

**Marieb's Human  
Anatomy and Physiology**

Marieb ♦ Hoehn

**Chapters 20 & 21  
Lymphatic System/Lymphoid Organs  
Innate/Adaptive Body Defenses  
Lecture 6**

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**Lecture Overview**

- Functions of the lymphatic system
- Lymphatic pathways
- Tissue fluid and lymph
- Lymph movement
- Lymphoid tissues (lymph nodes, spleen, thymus)
- Innate vs. adaptive immunity
- Immune responses and classification of immunity
- Allergic reactions, transplantation, and autoimmunity

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**Lymphatic System and Immunity**

**Functions of the Lymphatic System**

- network of vessels that assist in circulating fluids
- transports excess fluid away from interstitial spaces
- transports fluid to the bloodstream
- aids in absorption of dietary fats
- help defend the body against disease

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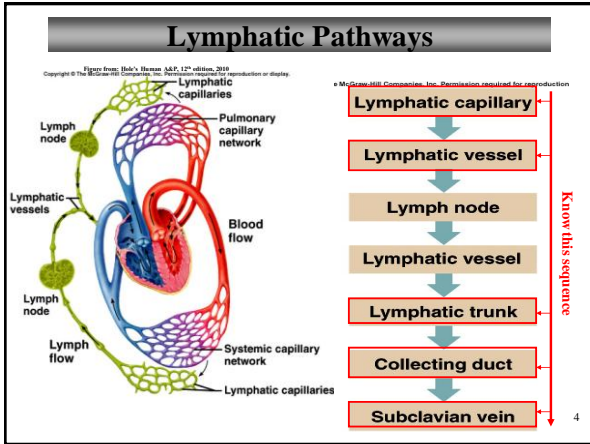
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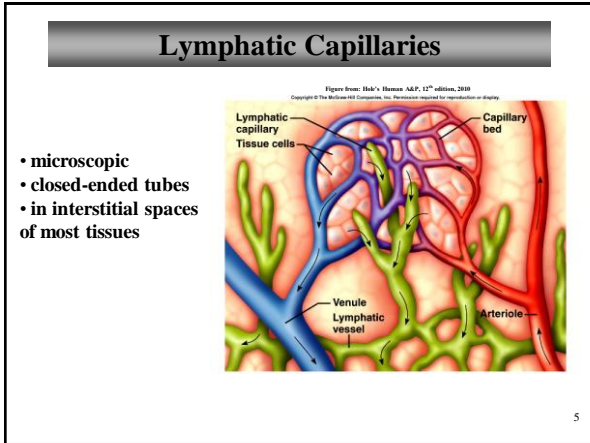
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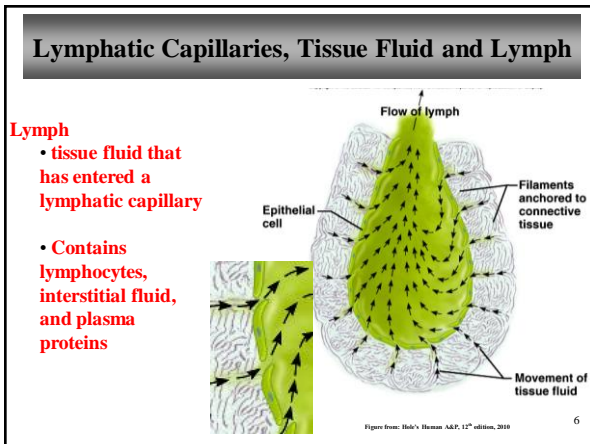
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## Lymphatic Vessels & Trunks

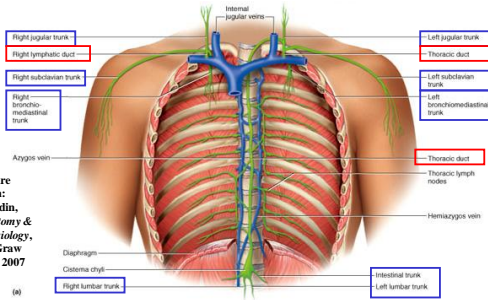


Figure from: Saladin, *Anatomy & Physiology*, McGraw Hill, 2007

- lymphatic vessels merge into **lymphatic trunks**
- lymphatic trunks drain into **collecting ducts**

