Infection, Infectious Disease, & Epidemiology

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Biological Associations

Symbiosis or "living together," is an association between two or more species

1) Mutualism— a condition in which both species benefit *(E. coli* in colon—Vitamin K synthesis!*)*

2) Commensalism—one species benefits but the other neither benefits nor is harmed (most normal flora)

3) Parasitism—an association in which the parasite lives at the expense of the other species, the host (all microbial pathogens)

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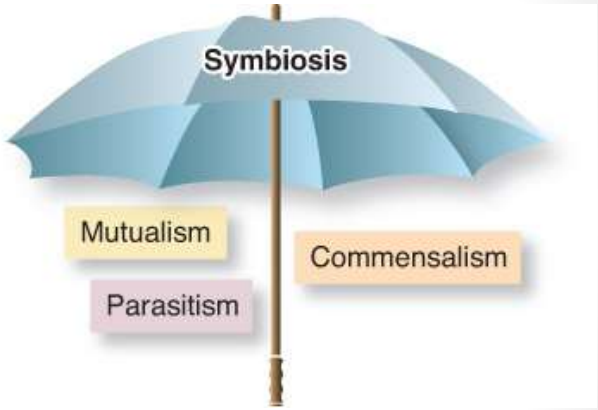

Figure 07.01: The symbiosis umbrella.

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The human normal flora is composed mainly of commensal bacteria

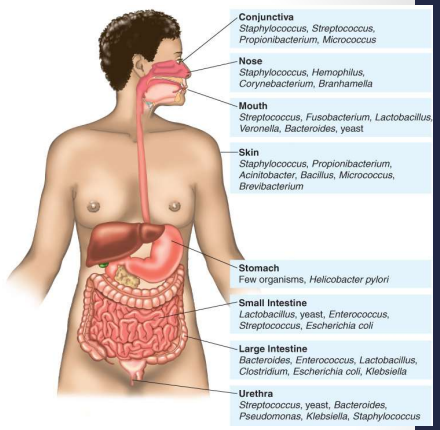

Figure 07.04: The normal flora: mostly commensal organisms.

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There is a see-saw relationship between mutualism, commensalism, and parasitism

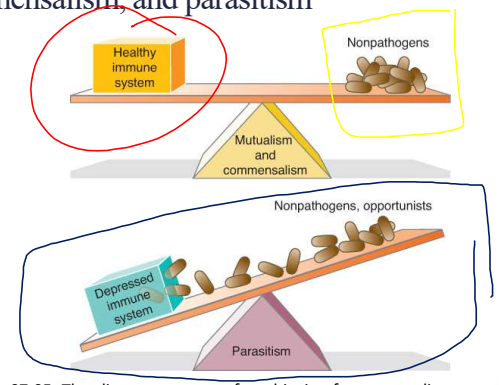

Figure 07.05: The slippery see-saw of symbiosis—from mutualism to parasitism.

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The normal flora can be opportunistic pathogens.

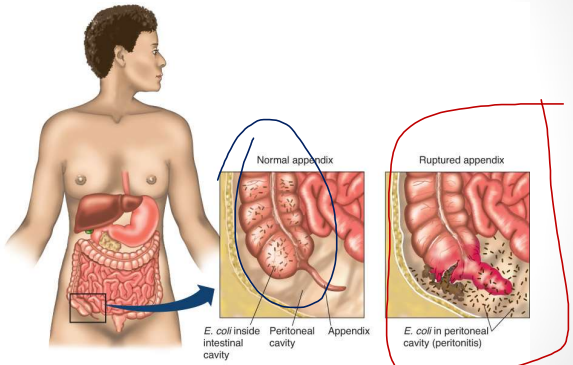

Figure 07.06: Peritonitis: microbes in the "wrong" place.

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Parasitism: A Way of Life

- **Parasites** are the cause of infectious disease
  - live at the expense of the host
  - cause damage or death to the host
- Parasitism results in a constant negotiation between the parasite and the host, as each evolves in response to the other
- Encompasses all microbes, including viruses, and worms that produce disease in the host

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Koch's Postulates

1. **Association:** The causative agent must be present in every case of a specific disease.
2. **Isolation:** The causative agent must be isolated in every case of the disease and grown in pure culture.
3. **Causation:** The causative agent in the pure culture must cause the disease when inoculated into a healthy and susceptible laboratory animal.
4. **Re-isolation:** The causative agent must be re-isolated from the laboratory animal and be identical to the original causative agent.

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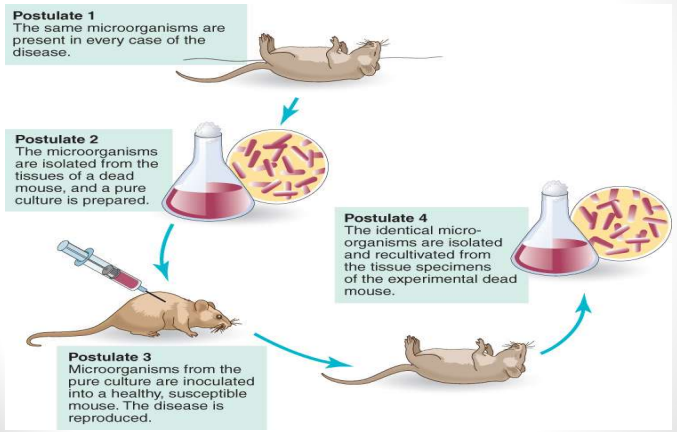
Koch's postulates: association, isolation, causation, and reisolation, are still used to establish the cause of infection.



