Chapter 35
The Immune System and Disease

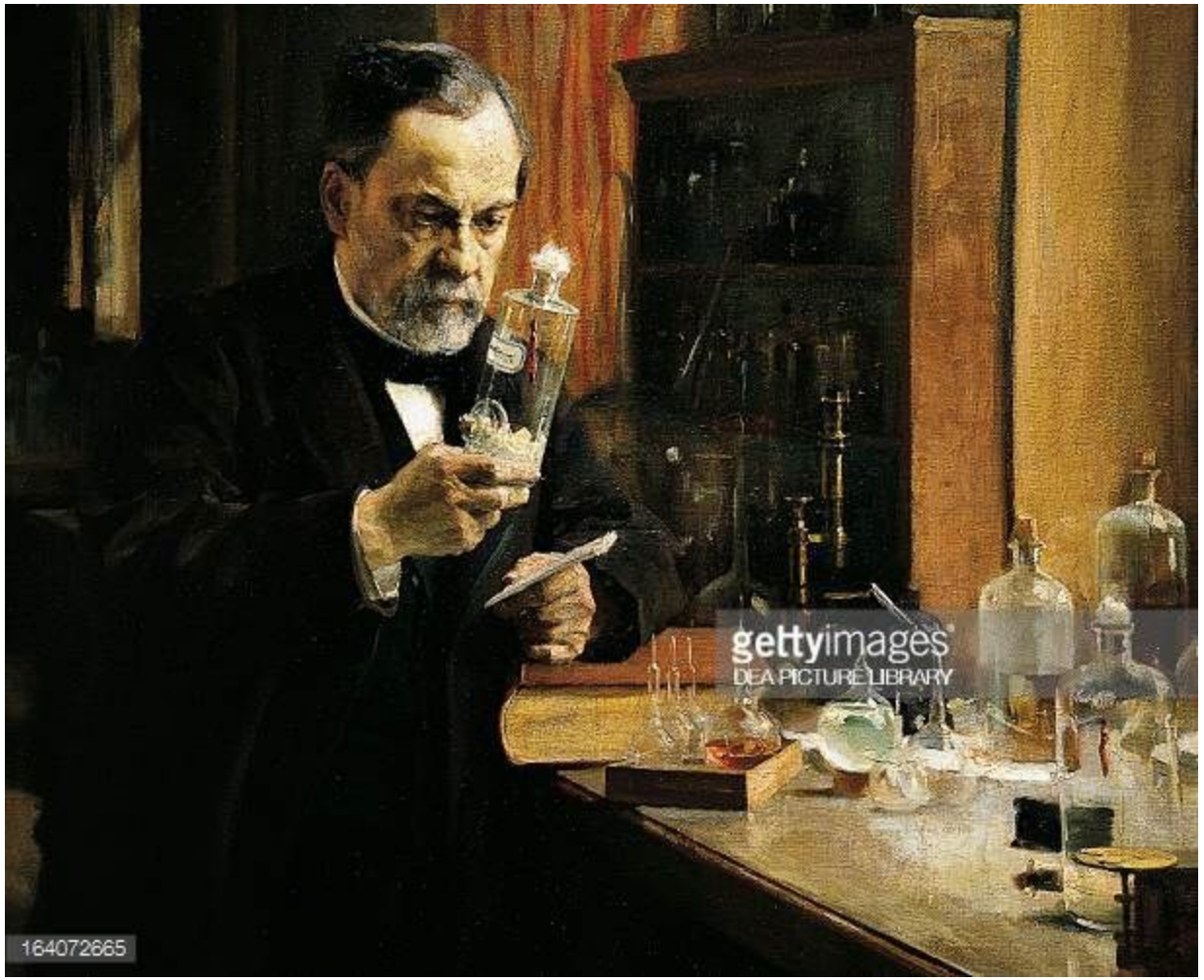
Chapter Mystery-The Search for a Cause

35.1 Infectious Disease
35.2 Defense Against Infection
www.youtube.com/watch?v=GIJK3dwCWCw

www.youtube.com/watch?v=2DFN4IBZ3rI

35.3 Fighting Infectious Disease

35.4 Immune System Disorders

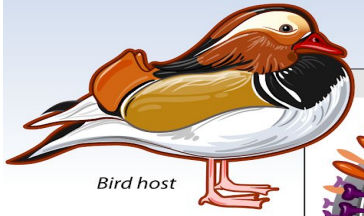


Koch and his wife, Emmy, upon receiving the Nobel Prize in 1905.