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## Lymphatic Ducts

- **Right lymphatic duct**  
- Drains right side of body above diaphragm and right arm
- **Thoracic duct**

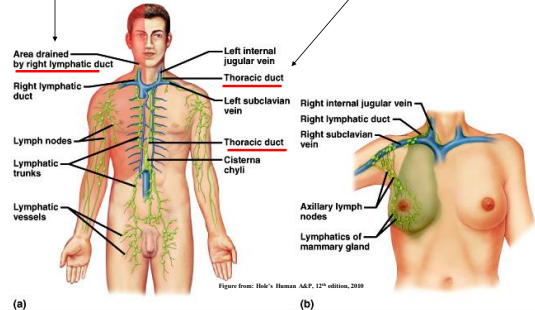


Figure from: *Rob's Human A&P, 12th edition, 2010*

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## Lymph Movement

- action of skeletal muscles
  - respiratory movements
  - smooth muscle in larger lymphatic vessels
  - valves in lymphatic vessels
- Just like veins!!**

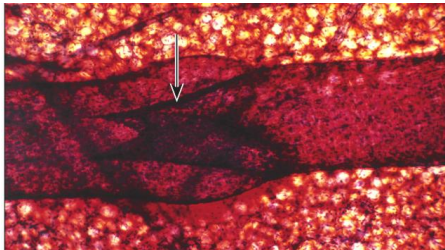


Figure from: *Rob's Human A&P, 12th edition, 2010*

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## Lymphatic Tissues

- **Aggregations of lymphocytes in the connective tissues of mucous membranes and various organs**

- **Diffuse lymphatic tissue** (scattered, rather than densely clustered), e.g., in respiratory, digestive, urinary, and reproductive tracts. Known as MALT (mucosa-associated lymphatic tissue)

- **Lymphatic nodules** (follicles) – densely clustered cell masses in lymph nodes, tonsils, appendix, small intestine (Peyer's patches)

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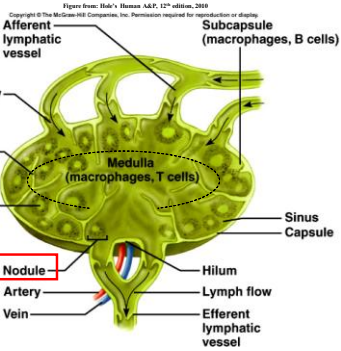
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## Lymph Nodes (Lymphatic Organs)



- Functions**
- **filter** potentially harmful particles from **lymph**
  - **immune surveillance** by macrophages and lymphocytes
  - areas of lymphocyte production

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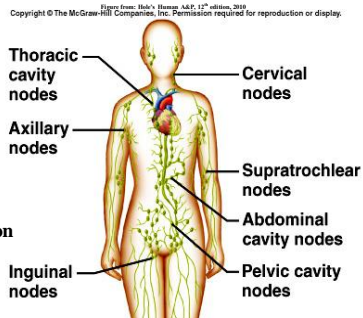
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## Major Lymph Nodes

- cervical region
- axillary region
- inguinal region
- pelvic cavity
- abdominal cavity
- thoracic cavity
- supratrochlear region



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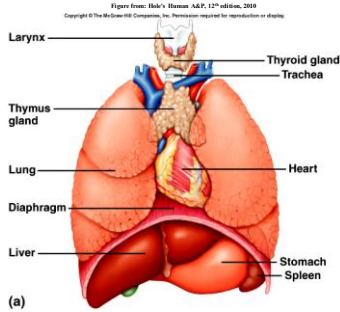
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## Thymus (Lymphatic Organ)

- large in children, small in an adult  
- decreases in size after puberty
- site of T lymphocyte 'education'
- secretes thymosins, interleukins, and interferons



13

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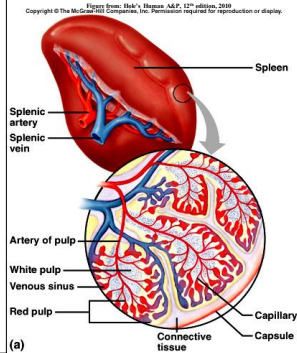
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## Spleen (Lymphatic Organ)