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Microbial Mechanisms of Disease

The chance of acquiring an infection depends upon three major factors:

- (*n*) **dose**, the number of microbes encountered
- (*V*) **virulence**, virulence factors
- (*R*) **resistance**, host immunity

Severity of infection = $\boldsymbol{D = nV/R}$

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Exceptions to Koch's Postulates

1) Some pathogens cannot be cultured in the lab
2) Some diseases are caused by a combo of pathogens or by a combination of pathogens and physical, environmental or genetic cofactors.
3) Ethical violations prevent application of Koch's postulates in humans in many cases.
4) Some diseases can be caused by more than one pathogen (ie meningitis, hepatitis, pneumonia)
5) Some pathogens have been historically overlooked (ie *H. pylori)*

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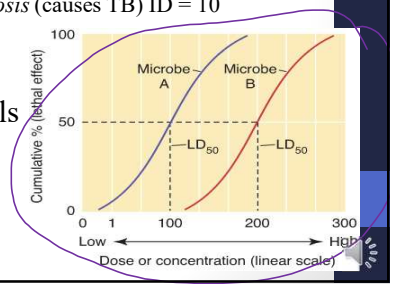
Pathogenicity and Virulence

- **Infective dose (ID)**, minimal number of microbes necessary for infection
  - More virulent organisms have smaller IDs than less virulent organisms
    - *Vibrio cholerae* (causes cholera) ID = one million
    - *Mycobacterium tuberculosis* (causes TB) ID = 10
- **LD_{50}** is the number of microbes necessary to kill 50% of the animals infected



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Pathogenicity and Virulence

Pathogenicity is the ability to cause disease

Virulence is a measure of pathogenicity, it encompasses two types of virulence factors:

1) **Defensive strategies** that allow microbes to escape destruction by the host immune system
2) **2) Offensive strategies** that result in damage to the host

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TABLE 7.1 Bacterial Mechanisms Of Virulence

Structure or Secretion	Function	Examples
Defensive strategies		
Adhesins	Fixation to cell surfaces and linings	*Neisseria gonorrhoeae* (attachment to urethral lining); *Streptococcus mutans* (causes tooth decay and sticks to surface of teeth)
Capsules	Interfere with uptake of bacteria (phagocytosis)	Anthrax, plague, streptococcal diseases (e.g., scarlet fever, "strep" throat, pneumococcal infection)
Miscellaneous	Interfere with uptake of bacteria (phagocytosis)	"Waxy coat" of tubercle bacilli; M protein in streptococcal cell walls
Offensive strategies		
Enzymes	Destroy integrity of tissue structure	Hyaluronidase (breaks down hyaluronic acid of connective tissue), hemolysins (bring about lysis of red blood cells), collagenases (break down collagen in connective tissue), leukocidins (destroy white blood cells)
Exotoxins	Specific activities that interfere with vital host functions	Botulinum toxin (one of the most potent toxins known; interferes with transmission of nerve impulse, resulting in flaccid paralysis); tetanus toxin (interferes with transmission of nerve impulses, resulting in irreversible muscle contraction)
Endotoxins	Produces shock-like symptoms, chills, fever, weakness	Structural components of gram-negative cells

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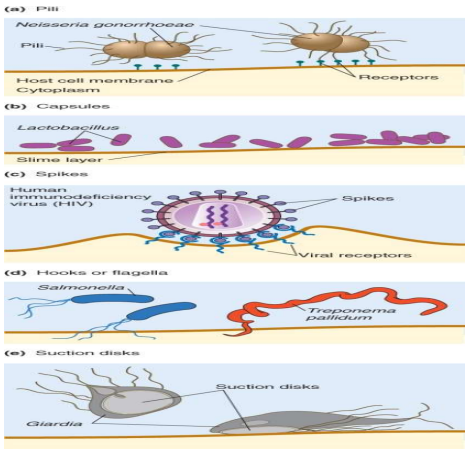
Adhesion Factors



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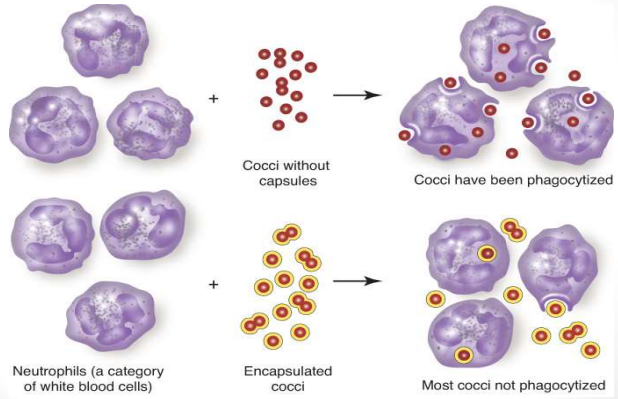
Defensive Strategy—Capsules
Evasion of phagocytosis by host immune cells



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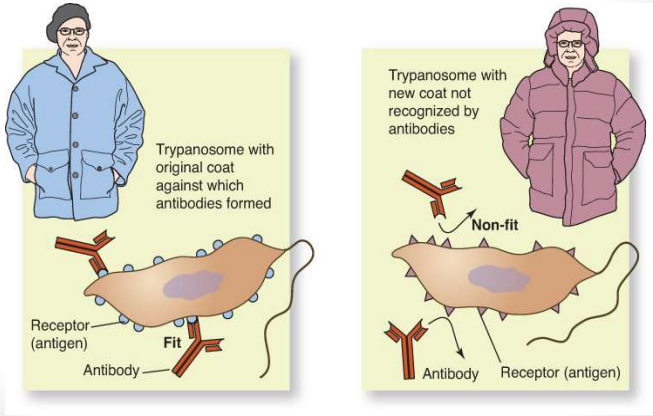
Defensive Strategy—antigenic variation change in surface antigens to evade host antibodies.



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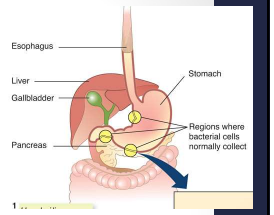
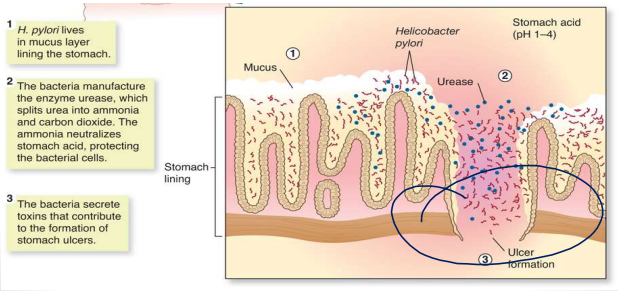
Defensive Strategy—Enzyme secretion

Helicobacter pylori, the bacterium that causes peptic ulcers, secretes the enzyme urease, which enables it to survive in the highly acidic environment of the stomach





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Offensive Strategys: Exoenzymes

- **Enzymes** are proteins with activities that allow the invading bacteria to spread throughout host tissues, causing damage in the process.
- These enzymes are useful to the pathogen in breaking down tissue barriers in the host
- Examples:
  - **Hyaluronidase** breaks down hyaluronic acid content of connective tissues
  - **Collagenase** breaks down collagen which can result in necrotic (dead) tissue that requires **debridement**
  - **Hemolysins** destroy red blood cells
  - **Kinases** break down clots
  - **Leukocidins** destroy white blood cells

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Offensive Strategy: Exotoxins

Exotoxins = proteins synthesized by the microbe and released into host tissue.

