Pathogenicity and Infections

Host – larger organism that supports the survival and growth of a smaller organism

Parasites are organisms that:
- Live on or within a host organism and are metabolically dependent on the host
- Are any organism that cause disease

Infection - a parasite growing and multiplying within/on a host and that may or may not result in overt infectious disease

Pathogen is any parasitic organism causing infectious disease
- Primary (frank) pathogen – causes disease by direct interaction with healthy host
- Opportunistic pathogen – may be part of normal flora and causes disease when it has gained access to other tissue sites or host is immunocompromised

Pathogenicity – the ability of parasite to cause disease

Source of pathogens
- Can be animate (other humans or animals; zoonoses, infections passed from animal to human)
- Can be inanimate (water, soil, food)
- Reservoir = natural environmental location in which the pathogen normally resides
Infection Process

- A pathogen must contact a host AND survive within it to cause a disease.
- To survive, it needs
  - A suitable environment
  - A source of nutrients
  - Protection from harmful elements

Infection Process (cont.)

- Virulence factors allow a pathogen to outcompete host cells and resist their defenses

Toxigenicity

- Some microbes possess the ability to produce toxins
- Toxin - specific substance that damages host

Toxigenicity

- Intoxications - diseases that result from entry of a specific preformed toxin into host
- Toxemia - condition caused by toxins in the blood of host

Course of Infectious Disease

- Incubation period - period after pathogen entry, before signs and symptoms
- Prodromal stage - onset of signs and symptoms, yet these are not clear enough for diagnosis
- Period of illness - disease is most severe, signs and symptoms
- Convalescence - signs and symptoms begin to disappear
Virulence

- Virulence is defined as the degree or intensity of pathogenicity
- Virulence factors help determine the degree to which the pathogen causes damage, invasion, and infectivity
- Determined in part by pathogen’s ability to survive outside host

Virulence (cont.)

- Pathogenicity Islands are major virulence factors on large segments of chromosomal or plasmid DNA
- Increase bacterial virulence
- Absent in nonpathogenic members
- Can be spread through horizontal transfer of virulence genes to bacteria

Virulence (cont.)

- Virulence and the ability to cause disease is determined by characteristics of the pathogen, including:
  - Adherence and colonization
  - Invasion

Virulence (cont.)

- Invasion - penetration can be active or passive
  - Active invasion occurs through lytic substances which attack the extracellular matrix, degrade carbohydrate-protein complexes between cells
  - Passive invasion (e.g., skin lesions, insect bites, wounds) involves the spread to deeper tissues and is facilitated by the production of specific products and/or enzymes that promote spreading
Virulence (cont.)

- Once in circulatory system, bacteria have access to all organs and systems
  - Bacteremia – presence of viable bacteria in the blood
  - Septicemia – pathogens or their toxins in the blood
- Two substances that play a significant role in bacterial pathogenesis: endotoxins and exotoxins

Virulence (cont.)

- Exotoxins
  - Soluble, heat-labile, proteins
  - Secreted into surroundings as pathogen grows
  - Most exotoxin producers are Gram-negative
  - Often travel from site of infection to other tissues or cells where they exert their effects
  - Usually synthesized by specific bacteria that have toxin genes in their plasmids or prophage DNA

Virulence (cont.)

- Exotoxins (cont.)
  - Among the most lethal substances known
  - Are highly immunogenic
  - Stimulate production of neutralizing Ab (antitoxins)
  - Chemically inactivated to form immunogenic toxoids, e.g., tetanus toxoid
  - Various types of exotoxins, including the model “AB Exotoxins”

Virulence (cont.)

- Endotoxins - lipopolysaccharide (LPS) in Gram-negative cell wall can be toxic to specific hosts
  - Called endotoxin because it is an endogenous (part) of the bacterium and released when organism lyses (some is also released during multiplication)
  - Toxic component is the lipid portion, lipid A
Virulence (cont.)

Endotoxins (cont.)
- Heat stable
- Toxic (nanogram amounts)
- Weakly immunogenic
- Generally similar, despite source
- Cause general system effects, e.g., fever, weakness, diarrhea, inflammation, intestinal hemorrhage, and fibrinolysis, the enzymatic breakdown of fibrin, the major protein component of blood clots

Virulence (cont.)

Mycotoxins - secondary metabolites of fungi
- Common contaminants of food crops
- Aspergillus flavus and A. parasiticus produce carcinogenic aflatoxin
- Claviceps purpurea (ergot) produce hallucinogen lysergic acid (LSD)

Virulence (cont.)

Biofilm development
- May cause chronic infection
- Increases virulence
- Become less sensitive to antibiotics
- Make cells in biofilm more resistant to host defense (“frustrates” phagocytes)

Virulence (cont.)

Resisting host defenses - successful pathogens evade the immune system
- Numerous mechanisms for both viral and bacterial pathogens
  - Infection of immune system cells, diminishing function
  - Fuse with adjacent cells to prevent exposure to antimicrobial proteins in host
  - Mutations change antigenic sites or alter expression of antigens

Virulence (cont.)

Numerous mechanisms (cont.)
- Capsules prevent phagocytosis
- Produce substances that resemble host tissue
- Produce proteases that degrade host proteins
- Special proteins that interfere with host defenses

Virulence (cont.)

Numerous mechanisms (cont.)
- Production of decoy proteins to bind available neutralizing antibodies
- Some survive inside host cells eject themselves from cell to cell using host actin
Pathogen Transmission

- Evidence suggests correlation between mode of transmission and degree of virulence
  - Direct contact → less virulent
  - Vector-borne → highly virulent in human host; relatively benign in vector
  - Greater ability to survive outside host → more virulent
- Transmission alone not enough for infection to occur

Pathogen Transmission (cont.)

- Five main modes of transmission
  - Airborne
  - Contact
  - Vehicle
  - Vector borne
  - Vertical

Pathogen Transmission (cont.)

- Airborne transmission
  - Pathogen suspended in air and travels ≥1 meter
  - Droplet nuclei
    - small particles (1–4 µm diameter) that can remain airborne for long time and can travel long distances
    - Usually propelled from respiratory tract of source organisms by sneezing, coughing, or vocalization
  - Dust particles also important route of airborne transmission

Pathogen Transmission (cont.)

- Contact transmission
  - Coming together or touching of source/reservoir and host
  - Direct contact (person-to-person) - physical interaction between source/reservoir and host, e.g., kissing, touching, and sexual contact
  - Indirect contact - involves an intermediate (usually inanimate), e.g., eating utensils, bedding
  - Droplet spread - large particles (>5 µm) that travel <1 meter

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Pathogen Transmission (cont.)

- Vehicle transmission
  - Vehicles - inanimate materials or objects involved in pathogen transmission
  - Common vehicle transmission - single vehicle spreads pathogen to multiple hosts, e.g., water and food
  - Fomites - common vehicles such as surgical instruments, bedding, and eating utensils

- Vector-borne transmission
  - External (mechanical) transmission
    - Passive carriage of pathogen on body of vector
    - No growth of pathogen during transmission
  - Internal transmission
    - Carried within vector
    - Harborage transmission – pathogen does not undergo changes within vector
    - Biologic transmission – pathogen undergoes changes within vector

Pathogen Transmission (cont.)

- Vertical transmission
  - Occurs when the unborn child acquires a pathogen from an infected mother
  - Not as common as horizontal transmission
  - Babies born with an infectious disease are said to have a congenital infection, e.g., gonorrhea (especially in the eyes), herpes, German measles