Viruses

- Composed of some genetic material (DNA or RNA) surrounded by a _________________
- Cannot _________________ on their own
- Take over cellular machinery of cells they infect

Many human illnesses are caused by viruses
- Flu (Influenza virus)
- Common cold (200 different viruses)
- AIDS (Human Immunodeficiency Virus, HIV)
- Herpes
  - Many types: HHV-1 = cold sores; HHV-2 = genital herpes; HHV-3 = chickenpox; HHV-4 = Epstein-Barr virus; HHV-5 = cytomegalovirus; and others
  - Warts
  - Hepatitis
  - Rabies
  - Etc.

Viruses can be transmitted in various ways:
- Inhalation
- Ingestion
- Sexual contact (STDs)

Immune system can eliminate some viruses
- Others can remain _________________ in body, and re-emerge later
  - Example: genital herpes
  - 1 out of ____ adolescents and adults infected
  - Causes recurrent painful sores
  - No _________________; antiviral drugs can reduce severity and length of outbreaks
  - Condom use can reduce likelihood of transmission, but cannot guarantee prevention of transmission

- Human Immunodeficiency Virus (HIV)
• Causes ______(Acquired Immune Deficiency Syndrome)
• Is a "__________" – contains RNA and enzyme
  "_______________________"
• RNA is used to make DNA, which integrates into the host DNA

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• Virus infects and kills "_____________ cells" (part of the immune system... will discuss later)
• Reduces body’s ability to fight off other diseases
  – Pathogens that would normally be easily handled by the immune system become deadly
  – Risk of cancer also increases
• Nearly always fatal, although medications are allowing people to survive longer with the disease

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– How HIV is spread
• Virus is most abundant in ___________, ___________, and ___________
• Sexual contact is a major route of transmission
• ______________ is another major mechanism of transmission
• Rarely: blood transfusion (screening procedures have greatly limited this risk)
• Mother-to-baby transmission
– Prevention
• Avoiding sexual contact with infected persons
• Use of ______________

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– Who is infected?
• Symptoms may not appear for ______________
• Initial symptoms are often minor
• Work continues to be done on development of vaccines
  – Clinical trials underway
• Therapeutic drugs are very expensive
  – $300 to >$2000 per month
  – often multiple drugs needed
• HIV/AIDS is an epidemic
  – 2011: 34 million people living with the disease
  – In 2011: 1.7 million people died from AIDS-related illnesses
  – AIDS orphans in 2009: 16.6 million

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• __________________________: the hardest-hit region of world
  – 10% of the world’s population; 60% of all HIV-infections
• Why?
  – Culture
Lack of money for drugs (could prevent mother-to-child transmission)

- AIDS has overtaken malaria as #__ killer in Africa
- May lead to economic collapse of many African countries

**Bacteria**
- Single-celled, prokaryotic organisms
  - No membrane-bound organelles
  - Can enter body through respiratory tract, digestive tract, or through wounds
  - Bacterial infections can be treated with ____________ (unlike viral infections)
  - Not taking full dose of ____________ can contribute to antibiotic resistance

Toxins are chemicals produced by some bacteria
- ____________ – proteins (often enzymes) produced and secreted from bacteria
  - Botulinum toxin – one of most potent toxins; one pint could kill all 6.5 billion people on planet!
- ____________ – a lipid portion of the bacterial cell wall
  - Only released upon death of the bacterial cell
  - May cause fever, weakness, aches, and chills
  - May also damage circulatory system by increasing permeability of blood vessels
  - Required in larger doses than exotoxins

Antibiotic resistance
- Bacteria are evolving mechanisms that allow them to survive when exposed to our antibiotics
- Bacterial diseases were easy to treat with antibiotics
- No new research was being done in 70’s and 80’s to develop new antibiotics
- Rise of resistant bacteria: in 1992, over 13,000 hospital patients died from infections with antibiotic-resistant bacteria
- Today, about ____________ people acquire bacterial infections in US hospitals each year; 90,000 die; 70% of those are due to antibiotic-resistant bacteria (that’s 63,000 deaths per year!)

