Pathogenicity and Infection
35.1 Pathogenicity and Infectious Disease

1. Compare and contrast competition between microbial species with competition between microbial and human cells

2. Predict the microbial virulence factors and host cell responses that result in disease

3. Relate the infectious disease process to time, identifying events associated with each stage of the process
Pathogenicity and Infectious Disease

- **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
Pathogenicity and Infectious Disease

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

• Pathogen
  – 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
  – ability of parasite to cause disease
The Chain of Infection

- Chain of events for a successful infection
  - agent identity
  - virulence of agent
  - dose of agent
  - means of exposure to agent
  - susceptibility of host to agent
Sources of Pathogens

- Can be animate (other humans or animals)
  - infections passed from animal to human are termed **zoonoses**
  - many examples of zoonoses exist (see tables on next two slides)
- Can be inanimate (water, soil, food)
- Reservoir = natural environmental location in which the pathogen normally resides
# Table 35.1 Infectious Organisms in Nonhuman Reservoirs That May Be Transmitted to Humans

<table>
<thead>
<tr>
<th>Disease</th>
<th>Etiologic Agent</th>
<th>Usual or Suspected Nonhuman Host</th>
<th>Usual Method of Human Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthrax</td>
<td><em>Bacillus anthracis</em></td>
<td>Cattle, horses, sheep, swine, goats, dogs, cats, wild animals, birds</td>
<td>Inhalation or ingestion of spores: direct contact</td>
</tr>
<tr>
<td>Babesiosis (undulant fever)</td>
<td><em>Babesia bovis, B. divergens, B. microti, B. equi</em></td>
<td>Ixodes ticks of various species</td>
<td>Bite of infected tick</td>
</tr>
<tr>
<td>Brucellosis</td>
<td><em>Brucella melitensis, B. abortus, B. suis</em></td>
<td>Cattle, goats, swine, sheep, horses, mules, dogs, cats, fowl, deer, rabbits</td>
<td>Milk; direct or indirect contact</td>
</tr>
<tr>
<td>Campylobacteriosis</td>
<td><em>Campylobacter fetus, C. jejuni</em></td>
<td>Cattle, sheep, poultry, swine, pets</td>
<td>Contaminated water and food</td>
</tr>
<tr>
<td>Cat-scratch disease</td>
<td><em>Bartonella henselae</em></td>
<td>Cats, dogs</td>
<td>Cat or dog scratch</td>
</tr>
<tr>
<td>Cryptosporidiosis</td>
<td><em>Cryptosporidium</em> spp.</td>
<td>Farm animals, pets</td>
<td>Contaminated water</td>
</tr>
<tr>
<td>Encephalitis (St. Louis)</td>
<td><em>Arboviruses</em></td>
<td>Birds</td>
<td>Mosquito</td>
</tr>
<tr>
<td>Encephalomyelitis (Venezuelan equine)</td>
<td><em>Arboviruses</em></td>
<td>Rodents, horses</td>
<td>Mosquito</td>
</tr>
<tr>
<td>Encephalomyelitis (Western equine)</td>
<td><em>Arboviruses</em></td>
<td>Birds, snakes, squirrels, horses</td>
<td>Mosquito</td>
</tr>
<tr>
<td>Giardiasis</td>
<td><em>Giardia intestinalis</em></td>
<td>Rodents, deer, cattle, dogs, cats</td>
<td>Contaminated water</td>
</tr>
<tr>
<td>Hantavirus pulmonary syndrome</td>
<td>Pulmonary syndrome hantavirus</td>
<td>Deer mice</td>
<td>Contact with the saliva, urine, or feces of deer mice; aerosolized viruses</td>
</tr>
<tr>
<td>Influenza</td>
<td><em>Influenza viruses</em></td>
<td>Water fowl, pigs</td>
<td>Direct contact or inhalation</td>
</tr>
<tr>
<td>Listeriosis</td>
<td><em>Listeria monocytogenes</em></td>
<td>Sheep, cattle, goats, guinea pigs, chickens, horses, rodents, birds, crustaceans</td>