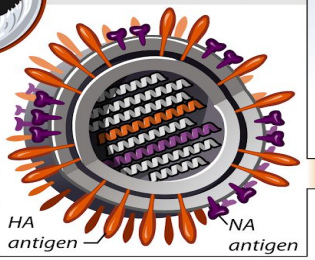
Infectious Disease

- Louis Pasteur and Robert Koch concluded that infectious disease occurs when microorganisms cause physiological changes that disrupt normal bodily functions. Germ Theory- unknown pathogens(bacteria, fungi, protists, virus & parasites) cause sickness. Germ not scientific.
  - Viruses-common cold, influenza, chicken pox, warts,. Take over cells and cause malfunctions. Non-living.
  - Bacteria-streptococcus, diphtheria, botulism, anthrax and tuberculosis. Breakdown tissues for food or release toxins.
  - Fungi-ringworm, thrush, yeast infections, athletes foot, valley fever. Eats skin.
  - Protists- malaria, African Sleeping sickness. Most inflict damage to skin or cells, vectors spread. Singled celled.
  - Parasites- trichinosis, schistosomiasis, hookworm, elephantiasis. Most enter body via openings and live in intestines and cause blockages, starvation etc..
- Koch's Postulates-Rules to identify causes of disease:
  - Must always be found in "sick" body, not in healthy body.
  - Pathogen must be grown in lab in pure culture.
  - When cultured and then introduced into healthy host, disease should result.
  - When isolated from 2nd host, it should be identical to the original pathogen.
- Nobel Prize- awarded to Robert Koch in 1905 for his work in modern medicine.
- Disease- Pathogens evolved with many "tricky ways" to spread. Natural selection favors this, otherwise the pathogen would die with host- end of story.
  - Cough, sneeze, body contact and fluid exchange- Adaptations to make a person sneeze/cough(cold, influenza, tuberculosis), to survive on host surfaces(streptococcus), to live on mucus membranes(sexually transmitted diseases).
  - Contaminated food/water- Adaptations to cause diarrhea(fecal material passes into water and crops). Meats, seafood, eggs also carry bacteria and are resistant to heat.
  - Zoonosis- Adaptation to use vectors that usually don't get sick. Zoonoses are diseases that are transferred from animals to humans. Mad cow(consuming meat), SARS, West Nile(mosquito), Lyme disease(tick), Ebola(fruit bats), Bird Flu.
- Good Microorganisms- live and reproduce etc. without causing disease. They are actually helpful.

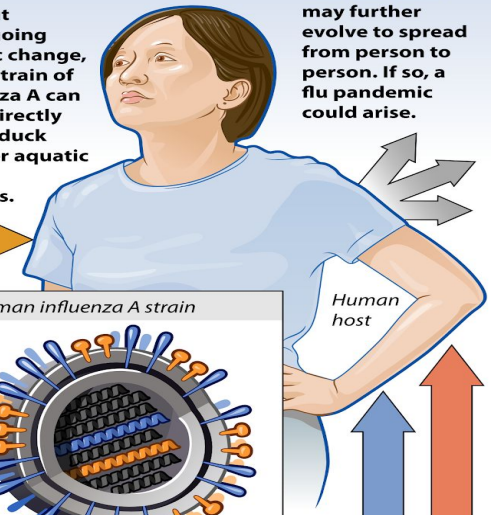
The genetic change that enables a flu strain to jump from one animal species to another, including humans, is called "ANTIGENIC SHIFT." Antigenic shift can happen in three ways:



Bird influenza A strain



B Without undergoing genetic change, a bird strain of influenza A can jump directly from a duck or other aquatic bird to humans.



The new strain may further evolve to spread from person to person. If so, a flu pandemic could arise.

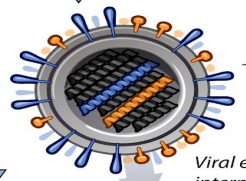
Human influenza A strain

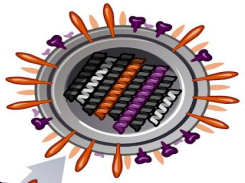
A-1 A duck or other aquatic bird passes a bird strain of influenza A to an intermediate host such as a chicken or pig.

C Without undergoing genetic change, a bird strain of influenza A can jump directly from a duck or other aquatic bird to an intermediate animal host and then to humans.

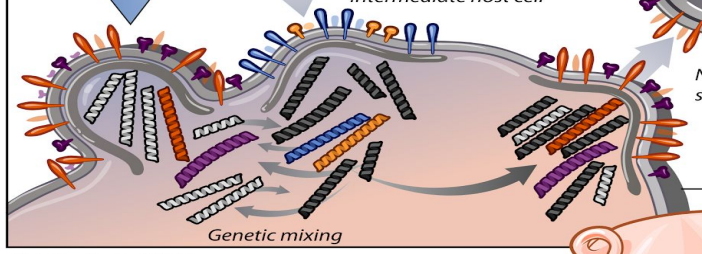
A-2 A person passes a human strain of influenza A to the same chicken or pig. ***(Note that reassortments can occur in a person who is infected with two flu strains.)***

A-3 When the viruses infect the same cell, the genes from the bird strain mix with genes from the human strain to yield a new strain.





