Microbiota and the Host

Relationships Between the Normal Microbiota and the Host

SYMBIOSIS: “Living together”. Relationship between the host and its normal flora.

1. Commensalism: One organism benefits, the other is not affected (+/0).
   - Many microbes live off secretions and dead cells and do not benefit or harm host.

   - E. coli synthesizes vitamin K and some B vitamins.

3. Parasitism: One organism benefits, the other is harmed (+/-).
   - Most disease causing bacteria.

Normal Microbiota

- Animals are generally free from microbes in utero.
- After birth, microbial populations rapidly establish themselves in the newborn’s body.
- Vaginal lactobacilli colonize newborn’s intestine.
- Feeding and breathing introduce many more microbes.
  - E. coli and other bacteria colonize large intestine.
  - Candida albicans colonizes mucous membranes.
- Normal Microbiota or Flora: Microorganisms that remain throughout an individual’s life.
- Transient Microbiota: Microorganisms that are present for a certain time period and then disappear.
- Cells in human body: \(1 \times 10^{13}\)
- Microbes associated with human body: \(1 \times 10^{14}\)
- There are ~10 microorganisms/human body cell.

Transient Microbiota: Microorganisms that are present for a certain time period and then disappear.

Microbial Antagonism: Normal flora inhibits overgrowth of closely related bacteria.

Pathogenesis: Studies how disease develops.

Opportunistic Pathogens: Organisms that normally do not cause disease in their natural habitat in a healthy person. They may cause disease if the host is weakened or if they enter a different part of the body.

- Pneumocystis carinii pneumonia in AIDS patients.
- Tooth decay and gum disease caused by mouth flora.
- Neisseria meningitidis is usually harmless in respiratory tract, but can cause meningitis.
- E. coli can cause urinary tract infections, meningitis, pneumonia, and abscesses.
Koch’s Postulates for Infectious Diseases

1. Same pathogen must be present in every case of the disease.
2. Pathogen must be isolated from diseased host and grown in pure culture.
3. Pathogen from pure culture must cause disease when inoculated in healthy, susceptible laboratory animal.
4. Pathogen must be isolated from inoculated animal and shown to be the original organism.

Effects of Infectious Diseases

Diseases alter normal body function and/or structure.

- **Symptoms**: Subjective feelings not obvious to an observer.
  - Example: Pain and malaise.
- **Signs**: Objective changes that can be measured.
  - Example: Fever, redness, swelling, paralysis.
- **Syndrome**: A group of signs and symptoms that are associated with a disease.
  - Example: AIDS (Acquired Immune Deficiency Syndrome) is a syndrome that varies from one individual to another.

Etiology of Infectious Diseases

Diseases can be caused by many factors: infection, genetics, degeneration, and others.

**Koch’s Postulates**

Developed by Robert Koch in 1877 to establish cause of infectious diseases: anthrax and TB.

1. Same pathogen must be present in every case of the disease.
2. Pathogen must be isolated from diseased host and grown in pure culture.
3. Pathogen from pure culture must cause disease when inoculated in healthy, susceptible laboratory animal.
4. Pathogen must be isolated from inoculated animal and shown to be the original organism.

Examples of diseases caused by microbes:
- **Tetanus, botulism, and yeast infections**
- **Noncommunicable Diseases**: Not spread from one host to another.
  - Example: Tuberculosis, herpes, flu, AIDS, chickenpox, mumps, polio, and hepatitis.
- **Communicable Diseases**: Spread from one host to another, directly or indirectly.
  - Example: Tuberculosis, herpes, flu, AIDS, chickenpox, mumps, polio, and hepatitis.
- **Contagious Diseases**: Spread easily from one person to another.
  - Example: Chickenpox and measles.
- **Noncommunicable Diseases**: Not spread from one host to another. Caused by microbes that live outside the body or by opportunistic pathogens that live inside the body.
  - Example: Tetanus, botulism, and yeast infections.
Host Resistance Determines Extent of Infection
- **Primary Infection**: Acute infection that causes initial illness.
  Example: Common cold
- **Secondary Infection**: Caused by opportunistic pathogen after primary infection has weakened host immune system.
  Example: Pneumonia or bronchitis may develop after the common cold.
- **Subclinical Infection**: Does not cause any noticeable illness in host.
  Example: Over 90% of polio infections are asymptomatic.

