



Basic Microbiology

A Refresher

Objectives

- Review the major characteristics of bacteria, fungi, viruses and parasites.
- Describe the differences between Gram-negative and Gram-positive bacteria.
- Summarize how microorganisms cause disease.
- Recognize the stages of an infectious disease.

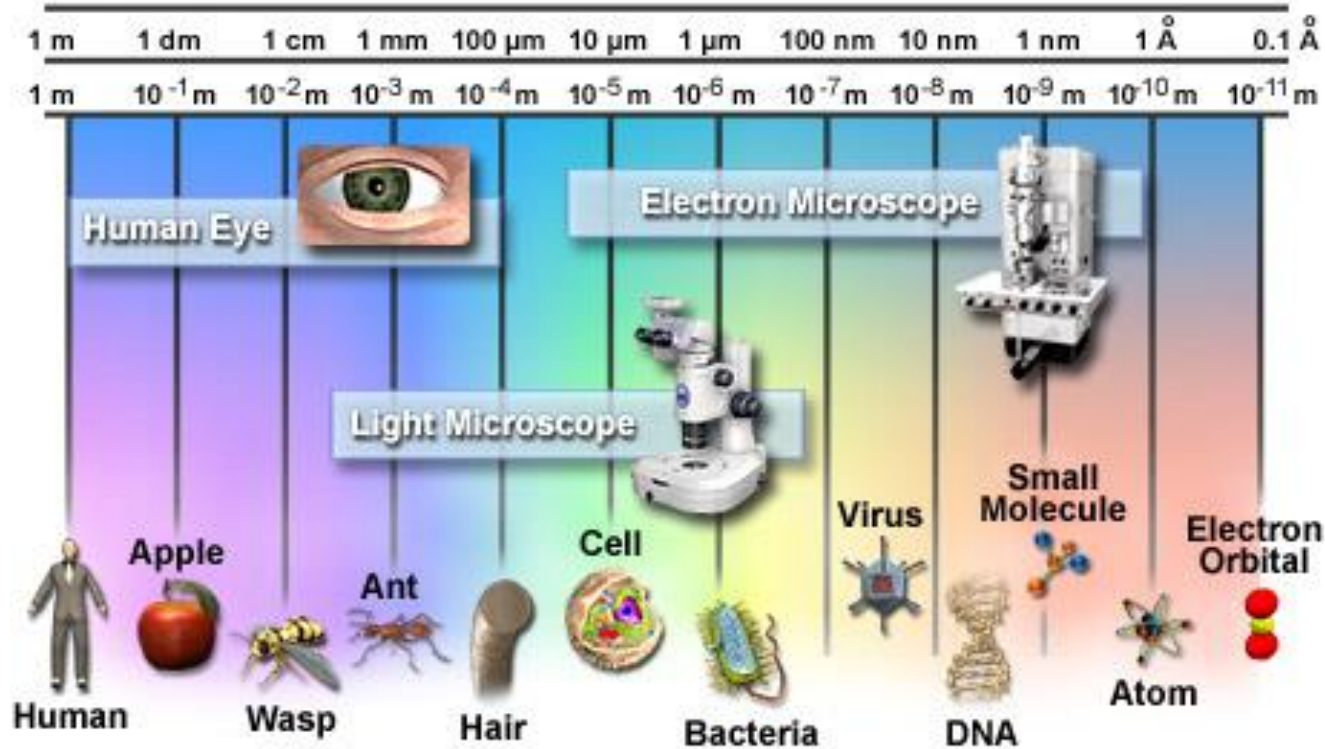
Outline

- Bacteria
- Fungi
- Viruses
- Parasites
- Disease progression

Microbiology

- Bacteria
- Fungi
- Viruses
- Parasites

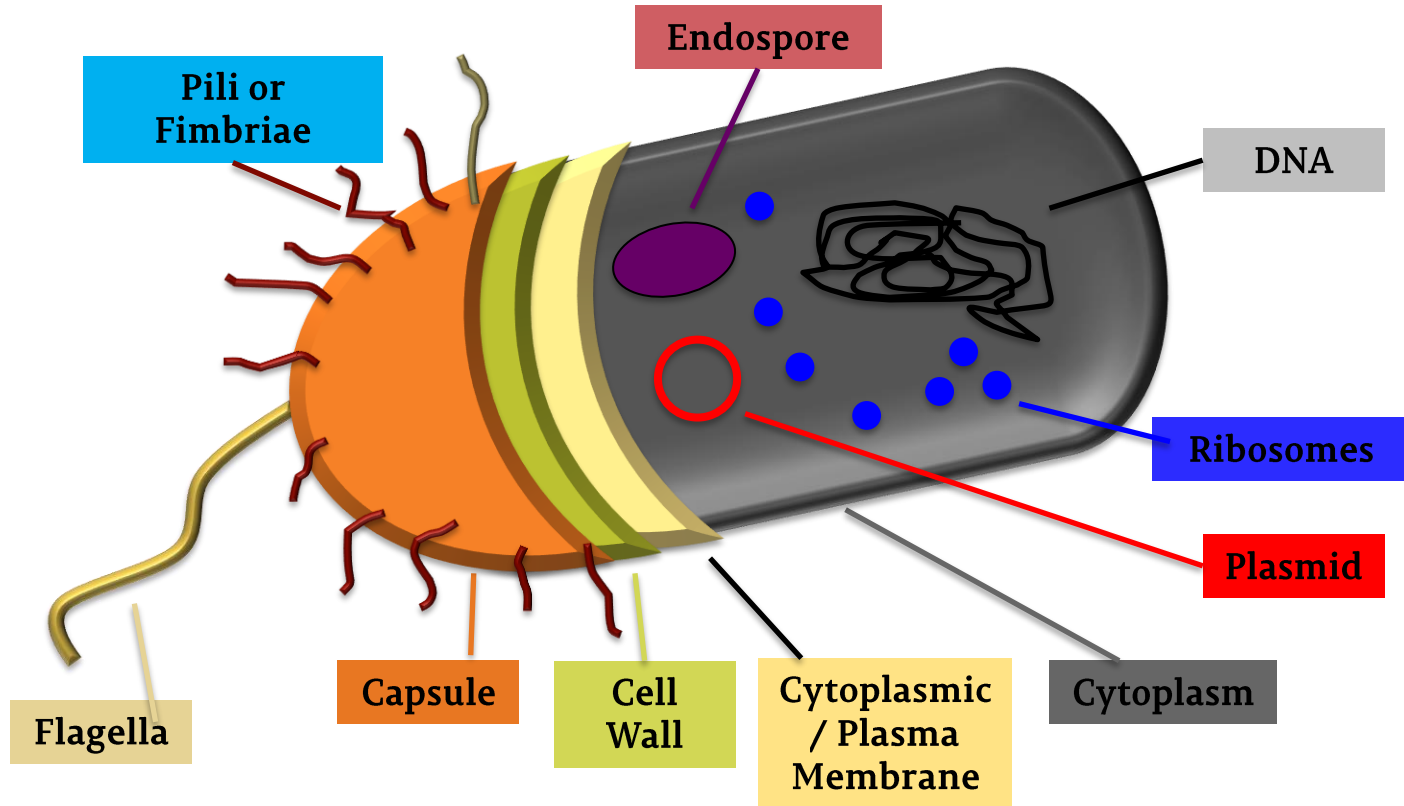
Relative Sizes and Detection Devices





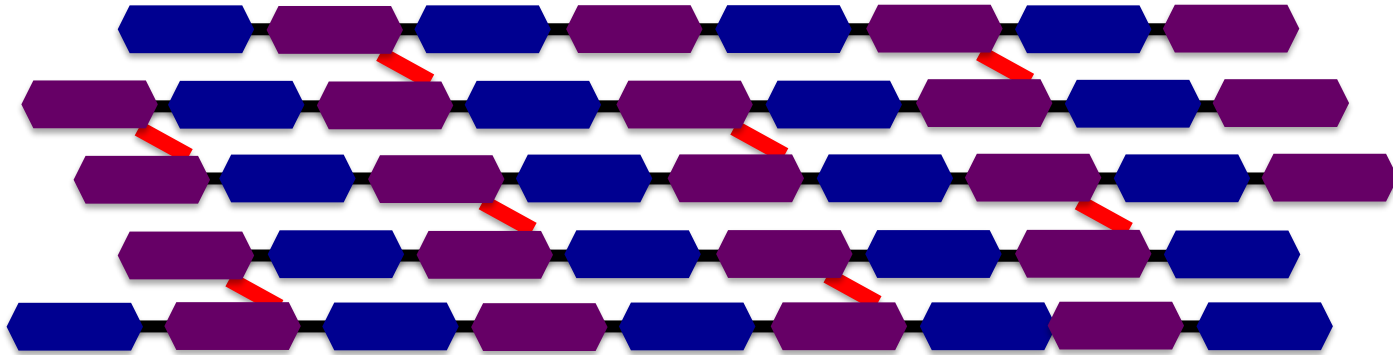
Bacteria

The Bacterial Cell



Cell Wall

- Function
 - Provide rigidity and structure
 - Prevents osmotic lysis
- Main component of cell wall
 - Peptidoglycan

