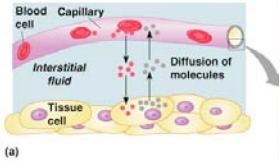


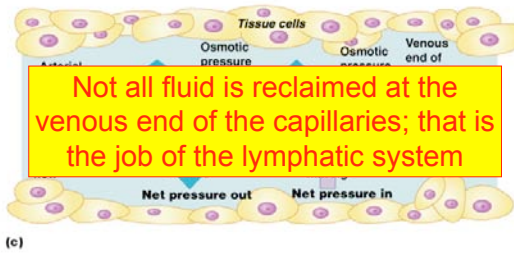
## Capillary exchange



(a)

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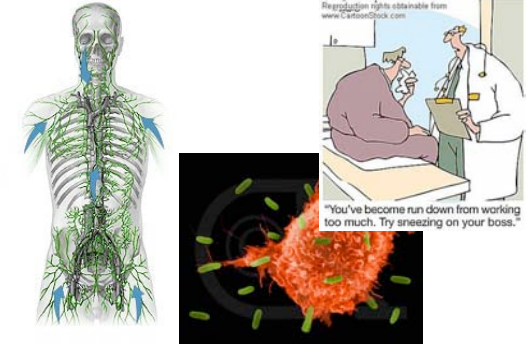
## Fluid movement in capillaries



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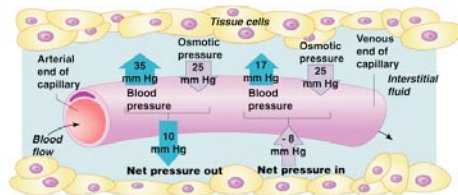
## Lymphatic system/body defenses



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"You've become run down from working too much. Try sneezing on your boss."

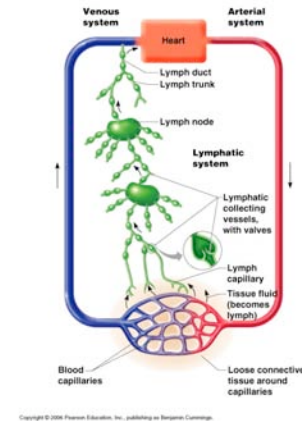
## A reminder



The excess fluid that accumulates is **lymph**, and it must be reclaimed by the circulatory system

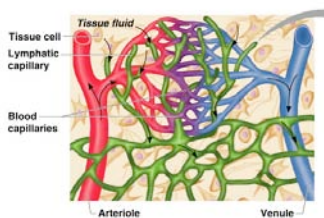
## Lymphatic vessels

**Lymphatic capillaries** permeate our tissues  
Amazingly permeable  
Contain **minivalves** that allow for only one-way flow  
All lymph flows toward heart  
Major collecting ducts (dump into subclavian veins):  
*right lymphatic duct*  
*thoracic duct*



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## Lymphatic capillaries



(a)

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## Lymphatic vessels

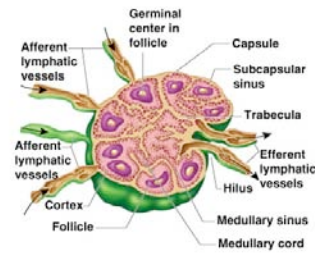
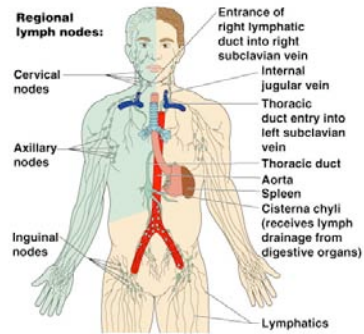
**Lymphatic capillaries** permeate our tissues  
Amazingly permeable  
Contain **minivalves** that allow for only one-way flow  
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*right lymphatic duct*  
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**Because the lymphatic capillaries are so permeable, diseases and viruses could easily use them as freeways to move through the body easily!**

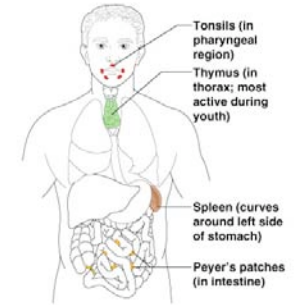
## Lymph nodes

Lymph is filtered through **lymph nodes** on its way back to the heart  
Found in large clusters in **inguinal, axillary, and cervical regions** of the body  
**Macrophages** are found in lymph nodes  
Helps produce **lymphocytes** (a type of white blood cell) that also function in the immune response