Disease Occurrence
- **Disease Incidence**: Percentage of population that contracts a disease in a given time period.
- **Disease Prevalence**: Percentage of population that has the disease during given time period.
- **Sporadic Disease**: Occurs only occasionally.
  Example: Polio in U.S.
- **Endemic Disease**: Constantly present in the population.
  Example: Common cold or ear infections.
- **Epidemic Disease**: Many people acquire disease in short time period.
  Example: Influenza, gonorrhea, chlamydia, and AIDS.
- **Pandemic Disease**: Worldwide epidemics.
  Example: Influenza and AIDS.

Disease Duration
- **Acute Disease**: Develops rapidly, but lasts a short time.
  Examples: Flu and common cold.
- **Chronic Disease**: Develops more slowly, and reactions are less severe. Tends to recur for long periods or to be continual.
  Examples: Tuberculosis, hepatitis B, and infectious mononucleosis.
- **Subacute Disease**: Intermediate between acute and chronic.
  Examples: Subacute bacterial endocarditis (streptococci).
- **Latent Disease**: Causative agent remains inactive for a time, but then becomes active and produces disease symptoms.
  Examples: Shingles, genital and oral herpes, AIDS.

Host Involvement
- **Local Infection**: Microbes are limited to small area of body.
  Examples: Boils, abscesses, and acne.
- **Systemic (Generalized) Infection**: Microbes are spread throughout body by blood or lymph.
  Examples: Measles, AIDS.
  - **Bacteremia**: Presence of bacteria in the blood.
  - **Septicemia**: Bacteria multiply in blood.
  - **Toxemia**: Presence of toxins in blood.
  - **Viremia**: Presence of viruses in blood.
- **Focal Infection**: Starts as a local infection and spread to other parts of body.
  Examples: From teeth, tonsils, and appendix.

Reservoirs of Infection
- **Human Reservoirs**: Infected individuals who may or may not present disease. **Carriers** are infected individuals without any signs or symptoms of disease (AIDS, polio, gonorrhea).
- **Animal Reservoirs**: Zoonoses are diseases that occur primarily in wild and domestic animals. About 150 different zoonoses are known (rabies, anthrax, and Lyme disease).
- **Nonliving Reservoirs**: Two major sources are soil and water.
  - Soil: *Clostridium tetani* and botulinum.
  - Water: *Vibrio cholerae* and *Salmonella typhi*.

Spread of Infection

Reported AIDS Cases in the United States

- **Number of cases**

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- Figures for 1995 may not be final; figures for 2006 through 2009 are through September.
Transmission of Disease

I. Contact Transmission: Spread by direct contact, indirect contact, or droplet transmission.
   A. Direct Contact Transmission: Person-to-person transmission. No intermediate object is involved.
      Examples: Touching, kissing, sexual intercourse.
   B. Indirect Contact Transmission: Agent is transferred via a nonliving object (fomite).
      Examples: Towels, eating utensils, thermometers, stethoscopes, bedding, clothes, money, and syringes.
   C. Droplet Transmission: Microbes are spread in mucus droplets that travel short distances (less than 1 meter).
      Examples: Sneezing, coughing, talking, and laughing.

II. Vehicle Transmission: Transmission of disease via medium such as water, food, air, blood, body fluids, and intravenous fluids.
   A. Waterborne Transmission: Usually caused by water contaminated with sewage.
   B. Airborne Transmission: Spread of agents by droplets in dust that travel more than 1 m to host.

III. Vectors: Animals that carry disease from one host to another. Arthropods (insects) are most important animal vectors.
   A. Mechanical Transmission: Passive transport of pathogens on insect’s body.
   B. Biological Transmission: Pathogen spends part of its life cycle in the vector.

Portals of Exit

Site at which microbes leave body. Most common exit portals are respiratory and gastrointestinal tracts.

Respiratory Tract: Exit in discharges (mucus droplets) from nose and mouth. Transmission by coughing, sneezing, spitting, etc.
   - Examples: Tuberculosis, influenza, pneumonia, common cold, measles, mumps, scarlet fever, and meningococcal meningitis.

Gastrointestinal Tract: Exit in feces or saliva.
   - Feces: Amoebas, poliovirus, cholera, typhoid fever, salmonella, shigella, and many helminths.
   - Saliva: Rabies virus, herpes simplex 1.

Blood: Transmission through insects, needles, and syringes.
   - Insects: Malaria, yellow fever, and Lyme disease.
   - Needles: AIDS and hepatitis B.