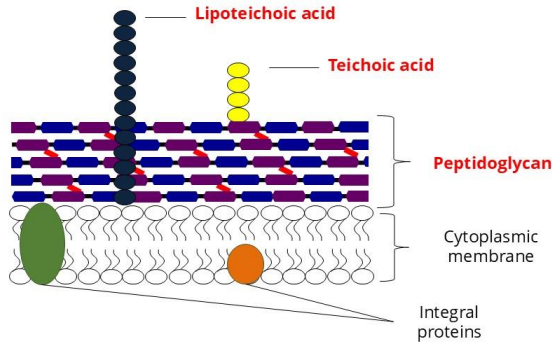


Cell Wall: Gram Positive vs. Gram Negative

Gram Positive Cell Wall

Key Features:

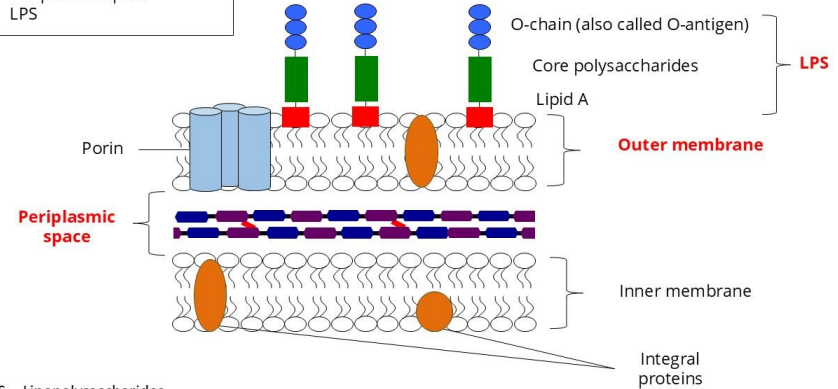
- Thick peptidoglycan layer
- Lipoteichoic acid
- Teichoic acid



Key Features:

- Thin peptidoglycan layer
- Inner & outer membrane
- Periplasmic space
- LPS

Gram Negative Cell Wall



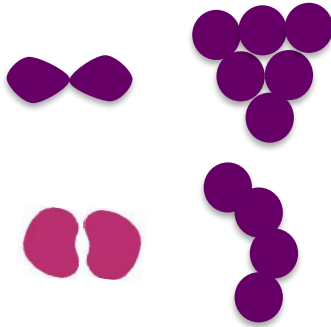
LPS = Lipopolysaccharides

Gram Stain

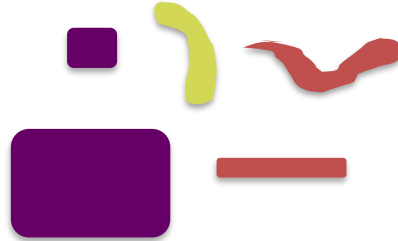
- Purpose
 - Rapid preliminary organism identification by direct visualization in patient specimens
 - Detection of different organisms present in the same specimen
 - Detection of organisms not easily cultivated in the laboratory

Gram Stain

Cocci



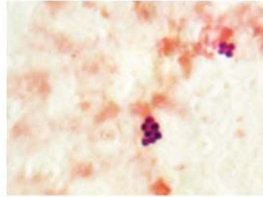
Bacilli / Rods



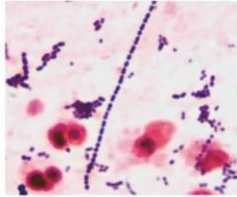
Spirochete

Gram-positive cocci

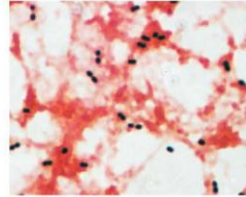
Clusters



Chains



Pairs (diplococci)

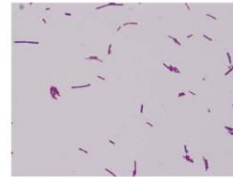
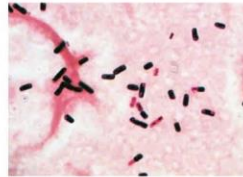


Gram-positive rods (bacilli)

Pleomorphic

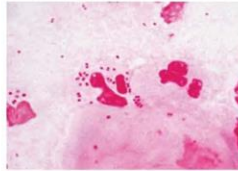


With spores

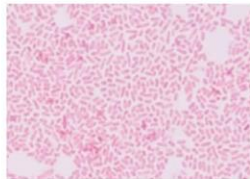


Gram-negative cocci

Pairs (diplococci)



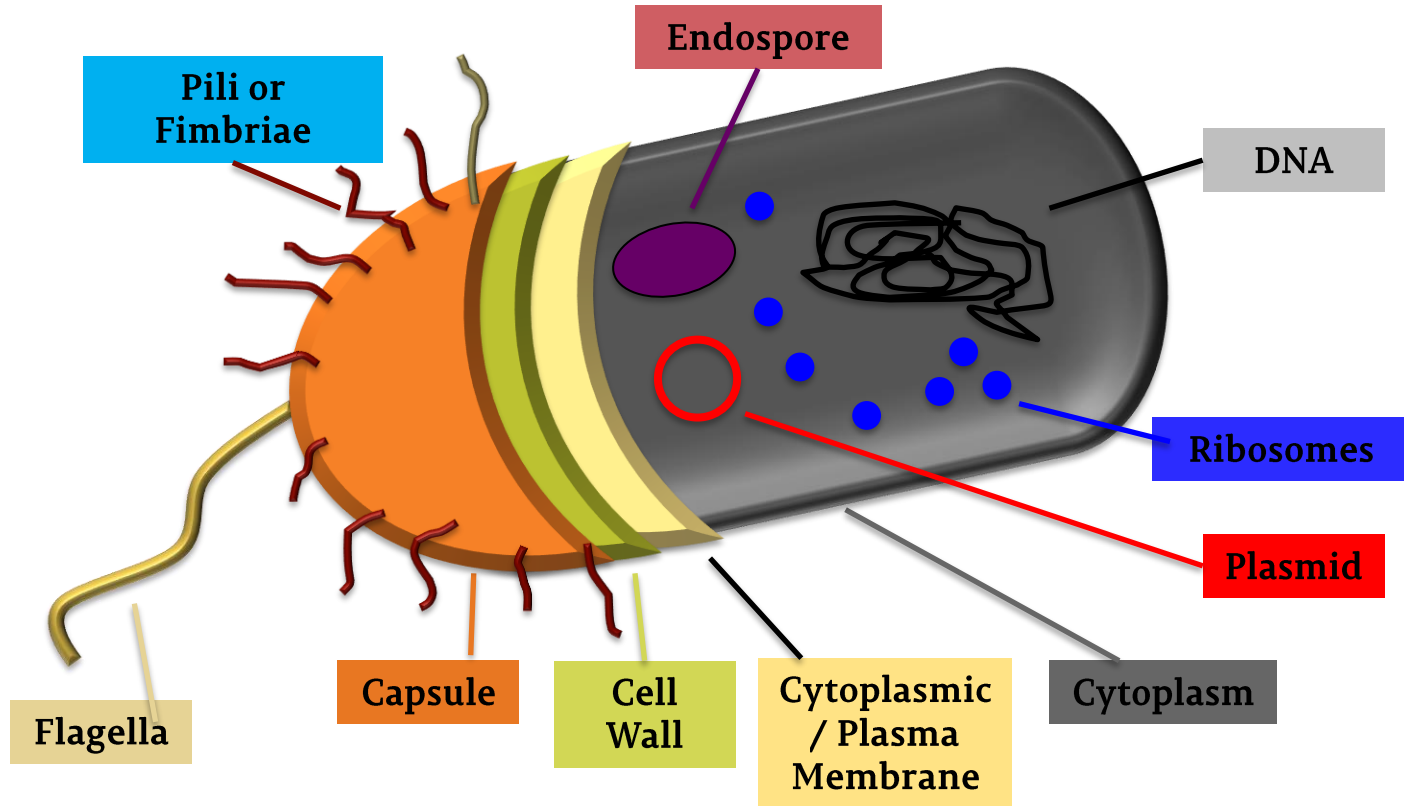
Gram-negative rods (bacilli)



