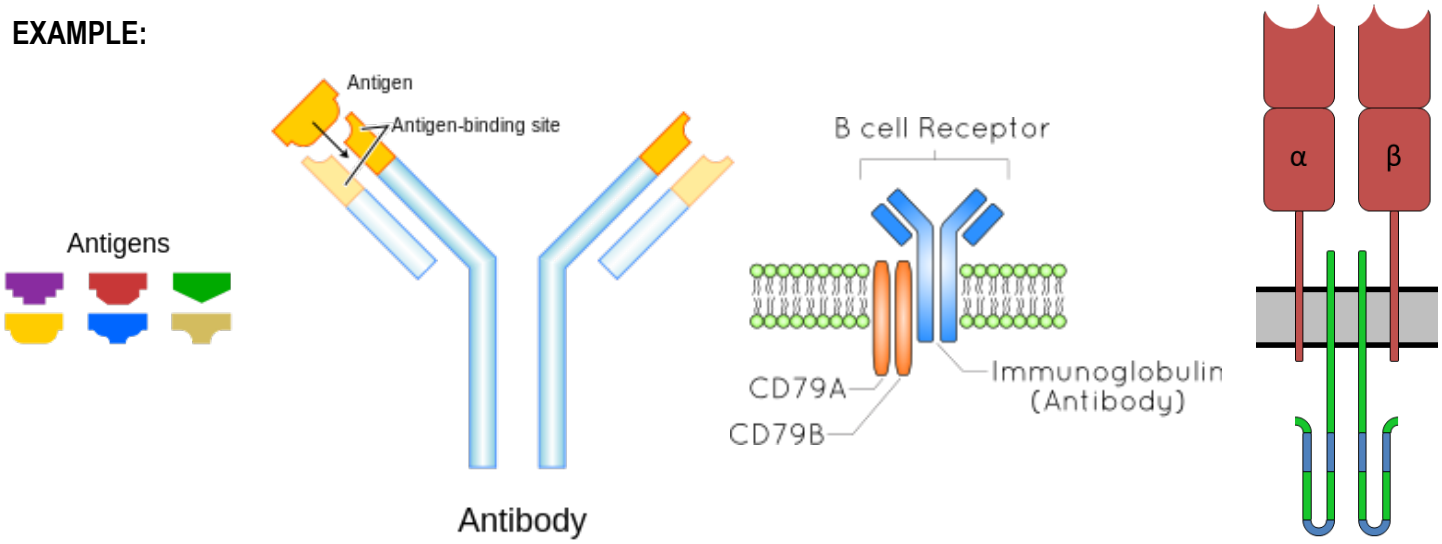
CONCEPT: ADAPTIVE IMMUNITY

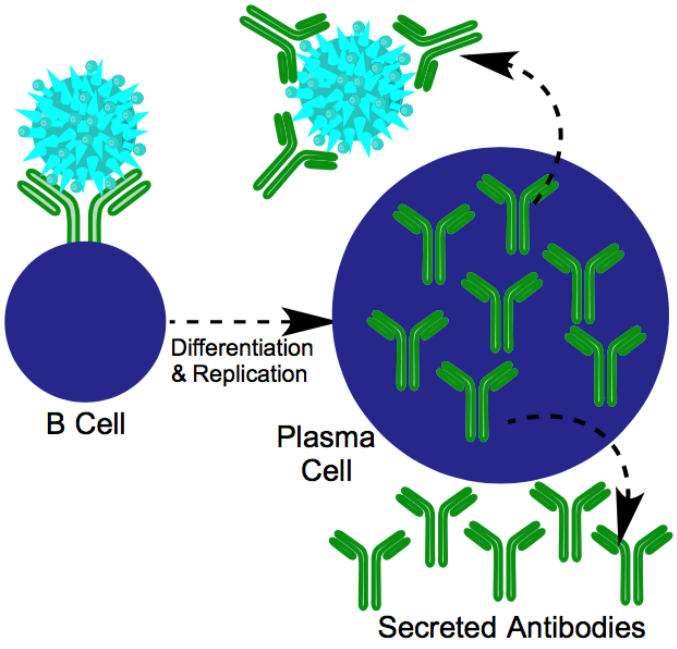
- ***Antigen*** – molecules that produce an immune response
    - □ ***Epitope*** – part of antigen that's recognized by immune system, to which antibodies and antigen receptors bind
- ***Antigen receptor*** – membrane protein found on B and T cells that bind to antigens
    - □ Recognition of the pathogen occurs when B and T cells bind antigens
- ***Antibody*** – Y-shaped protein produced by B cells that bind to antigens