- largest lymphatic organ
- upper left abdominal quadrant
- sinuses filled with blood – more difficult to stop bleeding if injured
- white pulp
  - lymphocytes
- red pulp
  - red blood cells
  - lymphocytes
  - macrophages
- filters blood
- destroys worn out RBCs



14

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## Body Defenses Against Infection

- **pathogen**
  - disease causing agent
  - bacteria, viruses, etc
- **innate (nonspecific) defenses**
  - general defenses
  - protects against many pathogens
- **adaptive (specific) defenses**
  - immunity
  - more specific
  - carried out by lymphocytes

What name do we give to an organism that lives harmlessly within a host and may or may not benefit it?

15

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## Innate (Nonspecific) Defenses

- **Species Resistance**
  - resistance to certain diseases to which other species are susceptible
- **Mechanical Barriers**
  - skin
  - mucous membranes
- **Chemical Barriers**
  - enzymes in various body fluids
  - pH extremes in stomach
  - high salt concentrations
  - **interferons**
  - **defensins**
  - **collectins**
- **Natural Killer Cells**
  - type of lymphocyte
  - lysis of virally-infected cells and cancer cells
- **Phagocytosis**
  - neutrophils
  - monocytes
  - macrophages
  - ingestion and destruction of foreign particles
- **Complement System**
  - 'complements' the action of antibodies
  - helps clear pathogens

These are not specific to a particular pathogen

16

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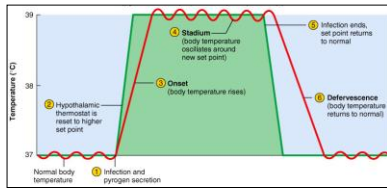
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## Innate Defenses (continued)

- **Inflammation**
  - tissue response to injury
  - helps prevent spread of pathogen
  - promotes healing
  - blood vessels dilate
  - capillaries become leaky
  - white blood cells attracted to area
  - clot forms
  - fibroblasts arrive
  - phagocytes are active
- **Fever**
  - inhibits microbial growth
  - increases phagocytic activity



These are not specific to a particular pathogen

17

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## Adaptive (Specific) Immunity

- resistance to particular pathogens or to their toxins or metabolic by-products
- \*\* based on the ability of lymphocytes to distinguish "self" from "non-self"
- antigens elicit immune responses
- **Adaptive (Specific) Immunity demonstrates:**
  - 1) specificity and 2) memory

Antigens are substances capable of eliciting an immune response

18

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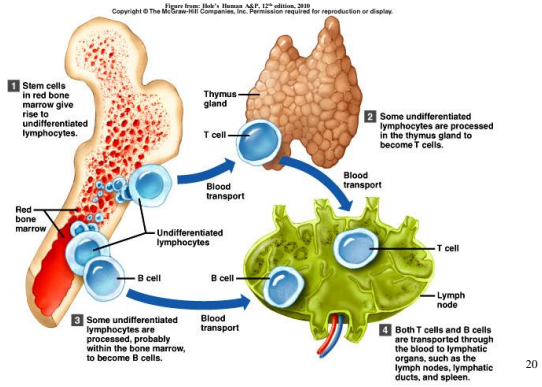
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## Lymphocyte Origins



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## Lymphocyte Functions

- **T cells**
  - secrete **lymphokines**
    - help activate T cells
    - cause T cell proliferation
    - activate cytotoxic T cells
    - stimulate leukocyte production
    - stimulate B cells to mature
    - activate macrophages
  - secrete toxins that kill cells
  - secrete growth-inhibiting factors
  - secrete interferon
  - **cellular immune response**
- **B cells**
  - differentiate into **plasma cells**
    - produce **antibodies**
  - **humoral immune response**

**Lymphocytes constitute about 25-30% of circulating leukocytes**

21

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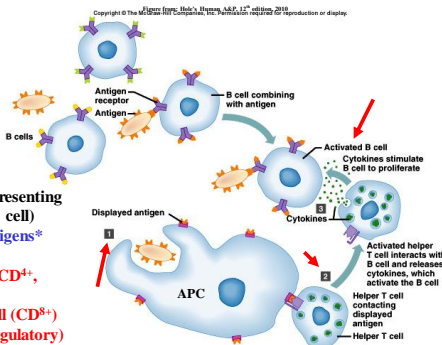
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## T Cell and B Cell Activation

You should know the steps (1-3; see arrows) on this slide...



