Causes for Infectious Disease:

- Pasteur's and Koch's observations and experiments led them to conclude that infectious diseases occur when microorganisms cause physiological changes that disrupt normal body functions
- Microorganisms were commonly called "germs"
  - Germ theory of disease

Agents of Disease:

- Infectious diseases can be caused by (1) viruses, (2) bacteria, (3) fungi, (4) "protists", and (5) parasites.
  - Except for parasites, most of these disease-causing microorganisms are called pathogens

Koch's Postulates

- For identifying the microorganism that causes a specific disease

1. The pathogen must always be found in the body of a sick organism and should not be found in a healthy one.
2. The pathogen must be isolated and grown in the laboratory in pure culture.
3. When the cultured pathogens are introduced into a healthy host, they should cause the same disease that infected the original host.
4. The injected pathogen must be isolated from the second host. It should be identical to the original pathogen

- There are exceptions to these rules

Symbionts vs. Pathogens

- Parts of the human body provide excellent habitats for microorganisms
  - Fortunately, most microorganisms that take advantage of our hospitality are *symbionts*
    - that are either harmless or actually beneficial.
  - Yeast and bacteria grow in the mouth and throat without causing trouble
  - Bacteria in the large intestine help with digestion and produce vitamins
  - If all your cells disappeared= the outlines of your body and digestive tract would be seen as a ghostly outline of microorganisms
- "Good guys" obtain nutrients, grow, and reproduce without disturbing normal body functions
- "Bad guys" cause problems in various ways:
  1. Some viruses and bacteria directly destroy the cells of their host
  2. Other bacteria and single-celled parasites release poisons that kill the host's cells or interfere with their normal functions
  3. Parasitic worms may block blood flow through blood vessels or organs, take up the host's nutrients, or disrupt other body functions

How Diseases Spread

- Some diseases are spread through (1) coughing, (2) sneezing, (3) physical contact, or (4) exchange of body fluids
- Some diseases are spread through contaminated water or food
- Other diseases are spread to humans from infected animals.
- Pathogens are often spread by symptoms of disease:
  1. Sneezing
  2. Coughing
  3. Diarrhea.
- In many cases, these symptoms are changes in host behavior that help pathogens spread and infect new hosts
- Virus infects only one host= virus will die when the host's immune system kills it or when the host dies.
- Viruses have adaptations that help them spread from host to host.

Coughing, Sneezing, and Physical Contact

- Many bacteria and viruses that infect the (1) nose, (2) throat, or (3) respiratory tract are spread by indirect contact
- Coughing and sneezing release thousands of tiny droplets that can be inhaled by other people.
- Those droplets also settle on objects such as doorknobs
- Other pathogens, including drug-resistant staphylococci that cause skin infections

Exchange of Body Fluids

- Some pathogens require specific kinds of direct contact to be transferred from host to host
    - EX. Wide range of diseases (herpes, gonorrhea, syphilis, and chlamydia) are transmitted by sexual activity
        - Therefore, these diseases are called sexually transmitted diseases. (STD)
- Other diseases (including certain forms of hepatitis) can be transmitted among users of injected drugs through blood from shared syringes
    - HIV can be transmitted through blood or sexual contact
        - STDs can only be completely prevented by avoiding sexual activity

<u>Contaminated Water or Food</u>

- Many pathogens that infect the digestive tract are spread through water contaminated with feces from infected people or other animals
- Symptoms of these diseases often include serious diarrhea (usually in places with poor sanitation)
- Contaminated water may be consumed, or it may carry pathogens onto fruits or vegetables
    - If those foods are eaten without being washed thoroughly, infection can result.
- Bacteria of several kinds are commonly present in seafood and uncooked meat

<u>Zoonoses: The Animal Connection</u>

- Any disease that can be transmitted from animals to humans is called a zoonosis
- Mad cow disease,Severe acute respiratory syndrome (SARS),West Nile virus,Lyme disease, Ebola, and Bird flu
- Transmission can occur in various ways:
    1. Sometimes an animal carries, or transfers, zoonotic diseases from an animal host to a human host.
        a. These carriers, *vectors*, transport the pathogen but usually do not get sick themselves.
        b. In other cases, may occur when a person is bitten by an infected animal, consumes the meat of an infected animal, or comes in close contact with an infected animal's wastes or secretions

<u>Nonspecific Defenses</u>

- The body's first defense against pathogens is a combination of physical and chemical barrier
    - These barriers are called nonspecific defenses because they act against a wide range of pathogens
    - Nonspecific defenses include skin,tears and other secretions,inflammatory response, interferons, and fever

<u>First Line of Defense</u>

- The most widespread nonspecific defense is the physical barrier we call skin
- Very few pathogens can penetrate the layers of dead cells that form the skin's surface.
    - But your skin doesn't cover your entire body
        - Pathogens could easily enter your body through your mouth, nose, and eyes—if these tissues weren't protected by other nonspecific defenses
        - EX: saliva, mucus, and tears contain *lysozyme* (an enzyme that breaks down bacterial cell walls)
        - Mucus in your nose and throat traps pathogens
            - Then, cilia push the mucus-trapped pathogens away from your lungs
            - Stomach secretions destroy many pathogens that are swallowed.

