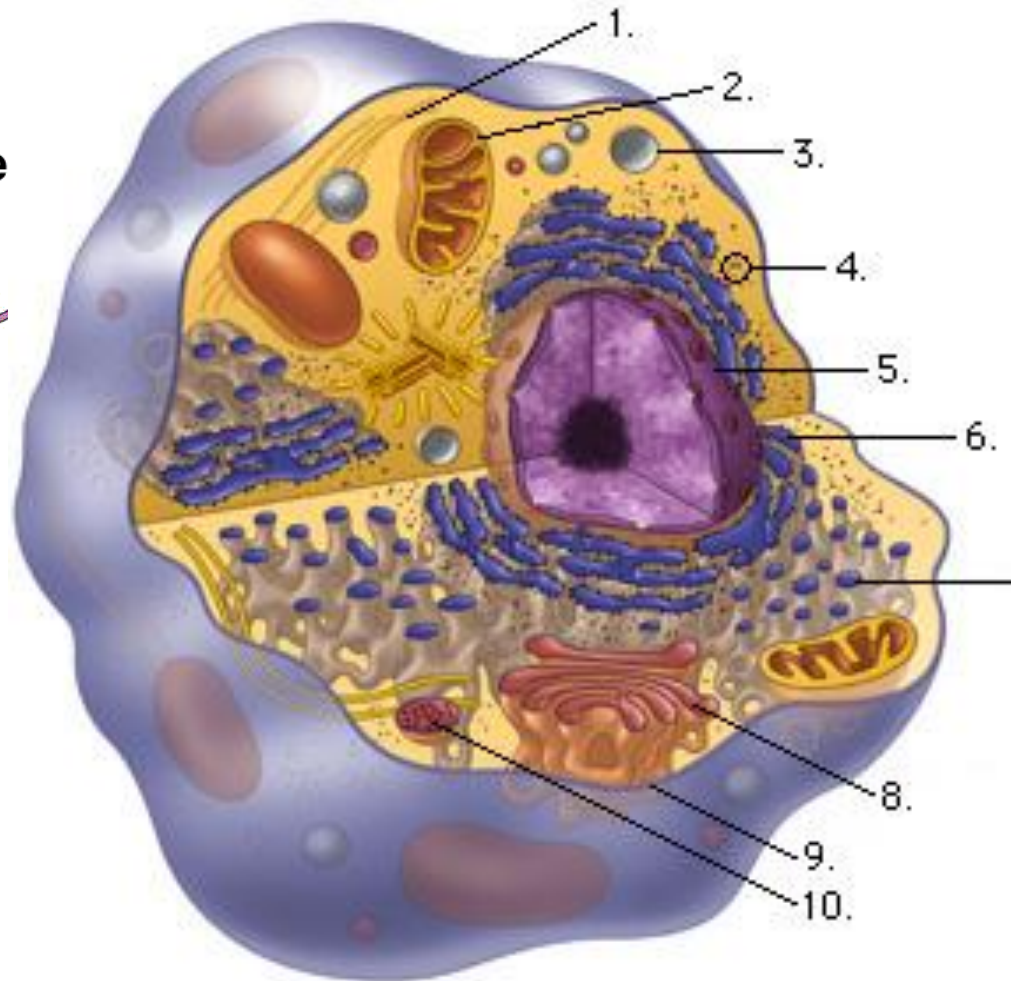
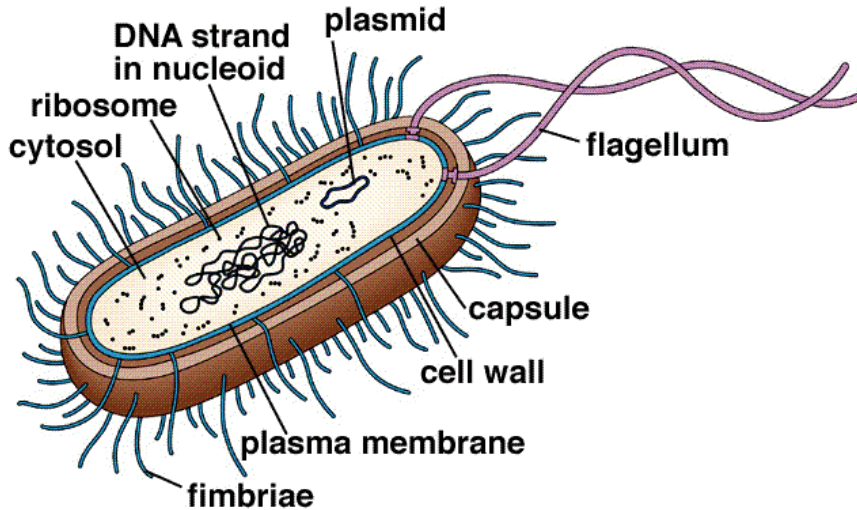
## Microbial world defined by cell type