Examples of Important Pathogens for IPs

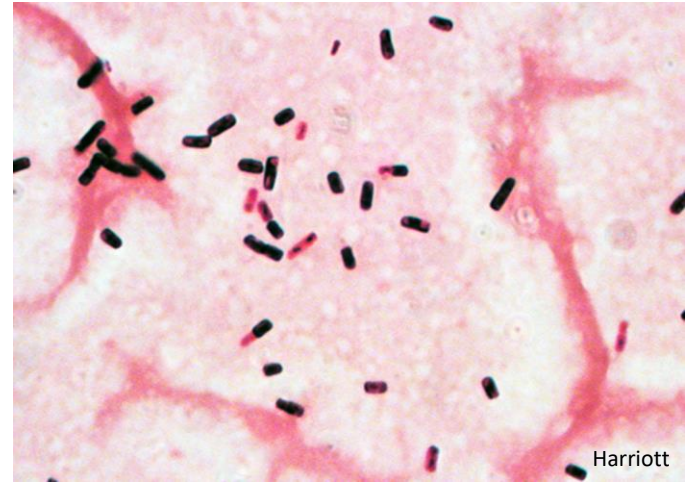
- Gram-positive bacilli
 - *Bacillus*
 - *Clostridium*
- Gram-positive cocci
 - *Enterococcus*
 - *Staphylococcus*
 - *Streptococcus*
- Gram-negative bacilli
 - *Acinetobacter baumannii*
 - *Bordetella pertussis*
 - *Enterobacterales*
 - *Escherichia coli*
 - *Klebsiella* spp.
 - *Enterobacter cloacae*
 - *Serratia marcescens*
 - *Legionella pneumophila*
 - *Pseudomonas aeruginosa*
- Gram-negative cocci
 - *Neisseria meningitidis*

The Bacterial Cell



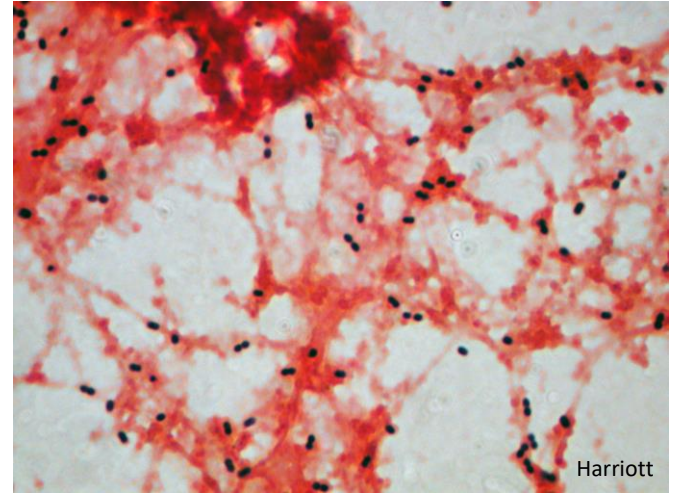
Endospores

- Help bacteria survive in harsh environments
- Results in increased stability to antimicrobials and disinfectants
- Important bacteria that produce endospores
 - *Bacillus*
 - *Clostridium*



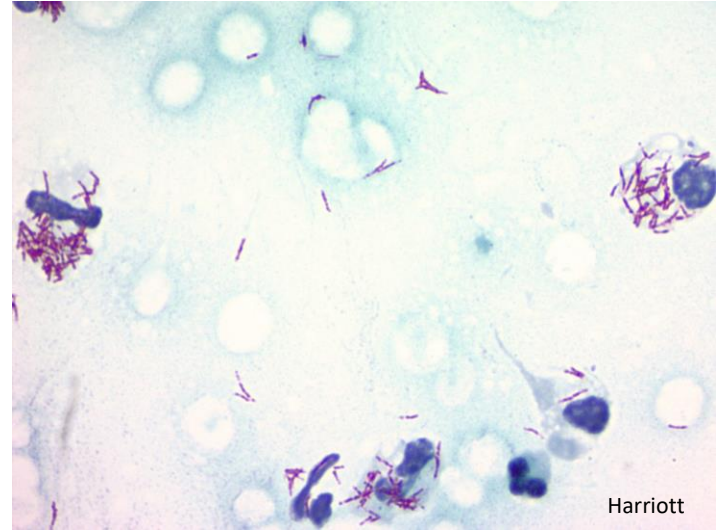
Capsules

- Help bacteria evade the host immune system
- Allows bacteria invade body sites resulting in invasive, serious infections
- Examples:
 - *Neisseria meningitides*
 - *Streptococcus pneumoniae*

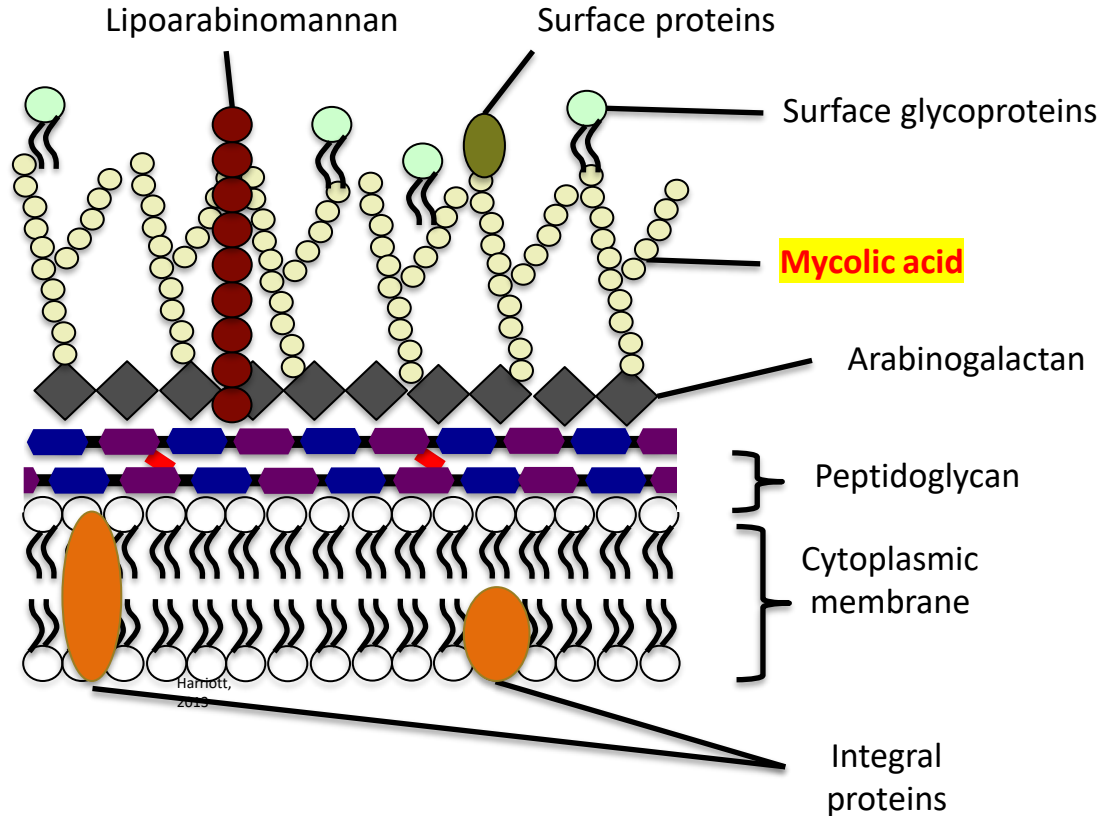


Mycobacteria

- Due to differences in the cell wall, they do not Gram stain
- A special stain (acid-fast stain) is needed to visualize microscopically
- Often referred to as AFB