<u>Second Line of Defense</u>

- If pathogens make it into the body (eg. through a cut in the skin) the body's second line of defense activates
- These mechanisms include:
1. Inflammatory response
2. Actions of interferons
3. Fever.

<u>Inflammatory Response</u>

- The inflammatory response gets its name because it causes infected areas to become red and painful, or inflamed
    - Response begins when pathogens stimulate cells,mast cells, to release chemicals known as histamines
        - Histamines increase the flow of blood and fluids to the affected area
        - Fluid leaking from expanded blood vessels causes the area to swell
        - White blood cells move from blood vessels into infected tissues
            - Many of these white blood cells are *phagocytes* (which engulf and destroy bacteria)
        - All this activity around a wound may cause a local rise in temperature
        - That's why a wounded area sometimes feels warm.

Interferons

- When viruses infect body cells, certain host cells produce proteins that inhibit synthesis of viral proteins
    - Scientists named these proteins interferons because they “interfere” with viral growth
    - By slowing down production of new viruses, interferons “buy time” for specific immune defenses to respond and fight the infection.

Fever

- The immune system also releases chemicals that increase body temperature, producing a fever.
- (1) Increased body temperature may slow down or stop the growth of some pathogens
- (2) Higher body temperature also speeds up several parts of the immune response.

Specific Defenses: The Immune System

- The immune system’s specific defenses distinguish between “self” and “other”
    - They inactivate or kill any foreign substance or cell that enters the body
    - Unlike nonspecific defenses, which respond to general threat of infection, specific defenses respond to particular pathogen.

Recognizing “Self”

- Healthy immune system recognizes all cells and proteins that belong in the body, and treats these them as “self.”
- It recognizes chemical markers that act like a secret password that says, “I belong here. Don’t attack me!”
    - Because genes program the passwords, no two individuals—except identical twins—ever use the same 1
    - This ability to recognize “self” is essential (the immune system controls powerful cellular and chemical weapons that could cause problems if turned against the body’s own cells)

Recognizing “Nonself”

- Immune system recognizes foreign organisms and molecules as “other,” or “nonself.”
- We’re surrounded by an almost infinite variety of bacteria, viruses, and parasites
- Once the immune system recognizes invaders as “others,” it uses cellular and chemical weapons to attack them.
- After encountering a specific invader, the immune system “remembers” it
    - This immune “memory” enables more rapid and effective response if that pathogen, or similar,attacks agai
- This specific recognition, response, and memory are called the immune response.

Antigens

- The way the immune system recognizes “others”
- Specific immune defenses are triggered by molecules called *antigens*
    - (An antigen is any foreign substance that can stimulate an immune response)
    - Typically, antigens are located on the outer surfaces of bacteria, viruses, or parasites
    - Immune system responds to antigens by increasing the number of cells that either attack the invaders directly or that produce proteins called *antibodies*.
- The main role of *antibodies* is to tag antigens for destruction by immune cells
    - Antibodies may be attached to particular immune cells or may be free-floating in plasma
    - The body makes up to 10 billion different antibodies
    - The shape of each type of antibody allows it to bind to one specific antigen

Lymphocytes

- The immune system guards the entire body, which means its cells must travel throughout the body.
- The main working cells of the immune response are *B lymphocytes (B cells) and T lymphocytes (T cells)*
    1. B cells are produced in, and mature in, red bone marrow.
        a. B cells, with their embedded antibodies, discover antigens in body fluids.
    2. T cells are produced in the bone marrow but mature in the thymus—an endocrine gland.
        a. T cells must be presented with an antigen by infected body cells or immune cells that have encountered antigens
    - Each B cell and T cell is capable of recognizing one specific antigen
    - A person’s genes determine the particular B and T cells that are produced
    - When mature, both types of cells travel to lymph nodes and the spleen, where they will encounter antigens.

