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Lymphatic System, Notes

I. Overview

A. Lymphatic vessels carry lymph, any fluid in the vessel.
   1. Blood leaks out of its vessels occasionally.

B. Lymph nodes – specialized swelling where lymph vessels are filtered
   1. Filters out pathogens and other potentially harmful microbes
   2. Swelling occurs during infection
   3. Protects humans from pathogens and other foreign invaders
   4. Three lines of defense: first, second, and third

C. Drains into the circulatory system

II. First Line of Defense

A. Nonspecific and universal for all pathogens

B. Skin – oily and acidic (pH from 3-5) secretions from sweat glands

C. Antimicrobial proteins – in saliva, tears, and other mucous membrane (i.e. lysozyme breaks down bacterial cell walls)

D. Cilia – sweep lungs

E. Gastric juices – secreted by the stomach; kills most microbes

F. Symbiotic bacteria – inhabit and outcompete other microbes that are potentially damaging

III. Second Line of Defense

A. Nonspecific and universal for all pathogens

B. Phagocytes – white blood cells that engulf pathogens by phagocytosis
   1. Neutrophils – 60-70% white blood cells; leave blood and enter infected tissue via amoeboid movements
      (1) Self-destruct after confronting pathogens
   2. Monocytes – 5% of white blood cells; transform into macrophages upon entering infected tissue
   3. Eosinophils – 1.5% of white blood cells; limited activity but have destructive enzymes in their cytoplasmic granules
      (1) Attack larger invaders such as parasitic worms where they secrete their enzymes for the granules
   4. Natural killer cells (NK cells) – attack irregular somatic cells rather than the pathogens themselves

C. Complement – group of twenty proteins which lure phagocytes to foreign cells

D. Interferons – substances secreted by infected cells which help healthy cells protect themselves

E. Inflammatory response – nonspecific response to pathogens
   1. Histamine – substance secreted by basophils, leukocytes in connective tissued, and mast cells which are located in connective tissue
   2. Histamine stimulates vasodilation, blood vessel dilation, which increases blood flow to the infected area and facilitates movement for white blood cells
      (1) Blood flow increases to area of pathogen
      (2) Blood clotting hinders the pathogens' ability to move throughout the body.

(3) Pyrogens – molecules secreted by white blood cells to increase body temperature

IV. Third Line of Defense: Immune Response

A. Responds to antigens molecules that can be identified as foreign; specific
B. Effector cells – cells that defend the body in an immune response
C. Major Histocompatibility Complex (MHC) – collection of glycoproteins, carbohydrates that protrude from the cellular membrane, which allows the immune system to differentiate between self and nonself cells
   1. MHC determined by twenty different genes
   2. Class I MHC – on almost all somatic cells
   3. Class II MHC – only on macrophages and B lymphocytes
D. Lymphocytes – white blood cells that concentrate in lymphatic tissues (i.e. lymph nodes, thymus gland, spleen)
   1. B cells – originate and mature in bone marrow
      (1) Have antibodies – specialized antigen receptors
         (a) Immunoglobulins – antibodies; five classes (IgA, IgD, IgE, IgG, IgM)
         (b) Y-shaped with constant and variable regions which have different amino acid differences for specialized for different antigens
         (c) Epitope – localized region on the surface of the antigen onto which antibodies latch onto; multiple epitopes means multiple antibodies for that antigen
      (2) Antibodies inactivate antigens via binding; followed by macrophage phagocytosis
      (3) Binding to surface antigens of nonself cells stimulates complements to bring about lysis of the pathogens
      (4) Different Types of B Cells
         (a) Plasma cells – B cells that release specific antigens which circulate thoughout the blood binding to antigens
         (b) Memory cells – perpetual B cells that release antibodies in response to invasion by the same antigen
   2. T cells – originate in bone marrow but mature in the thymus gland
      (1) Function by recognizing molecules markers rather than specific antigens
      (2) Infected cell displays abnormal pattern of markers so interpreted as nonself; includes tumors
      (3) Different Types of T Cells
         (a) Cytotoxic T cells – puncture nonself cells causing them to lyse
         (b) Helper T cells – aid in the proliferation of B cells and cytotoxic T cells
E. Clonal selection – antigen binding to B cell or nonself cell binding to T cell causes a rapid division of the B/T cell which are identical copies of the primary cell
   1. Cell-mediated response – T cell response
      (1) Nonself cell binds to T cell and clonal selection follows
      (2) Cytotoxic T cells – lyse the nonself cells

(a) Recognize class I MHC markers
(b) Perforin – protein which forms an open lesion on the infected cell's membrane

(3) Helper T cells – bind to macrophages with ingested nonself cells
(a) Cytokine – secreted molecule by a cell as a regulator of neighboring cells
(i) Interleukin-1 – cytokine secreted by the macrophage which stimulates interleukin-2
(ii) Interleukin-2 – stimulates the helper T cell to grow and divide more rapidly which increases the interleukin-2 supply as well as the helper T cell supply
(b) Positive feedback – amplification of interleukins, macrophages, helper T cells, B cells, and cytotoxic T cells

2. Humoral response (antibody-mediated response) – response to circulating antigens or pathogens in lymph or blood
(1) B cells produce plasma cells which release antibodies to bind with antigens or antigen-containing pathogens
(a) T-dependent antigens – stimulate antibody production with T cell involvement
(i) Macrophages engulf antigens or antigen-bearing pathogen
(ii) Antigens are presented
(iii) Helper T cells bind to macrophages in cell-mediated response and interleukins secreted by the helper T cells stimulate the production of plasma B cells
(iv) Production of antibodies
(b) T-independent antigens – without macrophage or T cell involvement
(i) Long chains of repeating units usually
(ii) Weaker response to these antigens
(2) B cells produce memory cells

V. Complement System

A. Antibody-Dependent

1. Antibodies lock onto antigens.
2. Complement proteins attach to a pair of antibodies.
3. Activated complement protein attach in a cascading fashion (step-by-step) forming a membrane attack complex.
4. Lysis follows

B. Antibody-Independent

1. Microbial substances are able to activate complements.
2. Histamine-containing cell – lysis can trigger inflammation

C. Opsonization

1. Complements attach to the invaders, so they stimulate phagocytes to ingest them.

VI. Supplemental Immunity

A. Antibiotics – substances derived from microbes successful in combating other microbes

B. Vaccines – inactivated fragments of pathogens are injected into the blood and an immune response will wipe out the fragments while retaining immunity
C. Passive immunity – transferring antibodies from an immune person to an non-immune person
    1. Antibodies are transferred to newborns in the placenta and through breast milk