- Associated primarily with gram + organisms

Toxigenicity = ability to produce toxins

3 Principal Types:

1) Cytotoxins—kill or damage cells
2) Neurotoxins—block nerve impulse transmission
3) Enterotoxins— affect cells lining gastrointestinal tract

Toxoids = detoxified toxins, retain antigenicity; used in immunizations against diseases that are primarily the result of exotoxin activity

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TABLE 7.2 Disease Manifestations by Exotoxins

Disease	Exotoxin Activity and Result
Botulism	Neurotoxin: prevents transmission of nerve impulse, resulting in (flaccid) limp paralysis
Tetanus	Neurotoxin: prevents transmission of inhibitory nerve impulse, resulting in rigid contractions of skeletal muscles (lockjaw)
Clostridial food poisoning	Enterotoxin: diarrhea
Traveler's diarrhea *E. coli* (enterotoxigenic)	Enterotoxin: diarrhea
Scarlet fever	Cytotoxin: causes damage to blood capillaries, resulting in a red rash
Diphtheria	Cytotoxin: kills cells in throat, resulting in a buildup of dead cells; causes damage to heart
Whooping cough	Cytotoxin: kills ciliated epithelial cells in the respiratory tract
Gastroenteritis (*E. coli* O157:H7)	Cytotoxin: bloody diarrhea; kidney damage

Table 07.02: Diseases Manifested by Exotoxins.

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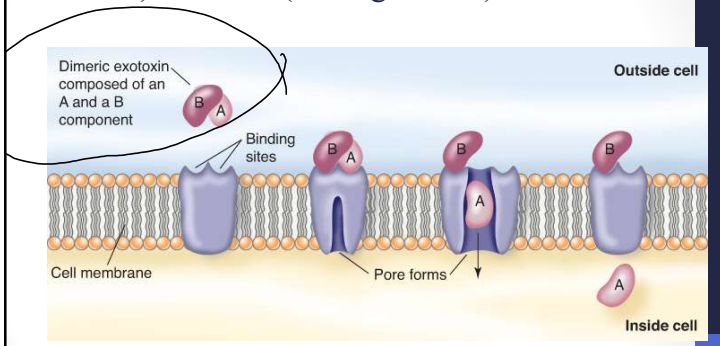
Many exotoxins have two subunits, the A (active subunit) and the B (binding subunit)



The AB model of exotoxin activity

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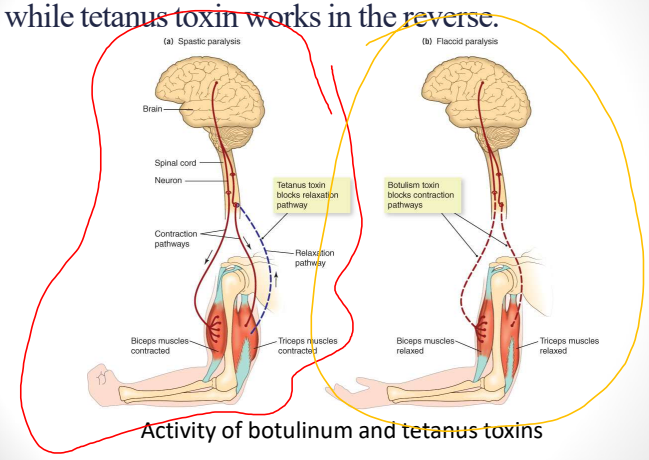
Botulinum toxin causes a flaccid muscle paralysis, while tetanus toxin works in the reverse.



Activity of botulinum and tetanus toxins

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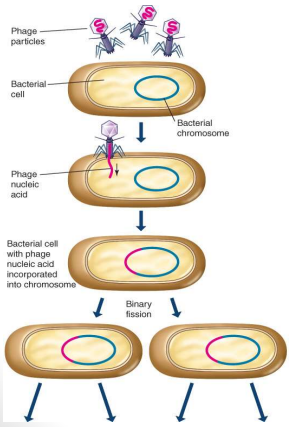
Offensive Strategy: Phage Conversion Confers Ability to produce toxins for some organisms



When bacteria become infected by bacteriophages, phage DNA may become incorporated into bacterial chromosome in a dormant state (prophage—lysogenization)

- With replication, new daughter cells have new properties, including toxin production
- Ex: *Corynebacterium diptheriae* with *tox* gene

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Offensive Strategy: Endotoxins

- Gram-negative bacteria have an outer membrane composed mainly of lipopolysaccharide (LPS)
- Endotoxin (aka lipid A) is the lipid portion of the menbrane's LPS.
- Many endotoxins stimulate the body to release chemicals that cause fever, inflammation, diarrhea, hemorrhaging, shock, and blood coagulation.
- Although exotoxin producing bacteria can produce more serious disease states, endotoxin-producing (gram-negatives) can produce life-threatening
- Endotoxin can be released when gram-negative bacteria:
  - Dividing
  - Disintegrating or dying naturally
  - Being digested by phagocytic cells

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Host response to endotoxins

Regardless of their source, endotoxins produce the same host response characterized by:

- Shock-like symptoms
- Chills
- Fever
- Weakness
- Formation of small blood clots
- Possible death

*Individuals with gram-negative infections may experience exaggerated symptoms during antibiotic treatment because of the release of endotoxins from dead cells.

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TABLE 7.3 Characteristics of Bacterial Exotoxins and Endotoxins

Property	Exotoxins	Endotoxins
Site	Released from cell during growth and metabolism	Retained (for the most part) within outer membrane and released when cell disintegrates
Cell source	Primarily gram-positive cells	Gram-negative cells
Activity	Specific for each toxin	Essentially similar for all endotoxins
Chemical nature	Protein	Lipopolysaccharide
Toxicity	High toxicity	Minimal toxicity
Heat stability	Unstable; usually destroyed at about 60°C	Stable; can withstand temperatures of 100°C
Examples of diseases	Tetanus, scarlet fever, diphtheria, gangrene, botulism	Meningococcal meningitis, typhoid fever, salmonellosis

Table 07.03: Characteristics of Bacterial Exotoxins and Endotoxins.