EXAMPLE:



- ***Adaptive immune response*** – antigen-specific response that occurs after antigen has been processed and recognized
    - □ Specificity: components of the adaptive immune system only bind to specific sites on specific antigens
    - □ Adaptability: recognizes an almost infinite diversity of antigens
    - □ Memory: adaptive immune response can be reactivated if a pathogen from a previous infection is recognized
    - □ Self-nonself recognition: molecules produced by the organism don't act as antigens

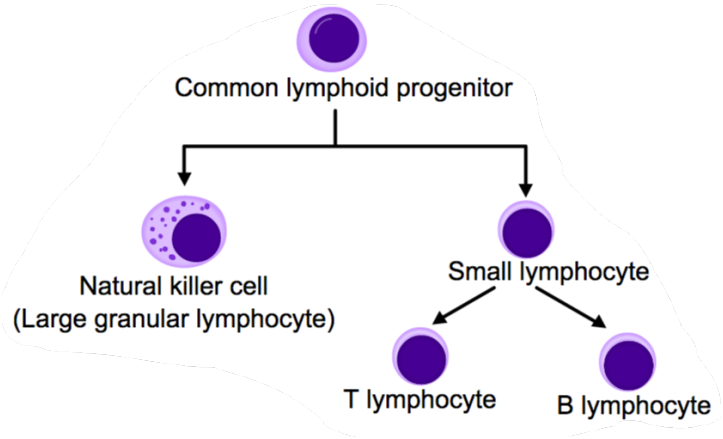
EXAMPLE:



CONCEPT: ADAPTIVE IMMUNITY

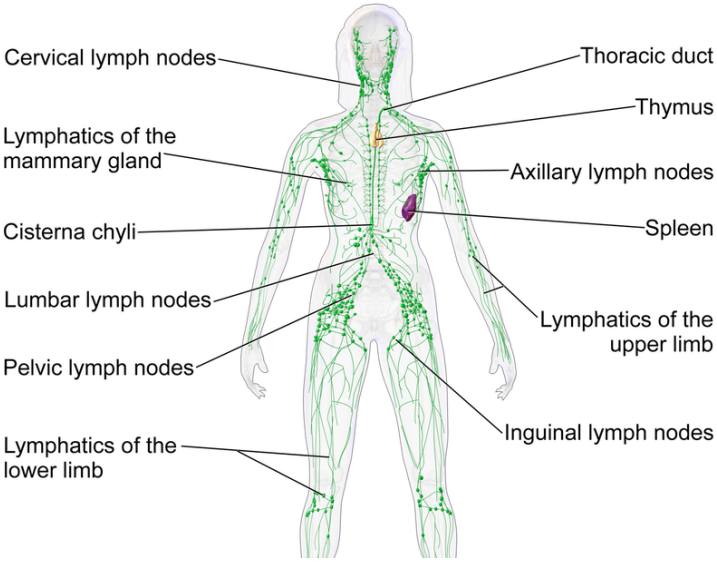
- ***Adaptive immune system*** – specialized cells that defend against specific pathogens
    - □ ***Lymphocytes*** – the main type of cell found in lymph, includes natural killer, T, and B cells
        - ***T cells*** – involved in cell-mediated response, help destroy infected cells
        - ***B cells*** – involved in humoral response, produce antibodies that recruit immune cells to fight pathogens

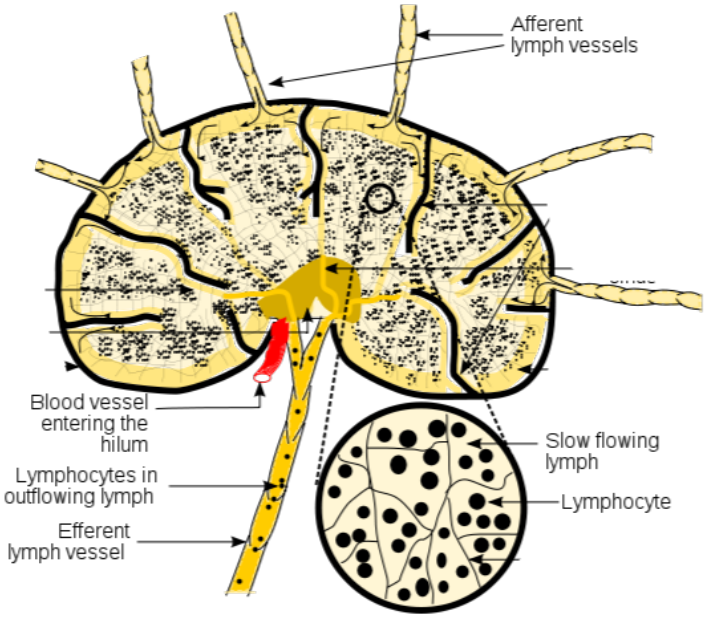
EXAMPLE:



- Lymphocytes are produced in the bone marrow, stem cell-containing tissue found in the hollows of bones
    - □ T cells mature in the thymus
    - □ B cells mature in the bone marrow
- Lymphocytes circulate through the blood, lymphatic system, and spleen and are activated by antigens
    - □ Spleen filters blood, lymph nodes filter lymph
    - □ Mucosal-associated lymphoid tissue (MALT) – immune system cells found in gut and respiratory organs

EXAMPLE:

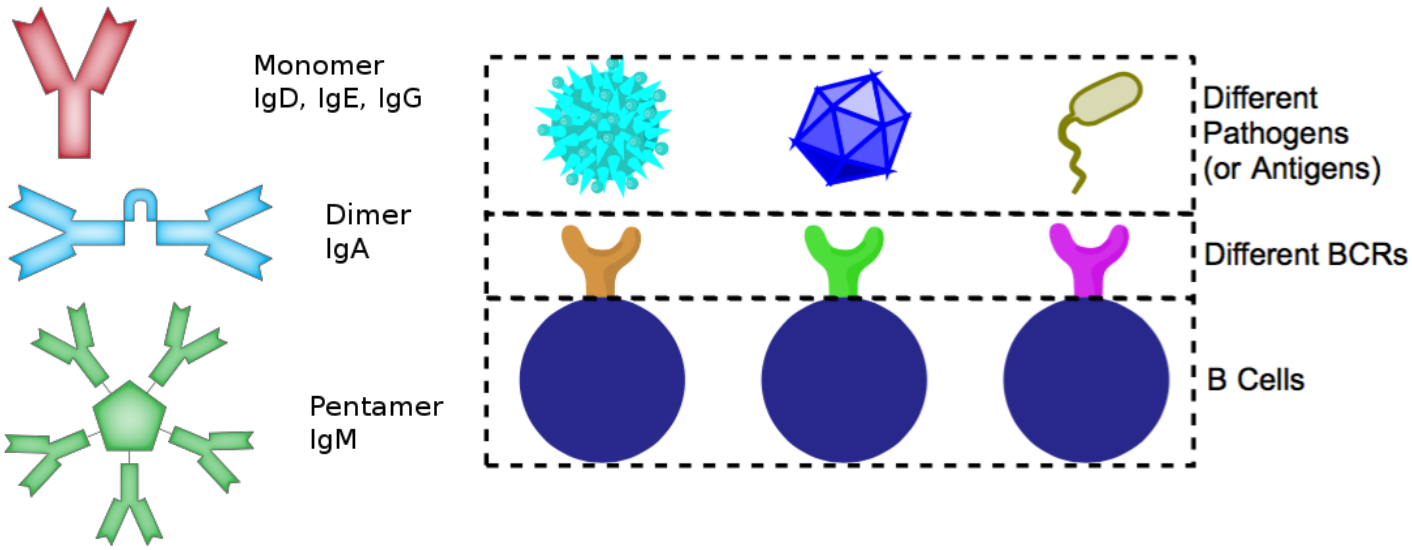




CONCEPT: ADAPTIVE IMMUNITY

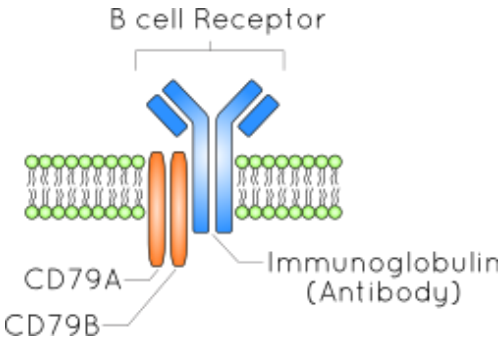
- Each T and B cell has a single type of antigen receptor specific to a single type of antigen
- ***Immunoglobulins*** (Ig) – class of proteins include antibodies and B-cell receptors
    - □ Five classes: IgG, IgD, IgE, IgA, and IgM, each isotype has a unique heavy chain and function