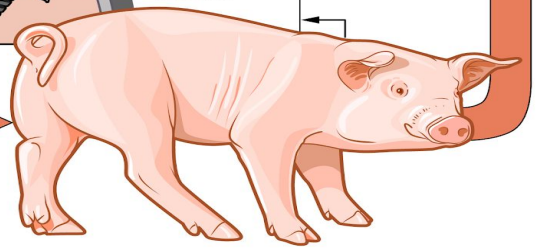
Viral entry intermediate host cell



New influenza strain

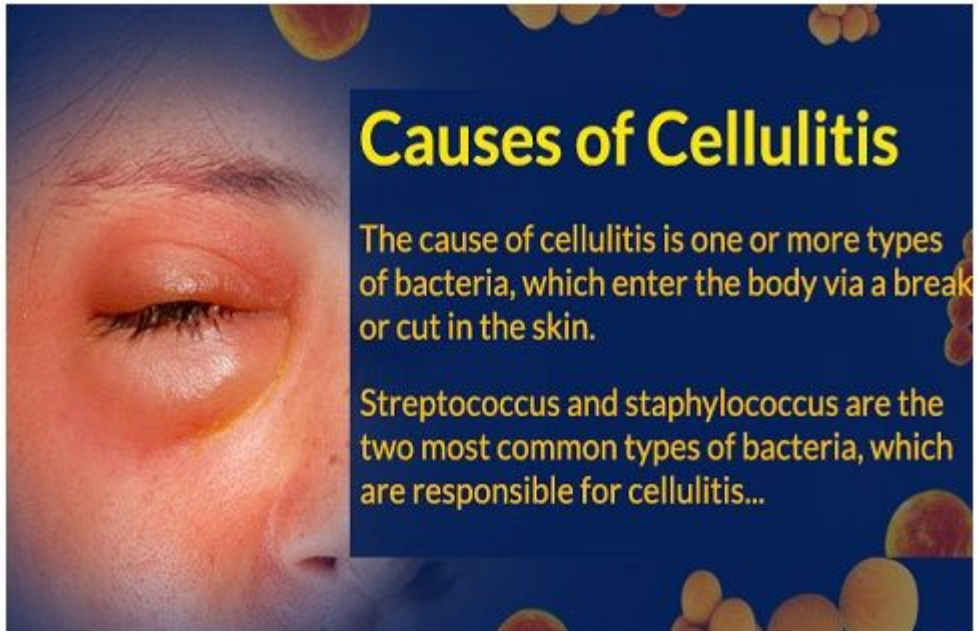
Intermediate host cell

A-4 The new strain can spread from the intermediate host to humans.



Intermediate host (pig)

Link Studio for NIAID

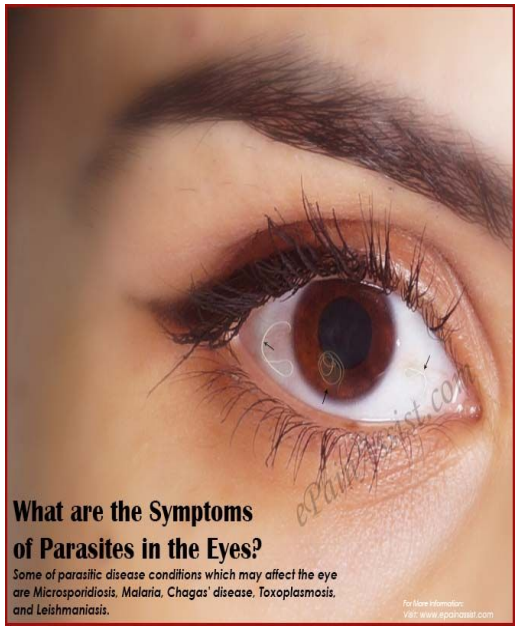


IS IT SERIOUS?

Herpes simplex infection of the mouth is very common; and though the appearance may cause concern, it presents no serious risks to your general health. The main danger involved is spreading the infection to the Eye by touching the sore and then touching the eye.

This can cause an eye infection or ulceration of the cornea. In very rare cases, herpes virus can infect the brain and other parts of the central nervous system, producing meningitis and encephalitis. This, however, is usually seen only in adults with an immune deficiency disorder or in young children.

There is some evidence that herpes virus may help protect the host against some types of cancer. Research is ongoing.



Clinical presentation of Non-bullous impetigo:

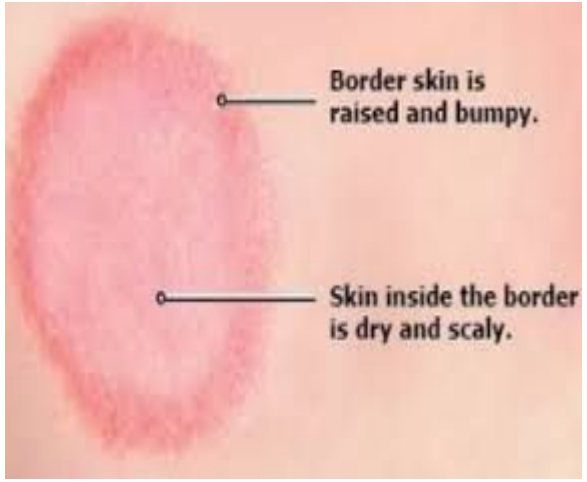
Staphylococcus impetigo

Streptococcus impetigo

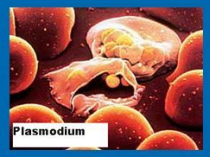
-Swab could be taken from lesions for detection of MRSA.

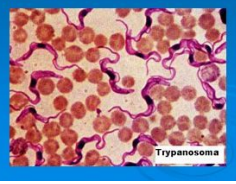
-The sores of impetigo heal slowly and seldom scar.

-Permanent skin damage and scarring (very rare).