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Virulence Mechanisms of Non-bacterial Pathogens

- **Viruses**
  - Defensive: antigenic variation (influenza), etc.
  - Offensive: death (lysis) of host cell from
    - Production of large numbers of replicating viruses
    - Inhibiting host protein synthesis
    - Damage to plasma membrane
    - Inhibiting host cell metabolism
- **Eukaryotic Microbes** (including helminths)
  - Combination of offensive and defensive strategies described for bacteria (adhesins, toxins, antigenic variation, etc.)

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TABLE 7.4 Stages of Microbial Disease

Stage	Description
Incubation	Period between initial infection and appearance of symptoms; considerable variation among diseases
Prodromal	Period in which early symptoms appear; usually short and not always well characterized
Illness	Period during which the disease is most acute and is accompanied by characteristic symptoms
Decline	Period during which the symptoms gradually subside
Convalescence	Period during which symptoms disappear and recovery ensues

Table 07.04: Stages of Microbial Disease.

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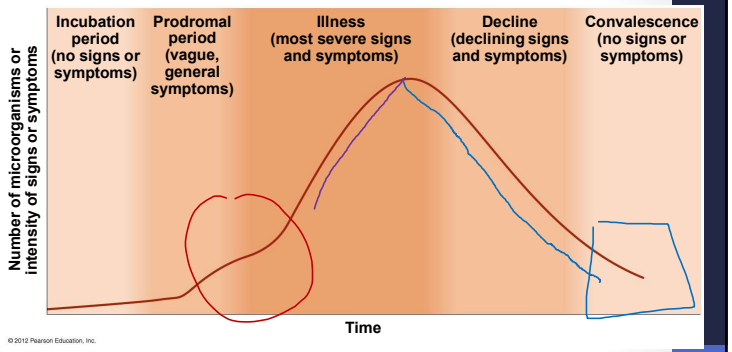
The Stages of Infectious Disease



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Epidemiology and Cycle of Microbial Disease

Epidemiology = an investigative branch of medicine that deals with the source, cause, and possible control of infectious disease and other public health problems

Epidemiologists attempt to determine why an outbreak of disease occurs at a particular time and/or particular place

- Dispatched by the CDC when the threat of an outbreak occurs anywhere in the world

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Epidemiology has a long and interesting history

- **Hippocrates** (460–377 B.C.) linked malaria, yellow fever, and swamps
- **Edward Jenner's** late 1700s observations regarding cowpox led to smallpox vaccine
- **Ignaz Semmelweis** (mid 1800s) proved that childbed fever resulted from physicians not washing their hands after dissections (remember how sad the outcome was for Semmelweis!)
- **John Snow's** 1849 detective work in London showed that most with cholera got water from the Broad Street pump, thus ending the epidemic

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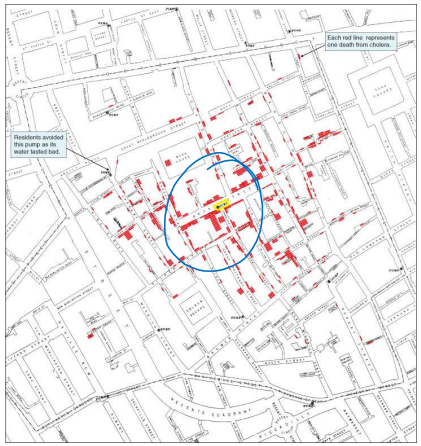

Figure 08.01A: portion of the map created by Dr. John Snow of the Broad Street area.

Courtesy of Frerichs, R. R. John Snow website: http://www.ph.ucla.edu/epi/snow.html, 2006

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1849 Cholera Outbreak, London

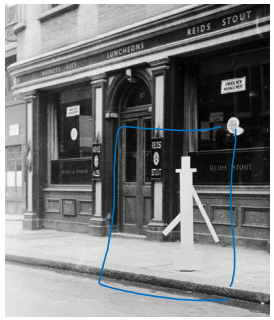

Figure 08.01B: The John Snow Pub and the famous "ghost" replica of the Broadstreet Pump.

© Wellcome Library, London

Figure 08.02: "Monster Soup," commonly called the Thames water.

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Terms for classification of diseases

- **Sporadic**—occur only occasionally and in an unpredictable fashion (tetanus, etc.)
- **Endemic**—regularly found at a steady level in a particular location (common cold, etc.)
- **Epidemic**—sudden increase in **morbidity** (illness rate) and **mortality** (death rate) above the norm (plague, etc.)
- **Pandemic**—epidemics that spread across continents (1918 influenza, HIV/AIDS)

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Tracking Disease--terminology

Two measures to track occurrence of disease by epidemiologists:

Incidence = the number of *new* cases of a disease in a given area or population during a given period of time

Prevalence = *total number of cases,* both new and already existing, in a given area or population during a given period of time (a cumulative number)

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2 Epidemic Types:

1) Common-source epidemics involve contact with a single contamination source (contaminated water)

2) Propagated epidemics result from person-to-person contact (mumps and chicken pox)

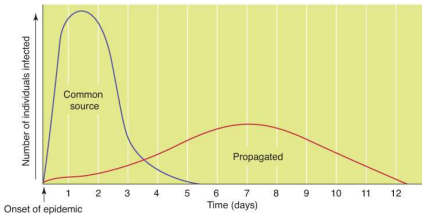

Figure 08.03: A comparison of the courses of common-source and propagated epidemics.

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Herd Immunity (Group Immunity)

- Refers to the proportion of immunized individuals in a population
  - The smaller the number of susceptible individuals, the less opportunity for contact between them and infected individuals.
- Public health officials strive to maintain high levels of herd immunity
- Basis for mass vaccination/immunization programs

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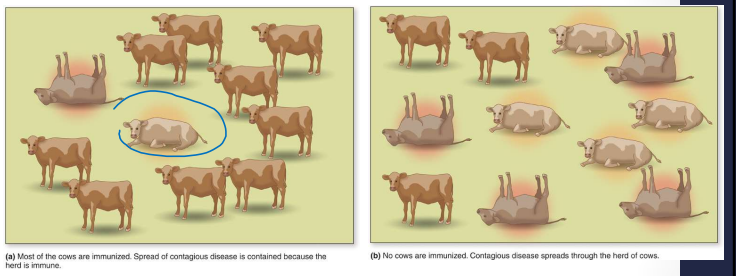
Herd Immunity



(a) Most of the cows are immunized. Spread of contagious disease is contained because the herd is immune.

(b) No cows are immunized. Contagious disease spreads through the herd of cows.

Figure 08.04: (a) Cows immunized and herd is protected. (b) Cows not immunized become infected and sick (lack of herd immunity).