The Immune System in Action

- B and T cells continually search the body for antigens or signs of antigens

- The specific immune response has two main styles of action:
  1. Humoral immunity
  2. Cell-mediated immunity.

Humoral Immunity

- The part of the immune response called *humoral immunity* depends on the action of antibodies that circulate in the blood and lymph.
  - This response is activated when antibodies embedded on a few existing B cells bind to antigens on the surface of an invading pathogen.
- (CHART) As shown in the figure, an antibody is shaped like the letter Y and has two identical antigen-binding sites. Shapes of the binding sites enable an antibody to recognize a specific antigen with a complementary shape.
  - When an antigen binds to an antibody carried by B cell, T cells stimulate B cell to grow and divide rapidly
  - That growth and division produces many B cells of two types: plasma cells and memory B cells.

Plasma Cells

- Plasma cells produce and release antibodies that are carried through the bloodstream
- These antibodies recognize and bind to free-floating antigens or to antigens on the surfaces of pathogens
- When antibodies bind to antigens, they act like signal flags to other parts of the immune system
- Several types of cells and proteins respond to that signal by attacking and destroying invaders.
  - Some types of antibodies can disable invaders until they are destroyed.
- Healthy adult can produce about 10 billion different types of antibodies, each can bind to a different type of antige
  - This antibody diversity enables immune system to respond to virtually any kind of "other" that enters body

Memory B Cells

- Plasma cells die after an infection is gone
- But some B cells that recognize a particular antigen remain alive
- These cells, *called memory B cells*, react quickly if the same pathogen enters the body again
- Memory B cells rapidly produce new plasma cells to battle the returning pathogen
  - This secondary response occurs much faster than the first response to a pathogen
  - Immune memory helps provide long-term immunity to certain diseases and why that vaccinations work

Cell-Mediated Immunity

- Another part of the immune response, which depends on the action of macrophages and several types of T cells, is called *cell-mediated immunity*
  - This part of the immune system defends the body against some viruses, fungi, and single-celled pathogens that do their dirty work inside body cells
  - T cells also protect the body from its own cells if they become cancerous.
- When a cell is infected by a pathogen or when a macrophage consumes a pathogen, the cell displays a portion of the antigen on the outer surface of its membrane
  - This membrane attachment is a signal to circulating T cells called *helper T cells*
    - Activated helper T cells divide -> into more helper T cells -> which go on to activate B cells, -> activate cytotoxic T cells, -> and produce memory T cells.
- Cytotoxic T cells hunt down body cells infected with a particular antigen and kill the cells
  - They kill infected cells by puncturing their membranes or initiating apoptosis (programmed cell death)
  - Memory helper T cells enable the immune system to respond quickly if the same pathogen enters the body again.
- Another type of T cell, *suppressor T cells*, helps to keep the immune response once an infection is under control
  - They may also be involved in preventing autoimmune diseases.
- Although *cytotoxic T cells* are helpful in the immune system, they make acceptance of organ transplants difficult
- When an organ is transplanted from one person to another, the normal response of the recipient's immune system would be to recognize it as nonself
  - T cells and proteins would damage and destroy the transplanted organ
  - This process is known as *rejection*
    - To prevent organ rejection, doctors search for a donor whose cell markers are nearly identical to the cell markers of the recipient

        - Still, organ recipients must take drugs,usually for the rest of their lives,to suppress the cell-mediated

Acquired Immunity

- Jenner put fluid from a cowpox patient's sore into a small cut he made on the arm of a young boy named James Phipps.
    - James developed mild cowpox
    - Two months later, Jenner injected James with fluid from a smallpox infection
    - Fortunately for James (and Jenner!), the boy didn't develop smallpox
    - His cowpox infection had protected him from smallpox infection
- Ever since that time, the injection of a weakened form of a pathogen, or of a similar but less dangerous pathogen, to produce immunity has been known as a *vaccination*
    - The term comes from the Latin word vacca, meaning "cow"

Active Immunity

- Vaccination stimulates the immune system with an antigen
- Immune system produces memory B cells and memory T cells that quicken and strengthen body's response to repeated infection
- This kind of immunity, called *active immunity*, may develop as a result of natural exposure to an antigen (fighting an infection) or from deliberate exposure to the antigen (through a vaccine)

Passive Immunity

- Disease can be prevented in another way
- Antibodies produced against a pathogen by other individuals or animals can be used to produce temporary immunity
    - If externally produced antibodies are introduced into a person's blood, the result is *passive immunity*
    - *Passive immunity* lasts only a short time because the immune system eventually destroys the foreign antibodies.
- Passive immunity can also occur naturally or by deliberate exposure
    - Natural passive immunity occurs when antibodies are passed from a (1) pregnant woman to the fetus (across the placenta), or to an infant through (2) breast milk
    - For some diseases, antibodies from humans or animals can be injected into an individual
    - Eg. people who have been bitten by rabid animals are injected with antibodies for the rabies virus

Public Health and Medications

- In 1900, more than 30 percent of deaths in the United States were caused by infectious disease
- In 2005, less than 5 percent of deaths were caused by infectious disease
- Two factors that contributed to this change are public health measures and the development of medications.