<td>Food-borne</td>
</tr>
<tr>
<td>Lyme disease</td>
<td><em>Borrelia burgdorferi</em></td>
<td>Ticks (Ixodes scapularis or related ticks)</td>
<td>Bite of infected tick</td>
</tr>
<tr>
<td>Lymphocytic choriomeningitis</td>
<td><em>Lymphocytic choriomeningitis virus</em></td>
<td>Mice, rats, dogs, monkeys, guinea pigs</td>
<td>Inhalation of contaminated dust; ingestion of contaminated food</td>
</tr>
<tr>
<td>Pasteurellosis</td>
<td><em>Pasteurella multocida</em></td>
<td>Fowl, cattle, sheep, swine, goats, mice, rats, rabbits</td>
<td>Animal bite</td>
</tr>
<tr>
<td>Plague (bubonic)</td>
<td><em>Yersinia pestis</em></td>
<td>Domestic rats, many wild rodents</td>
<td>Flea bite</td>
</tr>
<tr>
<td>Psittacosis</td>
<td><em>Chlamydia psittaci</em></td>
<td>Birds</td>
<td>Direct contact, respiratory aerosols</td>
</tr>
<tr>
<td>Q fever</td>
<td><em>Coxiella burnetii</em></td>
<td>Cattle, sheep, goats</td>
<td>Inhalation of contaminated soil and dust</td>
</tr>
<tr>
<td>Rabies</td>
<td>Rabies virus</td>
<td>Dogs, bats, opossums, skunks, raccoons, foxes, cats, cattle</td>
<td>Bite of rabid animal</td>
</tr>
<tr>
<td>Relapsing fever (boreliosis)</td>
<td><em>Borrelia spp.</em></td>
<td>Rodents, porcupines, opossums, armadillos, ticks, lice</td>
<td>Tick or louse bite</td>
</tr>
<tr>
<td>Rocky Mountain spotted fever</td>
<td><em>Rickettsia rickettsii</em></td>
<td>Rabbits, squirrels, rats, mice, groundhogs</td>
<td>Tick bite</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Disease</th>
<th>Etiologic Agent</th>
<th>Usual or Suspected Nonhuman Host</th>
<th>Usual Method of Human Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonellosis</td>
<td><em>Salmonella</em> spp. (except <em>S. typhosa</em>)</td>
<td>Fowl, swine, sheep, cattle, horses, dogs, cats, rodents, reptiles, birds, turtles</td>
<td>Direct contact; food</td>
</tr>
<tr>
<td>SARS</td>
<td>SARS coronavirus</td>
<td>Bats, civets</td>
<td>Contact with infected animal or person</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td><em>Mycobacterium bovis, M. tuberculosis</em></td>
<td>Cattle, horses, cats, dogs</td>
<td>Milk; direct contact</td>
</tr>
<tr>
<td>Tularemia</td>
<td><em>Francisella tularensis</em></td>
<td>Wild rabbits, most other wild and domestic animals</td>
<td>Direct contact with infected carcass, usually rabbit; tick bite, biting flies</td>
</tr>
<tr>
<td>Typhus fever (endemic)</td>
<td><em>Rickettsia mooseri</em></td>
<td>Rats</td>
<td>Flea bite</td>
</tr>
<tr>
<td>Yellow fever (jungle)</td>
<td>Yellow fever virus</td>
<td>Monkeys, marmosets, lemurs, mosquitoes</td>
<td>Mosquito</td>
</tr>
</tbody>
</table>
Infectious 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
    - in competition with eukaryotic host cells
  - Protection from harmful elements
    - *virulence factors* allow a pathogen to outcompete host cells and resist their defenses
Toxigenicity

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

• Infectious disease
  – infection with viruses, bacteria, fungi, protozoa, and helminths

• Signs
  – objective changes in body that can be directly observed

• Symptoms
  – subjective changes experienced by patient

• Disease syndrome
  – set of characteristic signs and symptoms
Course of Infectious Disease

- **incubation period**
  - period after pathogen entry, before signs and symptoms

- **prodromal stage**
  - onset of signs and symptoms
  - not clear enough for diagnosis