Mycobacterial Cell



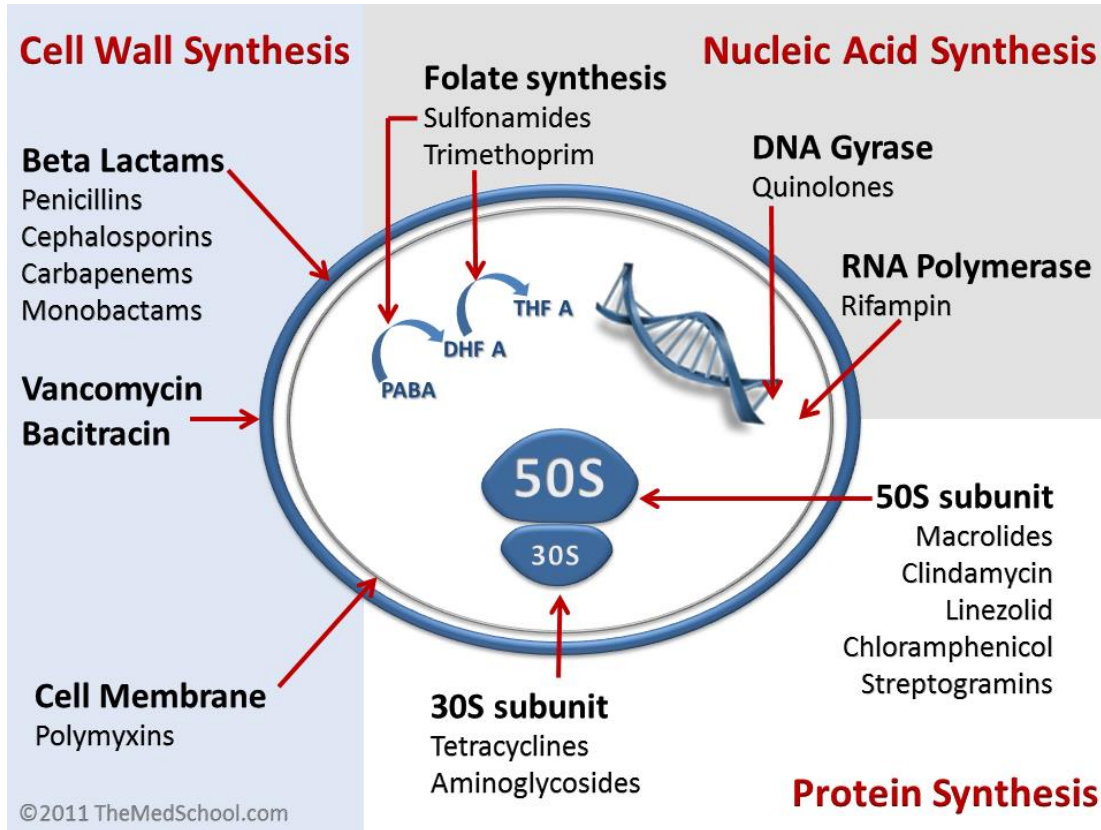
Mycobacteria

- Overall mycobacteria grow slower than other bacteria
- Terminology
 - Slow growing
 - Example: *M. tuberculosis*
 - Rapid growing
 - *M. fortuitum*, *M. abscessus*
 - Atypical
 - Often, any species other than *M. tuberculosis* is referred to as atypical or non-tuberculous mycobacteria (NTM)

Antimicrobial Agents: Antibiotics

- Antibiotics take advantages of the differences in the human vs. bacterial cell

Antibiotics Targets



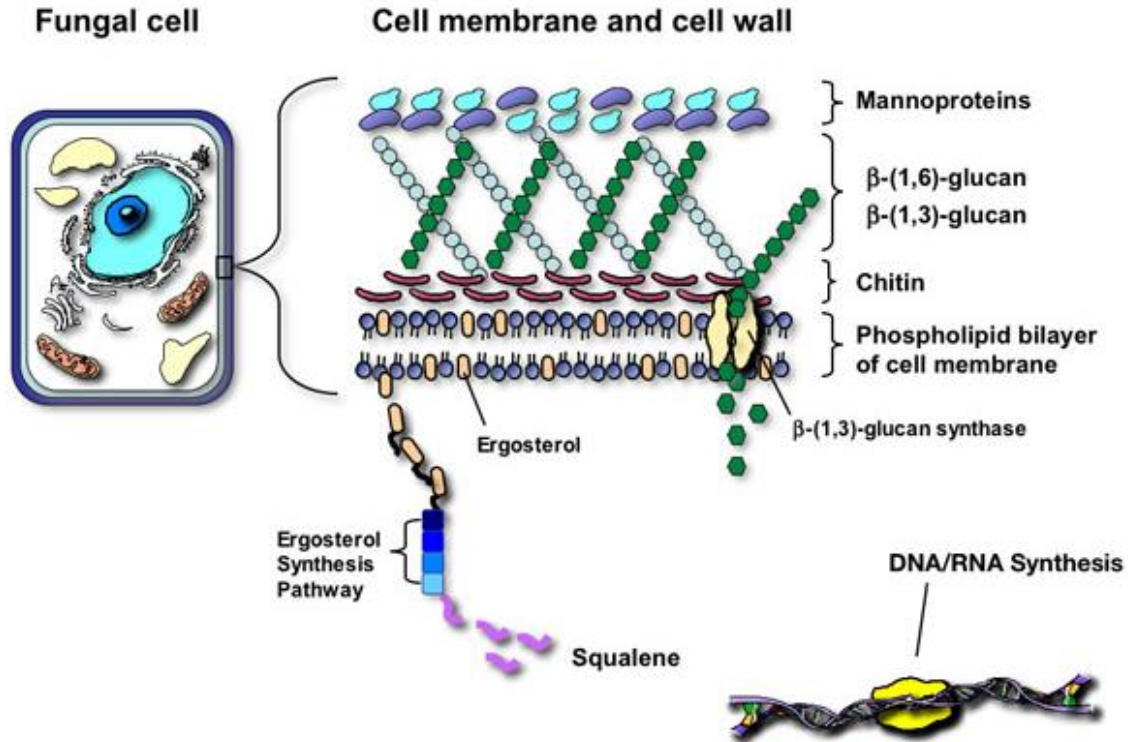


Fungi

Fungi

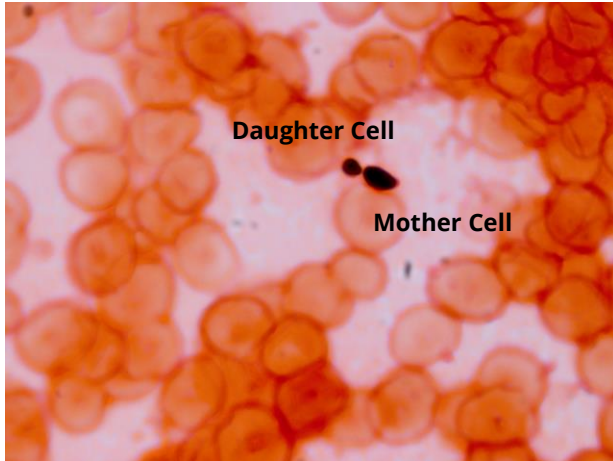
- Eukaryotic
 - Have cell walls
- Can exist as
 - Yeast
 - Molds
 - Both (dimorphic)

The Fungal Cell



Yeast

- Unicellular
- Reproduce by budding or fission
 - “Mamma cell” pinches off to produce “daughter cell”



Candida albicans, Harriott, 2012



Candida albicans, Harriott, 2011

Mold

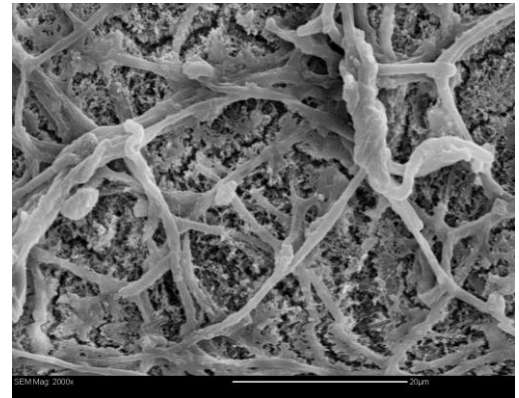
- Multicellular
- Have reproductive structures called spores or conidia
 - Usually, the infective form of the organism
- Form hyphae – long string-like structures
- Hyphae form mat-like masses called mycelium