## Distribution of lymph nodes



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## Nonspecific body defenses

= mechanical barriers that cover body surfaces/chemicals that initially act to protect the body from invading *pathogens*

### Surface membrane barriers

*Acid pH* of skin secretions inhibits bacterial growth

Stomach secretes *HCl* and *proteinases*

Saliva and lacrimal fluid contains *lysozyme*

*Mucus* traps bacteria that would enter respiratory tract

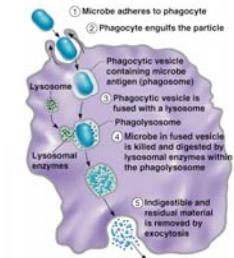
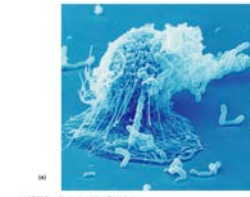
## Nonspecific body defenses

### Cells and chemicals

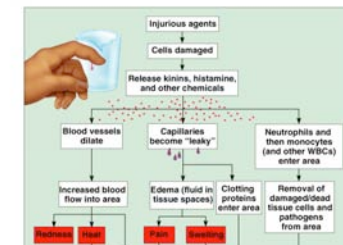
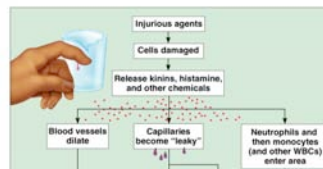
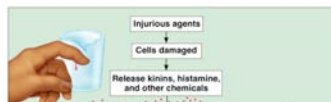
*Phagocytes* (macrophages and neutrophils) engulf foreign particles

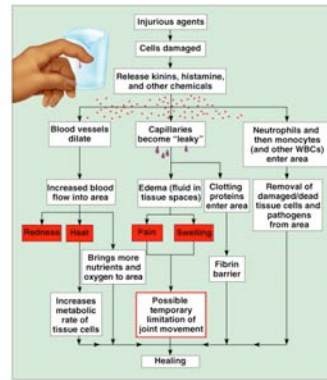
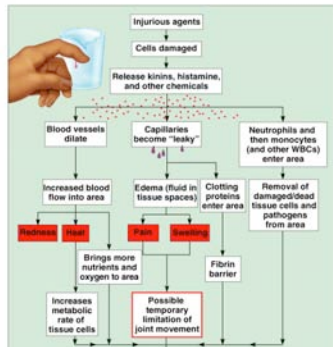
*Natural killer cells* can recognize foreign pathogens, and inject a lytic enzyme into the cell, causing it to disintegrate

## Phagocytosis



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## Nonspecific body defenses

### Antimicrobial chemicals

**Complement:** at least 20 plasma proteins that are inactivated until attached to foreign cells; can cause foreign cells to burst (*membrane attack complexes*), can release *chemotaxic chemicals* for WBCs, or can assist *macrophages*

**Interferon:** secreted by virus-infected cells to help protect neighboring cells from infection (“interferes” with viral infection)

## Nonspecific body defenses

### Fever

White blood cells secrete *pyrogens*, which act on the hypothalamus to raise body temperature; causes liver to “take away” chemicals bacteria need and it increases metabolic rate, which speeds healing

## Immune response

Very specific body defenses

*Antigen specific*

*Systemic*

*Has memory*--is able to prime itself for later attacks by the same antigen

*Humoral immunity:* provided by antibodies circulating in body fluids

*Cellular immunity:* lymphocytes themselves defend the body against antigens

## What is an antigen?

Any substance capable of exciting a response from our immune system (what we recognize as “*nonself*”)

Pollen grains, bacteria illicit an immune response because they have foreign proteins

Our cells often contain *self-antigens*, which our body recognizes, but other bodies may not

## Haptens

= *incomplete antigens*

Small molecules are not antigenic, but can link with our own proteins

*Allergies* result



## Lymphocytes

All blood cells originate from stem cells in the bone marrow

*T cells* become immunocompetent in the thymus

*B cells* become immunocompetent in the bone marrow

Once immunocompetent, a lymphocyte can bind with *only one* antigen--our genes determine what lymphocytes we make

## Macrophages

Acts non-specifically to engulf pathogens

Acts specifically by *presenting antigens* to T cells

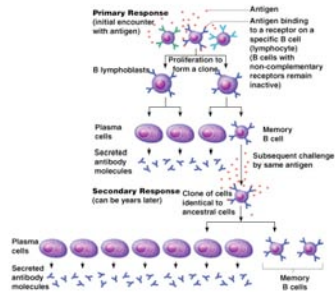
T cells then release chemicals that convert the macrophages to *killer macrophages*