Diseases caused by protists





- Some cause disease
- Giardia – causes diarrhea
- plasmodium – malaria (mosquitoes)
- trypanosoma – African sleeping sickness (tsetse fly)
- amoebic dysentery – diarrhea

Non-Specific Defenses Against Disease

- 1st Line- Physical or chemical barriers.
  - Skin- very few pathogens can penetrate the skin. Mouth, nose and eyes are more vulnerable.
  - Saliva, mucus and tears have lysozyme enzyme that breaks down pathogen cell walls.
  - Cilia and mucus trap and remove pathogens.
  - Stomach juices destroy pathogens.
- 2nd Line- Inflammatory response-red, swollen and painful area.
  - Histamines- cause increased blood flow to area which causes fluid to leak into the space between cells. Phagocytes leave blood and go to swollen area. They then engulf pathogens and damaged cells. This metabolism causes local spike in temperature.
  - Interferons- in viral infections some host cells produce proteins that interfere with viral reproduction which slows that growth of viral load and buys time for the specific immunity responses.
  - Fever- Chemicals are released that cause a spike in temperature. This can slow or stop bacterial infection and speeds other immune responses.

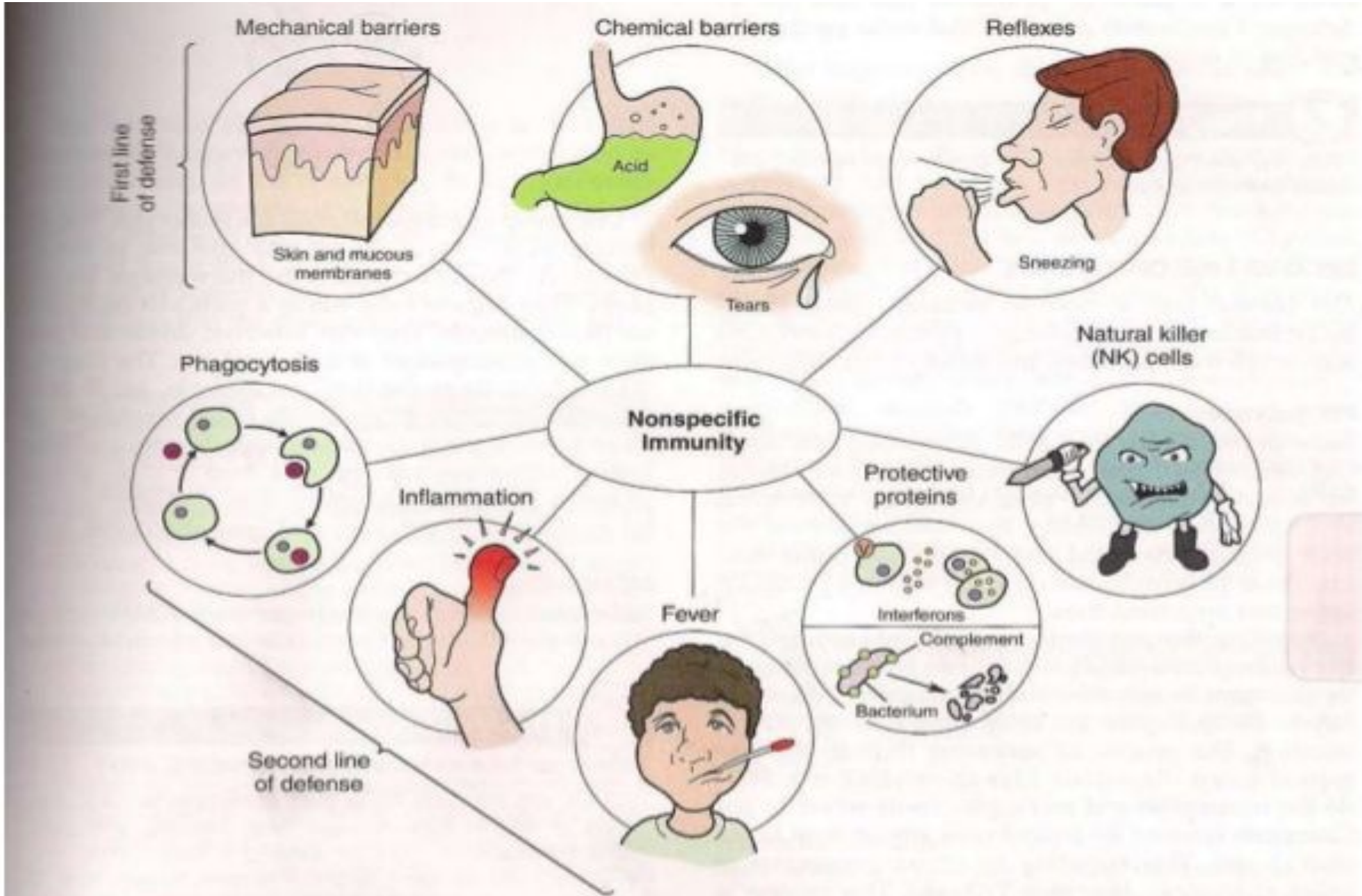
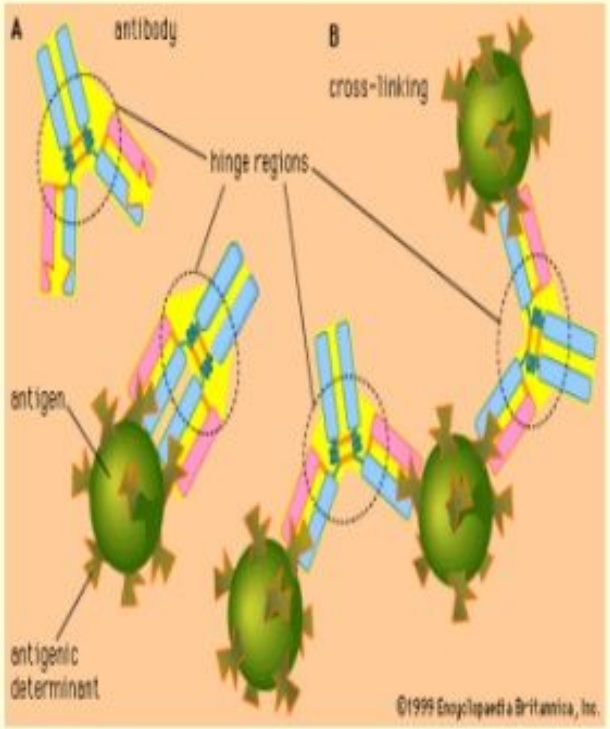