- requires antigen-presenting cell (APC; dendritic cell)
- requires **MHC antigens\***
- types of T cells
  - **helper T cell (CD<sup>4+</sup>, shown)**
  - **cytotoxic T cell (CD<sup>8+</sup>)**
  - **suppressor (regulatory) T cell**
  - **memory T cell**

\*MHC = Major Histocompatibility Complex

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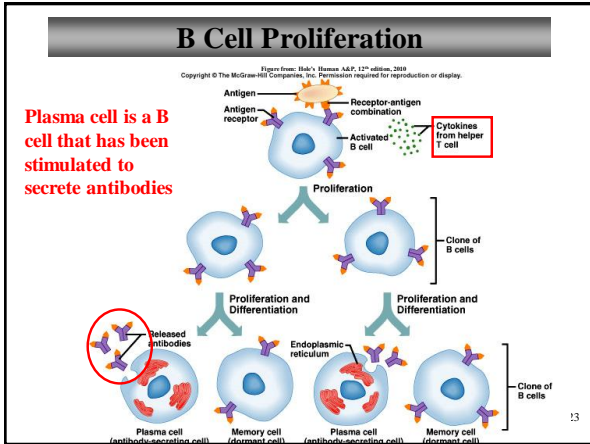
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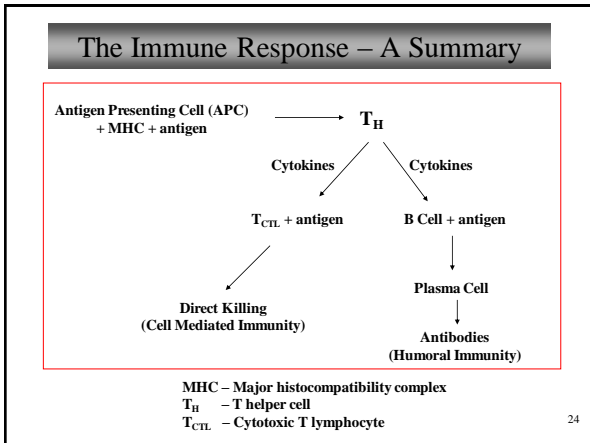
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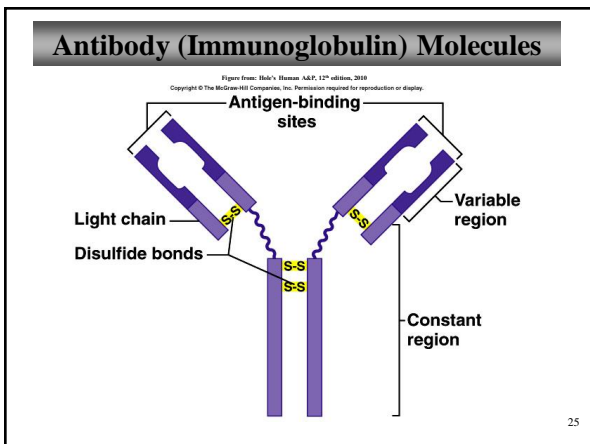
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## Types of Immunoglobulins (Ig)

Immunoglobulins are the 'gamma globulins' in plasma

### IgM

- located in plasma
- reacts with naturally occurring antigens on RBCs following certain blood transfusions
- **activates complement**

### IgG

- located in tissue fluid and plasma
- **activates complement**
- defends against bacteria, viruses, and toxins
- **can cross the placenta**

### IgA

- located in **exocrine gland secretions**
- defends against bacteria and viruses

26

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## Types of Immunoglobulins

### IgD

- located on surface of most B lymphocytes
- plays a role in B cell activation

### IgE

- located in exocrine gland secretions
- promotes **inflammation and allergic reactions**