Conidia and Hyphae



Harriott, 2020

Mycelium



Harriott, 2008

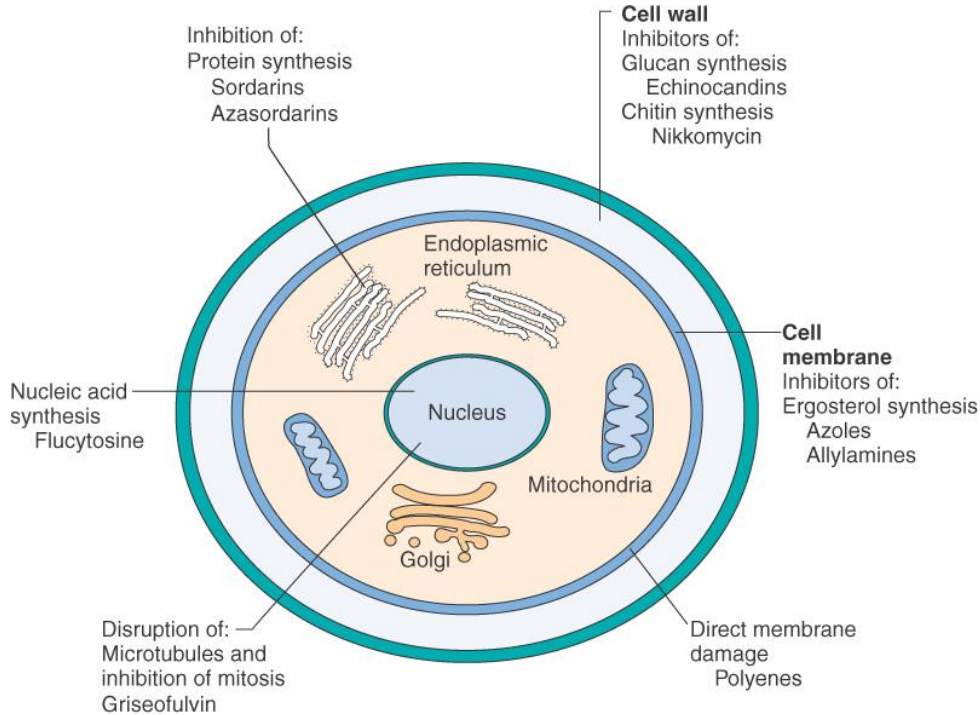
Important Fungi

- Yeast
 - *Candida* species
 - *Candida albicans*
 - *Candida auris*
- Mold
 - *Aspergillus*

Antimicrobial Agents: Antifungals

- Antifungals take advantages of the differences in the human vs. fungal cell

Antifungal Targets



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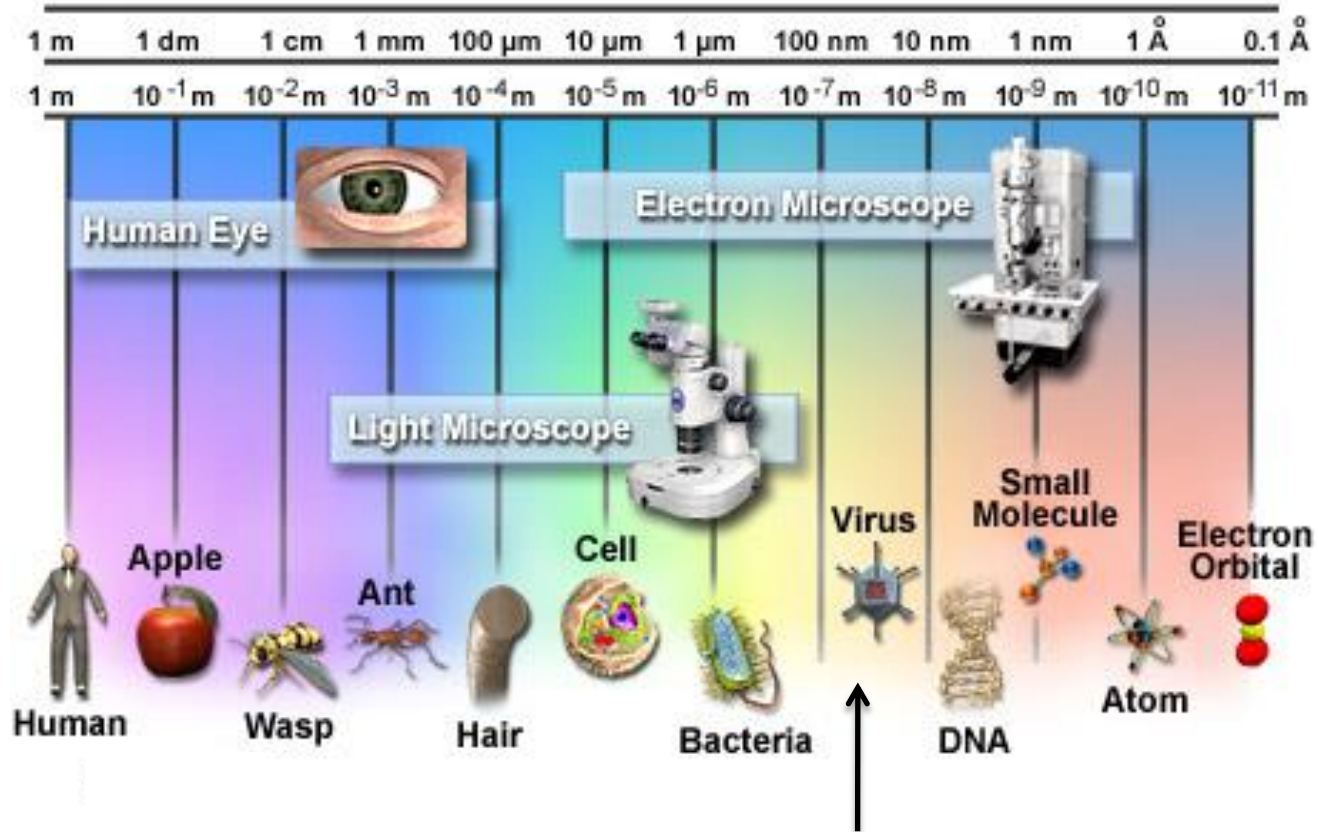


Viruses

What is a virus?

- A virus is an infectious agent.
- A virus is an obligate intracellular organism.
- Upon release into the cell, the viral genetic material redirects the genetic and metabolic apparatus of the host to produce new virus particles
- The genetic material in the virions (virus particle) is either DNA or RNA, but NOT both.

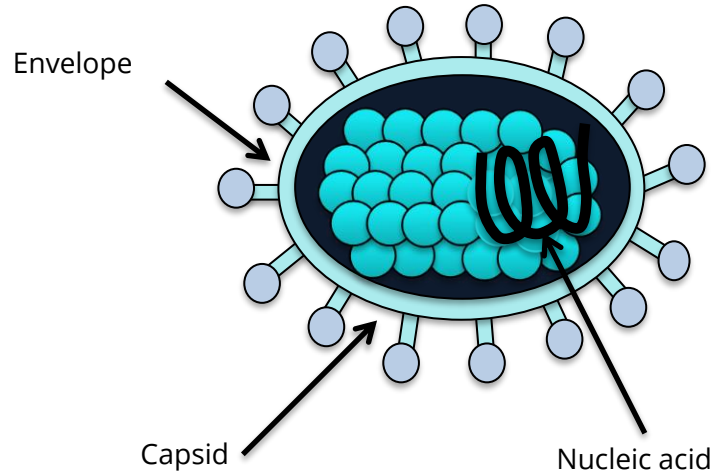
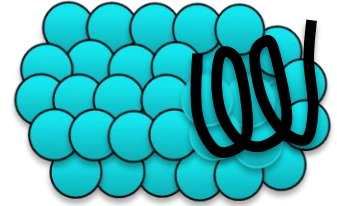
Relative Sizes and Detection Devices



Viral Structure

- Capsid
 - Coat that protects genetic material
- Envelope
 - Some viruses have an envelope surrounding the capsid
 - Plays a role in stability against disinfectants

Naked
(Non-Enveloped)