- **period of illness**
  - disease is most severe, signs and symptoms

- **convalescence**
  - signs and symptoms begin to disappear
35.2 Virulence

1. Identify and describe the features that allow microorganisms to overcome host resistance and immunity

2. Discuss the strategies microorganisms have evolved to exploit human cells and tissues as resources for their survival

3. Compare the molecular mechanisms by which microorganisms adhere to and invade human cells and tissues

4. Illustrate the mechanisms by which microbial toxins impact human cells

5. Model disease processes and explain virulence
Virulence

• Degree or intensity of pathogenicity

• Virulence factors
  – determine the degree to which the pathogen causes damage, invasion, infectivity

• Determined in part by pathogen’s ability to survive outside host
Pathogenicity Islands

- Major virulence factors on large segments on chromosomal or plasmid DNA
  - increase bacterial virulence
  - absent in nonpathogenic members
  - common sequence characteristics
    - insertion-like sequences for mobility
    - G + C content different from bacterial genome
    - several open reading frames
  - can be spread through horizontal transfer of virulence genes to bacteria
### Table 35.2  Examples of Pathogenicity Islands and the Products They Encode

<table>
<thead>
<tr>
<th>Organism</th>
<th>Pathogenicity Island(^1)</th>
<th>Gene Product</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>cagPl</td>
<td>Type IV secretion proteins</td>
<td>Cytotoxin</td>
</tr>
<tr>
<td><em>Helicobacter pylori</em></td>
<td>PAI-III</td>
<td>Type 1 pili Secreted protein</td>
<td>Attachment, Hemolysin, cytotoxic necrosing factor, uropathogenic protein</td>
</tr>
<tr>
<td><em>Legionella pneumophila</em></td>
<td>icm/dot</td>
<td>Type IV secretion proteins</td>
<td>Intracellular survival</td>
</tr>
<tr>
<td><em>Rhodococcus equi</em></td>
<td>PAI-vap</td>
<td>Secreted proteins</td>
<td>Intracellular survival</td>
</tr>
<tr>
<td><em>Salmonella enterica</em></td>
<td>SPI-1, SPI-2</td>
<td>Type III secretion proteins</td>
<td>Cytotoxin</td>
</tr>
<tr>
<td><em>Shigella flexneri</em></td>
<td>SHI-1, SHI-2</td>
<td>Type III secretion proteins</td>
<td>Cytotoxin</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>SaPI</td>
<td>Secreted proteins</td>
<td>Superantigens</td>
</tr>
<tr>
<td><em>Vibrio cholerae</em></td>
<td>VPI</td>
<td>Secreted protein</td>
<td>Toxin</td>
</tr>
<tr>
<td><em>Yersinia pestis</em></td>
<td>HPI-1</td>
<td>Siderophore synthesis</td>
<td>Iron uptake and storage</td>
</tr>
</tbody>
</table>

\(^1\) Pl and PAI are both common abbreviations for pathogenicity island.
Virulence Factors

- Animal model systems may be used to determine role of virulence factor in disease process
- Determined by characteristics of the pathogen
  - adherence and colonization
  - invasion

Table 35.3  Examples of Microbial Attachment Mechanisms

<table>
<thead>
<tr>
<th>Microbe</th>
<th>Disease</th>
<th>Adhesion Mechanism</th>
<th>Host Receptor</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Neisseria gonorrhoeae</em></td>
<td>Gonorrhea</td>
<td>Type I fimbriae</td>
<td>Sugar residue on urethral epithelium</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>Diarrhea</td>
<td>Type I fimbriae</td>
<td>Sugar residue on intestinal epithelium</td>
</tr>
<tr>
<td></td>
<td>Hemolytic uremic syndrome</td>
<td>P pili</td>
<td>Sugar residue on kidney cell</td>
</tr>
<tr>
<td></td>
<td>Urinary tract infection</td>
<td>Type I fimbriae</td>
<td>Sugar residue on urethral epithelium</td>
</tr>
<tr>
<td><em>Treponema pallidum</em></td>
<td>Syphilis</td>
<td>Outer membrane protein</td>
<td>Protein residue on mucosal cell</td>
</tr>
<tr>
<td><em>Mycoplasma pneumoniae</em></td>
<td>Pneumonia</td>
<td>Membrane protein</td>
<td>Protein residue on lung cell</td>
</tr>
<tr>
<td><em>Streptococcus pyogenes</em></td>
<td>Sore throat</td>
<td>Protein F</td>
<td>Protein residue on upper respiratory tract cell</td>
</tr>
<tr>
<td><em>Streptococcus mutans</em></td>
<td>Dental caries</td>
<td>Sugar residue</td>
<td>Salivary glycoprotein on tooth</td>
</tr>
<tr>
<td>Influenza virus</td>
<td>Influenza</td>
<td>Hemagglutinin spike protein</td>
<td>Protein residue on upper respiratory tract cell</td>
</tr>
<tr>
<td>HIV-1</td>
<td>AIDS</td>
<td>gp120 protein</td>
<td>CD4 receptor on T cells</td>
</tr>
<tr>
<td>Polio virus</td>
<td>Poliomyelitis</td>
<td>Capsid protein VP1</td>
<td>CD 155 protein on intestinal and nerve cells</td>
</tr>
</tbody>
</table>
Adherence and Colonization