FIGURE 21-1 Nonspecific immunity. First line of defense—mechanical barriers, chemical barriers, and reflexes. Second line of defense—phagocytosis, inflammation, fever, protective proteins, and natural killer (NK) cells.

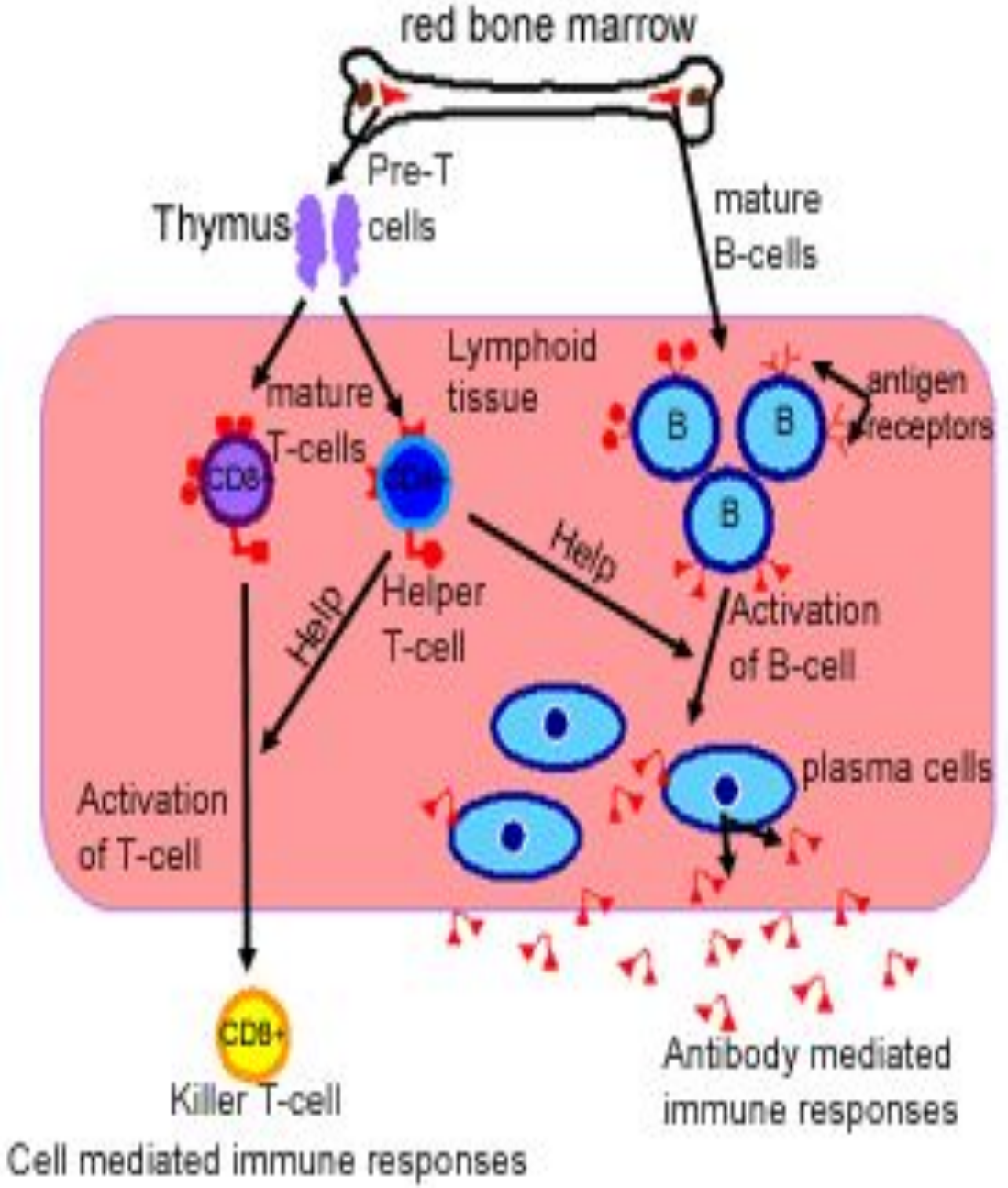
Specific Defenses to Disease

- Specific Defenses- distinguish between self and other, specifically inactivate or kill foreign substance or cell.
  - Self- the body recognizes it unique chemical markers that all people have. Identical twins are the only people that are alike.
  - Non-self-body recognizes and remembers chemical markers that are foreign.
- Immune response- the specific recognition, response and memory to these chemical markers.
- Antigen- any substance with foreign outer chemical markings. The body responds by increasing the number of cells that attack antigens or producing specific protein marker antibodies which tag invaders(10 billion different either attached or free floating)for destruction.
- B and T lymphocytes-main immune cells. When mature, both types of cells travel to spleen and lymph nodes to encounter the antigens. Every person's genetics determine what lymphocytes are produced but there are thousands of them that are specific to one antigen.
  - B-cells are made and mature in the red bone marrow. They attack antigens in bodily fluids. These cells have antibodies attached to them.
  - T-cells are made in the red marrow but mature in the thymus. Have no antibodies attached.

Antigen / Antibody Reactions



- (A) The hinge region of an antibody molecule opens and closes to allow better binding between the antibody and antigenic determinants on the surface of an antigen. (B) Hinge flexibility also facilitates the cross-linking of antigens into large antigen-antibody complexes.



The Immune System in Action

Humoral Immunity

- Depends on actions of B-cells and antibodies in blood and lymph. Humor=moisture
- 1).B-cell antibodies bind to pathogen's complementary shaped surface.