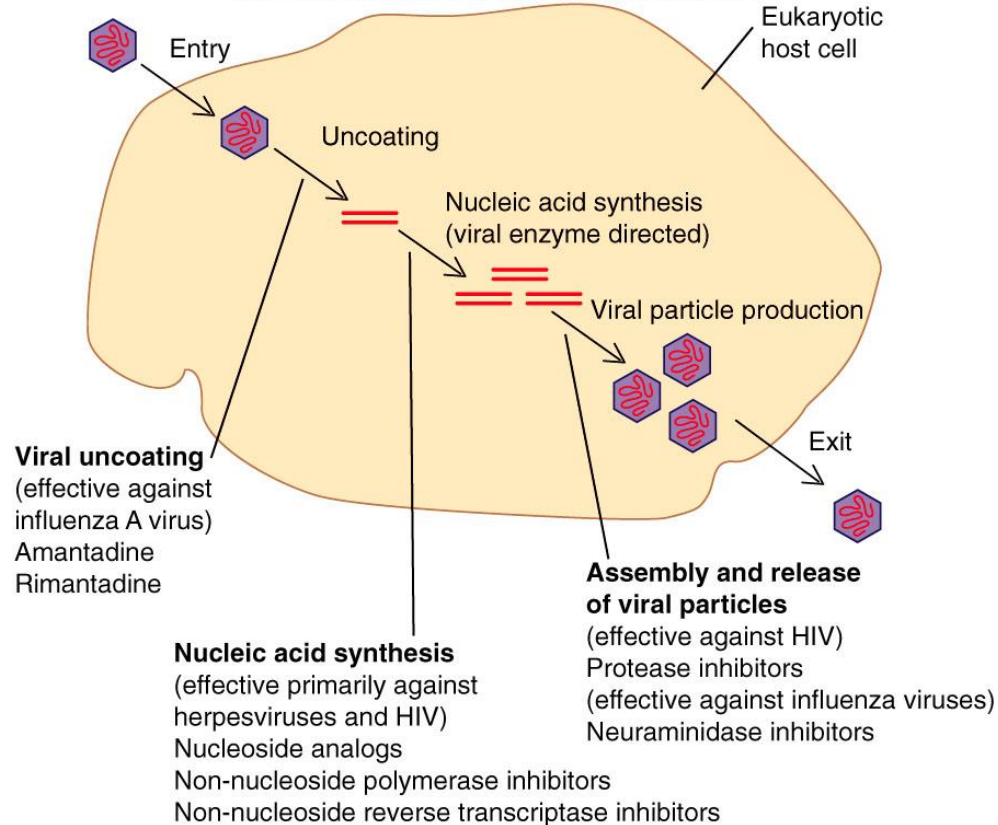


Antimicrobial Agents: Antivirals

- Most antiviral agents target pathways of viral reproduction cycle

Antiviral Targets

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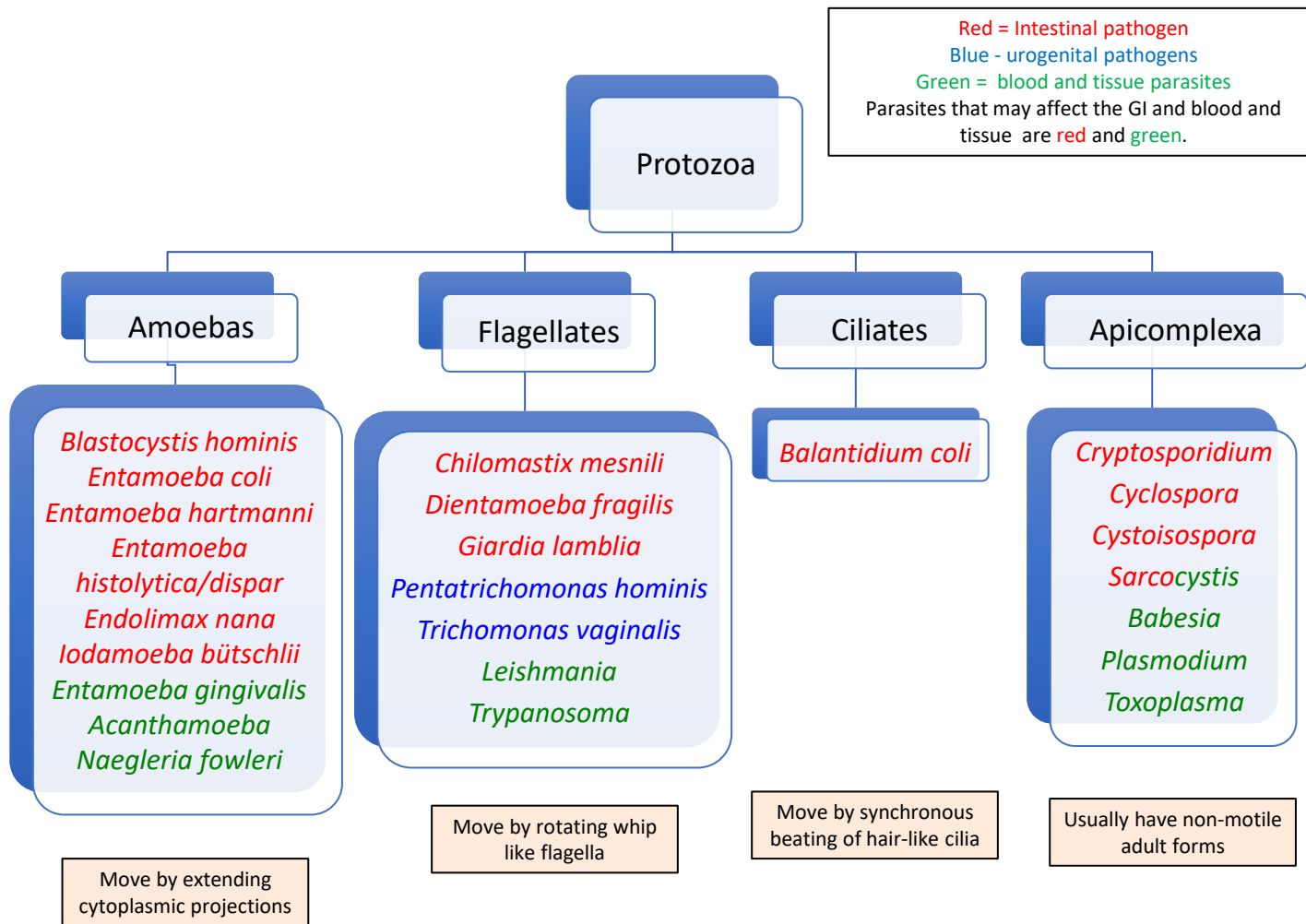
Parasites

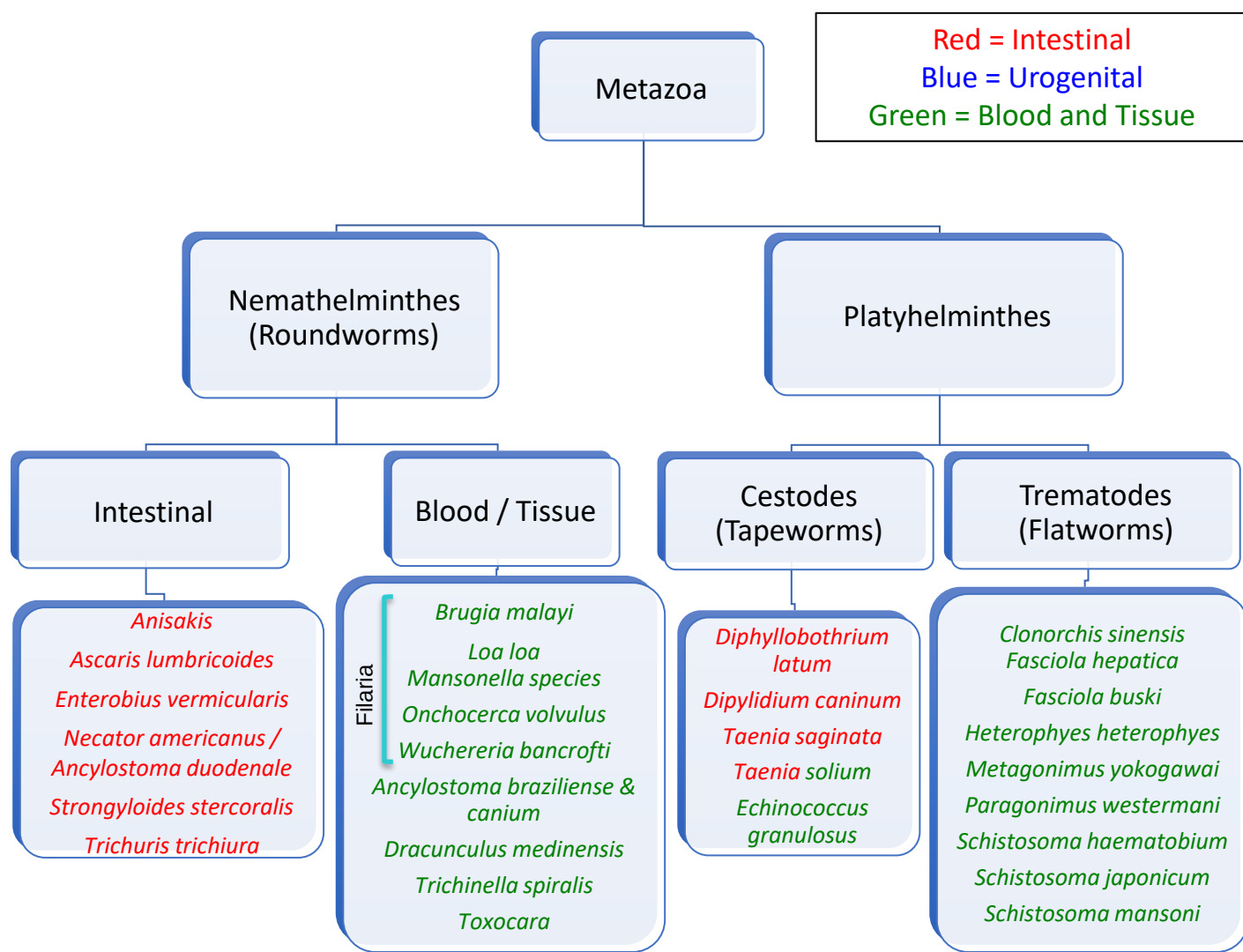
Types of Parasites

- Ectoparasite
 - Parasite that lives on the out surface of its host
 - Examples: lice, mites, ticks
- Endoparasite
 - Parasite that lives within its host