Public Health Measures

- When humans live in large groups, behavior, cleanliness of food and water supplies, and sanitation all influence th spread of disease
- The field of public health offers services and advice that help provide healthy conditions
    - *Public health measures help prevent disease by monitoring and regulating food and water supplies, promoting vaccination, and promoting behaviors that avoid infection*
    - Promoting childhood vaccinations and providing clean drinking water are two important public health activities that have greatly reduced the spread of many diseases that once killed many people

Medications

- Prevention of infectious disease is not always possible
- Medications, such as antibiotics and antiviral drugs, are other weapons that can fight pathogens
    - Antibiotics can kill bacteria, and some antiviral medications can slow down viral activity
- The term antibiotic refers to a compound that kills bacteria without harming its host
    - In 1928, Alexander Fleming was the first scientist to discover an antibiotic
        - Fleming noticed that a mold, Penicillium notatum, seemed to produce something that inhibited bacterial growth
        - Research determined that this "something" was a compound Fleming named penicillin
        - Researchers learned to mass-produce penicillin just in time for it to save thousands of World War II soldiers
        - Since then, dozens of antibiotics have saved countless numbers of lives
    - Antibiotics have no effect on viruses
    - However, antiviral drugs have been developed to fight certain viral infections
    - These drugs generally inhibit the ability of viruses to invade cells or to multiply once inside cells

New and Re-emerging Disease

- By 1980, many people thought that medicine had conquered infectious disease
- Vaccination and other public health measures had wiped out polio in the United States and had eliminated smallpo globally
- Antibiotics seemed to have bacterial diseases under control
- Some exotic diseases remained in the tropics, but researchers were confident that epidemics would soon be history. Unfortunately, they were wrong.
- In recent decades, a host of new diseases have appeared, including AIDS, SARS, hantavirus, monkeypox, West Nile virus, Ebola, and avian influenza ("bird flu")
    - Other diseases that people thought were under control are re-emerging as a threat and spreading to new areas

Changing Interactions With Animals

- Two major reasons for the emergence of new diseases:
    1. The ongoing merging of human animal habitats
    2. Increase in the exotic animal trade
- As people clear new areas of land and environments change, people contact with different animals and pathogens
- Exotic animal trade, for pets and food, has given pathogens new opportunities to jump from animals to humans
        - Both monkeypox and SARS are thought to have started this way
    - Pathogens are also evolving in ways that enable them to infect different hosts.

Misuse of Medications

- Misuse of medications has led to the re-emergence of diseases that many people thought were under control
    - EX : Many strains of the pathogens that cause tuberculosis and malaria are evolving resistance to a wide variety of antibiotics and other medications
        - In addition, diseases such as measles are making a comeback because some people fail to follow vaccination recommendations

When the Immune System Overreacts

- The immune systems of some people overreact to harmless antigens, such as pollen, dust mites, mold, pet dander, and possibly their own cells
- A strong immune response to harmless antigens can produce allergies, asthma, and autoimmune disease.
- Allergies Antigens that cause allergic reactions are called *allergens*
- When allergens enter the body of people affected by allergies, they trigger an inflammatory response by causing mast cells to release *histamines*
- If this response occurs in the respiratory system, it increases mucus production and causes sneezing, watery eyes, a runny nose, and other irritations
    - Drugs called *antihistamines* help relieve allergy symptoms by counteracting the effects of *histamines*

Asthma : Allergic reactions in the respiratory system can create a dangerous condition

- A chronic disease in which air passages narrow, causing wheezing, coughing, and difficulty breathing
- Both hereditary and environmental factors influence asthma symptoms
- Asthma attacks can be triggered by respiratory infections, exercise, emotional stress, and certain medications
- Other triggers include cold or dry air, pollen, dust, tobacco smoke, pollution, molds, and pet dander.
- Asthma is serious and can be life-threatening
  - If treatment is not started early enough or if medications are not taken properly, severe asthma can lead to permanent damage or destruction of lung tissue
  - There is no cure, but people with asthma can sometimes control the condition
  - If the attacks are caused by an allergen, tests can identify which allergens cause the problem
  - Inhaled medications can relax smooth muscles around the airways and relieve asthma symptoms.

