Pathogenicity and Infection
Pathogenicity and Infectious Disease

• **Infection**
  – a parasite growing and multiplying within/on a host
  – may or may not result in overt infectious disease
  – usually accompanied by an immune response

• **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

• **Virulence** – the degree of pathogenicity
The Chain of Infection

• Chain of events for a successful infection
• All the factors interrelate to cause disease
  – **agent** identity
  – **virulence** of agent
  – **dose** of agent
  – means of **exposure** to agent
  – **susceptibility** of host to agent
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
Sources of Pathogens

• Can be animate (other humans or animals)
  – pick up infection from a human “carrier”
  – 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 (can also be the same as the source)
Source or Reservoir continued

• carrier
  – infected hosts who are potential sources of infection for others
  – types of carriers
    • active carrier has overt clinical case of disease
    • convalescent carrier has recovered but continues to harbor large numbers of pathogen
    • healthy carrier harbors the pathogen but is not ill
    • incubatory carrier is incubating the pathogen in large numbers but is not yet ill
<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</td>
<td><em>Babesia bovis, B. divergens, B. microti, B. equi</em></td>
<td>Ticks (Ixodes tick species)</td>
<td>Bite of infected tick</td>
</tr>
<tr>
<td>Brucellosis (undulant fever)</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 spp.</em></td>
<td>Farm animals, pets</td>
<td>Contaminated water</td>
</tr>
<tr>
<td>Encephalitis (St. Louis)</td>
<td>Arboviruses</td>
<td>Birds</td>
<td>Mosquito</td>
</tr>
<tr>
<td>Encephalomyelitis (Venezuelan equine)</td>
<td>Arboviruses</td>
<td>Rodents, horses</td>
<td>Mosquito</td>
</tr>
<tr>
<td>Encephalomyelitis (Western equine)</td>
<td>Arboviruses</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>Influenza viruses</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 virus</td>
<td>Lymphocytic choriomeningitis virus</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, rats, 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 (borreliosis)</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>
<tr>
<td>Disease</td>
<td>Etiologic Agent</td>
<td>Usual or Suspected Nonhuman Host</td>
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<tr>
<td>-------------------------</td>
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<td>-------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------</td>
</tr>
<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>
Virulence

• Degree or intensity of pathogenicity
• Virulence factors
  – determine the degree to which the pathogen causes damage, invasion, infectivity
  – characteristics of the pathogen may allow it to adhere, colonize and invade tissues despite the host defenses
  – this includes normal characteristics of the cell such as fimbriae and glycocalyx
  – Biofilm formation
• Some microbes possess toxigenicity
  – ability to produce toxins
  – exotoxins and endotoxins
Virulence continued -

- Major virulence factors on large segments on chromosomal – called Pathogenicity Islands or on plasmid DNA
  - increase bacterial virulence
  - can be spread through horizontal transfer of virulence genes to bacteria

<table>
<thead>
<tr>
<th>Microbe</th>
<th>Disease</th>
<th>Adhesion Mechanism</th>
<th>Host Receptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neisseria gonorrhoeae</td>
<td>Gonorrhea</td>
<td>Type I fimbriae</td>
<td>Sugar residue on urethral epithelium</td>
</tr>
<tr>
<td>Escherichia coli</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 fimbriae</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>Treponema pallidum</td>
<td>Syphilis</td>
<td>Outer membrane protein</td>
<td>Protein residue on mucosal cell</td>
</tr>
<tr>
<td>Mycoplasma pneumoniae</td>
<td>Pneumonia</td>
<td>Membrane protein</td>
<td>Protein residue on lung cell</td>
</tr>
<tr>
<td>Streptococcus pyogenes</td>
<td>Sore throat</td>
<td>Protein F</td>
<td>Protein residue on upper respiratory tract cell</td>
</tr>
<tr>
<td>Streptococcus mutans</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
• 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
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
<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</em> perfringens</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>Cleave laminin associated with basement membranes</td>
</tr>
<tr>
<td>Hemolysins</td>
<td><em>Staphylococci</em>, streptococci, <em>Escherichia coli</em>, <em>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><em>Staphylococci</em>, pneumococci, and other streptococci</td>
<td>Pore-forming exotoxins that kill leukocytes; cause degradation 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</em> aureus</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>Degrades proteins</td>
</tr>
<tr>
<td>Pyrogenic exotoxin B (cysteine protease)</td>
<td>Group A streptococci <em>(Streptococcus pyogenes)</em></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>
Exotoxins