- 2).T-cells stimulate B-cell growth and reproduction to carry out #3&4.
- 3).Plasma B-cell(which die with the infection) produce and release antibodies, bind, signal or flag and other cells and proteins respond(10 billion types).
- 4).Memory B-cells stay alive for a much quicker secondary response in recurring infections. These B-cells keep the antibodies.

Cell-Mediated Immunity

- Depends on the actions of macrophages and T-cells. These also protect us against cancer.
- 1).Macrophage engulfs pathogen and displays the pathogen's antigen on its cell membrane. This signals helper T-cells to produce:
  - T-cells to activate more B-cells
  - Cytotoxic T-cells to hunt down body cells infected with the antigen, puncture them/initialize apoptosis. They make organ transplants difficult.
  - Memory T-cells that will recognize a pathogen and begin cell-mediated process on recurring infections.
  - Suppressor T-cell inhibit immune responses once an infection is in check. May also play a roll in preventing autoimmune diseases.

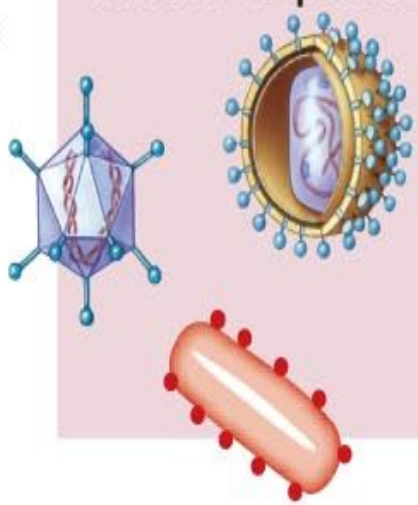
An overview of the immune response

Antigens or Antigenic Fragments in Body Fluids

Most antigens must either infect cells or be "processed" by phagocytes before specific defenses are activated. The trigger is the appearance of antigens or antigenic fragments in plasma membranes; this is called **antigen presentation**.

Specific Defenses

Antigen presentation triggers specific defenses, or an immune response.



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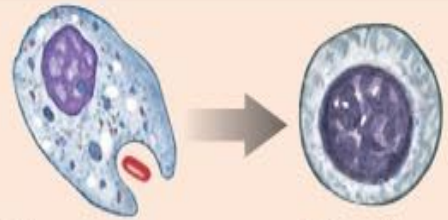
Cell-Mediated Immunity



Phagocytes activated

T cells activated

Direct Physical and Chemical Attack

Activated T cells find the pathogens and attack them through phagocytosis or the release of chemical toxins.

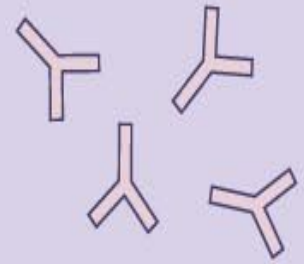
Communication and feedback

2

Antibody-Mediated Immunity

Activated B cells give rise to cells that produce antibodies.