Classification of Parasites

- Protozoa – single single-celled organism
- Metazoa / Helminths – multicellular worms
- Animalia – arthropods
 - Examples:
 - Sabies (*Sarcoptes scabiei*)





Example Parasites

Giardia lamblia - trophozoite



Taenia saginata- adult tapeworm



Pediculus corporis –
adult body louse



Parasites

- Not many parasites involved in HAIs
- Antiparasitic agents have a variety of targets



Host-Pathogen Interaction

How do microorganisms cause disease?

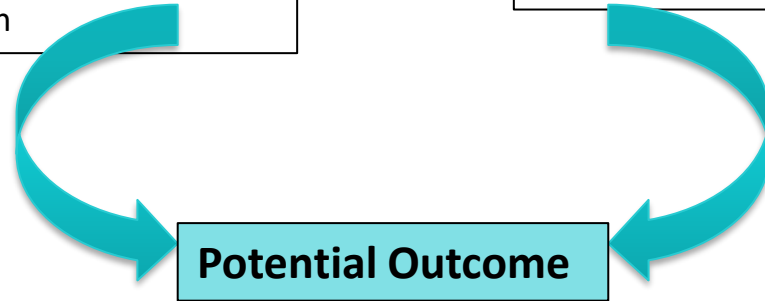
- It's a balance between the host and the pathogen!

Host factors

- General state of health
- Integrity of surface defenses
- Capacity for inflammatory and immune response
- Level of immunity
- Impact of medical intervention

Microbial factors

- Level of virulence
- Number of organisms introduced into host
- Body sites pathogen targets for invasion



Potential Outcome

Definitions

- Microorganism (or organism)
 - Microscopic organism (i.e. bacteria, fungi, virus, parasite)
- Pathogen
 - A microorganism that causes disease
- Colonization
 - Microorganisms present in the body without causing disease
- Infection
 - Microorganism causing illness

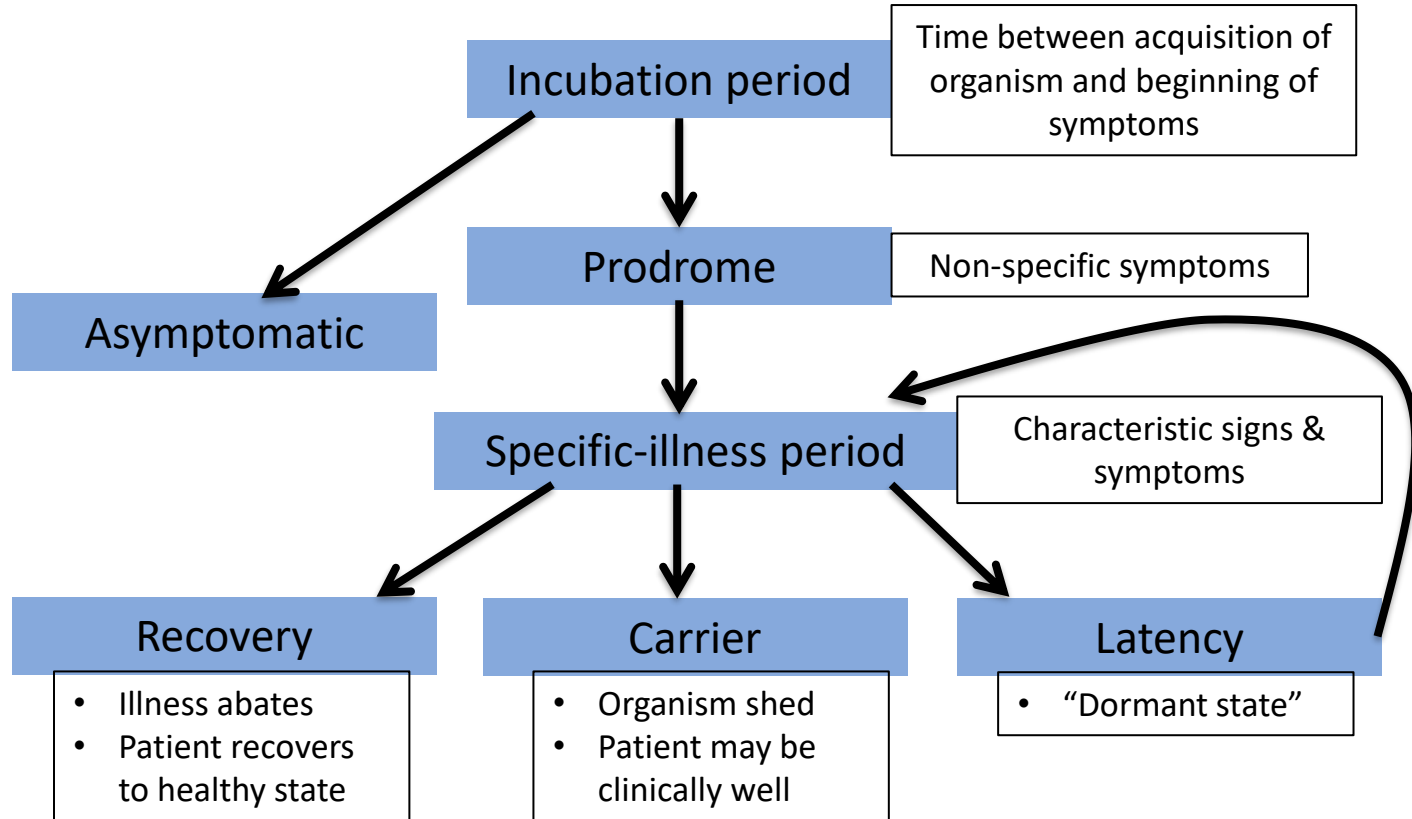
Path to Infection

- Phase 1: Contact with the host
 - Transmission (direct, indirect)
 - Evasion and survival of host primary defenses
 - Colonization
 - Adherence
 - Proliferation
- Phase 2: Production of disease
 - Invasion and inflammation
 - Toxin production
 - Exotoxins
 - Immunopathogenesis