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Reproduction rate ($\mathbf{R_0}$ or **R-nought**)

- Measure of the potential for transmission of a particular disease
- Mathematical equation
- Mean number of secondary cases, occurring in a susceptible population in the wake of a particular infection.
  - Population density, duration of contagiousness, other factors considered
  - R_0 must be greater than 1 to spread; if less, it will die out.

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TABLE 8.1 Basic Reproduction Rate (R_0) Within Human Populations

Disease	Type of Causative Agent	R_0
Measles	Virus	12–18
Pertussis	Bacterium	12–17
Diphtheria	Bacterium	6–7
Smallpox	Virus	5–7
Poliomyelitis	Virus	5–7
Rubella	Virus	5–7
Mumps	Virus	4–7
HIV/AIDS	Virus	2–5
Influenza A	Virus	2–3
Ebola hemorrhagic fever	Virus	1
Rabies	Virus	<1

Table 08.01: Basic Reproduction Rate (R0) Within Human Populations.

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Graphs, charts, and maps are used by epidemiologists to illustrate the frequency and distribution of diseases

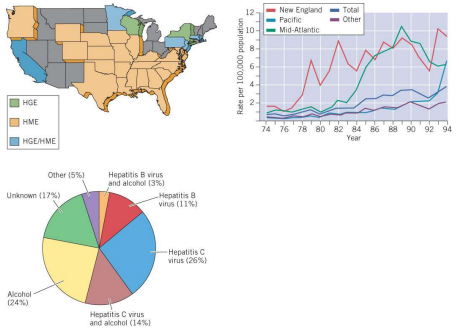

Figure 08.05: Graphs, charts, and maps used by epidemiologists to illustrate disease frequency and distribution. (Adapted from the CDC)

Adapted from CDC

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Tracking Disease Incidence & Prevalence

Frequency and distribution of disease includes monitoring of the following re: a disease-afflicted population:

- Age
- Gender
- Diet
- Lifestyle

The above are used as starting points to establish a strategy for halting an outbreak

Center for Disease Control (CDC),The World Health Organization (WHO), and local and state agencies are responsible for ongoing surveillance of disease (See Table 8.2 for list of Nationally Notifiable Diseases, 2011)

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TABLE 8.2 Major Infectious Diseases Designated as Notifiable at the National Level, United States, 2011

AIDS
Anaplasmosis
Anthrax
Arboviral neuroinvasive and nonneuroinvasive diseases
Babesiosis
Botulism
Brucellosis
California encephalitis
Chancroid
Chlamydia (eye, genital infections)
Cholera
Coccidioidomycosis
Cryptosporidiosis
Cyclosporiasis
Dengue fever
Dengue hemorrhagic fever
Dengue shock syndrome
Diphtheria
Eastern equine encephalitis
Ehrlichiosis
Giardiasis
Gonorrhea
Haemophilus influenzae, invasive disease
Hansen disease (leprosy)
Hantavirus pulmonary syndrome
Hemolytic uremic syndrome, postdiarrheal
Hepatitis A
Hepatitis B
Hepatitis C
HIV infection
Influenza-associated pediatric mortality
Jamestown Canyon virus
Legionellosis
Listeriosis
Lyme disease
Malaria
Measles
Meningococcal disease (*Neisseria meningitidis*)
Mumps
Neurosyphilis
Novel influenza A virus infections
Pertussis
Plague
Poliomyelitis, nonparalytic
Poliomyelitis, paralytic
Powassan encephalitis
Psittacosis
Q fever
Rabies
Rocky Mountain spotted fever
Rubella
Rubella, congenital syndrome
Salmonellosis
Severe acute respiratory syndrome-associated coronavirus (SARS-CoV disease)
Shiga toxin-producing *Escherichia coli* (STEC)
Shigellosis
Smallpox
Spotted fever; rickettsiosis
St. Louis encephalitis
Streptococcal disease invasive, group A
Streptococcal toxic shock syndrome
Streptococcus pneumoniae, drug-resistant invasive disease
Streptococcus pneumoniae, invasive disease nondrug resistant, in children less than five years of age
Syphilis
Tetanus
Toxic shock syndrome (staphylococcal)
Trichinellosis
Tuberculosis
Tularemia
Typhoid fever
Vancomycin-intermediate *Staphylococcus aureus* (VISA)
Vancomycin-resistant *Staphylococcus aureus* (VRSA)
Varicella (deaths only)
Varicella (morbidity)
Vibriosis
Viral hemorrhagic fevers
West Nile encephalitis
Western equine encephalitis
Yellow fever

Adapted from the CDC, *Summary of Notifiable Diseases*, 2011.

Reproduced from the CDC. Summary of Notifiable Disease, 2011.

To keep track of infectious diseases in the United States, physicians are required to report cases of certain **notifiable diseases**

Table 08.02: Major Infectious Diseases Designated as Notifiable at the National Level, United States, 2011.

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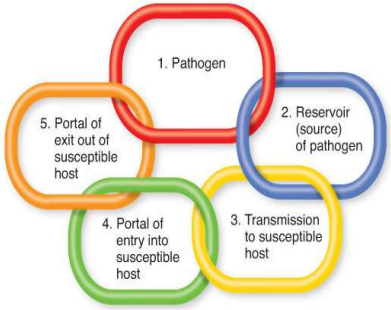
Cycle of Microbial Disease

- For infectious dz to exist at the community level, a chain of linked factors (reservoirs, modes of transmission, portals of entry and exit) contributes to the cycle of microbial disease



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Reservoirs of Infection

Reservoir is a site in nature in which microbes survive (and possibly multiply) and from which they may be transmitted

- All pathogens, to exist, must have one or more reservoirs
- Reservoirs are prime targets for preventing, minimizing, and eliminating existing and potential epidemics
- Humans are the only known reservoir for pathogens that cause smallpox, gonorrhea, measles, polio, among others.

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Reservoirs of Infection

- **Active carriers** are individuals who have a microbial disease
- **Chronic carriers** harbor the pathogen for long periods of time after recovery, without ever becoming ill again
- **Healthy carriers** have no symptoms and may unwittingly pass the disease on to others
  - Chronic carriers continue to harbor the microbe after recovery, this state can continue indefinitely without illness (Typhoid Mary)
  - Carriers play a significant role in spread of TB.
- **Zoonoses** are diseases in which animals serve as reservoirs

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Zoonoses are diseases of animals that can affect humans. Animals act as reservoirs of pathogen.