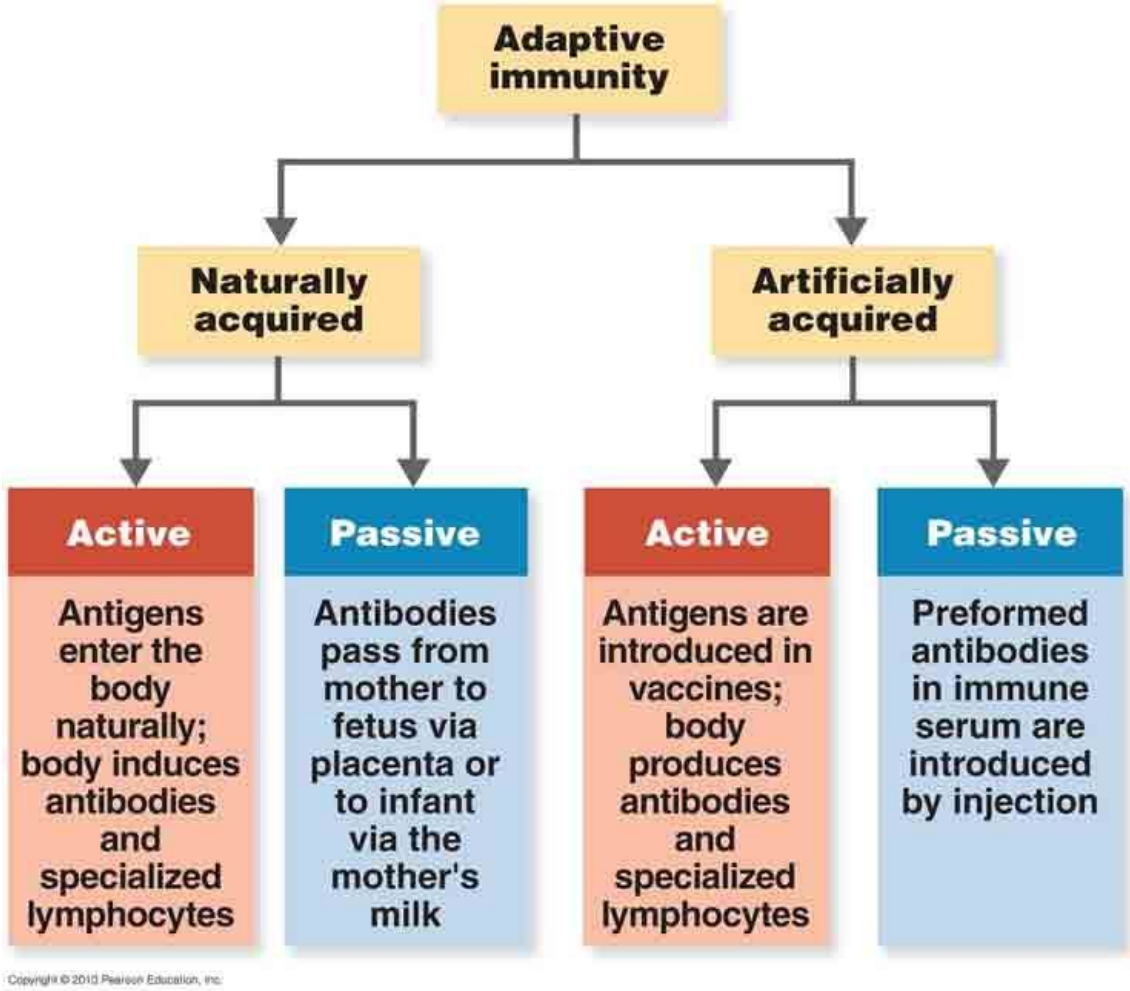
Attack by Circulating Antibodies



Destruction of antigens

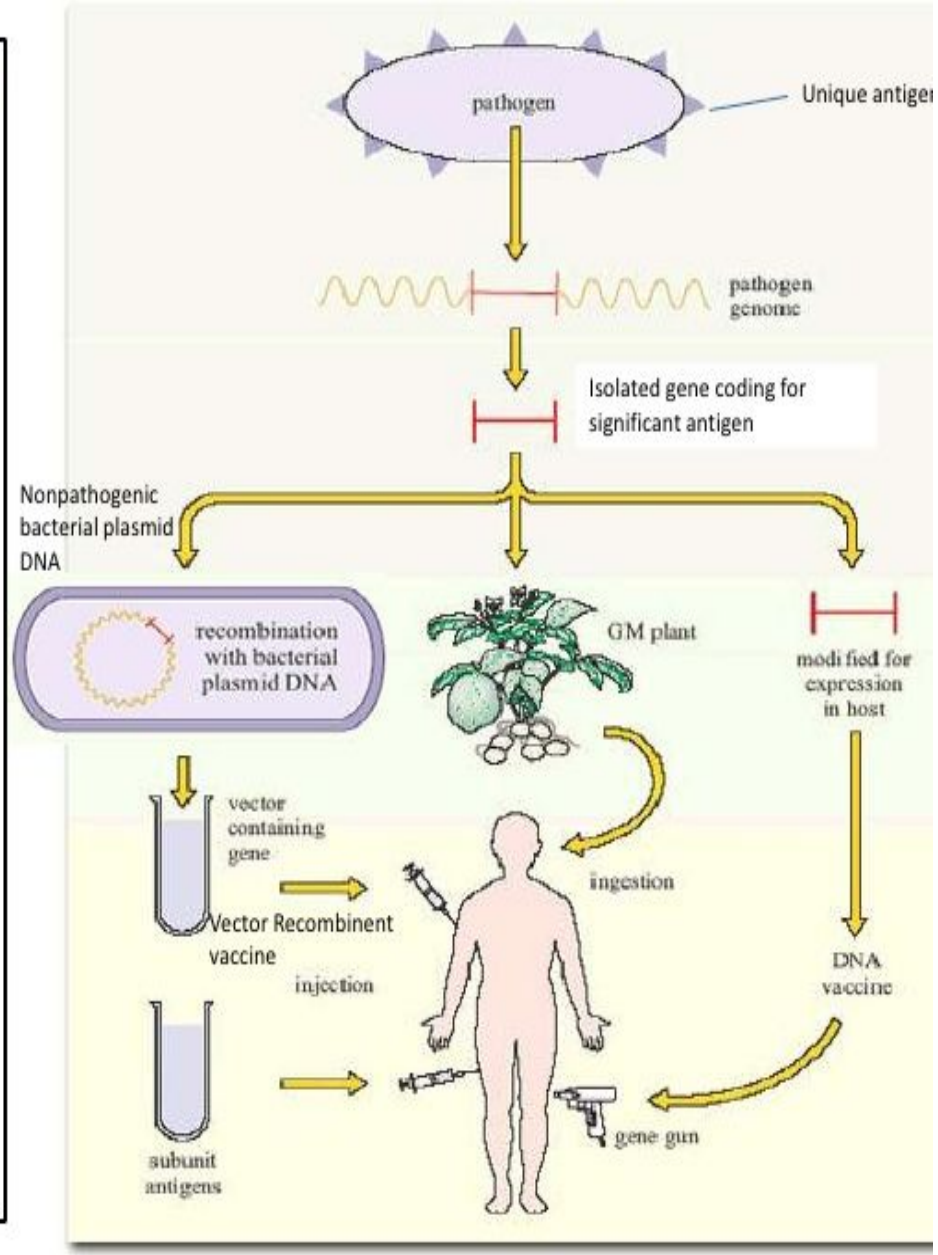
Fighting Infectious Disease

- Acquired Immunity- Edward Jenner, Cowpox vaccination inventor. He noted that milkmaids contracting mild cowpox disease didn't contract deadly smallpox. He exposed young James Phipps to cowpox via a cut. After James recovered from the mild cowpox, Jenner injected him with fluid from smallpox infection and the boy didn't contract the disease. Vacca=cow
- Active Immunity-vaccinations or exposure to disease will both expose the body to an antigen causing the production of memory B and T cells to strengthen the body's response to future infections. Long lasting.
- Passive immunity-Antibodies produced against a pathogen by other individuals or animals can be used to produce temporary immunity. Naturally occurs across placental barrier or through breast milk. Can also be injected. Rabies victims can be injected with antibodies for the rabies virus. Short lived.
- Public Health Organizations help prevent disease by monitoring and regulating food and water supplies, promoting vaccinations, and promoting behaviors that avoid infection. Death from infectious disease stats: 1900s 30% vs 2005 5%!!
- Alexander Fleming-mold *Penicillium notatum* inhibited bacterial growth. He studied this and extracted a chemical that he called penicillin and that became a widely used antibiotic. Antibiotic kill bacteria. Antivirals slow virus replication. www.youtube.com/watch?v=xZbcwi7SfZE
- New and Re-emerging diseases- Polio was wiped out in U.S. and smallpox globally. (vaccinations) New viral diseases like AIDs, SARS, hantavirus, monkeypox, West Nile, Ebola and avian flu are likely due to merging of human and animal habitats, exotic animal trade, misuse of medications and genetics.



Genetic approaches to vaccine development:

One or more genes encoding pathogen-specific antigens are isolated and