Example: Pertussis

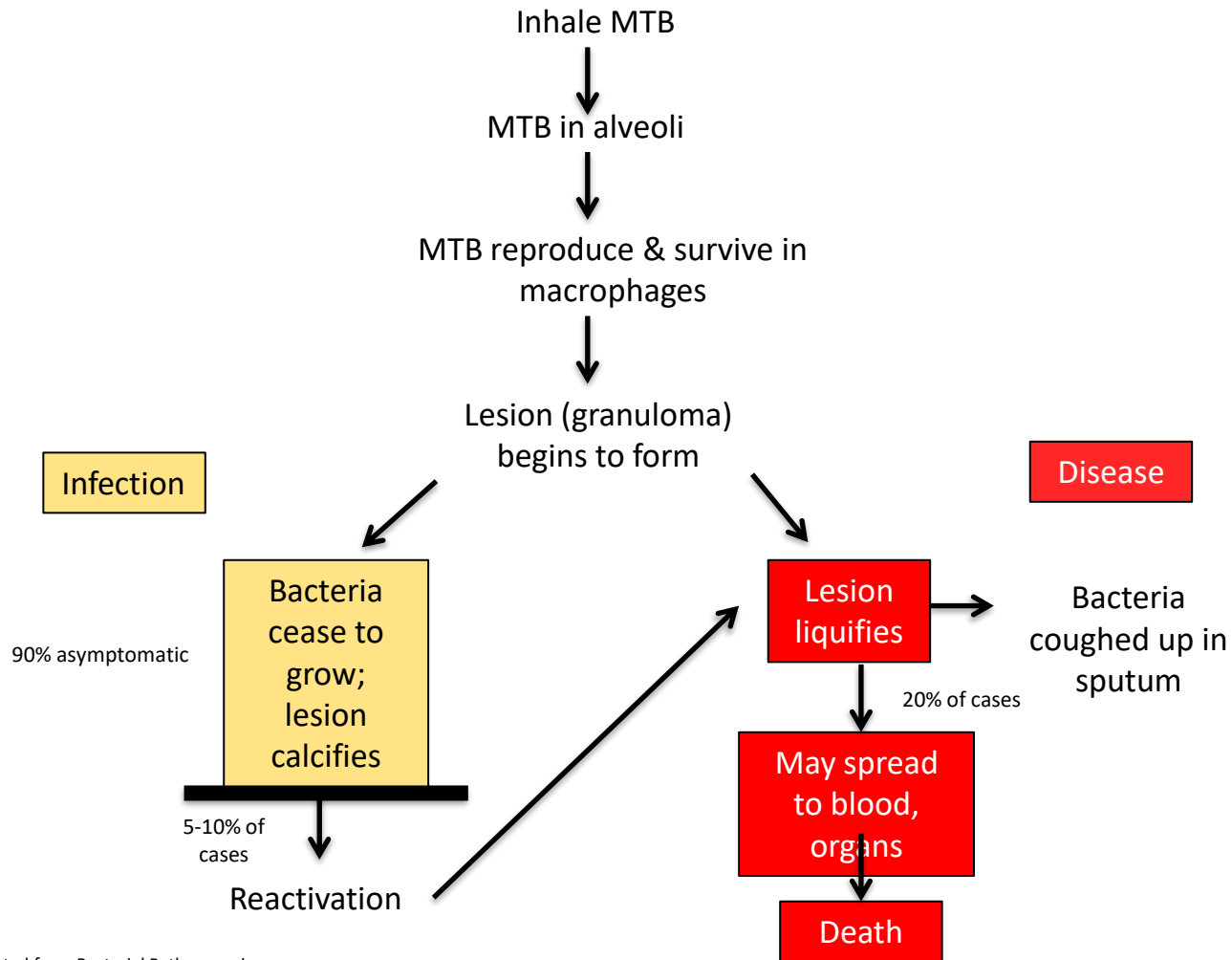
- Transmission
 - Respiratory droplets
- Evasion and survival of host's primary defenses
- Colonization
 - Adheres to ciliated epithelial cells in the trachea
 - Proliferates
- Produces disease
 - Pertussis exotoxin and tracheal cytotoxin cause death and sloughing of ciliated cells

Typical Stages of Infectious Disease



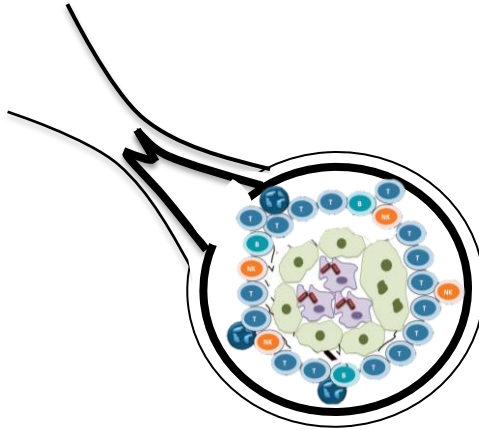
What about TB?

- Infection vs. Disease



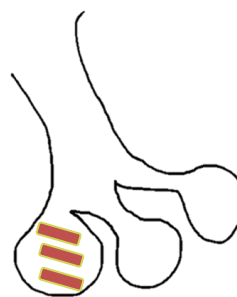
Infection

- Immunocompetent
- Intact cell-mediated response



Granuloma is contained

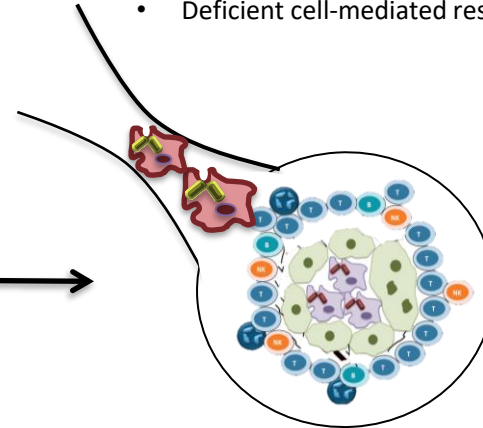
- Lesion undergoes fibrosis and calcification, containing MTB
- Patient not infectious



Alveoli with MTB

Disease

- Immunodeficient
- Deficient cell-mediated response



Reactivation

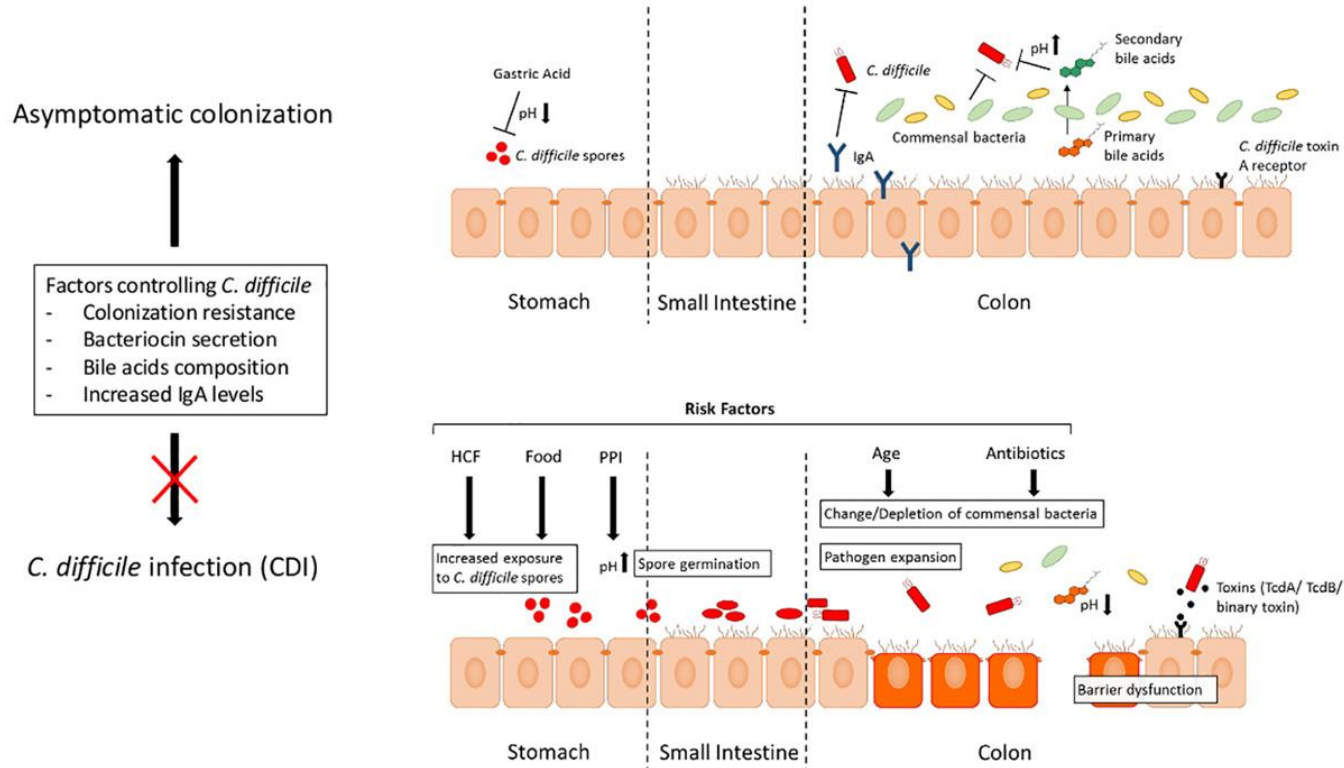
Granuloma is not contained

- Necrotic tissue undergoes liquefaction and fibrous wall loses structural integrity.
- Material can drain into
 1. Bronchus (coughed up, infect others)
 2. Blood vessel (extrapulmonary TB)

What about C. diff?

- Infection vs. Colonization

Infection vs. Colonization



Summary

- Bacteria, fungi, viruses and parasites are different, each with unique characteristics
- The Gram stain is still important in the clinical lab
 - Gram-positive and Gram-negative bacteria are different based on cell wall features
- To cause disease microorganism must overcome host barriers and / or produce factors to cause infection
- The infection process, no matter what infection goes through typical phases



Questions?
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