Localized to lymphoid organs

(T cells mature in lymph tissue, but can go all over the body)

## Humoral immunity

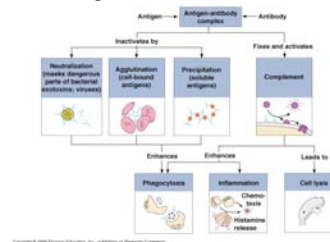
= antibody-mediated immunity



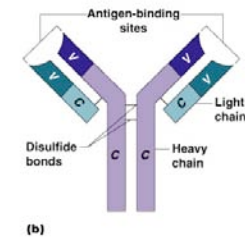
## Antibodies

= immunoglobulins

Capable of binding with a specific antigen  
Inactivates antigens in a number of ways



## Antibody structure

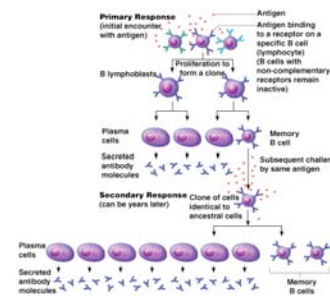


Class	Generalized structure	Where found	Biological function
IgD		Virtually always attached to B cell.	Believed to be cell surface receptor of immunocompetent B cell; important in activation of B cell.
IgM		Attached to B cell; free in plasma.	When bound to B cell membrane, serves as antigen receptor; first Ig class released to plasma by plasma cells during primary response; potent agglutinating agent; fixes complement.
IgG		Most abundant antibody in plasma; represents 75-85% of circulating antibodies.	Main antibody of both primary and secondary responses; crosses placenta and provides passive immunity to fetus; fixes complement.
IgA		Some monomer in plasma; dense in secretions such as saliva, tears, intestinal juice, and milk.	Bathes and protects mucosal surfaces from attachment of pathogens.
IgE		Secreted by plasma cells in skin, mucosa of gastrointestinal and respiratory tracts, and tonsils.	Binds to mast cells and basophils, and triggers release of histamine and other chemicals that mediate inflammation and certain allergic responses.

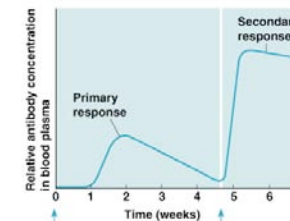
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## Humoral immunity

= antibody-mediated immunity



## Primary and secondary humoral responses



## Active humoral immunity

Can be naturally acquired

Can be artificially acquired via **vaccines**

Vaccines “prime” the immune system (like jumping ahead to the secondary response)

We are spared the discomfort of the disease itself

Sometimes booster shots are necessary to re-intensify the immune system

## Passive humoral immunity

Antibodies are obtained from another human or animal

“Borrowed” antibodies naturally degrade in the body with time

Conferred naturally mother–fetal exchange

Conferred artificially when one receives injections

Gamma globulin (hepatitis exposure)

Snake bites

Tetanus

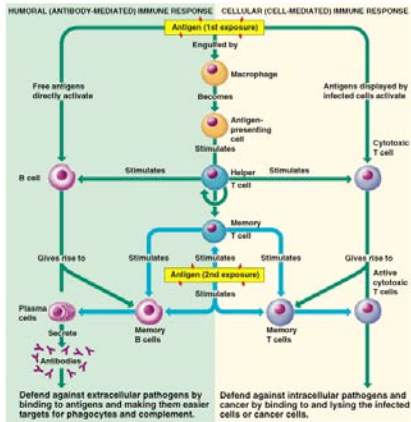
## Cell-mediated immunity

Immature T cells must be presented antigens by macrophages in order to bind them

**Cytotoxic (killer) T** cells specialize in killing virus-infected, cancer or foreign graft cells by injecting **perforins** under their cell membrane

**Helper T cells** recruit B cells and cytotoxic T cells by releasing **lymphokines**

**Suppressor T** cells suppress T and B cells, winding down the immune response



## Immunodeficiencies

*Severe combined immunodeficiency disease:* a severe lack of B and T cells; sometimes bone marrow or umbilical cord stem cell transplants can help; victims must live in a bubble; congenital

*Acquired immune deficiency syndrome:* interferes with the activity of helper T cells

## Autoimmune diseases

The immune system loses its ability to recognize *self-antigens*

~5% of adults in North America suffer from an autoimmune disease

Several very common: multiple sclerosis, type I diabetes, rheumatoid arthritis, among others