- Cell= the fundamental unit of all life and carries out all basic functions of living things.
- Two Types:
  - \_\_\_\_\_ cells such as bacteria and archaea that have single circular chromosome, ribosomes, but no membrane bound organelles. Usually small.
  - \_\_\_\_\_ cells such as fungi, worms, animals, plants that have chromosomes enclosed by a nuclear envelope, ribosomes and membrane bound organelles such as mitochondria. Usually larger.

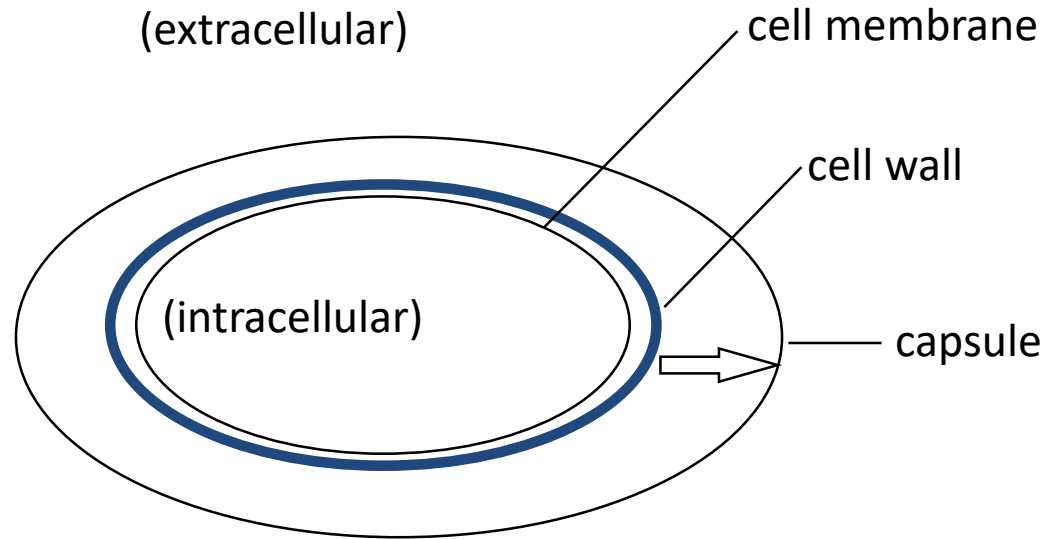
# Prokaryotic vs. Eukaryotic

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## Generalized structure of a prokaryote



# cell membrane, cell wall, capsule



Prokaryotic cells (bacteria) are relatively simple and *always* unicellular.

- from intra- to extracellular (i.e. inside to outside cells)



# Endosymbiotic theory

- eukaryotic cells came about when small prokaryotic cells started living inside of larger prokaryotic cells
- eukaryotic mitochondria and chloroplasts similar to bacteria: circular DNA, 70s ribosomes, fission, etc.