TABLE 8.3 Selected Zoonotic Diseases

Transmission by Arthropod Bites	Transmission Via Food, Water, or Animal Bites
Bacteria	***Bacteria***
Ehrlichiosis	Undulant fever
Relapsing fever	Leptospirosis
Lyme disease	Anthrax
Rocky Mountain spotted fever	Cat scratch fever
Plague	Tularemia
Typhus fever	***Viruses***
Viruses	Rabies
Yellow fever	Hantavirus disease
Eastern equine encephalitis	Viral gastroenteritis
West Nile virus disease	Severe acute respiratory syndrome (SARS)
La Crosse encephalitis	***Protozoans***
Rift Valley fever	Giardiasis
Dengue fever	*Cyclospora* infection
Protozoans	Toxoplasmosis
Babesiosis	
Sleeping sickness	
Malaria	
American trypanosomiasis	
Leishmaniasis	

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Nonliving Reservoirs

Some organisms are able to survive and multiply in nonliving environments, such as soil and water

- Spore formers, like the group of *Clostridium* bacteria (cause of tetanus and botulism) can survive for many years in soil

Figure 08.07: Soil can be a nonliving reservoir for microbes and helminth eggs.

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TABLE 8.4 Water and Food as Reservoirs of Infection

Type of Microbe	Examples of Waterborne and Foodborne Infections
Bacteria	Salmonellosis, shigellosis, cholera, gastroenteritis
Viruses	Hepatitis A, poliomyelitis, viral gastroenteritis (e.g., norovirus)
Protozoa	Giardiasis, amebiasis, cryptosporidiosis
Worms	Ascariasis, trichinellosis, *Trichuris* infection

Table 08.04: Water and Food as Reservoirs of Infection.

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Transmission

Transmission = the mechanism by which an infectious agent is spread to a susceptible person

TABLE 8.5 Modes of Transmission

Direct	Indirect
Contact (e.g., kissing, sneezing, coughing, singing, sexual contact)	Vehicles (fomites, e.g., doorknobs, eating utensils, toys, facial tissue)
Animal bites	Airborne (via aerosols created by, e.g., shaking bedsheets, sweeping, mopping)
Transplacental	Vectors (e.g., mosquitoes, ticks, flies)

Table 08.05: Modes of Transmission.

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Direct transmission—infectious agent is directly and immediately transferred from a port of exit into a port of entry

- **Horizontal**: person-to-person, touch (including sex), droplets, etc.
- **Vertical**: mother-to-child (transplacental, breast milk, birth canal)

Means of transmission:

- **Contact** (kissing, sneezing, sex, etc.) <horizontal>
- **Animal Bites** <horizontal>
- **Transplacental** <vertical>

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Indirect transmission = microbes pass from reservoir (or source) to an intermediate agent and then to a host

1) Vehicle-borne: via food, water, biological products (organs, blood, blood products), and **fomites** (inanimate objects)

2) Airborne: aerosols of water or dust particles (less than 4 µm) in the air; unlike droplets (10 µm or larger) aerosols remain airborne for extended periods

3) Vector-borne: Arthropods (i.e., ticks, flies, mosquitoes, lice, and fleas) or insects (Chagas' kissing bug, etc.)

- **Mechanical** passive transmission on feet, etc.; microbes do not invade, multiply, or develop in the vector
- **Biological vectors** are a necessary part of the life cycle of a pathogen, transmission is an active process

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Transmission

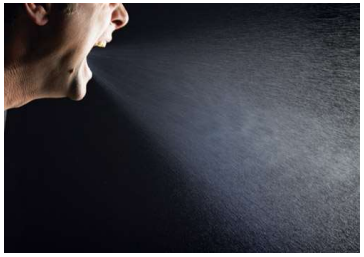

Figure 08.08: Droplet transmission (sneezing)--DIRECT

Figure 08.09: Exercise machines can be reservoirs for microbes--FOMITES

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Arthropods—indirect, vector transmission

TABLE 8.6 The Phylum Arthropoda

Subphylum Chelicerata	***Subphylum Hexapodia***
Scorpions	Insects (many subgroups)
Chiggers	Flies[a]
Spiders	Fleas[a]
Daddy longlegs	Mosquitoes[a]
Mites[a]	Lice[a]
Horseshoe crabs	***Subphylum Myriapodia***
Ticks[a]	Centipedes
Subphylum Crustacea	Millipedes
Water fleas	
Isopods	
Fairy shrimp	
Crabs	
Copepods[a]	
Lobsters	
Barnacles	
Shrimp	

[a]Vectors of human disease.

Table 08.06: The Phylum Arthropoda.

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TABLE 8.7 Diseases Transmitted by Arthropod Bites

Disease	Type of Microbe	Genus of Microbe	Arthropod Vector	Distribution
Plague	Bacterium	*Yersinia pestis*	Fleas	Southeast Asia, Central Asia, South America, western North America
Relapsing fever	Bacterium	*Borrelia* sp.	Lice or ticks	South America, Africa, Asia, western North America
Lyme disease	Bacterium	*Borrelia* sp.	Ticks	Europe, North America, Australia, Japan
Typhus fever (endemic)	Bacterium	*Rickettsia* sp.	Fleas	Worldwide
Typhus fever (epidemic)	Bacterium	*Rickettsia* sp.	Lice	Eastern Europe, Asia, Africa, South America
Eastern equine encephalitis	Virus	Alphavirus	Mosquito (*Culex, Coquillettidia, Aedes*)	North and South America
Japanese encephalitis	Virus	Flavivirus	Mosquito (*Culex*)	Asia, Pacific Islands, Torres Strait of Australia, Papua New Guinea
La Crosse encephalitis	Virus	Bunyavirus	Mosquito (*Ochlerotatus*)	United States
St. Louis encephalitis	Virus	Flavivirus	Mosquito (*Culex*)	North and South America
West Nile encephalitis	Virus	Flavivirus	Mosquito (*Culex*)	Africa, North America, Caribbean, South and Central America, India, Australia, Middle East, Russia, Europe, Southeast Asia
Western equine encephalitis	Virus	Alphavirus	Mosquito (*Aedes*)	North and South America

(*continues*)

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TABLE 8.7 Diseases Transmitted by Arthropod Bites (*continued*)