- *Staphylococcus aureus* (staph) infections are common form of hospital infections
  - In 2002, over 57% of staph bacteria in hospitals were methicillin-resistant (MRSA)
  - Caused 12,000 deaths in 2001-2002
  - Caused 18,650 deaths in 2005; more people die from MRSA in the US than AIDS (as of 2007)
Outbreaks of MRSA have been seen among athletes, prisoners, and military personnel in recent years.
Staph bacteria are common on human __________; the resistant form can result in skin infections; can spread to heart, lungs, and bloodstream.

Dealing with antibiotic resistance
• Make sure illness is due to bacteria, not viruses, before treating with antibiotics
• Educating patients about need to take __________________ of antibiotics
• FDA currently recommending farmers phase out use of many common antibiotics in the feed of livestock
  – Used to grow animals larger, not treat infections

Prions
• “Nontraditional” infectious agent
  – Composed only of ______________________
• Misfolded brain cell protein
  – Enter nerve cells and trigger misfolding of other nearby proteins
  – Nerve cells die and burst, releasing prions which infect other neurons
  – Results in neurological symptoms, such as trembling, jerking, and unusual behavior
    • Transmissible __________________________ (TSE’s)
  – Progressive and fatal; no cure

• Includes __________________________ Disease (Bovine Spongiform Encephalopathy) in cows, ________________ in sheep, and ________________ disease in humans
• Produces sponge-like appearance of brain

• Mad Cow Disease = Bovine Spongiform Encephalopathy

• Consume beef from cows infected with BSE can lead to variant Creutzfeldt-Jakob Disease (vCJD) in humans, although the risk is very low
  – CJD always _______________, usually within 1 year of infection
  – v-CJD first described in U.K. in 1996, after the epidemic of “mad cow disease”
  – It is estimated that currently, in the UK, the risk of acquiring v-CJD from eating beef is
Flu (Influenza virus) ___________ (___ cells) directly attack their targets

Initial symptoms are often minor

_________________ Cells: lymphocytes that destroy tumor cells and virus

Attacks _______________

Inflammation _______________ is

Caused by the Human Immunodeficiency Virus (HIV)

1879 _______________________ began working on an anthrax vaccine

Causes  ______(Acquired Immune Deficiency Syndrome)

Active and Passive Immunity

Avoiding sexual contact with infected persons

_____________________ = antibody

Antimicrobial mucus secreted by lining of respiratory tract

antibodies, or can bind to

Skin punctures with contaminated objects (e.g. tetanus)

Extra oxygen and nutrients to speed healing

Rabies

Temporary protection, because body has not activated its B and T cells

of other nearby proteins

Tissue comes from own body

Break…

Causes recurrent painful sores

_______________________ (___ cells) produce antibodies

Mad Cow Disease = Bovine Spongiform Encephalopathy

May lead to economic collapse of many African countries

Reduce T cell division

Anti

Defends body against _____________

contains RNA and enzyme
defend the throat

Inhalation

No ___________; antiviral drugs can reduce severity and length of outbreaks

Skin secretions are slightly ____________________

Mother

shock

Nearly always fatal, although medications are allowing people to survive longer with

• Specific Defense:

• Nonspecific Defenses:

The First Line of Defense

Lymphatic System

• Helps maintain _________________ in cardiovascular system

• Transports __________ and ________-soluble vitamins from digestive system to cardiovascular system

• Defends body against _____________

•

•

•

•

Most cells of immune system are housed within the lymphatic system

• Lymphatic system is composed of

– Lymph __________

– Lymph __________

– Spleen

– ____________ gland

– ____________

–

•

•

Fluid in lymph vessels = lymph

– Contains white blood cells, fats, proteins, and occasionally pathogens

• ____________ nodes – remove microorganisms, debris, and abnormal cells from lymph

before returning it to circulatory system

– Inside lymph nodes: connective tissue, macrophages, and lymphocytes

• ____________ – largest lymphatic organ

– Removes old, damaged RBCs

– Helps fight infection

Thymus gland – secretes hormones that cause _________________ to mature

– Located in lower neck, behind sternum and above heart

– Most active during _________________

• ____________ – defend the throat
Keeping Pathogens Out:  
**The First Line of Defense**