Prokaryotic

Eucaryotic

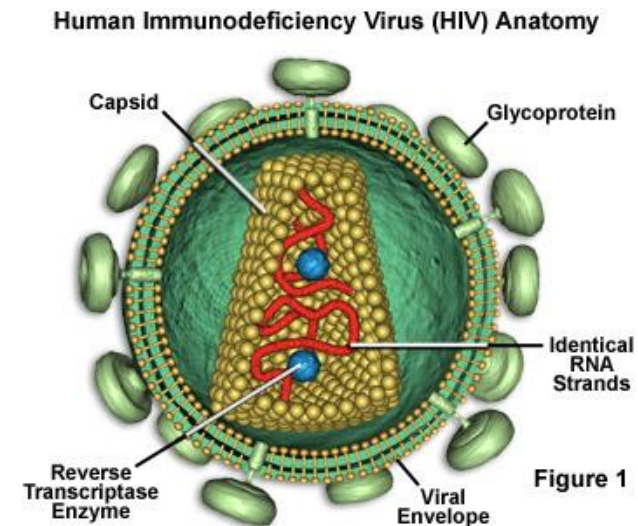
Mitochondrion

Chloroplast



# Viruses and Prions

- Viruses are non-living or semi-living
- Prions are infection protein particles
- All living things can:
  - Maintain Homeostasis
  - Reproduce
  - Require Energy
  - Have a genetic information base
  - Are capable of evolving.



# Classifying Organisms

- 1. The # and type of cells present.
  - Cell type is based on complexity, presence or absence of a cell wall.

# Criterion 2: Modes of nutrition

- Nutrition refers to the means by which an organism obtains matter (e.g. for growth and repair) and energy (which drives life's processes).
- Sources of matter include 2 types:
- **organic**: molecule containing *both* carbon and hydrogen  
e.g.  $\text{CH}_4$ ,  $\text{C}_6\text{H}_{12}\text{O}_6$
- **inorganic**: molecule not containing both C and H (could have one or the other or neither)  
e.g.  $\text{NaCl}$ ,  $\text{H}_2\text{O}$ ,  $\text{CO}_2$
- In addition, energy may be obtained from light or chemical sources.

# Nutritional Modes

**Table 27.1 Major Nutritional Modes**

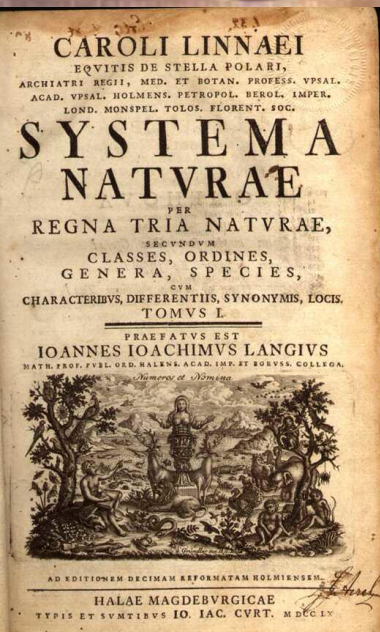
| Mode of Nutrition  | Energy Source       | Carbon Source     | Types of Organisms  |
|--------------------|---------------------|-------------------|---|
| <b>Autotroph</b>   |                     |                   |   |
| Photoautotroph     | Light               | CO <sub>2</sub>   | Photosynthetic prokaryotes (for example, cyanobacteria); plants; certain protists (algae)     |
| Chemoautotroph     | Inorganic chemicals | CO <sub>2</sub>   | Certain prokaryotes (for example, <i>Sulfolobus</i> )   |
| <b>Heterotroph</b> |                     |                   |   |
| Photoheterotroph   | Light               | Organic compounds | Certain prokaryotes (for example, <i>Rhodobacter</i> , <i>Chloroflexus</i> )                  |
| Chemoheterotroph   | Organic compounds   | Organic compounds | Many prokaryotes (for example, <i>Clostridium</i> ) and protists; fungi; animals; some plants |

Another good essay question!