### Actions of Antibodies (Ig)

- **agglutination**
- **precipitation**
- **neutralization**
- **activation of complement**

27

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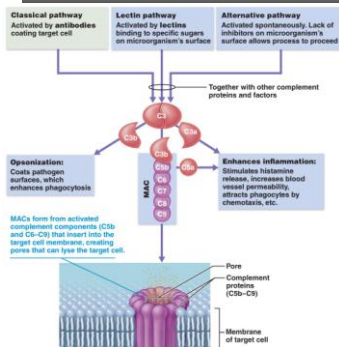
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## The Complement Cascade



Activation of the complement cascade stimulates inflammation, attracts phagocytes, and enhances phagocytosis

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Figure from: Marieb & Hoehn, *Human Anatomy & Physiology*, Pearson, 2012

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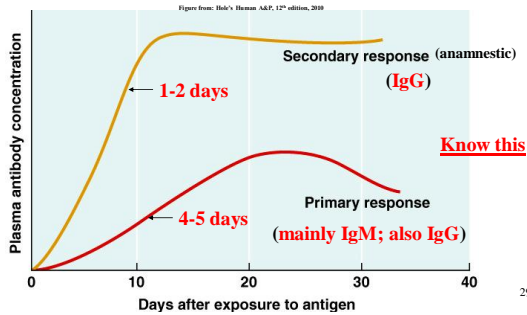
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## Immune Responses

A primary immune response produces a lesser concentration of antibodies than does a secondary immune response




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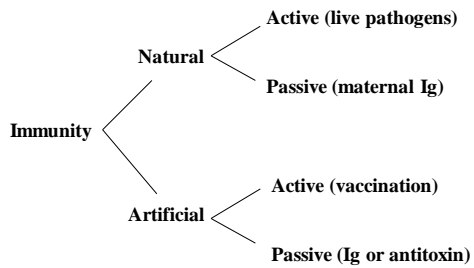
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## Practical Classification of Immunity




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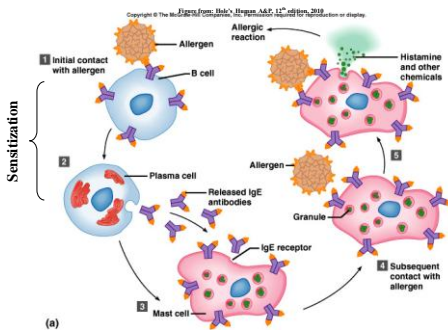
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## Allergic Response



Anaphylaxis is a severe allergic reaction involving the whole body caused by histamine release.

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## Allergic (Hypersensitivity) Reactions

- **Type I**
  - immediate-reaction allergy - **anaphylactic shock**
- **Type II**
  - antibody-dependent cytotoxic reaction
  - takes 1-3 hours to develop
  - transfusion reaction
- **Type III**
  - immune-complex reaction
  - takes 1-3 hours to develop
- **Type IV**
  - delayed-reaction allergy
  - results from repeated exposure to allergen
  - eruptions and inflammation of the skin
  - takes about 48 hours to occur

32

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## Transplantation and Tissue Rejection

### Transplanted tissues

- corneas
- kidneys
- livers
- pancreases
- hearts
- bone marrow
- skin

### Tissue rejection reaction

- resembles cellular immune response against antigens
- **important to match MHC antigens**
- immunosuppressive drugs used to prevent rejection

### Types of grafts (transplantation)

- **Isograft** – identical twin
- **Autograft** – self graft
- **Allograft** – same species
- **Xenograft** – different species