Disease	Type of Microbe	Genus of Microbe	Arthropod Vector	Distribution
Dengue fever	Virus	Flavivirus (Dengue 1, 2, 3 and 4)	Mosquito (*Aedes*)	India, Southeast Asia, Pacific, Mexico, South America, Caribbean, United States (Texas/ Mexico border)
Rift Valley fever	Virus	Phlebovirus	Mosquito (*Aedes*)	Africa, Arabia
Yellow fever	Virus	Flavivirus	Mosquito (*Aedes*)	Tropical South America, Africa
Chikungunya fever	Virus	Alphavirus	Mosquito (*Aedes*)	Africa, Southeast Asia, Philippines
O'nyong-nyong fever	Virus	Alphavirus	Mosquito (*Anopheles*)	Africa
Ross River fever	Virus	Alphavirus	Mosquito (*Culex, Aedes*)	Australia, South Pacific
Venezuelan encephalitis	Virus	Alphavirus	Mosquito (*Culex, Aedes*)	North and South America
Murray Valley or Australian encephalitis	Virus	Flavivirus	Mosquito (*Culex*)	Australia, New Guinea
Barmah Forest fever	Virus	Alphavirus	Mosquito (*Culex, Aedes*)	Australia
California encephalitis	Virus	Bunyavirus	Mosquito (*Aedes*)	United States
Colorado tick fever	Virus	Orbivirus	Tick	United States and Canada
Malaria	Protozoan	*Plasmodium* sp.	Mosquito (*Anopheles*)	Africa, Southwestern Pacific, South America, Southeastern Asia, India
Babesiosis	Protozoan	*Babesia* sp.	Ticks	United States, Europe
American trypanosomiasis (Chagas disease)	Protozoan	*Trypanosoma* sp.	Kissing bug	South and Central America
African trypanosomiasis (sleeping sickness)	Protozoan	*Trypanosoma* sp.	Tsetse flies	West, Central, and East Africa
Leishmaniasis	Protozoan	*Leishmania* sp.	Sand flies	Central and South America, Africa, India, and other parts of Asia, Europe
Filariasis or elephantiasis	Worm	*Wuchereria* sp. *Brugia* sp.	Mosquito (*Culex, Anopheles, Aedes, Mansonia, Coquillettidia*)	Central and South America, Africa, India, and other parts of Asia
Onchocerciasis	Worm	*Onchocerca* sp.	Black flies	Central America, tropical South America, Africa

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Vectors of infectious diseases are numerous and varied

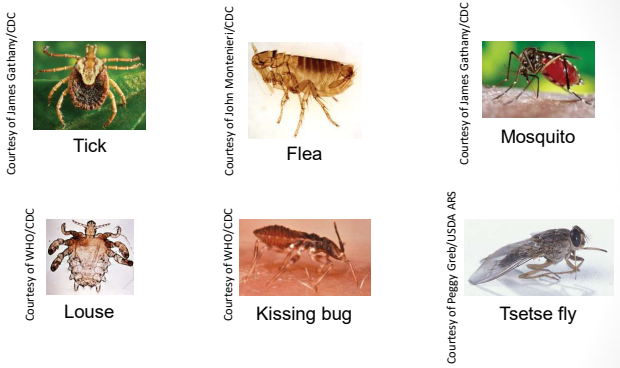

Figure 08.11: A "bug" parade".

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TABLE 8.8 Successful Vector-Borne Disease Control

Disease	Location	Year(s)
Yellow fever	Cuba	1900–1901
Yellow fever	Panama	1904
Yellow fever	Brazil	1932
Anopheles gambiae infestation	Brazil	1938
Anopheles gambiae infestation	Egypt	1942
Louseborne typhus	Italy	1942
Malaria	Sardinia	1946
Yellow fever	Americas	1947–1970
Yellow fever	West Africa	1950–1970
Malaria	Americas	1954–1975
Malaria	Global	1955–1975
Onchocerciasis	West Africa	1974–present
Bancroftian filariasis	South Pacific	1970s
Chagas disease	South America	1991–present

Reproduced from Duane J. Gubler and CDC, *Emerging Infectious Diseases*, 4 (1998): 442–450.

Table 08.08: Successful Vectorborne Disease Control or Elimination Programs.

Reproduced from Duane J. Gubler and CDC, Emerging Infectious Diseases, 4 (1998): 442-450

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Summary Figure: Direct vs. Indirect Transmission

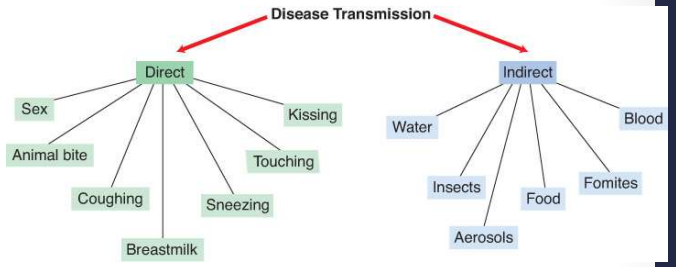

Figure 08.10: Direct vs. indirect transmission of microbial diseases.

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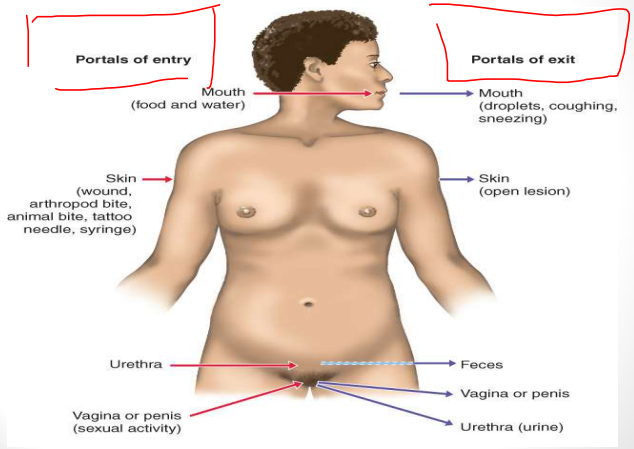
The **portal of entry** can be important in the outcome of infection; a **portal of exit** is required for transmission to a new host