-recombined with a harmless or disabled vector for delivery by injection,
- or incorporated into food plants for ingestion,
-or modified for injection as naked DNA.
-subunit antigens can be produced by genetic engineering.



Immune System Disorders

- Immune System Disorders are strong responses to harmless antigens.
- Allergies- antigens trigger histamine release which produces inflammatory response. Antihistamine drugs block this process.
- Asthma- chronic and dangerous. Airways narrow due to smooth muscle contraction. Allergen, emotional/physical stress, temperature change etc. can cause an attack. Albuterol/medications relax smooth muscles to relieve symptoms. Long term=tissue damage.
- Autoimmune Disease- Immune system fails to organize and it attacks itself. Lupus is a disease in which organs are attacked and great pain results. Type I diabetes occurs when insulin producing cells of pancreas are attacked. Rheumatoid arthritis occurs when joint connective tissue is attacked and inflammation causes serious pain.
- HIV and AIDS- HIV is a retrovirus. It has RNA and once inside the host cell, reverse transcriptase uses it as a template to make HIV DNA. It then inserts itself into the host DNA in the nucleus and the body cell begins to make viral RNA and mRNA.
  - HIV destroys the helper T-cells thus slowly disabling the immune system. Ultimately secondary diseases like *Pneumocystis carinii* pneumonia, Kaposi sarcoma, and thrush in the mouth and throat are the causes of serious illness and death. A person with 1/6 of normal T-cell count due to HIV is said to have AIDS.
  - Transmitted through infected blood, semen, vaginal secretions and breast milk. Therefore the virus is passed from person to person in sexual intercourse, sharing needles and breast feeding.
  - No cure yet, enzymes used for virus to reproduce are used and prolonging lives.

Tissues of The Body Affected By Autoimmune Attack