- First step in disease is entrance and attachment
- Portal of entry
  - skin, respiratory, gastrointestinal, urogenital systems, or conjunctiva of eye
  - vector borne, sexual contact, blood transfusion, or organ transplant
- Adherence
  - mediated by special molecules called adhesins
- Colonization
  - a site of microbial reproduction on or within host
  - does not necessarily result in tissue invasion or damage
Attachment and Colonization

• Adherence structures
  – pili, fimbriae (adhesion molecules on bacterium’s cell surface) bind complementary receptor sites on host cell surface

• Colonization
  – a site of microbial reproduction on/in host
  – does not necessarily result in tissue damage
Invasion

• Infectivity - ability to create a discrete point of infection

• Invasiveness - ability to spread to adjacent tissues

• Penetration can be active or passive
  – active occurs through lytic substances which
    • attack the extracellular matrix and basement membranes of integuments and intestinal linings
    • degrade carbohydrate-protein complexes between cells
    • disrupt host cell surface
  – passive (e.g., skin lesions, insect bites, wounds)
    • spread to deeper tissues involves production of specific products and/or enzymes that promote spreading
<table>
<thead>
<tr>
<th>Product</th>
<th>Organism Involved</th>
<th>Mechanism of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulase</td>
<td><em>Staphylococcus aureus</em></td>
<td>Coagulates (clots) the fibrinogen in plasma. The clot protects the pathogen from phagocytosis and isolates it from other host defenses.</td>
</tr>
<tr>
<td>Collagenase</td>
<td><em>Clostridium</em> spp.</td>
<td>Breaks down collagen that forms the framework of connective tissues; allows the pathogen to spread</td>
</tr>
<tr>
<td>Deoxyribonuclease</td>
<td>Group A streptococci, staphylococci, <em>Clostridium perfringens</em></td>
<td>Lowers viscosity of exudates, giving the pathogen more mobility</td>
</tr>
<tr>
<td>Elastase and alkaline protease</td>
<td><em>Pseudomonas aeruginosa</em></td>
<td>Cleaves laminin associated with basement membranes</td>
</tr>
<tr>
<td>Hemolysins</td>
<td>Staphylococci, streptococci, <em>Escherichia coli, Clostridium perfringens</em></td>
<td>Lyse erythrocytes; make iron available for microbial growth</td>
</tr>
<tr>
<td>Hyaluronidase</td>
<td>Groups A, B, C, and G streptococci, staphylococci, clostridia</td>
<td>Hydrolyzes hyaluronic acid, a constituent of the extracellular matrix that cements cells together and renders the intercellular spaces amenable to passage by the pathogen</td>
</tr>
<tr>
<td>Hydrogen peroxide (H₂O₂) and ammonia (NH₃)</td>
<td><em>Mycoplasma</em> spp., <em>Ureaplasma</em> spp.</td>
<td>Are produced as metabolic wastes. These are toxic and damage epithelia in respiratory and urogenital systems.</td>
</tr>
<tr>
<td>Immunoglobulin A protease</td>
<td><em>Streptococcus pneumoniae</em></td>
<td>Cleaves immunoglobulin A into Fab and Fc fragments</td>
</tr>
<tr>
<td>Lecithinase or phospholipase</td>
<td><em>Clostridium</em> spp.</td>
<td>Destroys the lecithin (phosphatidylcholine) component of plasma membranes, allowing pathogen to spread</td>
</tr>
<tr>
<td>Leukocidins</td>
<td>Staphylococci, pneumococci, and other streptococci</td>
<td>Pore-forming exotoxins that kill leukocytes; cause degranulation of lysosomes within leukocytes, which decreases host resistance</td>
</tr>
<tr>
<td>Porins</td>
<td><em>Salmonella enterica</em> serovar Typhimurium</td>
<td>Inhibit leukocyte phagocytosis by activating the adenylate cyclase system</td>
</tr>
<tr>
<td>Protein A</td>
<td><em>Staphylococcus aureus</em></td>
<td>Located on cell wall. Immunoglobulin G (IgG) binds to either protein A or protein G by its Fc end, thereby preventing complement from interacting with bound IgG.</td>
</tr>
<tr>
<td>Protein G</td>
<td><em>Streptococcus pyogenes</em></td>
<td></td>
</tr>
<tr>
<td>Pyrogenic exotoxin B (cysteine protease)</td>
<td>Group A streptococci <em>(Streptococcus pyogenes)</em></td>
<td>Degrades proteins</td>
</tr>
<tr>
<td>Streptokinase (fibrinolysin, staphylokinase)</td>
<td>Groups A, C, and G streptococci, staphylococci</td>
<td>A protein that binds to plasminogen and activates the production of plasmin, thus digesting fibrin clots; this allows the pathogen to move from the clotted area</td>
</tr>
</tbody>
</table>
Invasion