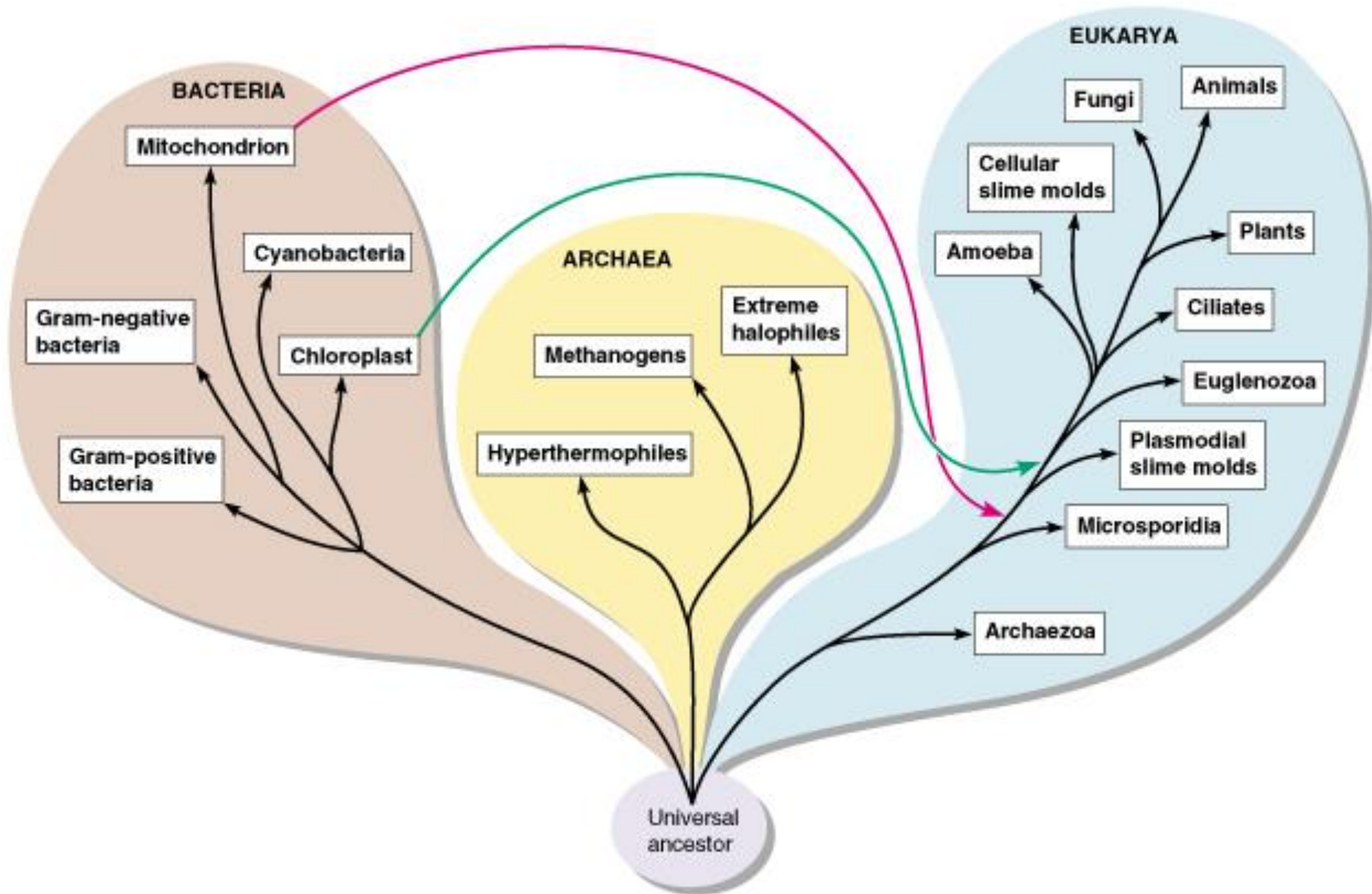
# Carl Linnaeus

- ❑ Father of “\_\_\_\_\_”
- ❑ Swedish botanist, physician, and zoologist
- ❑ Wrote *Systema Naturae* in 1735
- ❑ The science concerned with naming and classifying the diverse forms of life





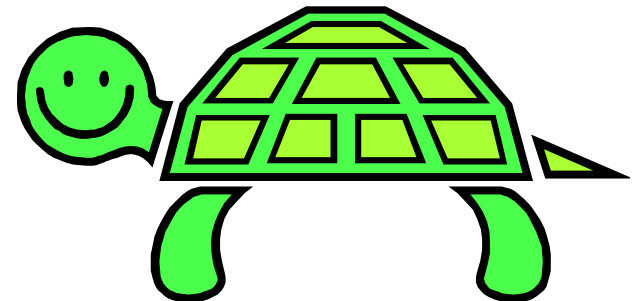
# 3 Domain System!