- Mechanisms that prevent microbes from infecting tissue
- Linings of respiratory, urinary, and digestive tracts, and the skin
- Chemical defense
  - Skin secretions are slightly ________________
  - Acids produced in stomach
  - ________________ in saliva
  - Antimicrobial mucus secreted by lining of respiratory tract

Nonspecific Defenses:  
**The Second Line of Defense**

- Phagocytes engulf foreign cells
  - ________________: first WBCs to respond to infection
  - ________________: engulf and digest viruses and bacteria in large numbers
  - ________________: cluster around large parasites and secrete digestive enzymes; can also engulf foreign proteins

Inflammation

- Characterized by warmth, redness, swelling, and pain
- Chemicals released from damaged cells send signal for ________________ response
  - ________________ cells are stimulated to release histamine
  - Promotes ________________; vessels become more permeable to white blood cells
  - More blood to infected area → redness, swelling, and warmth
  - Extra oxygen and nutrients to speed healing
• **Suppressor T Cells**: lymphocytes that destroy tumor cells and virus-infected cells
  – Recognize changes in cell membranes
  – Release chemicals that break down target cells’ membranes

• **Interferons**: at least 20 different proteins that aid in defense
  – When activated by infection, initiate a cascade of protein activations
  – Can form “pores” or holes in bacterial walls
  • Cell bursts

• **:** interfere with viral replication
  – Produced by cells already infected with virus
  – Interferons bind to healthy cells, stimulating their production of proteins that prevent synthesis of proteins

• **Fever:** raises body temperature
  – Normal body temp between 97-99°F
  – Activated macrophages release
  – __________ signal brain to increase body temp
  – Makes conditions less favorable for pathogens
  – Also speeds tissue repair

• **Break...**

**Specific Defense:**

**The Third Line of Defense**

– Cells of the immune system are spread out (in blood, lymph, lymphoid organs, and other body tissues)
– Cells of immune system specifically target certain organisms or chemicals
– Large foreign molecules (called ________________) trigger the immune system
  • __________ = antibody-generating substances

• What contains antigens?
  – Bacteria
  – Viruses
  – Parasites
  – Cells transplanted from another person
  – Cancer cells

• The proteins or polysaccharides in the membranes or coats surrounding the microbes are recognized as foreign

• **Lymphocytes are an important part of the immune system**
  • _______________ (___ cells) directly attack their targets
  – Usually respond to the body’s own cells that have become abnormal
  » Cancer cells
Viral-infected cells
- Also responds to large invading organisms, like fungi and parasites
- Also responds to transplanted cells
  - ______________________ (___ cells) produce antibodies
  - Usually respond to bacteria, bacterial toxins, and some viruses

-B Cells
- Produce “humoral immunity”
- B cells are specialized to fight different kinds of microbes (different kinds of bacteria, for example)
- When a bacterium enters the body, B cells specialized for that type of bacteria begin dividing
- Some of these B cells differentiate to form _______ cells, which produce antibodies
- ___________ (aka immunoglobulins) work by:
  - Coating antigen, preventing them from doing harm
  - Causing antigens to clump together

- Primary Response
  - The body's first exposure to an antigen is usually ______
    - There are fewer B cells that recognize the particular antigen
    - After first exposure, B cells multiply, but takes about a week to produce enough antibodies to fight the infection

- Secondary Response
  - Because of the build up of __________________, response to second exposure is much faster

-T Cells and the Cell-Mediated Response
- Also respond to specific antigens
- Produce 4 different kinds of cells

- Cytotoxic T Cells (aka __________________)
  - Attack and kill:
    - Infected body cells
    - Bacteria
    - Fungi
    - Multicellular parasites
Flu (Influenza virus) bind to healthy cells, stimulating their production of proteins that prevent ________________

No ___________; antiviral drugs can reduce severity and length of outbreaks

Nearly always fatal, although medications are allowing people to survive longer with ________________