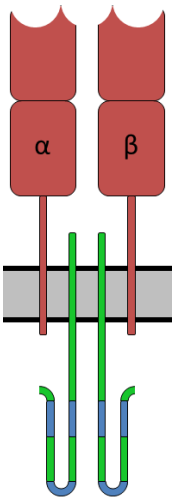
EXAMPLE:



- ***B-cell receptor*** (***BCR***) – same structure as antibodies produced by B cells, made of 2 heavy chains and 2 light chains
    - □ ***Light chain*** – smaller polypeptide
    - □ ***Heavy chain*** – larger polypeptide
    - □ BCR will have same molecular structure as the antibodies it produces, but with a trans membrane domain
- ***T-cell receptor*** (***TCR***) – similar in structure to one of the arms of an Ig, made of α chain and β chain
    - □ BCR bind directly to antigens, but TRC only bind to antigens that are presented on the surfaces of other cells

EXAMPLE:

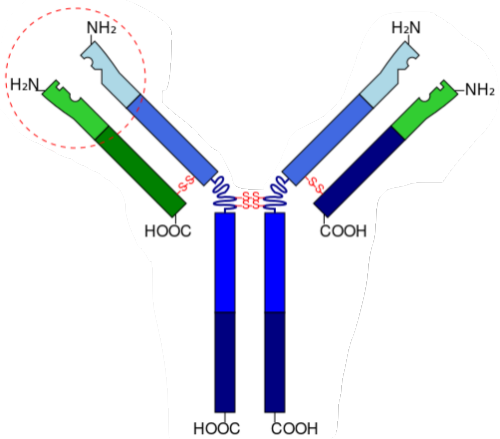




CONCEPT: ADAPTIVE IMMUNITY

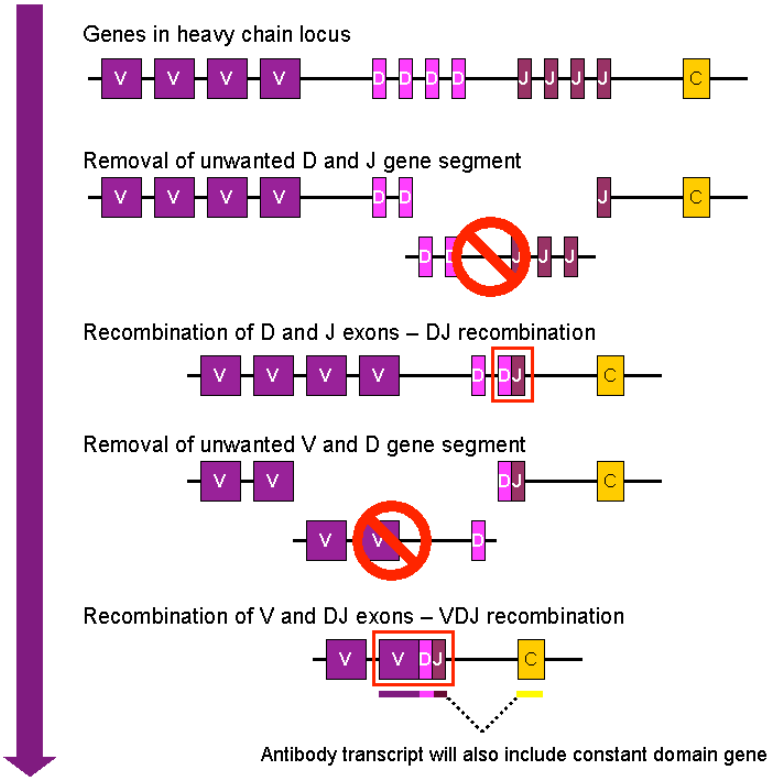
- A single antigen can have many different epitopes in its structure
- BCR bind to epitopes on complete antigens, but TCR bind to epitopes that have been processed and presented
- ***Constant regions*** – parts of the light and heavy chains, and α and β chains that will be the same in each isotype
- ***Variable regions*** – parts of light and heavy chains, and α and β chains that will be different in different cell types

EXAMPLE:



- Genes for antigen receptors include many V regions, and other regions that recombine to produce their unique structures
  - □ Light chain has 40 V regions, and 5 Joining segments, leading to 200 possible combinations
  - □ As lymphocytes mature, genetic recombination of the various regions results in unique antigen receptors
  - □ Genetic recombination forms the basis of the specificity and flexibility of the adaptive immune system
- If maturing B and T cells have antigen receptors that bind to self molecules, they are destroyed or deactivated