- 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
- varies among pathogens
  - e.g., *Clostridium tetani* (tetanus) produces a number of virulence factors but is non-invasive
  - e.g., *Bacillus anthracis* (anthrax) and *Yersinia pestis* (plague) also produce many virulence factors and are highly invasive
  - e.g., *Streptococcus* spp. span the spectrum of virulence factors and invasiveness
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
• 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
Types of Exotoxins

- AB exotoxins
  - composed of two subunits
    - A subunit – responsible for toxic effect
    - B subunit – binds to specific target cell

- Specific host site exotoxins

- Membrane-disrupting exotoxins

- Superantigens
<table>
<thead>
<tr>
<th>Exotoxins Produced by Human Pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Toxin</strong></td>
</tr>
<tr>
<td>Edema factor (EF)</td>
</tr>
<tr>
<td>Lethal factor (LF)</td>
</tr>
<tr>
<td>Protective antigen (PA)</td>
</tr>
<tr>
<td>Pertussis toxin</td>
</tr>
<tr>
<td>Botulinum toxin</td>
</tr>
<tr>
<td>CPE enterotoxin</td>
</tr>
<tr>
<td>Tetanospasmin</td>
</tr>
<tr>
<td>Diphtheria toxin</td>
</tr>
<tr>
<td>Enterotoxin</td>
</tr>
<tr>
<td>Shiga-like toxin</td>
</tr>
<tr>
<td>Cytolysin</td>
</tr>
<tr>
<td>Shiga toxin</td>
</tr>
<tr>
<td>Exfoliative toxin</td>
</tr>
<tr>
<td>Toxoid shock syndrome toxin-1</td>
</tr>
<tr>
<td>Panton-Valentine leukocidin</td>
</tr>
<tr>
<td>Streptolysin O</td>
</tr>
<tr>
<td>Erythrogenic toxin</td>
</tr>
<tr>
<td>Cholera toxin</td>
</tr>
</tbody>
</table>
Superantigens

- Stimulate ~30% of T cells of the immune system
  - causes the T cells to overexpress and release cytokines
  - results in failure of multiple host organs allowing time for the microbe to disseminate

- Example is staphylococcal enterotoxin B
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
Endotoxins

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

• Bring about these effects indirectly
  – endotoxin interacts with host molecules and cells, activating host systems
    • coagulation, complement, fibrinolytic, and kininogen system
  – e.g., interaction with macrophages $\rightarrow$ release of endogenous pyrogen (induces fever)
  – e.g., binding to LPS-binding protein $\rightarrow$ release of cytokines
    • tumor necrosis and others lead to septic shock
Mycotoxins