Cell bursts

B cells are specialized to fight different kinds of microbes (different kinds of bacteria, ________________) to remove microorganisms, debris, and abnormal cells from lymph

___________ cells directly attack their targets

How do ______ Cancer Cells
— Foreign cells from transfusions/transplants

• How do Cytotoxic T Cells work?
— Can release a protein called ________________, which ruptures cell membranes
— Can release a poison, ________________, which kills target cells
— Can cause the activation of special genes in the target cell, which tell the cell to die
(_______________ = programmed cell death)

• Helper T Cells
— Produced when antigen is detected
— The most ________________ T cell (60-70% of T cells)
— Stimulate Plasma B Cells and Cytotoxic T Cells
— HIV attacks these cells

• Suppressor T Cells
— Turn ______ immune response when antigens disappear
— Reduce T cell division

• Memory T Cells
— Analogous to Memory B Cells
— Become activated during subsequent infections with the same antigen
— During second exposure, they divide to form Cytotoxic T Cells and Helper T Cells

Active and Passive Immunity

— Active Immunity
— Immunity that results in body actively creating ________________
— Occurs naturally when first exposed to an antigen
— Can be induced through ________________
— Injection with inactivated or weakened strains of viruses, bacteria, or bacterial toxins
• First large-scale studies of vaccines carried out in 1796 by
  ________________
  –A physician
  –Had heard farm workers say that if you contracted cowpox, you would not get
  smallpox
  –Studied this phenomenon and found it to be true
  –Did not understand the mechanism
• No other vaccines developed or tested for 84 years
• 1879 _____________________ began working on an anthrax vaccine

–Passive Immunity
  • Injection with ________________ produced by animals
  • Temporary protection, because body has not activated its B and T cells
  • Lasts a few weeks
    –Antibodies eventually removed by liver
  *
  *

• Blood Transfusions and Tissue Transplants
  –A, B, AB and O blood types
  –Antigens on surface of blood cells can elicit an immune response (recall previous lecture)
  –Organ/tissue transplants can only be successful when:
    • Tissue comes from own body
    • Tissue comes from identical twin
    • Anti-rejection drugs used
      –Interfere with immune response, making individuals more susceptible to infections
      –Must be taken for life
  *
  *

• Diseases of Immune System
  –Allergies: overreactions to specific antigens
    • ________________ = allergy-causing antigens
    • Various foods and pollen are examples
    • Cause increase in production of IgE antibodies, or can bind to IgE antibodies on mast
cells
      –Mast cells contain high levels of histamine
      –In the lungs, histamine can restrict airflow, making breathing difficult (=asthma)
    • Most allergic reactions localized and minor

• Allergic responses in bloodstream can be life-threatening
  –Histamine released in large amounts
–Dilation of blood vessels
–Reduced blood pressure
–Constriction of bronchioles
–Result: ___________________ shock
–Injection with epinephrine (adrenalin) can reverse restriction of bronchioles

–AIDS
  • Caused by the Human Immunodeficiency Virus (HIV)
  • Attacks __________________
  • Interference in immune system makes victims susceptible to infections
  • No cure

–How is disease spread?
  –Direct transmission – direct ________________________________
    • Hand-shaking, kissing, sexual intercourse, or blood transfusions
    • Respiratory droplets (from coughing or sneezing)
    • Mother-to-child transmission via placenta, during childbirth, or through breast milk
      –HIV
    • Some disease can be transmitted by contact with infected animals
      –rabies

–Indirect Transmission
  • Occurs when a person contacts a pathogen on an ________________________________
    (e.g. doorknobs and faucet handles)
  • Skin punctures with contaminated objects (e.g. tetanus)
  • Aerosols – some pathogens may be present on dust or moisture particles suspended
    in the air

–Arthropods (e.g. mosquitoes, ticks, flies, fleas, and lice) may also carry disease
  –vectors
  –Deer ticks may carry the bacterium responsible for Lyme disease
–Contaminated food or water
  –E. coli infections from eating contaminated meats
  –Be sure to cook food properly to help avoid such illnesses!

• All for today...