- Soluble, heat-labile, proteins
- Secreted into surroundings as pathogen grows
- Most exotoxin producers are Gram-positive
- Very specific in their action - often travel from site of infection to other tissues or cells where they exert their effects
  - neurotoxins, enterotoxins, cytotoxins, etc.
- 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
<table>
<thead>
<tr>
<th>Toxin</th>
<th>Organism</th>
<th>Gene Location</th>
<th>Toxin Type</th>
<th>Mechanism of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edema factor (EF)</td>
<td><em>Bacillus anthracis</em></td>
<td>Plasmid</td>
<td>Tripartite AB</td>
<td>EF causes edema. LF is a cytotoxin. PA is a B component.</td>
</tr>
<tr>
<td>Lethal factor (LF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protective antigen (PA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pertussis toxin</td>
<td><em>Bordetella pertussis</em></td>
<td>Chromosome</td>
<td>AB</td>
<td>↓ATP, ↑cAMP alters cell function, leading to death.</td>
</tr>
<tr>
<td>Botulinum toxin</td>
<td><em>Clostridium botulinum</em></td>
<td>Prophage</td>
<td>AB</td>
<td>Blocks neurotransmitter release, leading to paralysis</td>
</tr>
<tr>
<td>CPE enterotoxin</td>
<td><em>Clostridium perfringens</em></td>
<td>Chromosome</td>
<td>Cytotoxin</td>
<td>Hemolysis</td>
</tr>
<tr>
<td>Tetanospasmin</td>
<td><em>Clostridium tetani</em></td>
<td>Plasmid</td>
<td>AB</td>
<td>Blocks neurotransmitter, leading to spastic paralysis</td>
</tr>
<tr>
<td>Diphtheria toxin</td>
<td><em>Corynebacterium diphtheriae</em></td>
<td>Phage</td>
<td>AB</td>
<td>Alters translation, leading to protein synthesis inhibition</td>
</tr>
<tr>
<td>Enterotoxin</td>
<td><em>Escherichia coli</em></td>
<td>Plasmid</td>
<td>AB &amp; AB</td>
<td>↑cAMP, leading to water secretion from cell Inhibits protein synthesis leading to death</td>
</tr>
<tr>
<td>Shiga-like toxin</td>
<td><em>E. coli O157:H7</em></td>
<td>Plasmid gene integrated into chromosome</td>
<td>AB &amp; AB</td>
<td>↑cAMP, leading to water secretion from cell Inhibits protein synthesis leading to death</td>
</tr>
<tr>
<td>Cytolysin</td>
<td><em>Salmonella spp.</em></td>
<td>Chromosome</td>
<td>Cytotoxin</td>
<td>↑cAMP, leading to water secretion from cell</td>
</tr>
<tr>
<td>Shiga toxin</td>
<td><em>Shigella dysenteriae</em></td>
<td>Chromosome</td>
<td>AB</td>
<td>Inhibits protein synthesis, leading to death</td>
</tr>
<tr>
<td>Exfoliative toxin</td>
<td><em>Staphylococcus aureus</em></td>
<td>Chromosome Phage</td>
<td>Protease Superantigen</td>
<td>Skin peeling Cytokine-induced shock Necrotizing pneumonia</td>
</tr>
<tr>
<td>Toxic shock syndrome toxin-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panton-Valentine leukocidin</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Streptolysin O</td>
<td><em>Streptococcus pyogenes</em></td>
<td>Chromosome Phage</td>
<td>Cytolysin Superantigen</td>
<td>Hemolysis Cytokine-induced shock</td>
</tr>
<tr>
<td>Erythrogenic toxin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cholera toxin</td>
<td><em>Vibrio cholerae</em></td>
<td>Phage</td>
<td>AB</td>
<td>↑cAMP, leading to water secretion from cell</td>
</tr>
</tbody>
</table>
Endotoxins

- Heat stable
- Toxic (nanogram amounts)
- Lipopolysaccharide (LPS) in Gram-negative cell wall
  - 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
- Weakly immunogenic
- Generally similar, despite source
Endotoxins continued

• Cause general system effects
  – fever, weakness, diarrhea, inflammation, intestinal hemorrhage, and fibrinolysis, the enzymatic breakdown of fibrin, the major protein component of blood clots

• 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 → release of endogenous pyrogen (induces fever)
  – e.g., binding to LPS-binding protein → release of cytokines
    • tumor necrosis and others lead to septic shock
Mycotoxins

• 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)
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 – virulence factors
  – 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
  – Produce substances that resemble host tissue
  – Produce proteases that degrade host proteins
  – Special proteins that interfere with 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
Pathogen Transmission

• Initial transmission of pathogen to host
• 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
• Five main modes of transmission
  – airborne
  – contact
  – vehicle
  – vector borne
  – vertical
Airborne Transmission

• Pathogen suspended in air and travels $\geq 1$ meter

• Droplet nuclei
  – small particles (1–4 $\mu$m 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 µm) 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\textsubscript{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

- **Lethal dose 50 (LD\textsubscript{50})**
  - dose that kills 50% of experimental animals within a specified period
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