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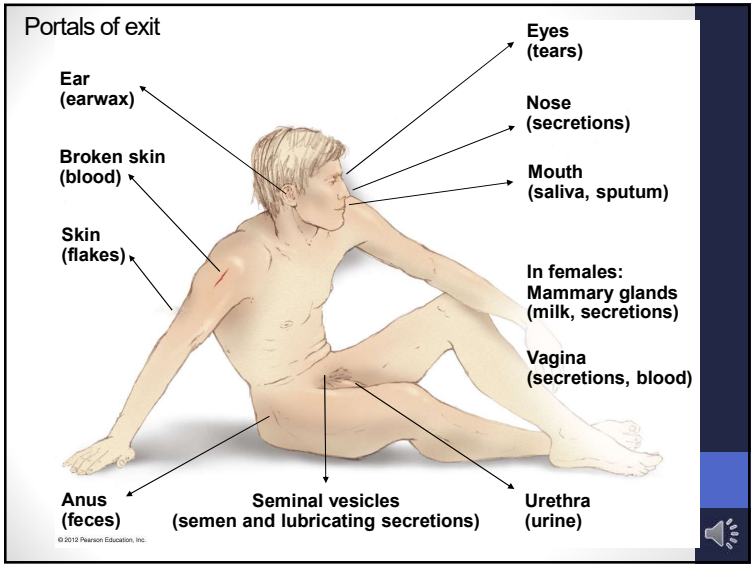

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TABLE 8.9 Infectious Disease Cycle: Portals of Entry and Exit

	Examples of Disease or Microbe
Portals of entry	
Mucous membranes	
Respiratory tract	*Streptococcus pneumoniae*, tuberculosis, Legionnaires' disease, influenza, hantavirus, common cold
Gastrointestinal tract	Cholera, salmonellosis, *E. coli*, rotavirus, norovirus, hepatitis A, poliomyelitis, guinea worm disease, giardiasis
Urogenital tract	Gonorrhea, chlamydia, AIDS, genital warts genital herpes
Skin (hair follicles, sebaceous glands, wounds, arthropod bites)	Boils, abscesses, cutaneous anthrax, rabies, warts, hookworm, schistosomiasis, malaria
Blood (transfusion, blood products, arthropod bites, placental transfer)	Congenital syphilis, AIDS, German measles, toxoplasmosis, Chagas disease, hepatitis C
Portals of exit	
Respiratory tract	Tuberculosis, Legionnaires' disease, influenza, common cold
Gastrointestinal tract	Cholera, salmonellosis, rotavirus, norovirus, hepatitis B and A, poliomyelitis, hookworm, guinea worm disease
Urogenital tract	Gonorrhea, chlamydia, HIV, schistosomiasis, genital herpes
Skin	Impetigo, boils, abscesses, warts, cold sores, fever blisters, guinea worm disease, candidiasis
Blood (transfusion, blood products, arthropod bites, placental transfer)	Congenital syphilis, toxoplasmosis, HIV, hepatitis B and C, rubella, malaria

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Nosocomial Infections

= infections acquired by patients or health care workers while they are in a health care facility (including hospitals, dental offices, nursing homes, and waiting rooms in doctor's offices)

- CDC estimate: 10% of American patients acquire a nosocomial infection each year
- Result in 90,000 deaths annually.

2 types of nosocomial infections:

1) Exogenous nosocomial infection
2) Endogenous nosocomial infection

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Exogenous vs. Endogenous Nosocomial Infections

Exogenous= caused by pathogens acquired from the health care environment

Endogenous= situation in which the normal flora becomes a pathogen as a result of medical treatments or hospitalization (i.e. chemotherapy)

Iatrogenic Infections = subset of nosocomial infections that are the direct result of modern medical proceduressuch as use of catheters, invasive diagnostic procedures and surgery ("doctor-induced")

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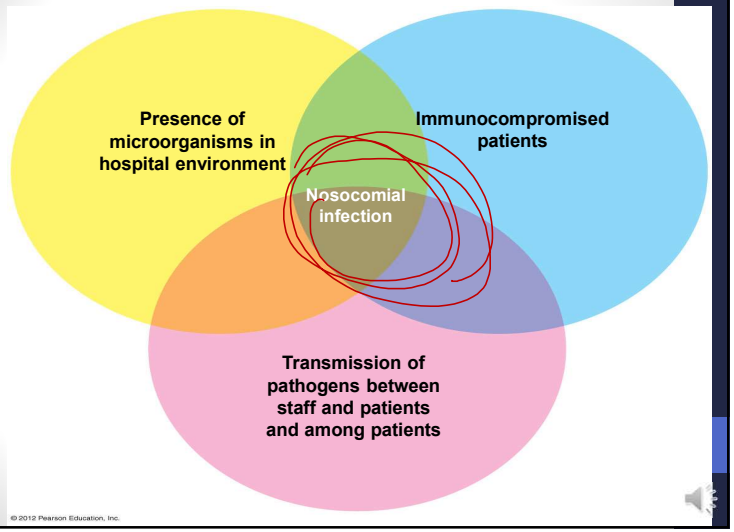
Figure 14.20 The interplay of factors that result in nosocomial infections



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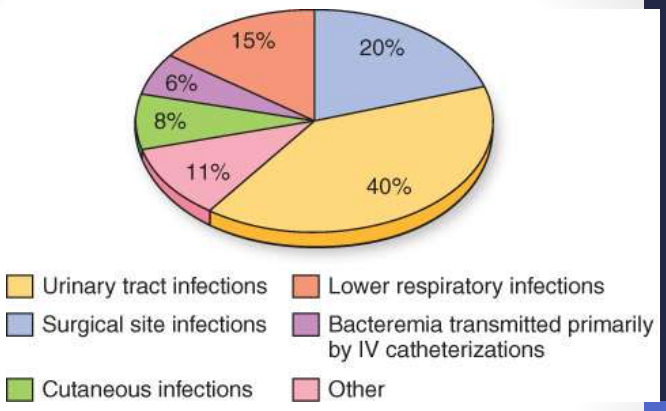

Figure 08.13: Body Site Distribution of Nosocomial Infections.

Data from: CDC, National Nosocomial iInfection Surveillance

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Nosocomial (Hospital-Acquired) Infections

Control Measures

- All hospitals are required to have an infection-control officer and an infection control committee to maintain accreditation.

TABLE 8.10 Nosocomial Infections Caused by Antibiotic-Resistant Bacteria

Most Common Type of Infection	Pathogen
Bloodstream infections	*Acinetobacter baumannii*
Surgical site infections	*Staphylococcus aureus*
Diarrhea	*Clostridium difficile*
Ventilator-associated pneumonia	*Klebsiella pneumoniae*
Pneumonia, urinary tract infections, and bloodstream infections	*Pseudomonas aeruginosa*
Catheter-associated urinary tract infections	*Escherichia coli*
Catheter-associated urinary tract infections	*Enterococcus faecalis*

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