Nosocomial (Hospital Acquired) Infections

“Nosocomial” Greek word for hospital.
- Infections acquired at a health care facility.
- According to Center for Disease Control (CDC), 5-15% of all hospital patients acquire N.I.s.
- At least 100,000 deaths in US from N.I.s every year.

Predisposing Factors:
   - Wide variety of microbes in hospital environment
   - Weakened or immunocompromised patients
   - Chain of transmission: Mainly through direct or indirect contact.
      - From health care workers to patient
      - From patient to patient
      - Fomites: Catheters, needles, dressings, beds, wheelchairs
      - Airborne transmission

Important Nosocomial Pathogens

- Normal microbiota: Many are opportunistic pathogens
- Antibiotic resistance: Very high due to the use of antimicrobials in health care facilities.
- Principle microorganisms: Used to be gram-positive microbes. Today most are gram-negative bacteria.
   - Enterobacteria: Over 40% of all infections. E. coli, Klebsiella spp., Proteus spp., Enterobacter spp., and Serratia marcescens.
   - Staphylococcus aureus (11%)
   - Pseudomonas aeruginosa (9%)
**Principal Kinds of Nosocomial Infections**

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<tr>
<td>Urinary Tract</td>
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<tr>
<td>Other</td>
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**Control of Nosocomial Infections**
- Aseptic techniques to avoid contamination
- Careful handling and disposal of contaminated material
- Frequent and adequate hand washing
- Proper infection control training of staff
- Isolation wards and rooms
- Avoid unnecessary antibiotic prescriptions
- Avoid unnecessary invasive procedures
- Regular disinfection of respirators and humidifiers and maintenance of autoclaves
- Use disposable and/or sterile supplies
- Infection control committee

**Predisposing Factors for Disease**

Factors that make an individual more susceptible to a given disease.

- Gender
- Genetic factors
- Climate and weather
- Nutrition
- Fatigue/Stress
- Occupation
- Environment
- Lifestyle
- Age
- Other illness

**Development of Disease**

1. **Incubation Period**: Time between initial infection and appearance of signs and symptoms
2. **Prodromal Period**: Early, mild symptoms of disease
3. **Illness Period**: Disease is most acute. Overt signs and symptoms. Patient immune system actively fights off infection. If not successful may die at this stage.
4. **Decline Period**: Signs and symptoms subside. Patient is vulnerable to secondary infections.
5. **Convalescence Period**: Recovery. Body returns to predisease state.

**The Stages of a Disease**

- Incubation period
- Prodromal period
- Period of illness
- Death if immune response or medical treatment fails
- Period of decline
- Period of convalescence

**Epidemiology**

Science that studies when and where diseases occur and how they are transmitted in a population.

Modern epidemiology began in 1848 during a cholera epidemic in London.

Epidemiologists collect information to determine:
- **Etiology**: Cause of disease (pathogen).
- **Predisposing factors**: Age, sex, lifestyle, etc.
- **Incidence**: Number of individuals acquiring disease in a given time period.
- **Prevalence**: Number of individuals with disease in a given time period.
- **Transmission**
- **Public Health Policy and Prevention**
Types of Epidemiological Investigation

- **Descriptive Epidemiology**: Retrospective studies that collect data on diseases occurrence.
  - Examples: Initial studies on toxic shock syndrome outbreaks.

- **Analytical Epidemiology**: Analyzes a disease to determine its probable cause.
  - **Case control method**: Look for factors that precede disease. Compare sick individuals to healthy individuals.
  - **Cohort method**: Study two populations, one that has been exposed to a certain risk factor (e.g., blood transfusion or sexual contact). Control group is not exposed to risk factor.

- **Experimental Epidemiology**: Test drugs or vaccines on susceptible populations.

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Case Reporting

Procedure that requires health workers to report specified diseases to government agencies.

**Partial list** of reportable diseases in the U.S.:

- AIDS
- Botulism
- Chlamydia
- Diphtheria
- Gonorrhea
- Hepatitis A, B, and C
- Pediatric HIV infection
- Malaria
- Tetanus
- Tuberculosis

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Center for Disease Prevention and Control (CDC)

- **Central source of epidemiological information in U.S.**
- **Branch of U.S. Public Health Service**
- **Located in Atlanta, Georgia**
- **Weekly publication “Morbidity and Mortality Report” (MMWR)**
  - **Morbidity**: Number of specific notifiable diseases.
  - **Mortality**: Number of deaths from diseases.
  - Reports on disease outbreaks
  - Special interest case histories
  - Summaries on status of diseases
  - Recommendations for diagnosis, immunization, and treatment.