Autoimmune Diseases

- Sometimes a disease occurs in which the immune system fails to properly recognize “self,” and attacks cells or compounds in the body as though they were pathogens
- When the immune system attacks the body’s own cells, it produces an autoimmune disease
- Examples of autoimmune diseases are Type I diabetes, rheumatoid arthritis, and lupus.
- (1) In Type I diabetes, antibodies attack insulin-producing cells in the pancreas
  - In rheumatoid arthritis, antibodies attack tissues around joints
  - Lupus is an autoimmune disease in which antibodies attack organs and tissues causing areas of chronic inflammation throughout the body.
- Some autoimmune diseases can be treated with medications that alleviate specific symptoms
  - For example, people with Type I diabetes can take insulin
  - Other autoimmune diseases are treated with medications that suppress the immune response
    - However, these medications also decrease the normal immune response and must be monitored

HIV and AIDS

During late 1970s, physicians reported serious infections produced by microorganisms that didn’t normally cause disease

  - Previously healthy people began to suffer from Pneumocystis carinii pneumonia, Kaposi sarcoma (a rare form of skin cancer), and fungal infections of the mouth and throat.
  - Because these diseases are normally prevented by a healthy immune response, doctors concluded that these patients must have weakened immune systems
  - Diseases that attack a person with a weakened immune system are called *opportunistic diseases*
  - Researchers concluded that these illnesses were symptoms of a new disorder they called *acquired immunodeficiency syndrome (AIDS)*
  - Research revealed that this “syndrome” was an infectious disease caused by a pathogen new to science

HIV

- In 1983, researchers identified the cause of AIDS—a virus they *called human immunodeficiency virus (HIV)*
  - HIV is deadly for two reasons:
    1. HIV can hide from the defenses of the immune system
    2. HIV attacks key cells within the immune system, leaving the body with inadequate protection against other pathogens.
- HIV is a retrovirus that carries its genetic information in RNA, rather than DNA
- When HIV attacks a cell, it binds to receptor molecules on the cell membrane and inserts its contents into the cell

Target: T Cells

- Among HIV’s main targets are helper *T cells*—the command centers of the specific immune response
  - Over time, HIV destroys more T cells, crippling ability of immune system to fight HIV and other pathogen
  - The progression of HIV infection can be monitored by counting helper T cells
  - The fewer helper T cells, the more advanced the disease and the more susceptible the body becomes to other diseases
  - When an HIV-infected person’s T cell count reaches about ⅙ normal level, he is diagnosed with AIDS.

HIV Transmission

- Although HIV is deadly, it is not easily transmitted
- It is not transmitted through coughing, sneezing, sharing clothes, or other forms of casual contact
- HIV can only be transmitted through contact with infected blood, semen, vaginal secretions, or breast milk
- The four main ways that HIV is transmitted:
  1. Sexual intercourse with an infected person
  2. Sharing needles with an infected person
  3. Contact with infected blood or blood products
  4. Infected mother to her child during pregnancy, birth, or breast-feeding.
- Preventing HIV Infection You can choose behaviors that reduce your risk of becoming infected with HIV
- Only no-risk behavior with respect to HIV transmission is abstinence from sexual activity and intravenous drug us
- People who share needles to inject themselves with drugs are at a high risk for contracting HIV
  - For this reason, people who have sex with drug abusers are also at high risk
- Before 1985, HIV was transmitted to some patients through transfusions of infected blood or blood products
- Such cases have been virtually eliminated by screening the blood supply for HIV antibodies and by discouraging potentially infected individuals from donating blood

Can AIDS Be Cured?

- So far, no cure for AIDS
- A steady stream of new drugs makes it possible to survive HIV infection for years
  - Unfortunately, HIV mutates and evolves rapidly
  - For this reason, the virus has evolved into many strains that are resistant to most drugs used against them
  - No one has developed a vaccine that offers protection for any length of time.
- At present, only way to control virus is to use a combination of expensive drugs that fight the virus in several way
  - Current drugs interfere with the enzymes HIV uses to insert its RNA into a host cell, to convert RNA to DNA, and to integrate its DNA into the host's DNA
- Because of these drugs, more people infected with HIV in the U.S are living with HIV rather than dying from it
  - In many parts of Africa and Asia, however, these expensive drugs are not available
- Unfortunately, the knowledge that HIV can be treated (though not cured) has given some people the misconception that HIV infection is not serious