• Secondary metabolites of fungi
  – common contaminants of food crops
  – *Aspergillus flavus* and *A. parasiticus* produce carcinogenic aflatoxin
  – *Stachybotrys* produce tissue-damaging satratoxins
  – *Claviceps purpurea* (ergot) produce hallucinogen lysergic acid (LSD)
Biofilm Development

Biofilm growth is physiologically different from planktonic growth

– may cause chronic infection
– increases virulence
– become less sensitive to antibiotics
– make cells in biofilm more resistant to host defense (“frustrates” phagocytes)
Resisting Host Defenses

• Most microbes eliminated before they can cause disease due to immune system
• Successful pathogen evades immune system
• Numerous mechanisms for both viral and bacterial pathogens
Resisting Host Defenses

- Infection of immune system cells, diminishing function
- Fuse with adjacent cells to prevent exposure to antimicrobial proteins in host
- Capsules prevent phagocytosis
- Mutations change antigenic sites or alter expression of antigens
  - through downregulation or phase variation
- Produce substances that resemble host tissue
- Produce proteases that degrade host proteins
- Special proteins that interfere with host defenses
Resisting Host Defenses

• Production of decoy proteins to bind available neutralizing antibodies

• Lengthened O-chains to prevent host detection or lysis

• Some survive inside host cells
  – eject themselves from cell to cell using host actin
35.3 Exposure, Transmission, and Host Factors

1. List and describe the means by which microorganisms access humans to cause disease

2. Correlate initial microbial numbers and replication rates to infection and lethality

3. Synthesize a concept map of the infectious process
Pathogen Transmission

• Initial transmission of pathogen to host
  – evidence suggests correlation between mode of transmission and degree of virulence
    • direct contact $\rightarrow$ less virulent
    • vector-borne $\rightarrow$ highly virulent in human host; relatively benign in vector
    • greater ability to survive outside host $\rightarrow$ more virulent

• Transmission from host to host

• Transmission alone not enough for infection to occur
  – Tropism - pathogen must make contact with appropriate host tissue
    • determined by specific cell surface receptors
Transmission of infectious diseases

Horizontal contact (kissing, sex)

Airborne droplets

Contact (fomites)

Fecal-oral contamination can also lead to both of these types of transmission.

Food, water, biological products

Indirect (vehicles)

Direct

Vertical contact

Vector

Airborne

Droplet nuclei
Pathogen Transmission

• Five main modes of transmission
  – airborne
  – contact
  – vehicle
  – vector borne
  – vertical
Airborne Transmission

• Pathogen suspended in air and travels ≥1 meter

• Droplet nuclei
  – small particles (1–4 μm diameter)
  – can remain airborne for long time
  – 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
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 \( \mu \)m) that travel <1 meter
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
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
• Examples include
  – gonorrhea (especially in the eyes)
  – herpes
  – german measles
  – toxoplasmosis
Infectious Dose

- Infectious dose 50 (ID$_{50}$, $	ext{ID}_{50}$)
  - number of pathogens that will infect 50% of an experimental group of hosts in a specified time
  - varies with pathogen
  - handwashing reduces number of pathogens
Infectious Dose

• Lethal dose 50 (LD$_{50}$)
  – dose that kills 50% of experimental animals within a specified period

• Cytopathology – cellular changes
  – Can be used to observe cells in tissue culture for death rates rather than entire organisms

• Examining virulence factors and their release
Growth Rate

• Pathogen must find most favorable conditions in the host
  – extracellular pathogens
    • grow outside cells in blood, tissue fluids
  – intracellular pathogens
    • grow and multiply within cells
    • facultative intracellular pathogens
      – grow within or outside cells
    • obligate intracellular pathogens
      – only grow when inside cells
Host Susceptibility

- Two main factors
  - defense mechanisms of host (discussed in Chs. 33 and 34)
  - pathogenicity of pathogen

- Nutrition, genetic predisposition, and stress also play a role in host susceptibility to infection