33

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## Autoimmunity

Table from: Rakic, Bruce M.D. 17<sup>th</sup> edition, 2009  
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Disorder	Symptoms	Antibodies Against
Glomerulonephritis	Lower back pain	Kidney cell antigens that resemble streptococcal bacteria antigens
Graves disease	Restlessness, weight loss, irritability, increased heart rate and blood pressure	Thyroid gland antigens near thyroid-stimulating hormone receptor, causing overactivity
Type I diabetes mellitus	Thirst, hunger, weakness, emaciation	Pancreatic beta cells
Hemolytic anemia	Fatigue and weakness	Red blood cells
Multiple sclerosis	Weakness, incoordination, speech disturbances, visual complaints	Myelin in the white matter of the central nervous system
Myasthenia gravis	Muscle weakness	Receptors for neurotransmitters on skeletal muscle
Pernicious anemia	Fatigue and weakness	Binding site for vitamin B on cells lining stomach
Rheumatic fever	Weakness, shortness of breath	Heart valve cell antigens that resemble streptococcal bacteria antigens
Rheumatoid arthritis	Joint pain and deformity	Cells lining joints
Systemic lupus erythematosus	Red rash on face, prolonged fever, weakness, kidney damage	DNA, neurons, blood cells
Ulcerative colitis	Lower abdominal pain	Colon cells

- **Basis of autoimmunity: Inability to distinguish “self” from “non-self” with an immune response generated against self**

34

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## Life-Span Changes

- immune system declines early in life when thymus gland shrinks
- higher risk of infections
- antibody response to antigens becomes slower
- IgA and IgG antibodies increase
- IgM and IgE antibodies decrease

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## Clinical Application

### Immunity Breakdown: AIDS

- Symptoms include: recurrent fever, weakness, weight loss, recurrent opportunistic infections
- caused by HIV (human immunodeficiency virus)
- HIV impair macrophages and helper T cells
- later in infection, HIV impairs cytotoxic T cells
- HIV mutates quickly
- immune system cannot keep up with HIV

36

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## Review

- Major functions of the lymphatic system
  - Return excess tissue fluid to circulation
  - Absorption of intestinal fats (lacteals)
  - Protection against infection
- The vessels of the lymphatic system include
  - Capillaries – small, closed-ended
  - Vessels – similar to veins but thinner; lead to LN; have valves
  - Trunks – Collect lymph from vessels; lead to LN; named after the region they serve
  - Collecting ducts
    - Thoracic duct
    - Right lymphatic duct

37

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### Review

- Lymph is similar to plasma, without the plasma proteins
- Lymph movement is promoted by the same things that promote movement of blood in veins
  - Action of skeletal muscles
  - Breathing mechanism
  - Constriction of lymphatic vessels
  - Collecting ducts

38

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### Review

- Lymph nodes filter the lymph and serve as an early warning system for pathogens
  - The structural unit of the LN is the nodule
  - Some tissues contain isolated nodules
- Lymph nodes are usually located in chains
  - Cervical, axillary, inguinal, pelvic, abdominal, thoracic, and supratrochlear
- The thymus is the site of 'education' of T lymphocytes
- The spleen is the filter of the blood

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### Review

- A pathogen is a disease-causing organism
- Body defenses are of two types
  - Innate or non-specific
    - Species resistance, mechanical barriers, chemical barriers, fever, NK cells, inflammation, phagocytosis
    - Not pathogen-specific
  - Adaptive or specific
    - Confers immunity to a specific pathogen
    - Mediated by T cells, B cells, and antigen-presenting cells
    - Relies on discrimination of 'self' from 'non-self'

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## Review

- **T cells**
  - Participate in cell-mediated immunity
  - Provide help (factors) for production of Ig by B cells
  - Are educated in the thymus
- **B cells**
  - Participate in humoral (antibody-mediated) immunity
  - Produce immunoglobulins (antibodies) that are specific for one particular antigen
    - IgM, IgG, IgA, IgD, IgE
    - Agglutination, C' activation, Localization of infection
  - Usually require help from T cells

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## Review

- **Immune responses can be**
  - **Primary**
    - 4 or 5 days to develop
    - Usually IgM
  - **Secondary**
    - 1 or 2 days to develop
    - Usually IgG or IgA
- **Immunity can be classified as**
  - **Natural or artificial**
  - **Passive or active**

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## Review

- **Allergic reactions**
  - Immune responses against non-harmful substances
  - Can be classified as **Type I, II, III, IV**
- **Transplantation**
  - **Isograft, autograft, allograft, or xenograft**
  - Important to match MHC antigens closely
- **Autoimmunity**
  - Failure of immune system to distinguish self from non-self
  - Cross-reactivity, failure of T-cell education, pathogens hijacking self proteins, persistence of fetal cells in body

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