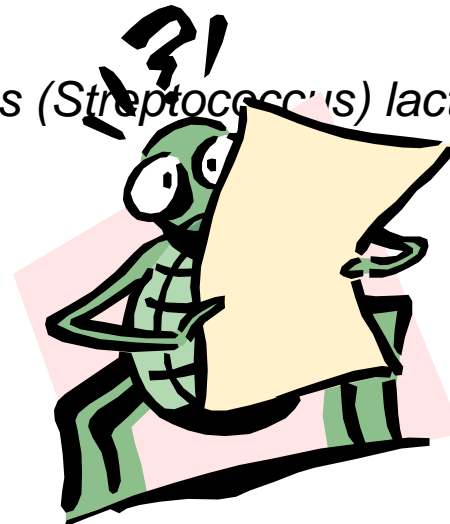
# The Species Concept

- 1. a group of individuals capable of mating and producing fertile offspring (or)
- 2. a basic kind of organism
- 3. Often has issues (particularly with bacteria!)



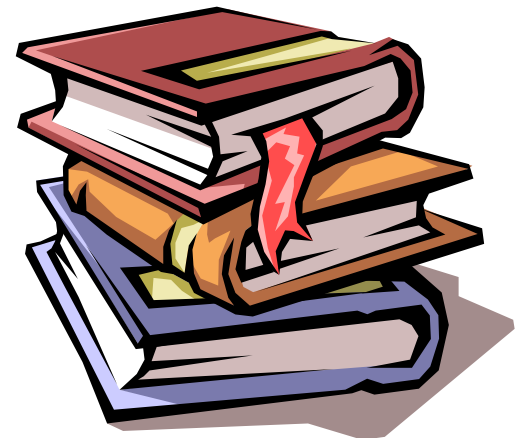
# Genus

- a group of closely related species; e.g.  
*Clostridium tetani*  
*Clostridium botulinum*  
*Clostridium perfringens*
- members of a genus will be the same in most respects; different in a few specific ways
- placement in a genus is “a matter of opinion”
  - species are moved from genus to genus
  - *Neisseria catarrhalis* became *Branhamella catarrhalis* and is now *Moraxella catarrhalis*
  - *Streptococcus lactis* now *Lactococcus* (~~*Streptococcus*~~) *lactis*
  - Was based on shared properties vs. now evolutionary relationships



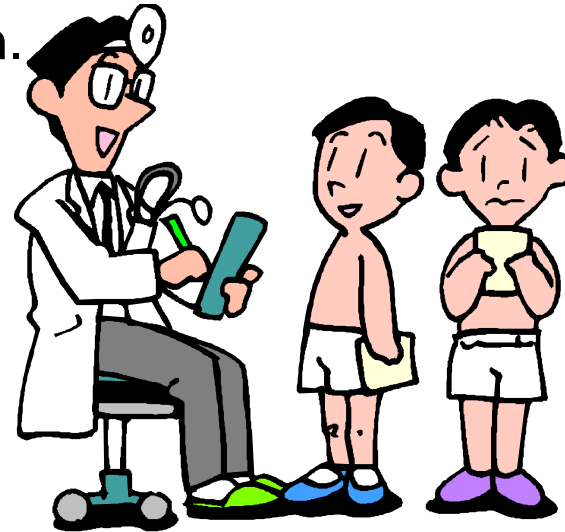
# Some abbreviations

- *sp.* Refers to species in singular. Often used to refer to an unknown species of a known genus,  
e.g. *Mycobacterium sp.*
- *spp.* Refers to species in plural. Often used to refer to all members of a genus,  
e.g. *Mycobacterium spp.*



# Subspecific levels of classification

- subspecies: group within a species, usually defined by visible traits; different subspecies usually live in different areas
- strain: group within a species, usually defined by physiological traits
- clone: group of organisms all derived from a single cell. All cells in the clone should be identical. However in some cases this isn't so, and each such group is called a strain.
- E.g. *E. coli* 0157:H7
- E.g. *Vibrio cholerae* classic & *Vibrio cholerae* El Tor
- Subspecies, strain, serotype morpho type and variety are terms used



# Populations

- A group of individuals capable of reproducing (a species) that occupy the same place and time.
- **IMPORTANT** for understanding evolution (genetic change in a group of organism over time).



# Viruses are in a class by themselves

- Viruses are neither prokaryotic nor eukaryotic.
- They are not considered “true cells” nor living by most scientists.
- They are much simpler than even the simplest cells.
- we consider them “microorganisms” due to their infectious nature.