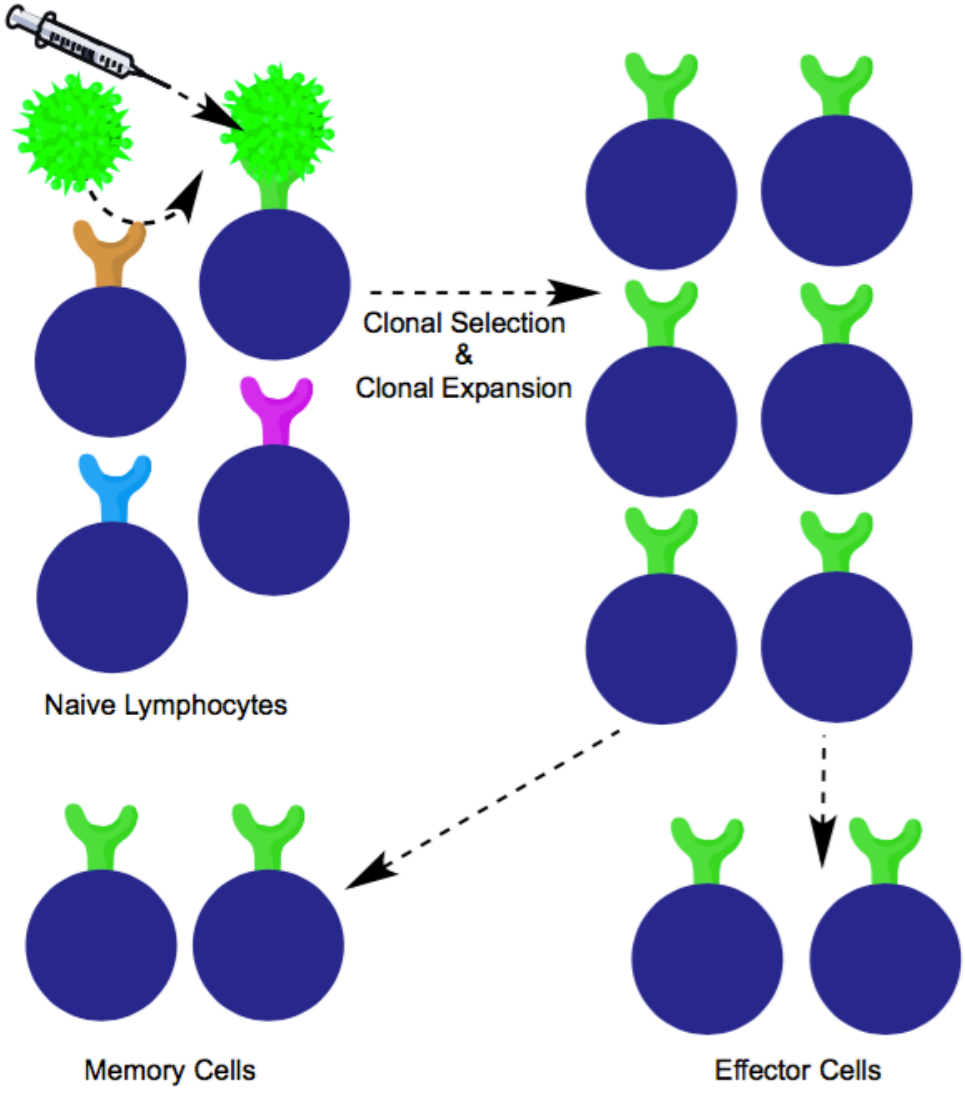
EXAMPLE:



CONCEPT: ADAPTIVE IMMUNITY

- Lymphocytes flow through the lymphatic system, blood, and spleen, some will hang around the skin and MALT
    - □ Lymphocytes are in inactive state, until they encounter an antigen they can bind
        - Cells will eventually die if they do not encounter the proper epitope
- ***Clonal selection theory*** – antigens select lymphocytes to divide into a clonal population
    - □ Lymphocytes are activated when they encounter an antigen with an epitope they can bind
        - ***Naïve lymphocyte*** – mature lymphocyte that hasn't been exposed to an antigen
    - □ Activated lymphocytes make many clones which will become effector cells and memory cells
- ***Effector cells*** – short-lived cells that take immediate action against pathogens
- ***Memory cells*** – longer-living cells that continue to divide at a low rate, used to fight future infections

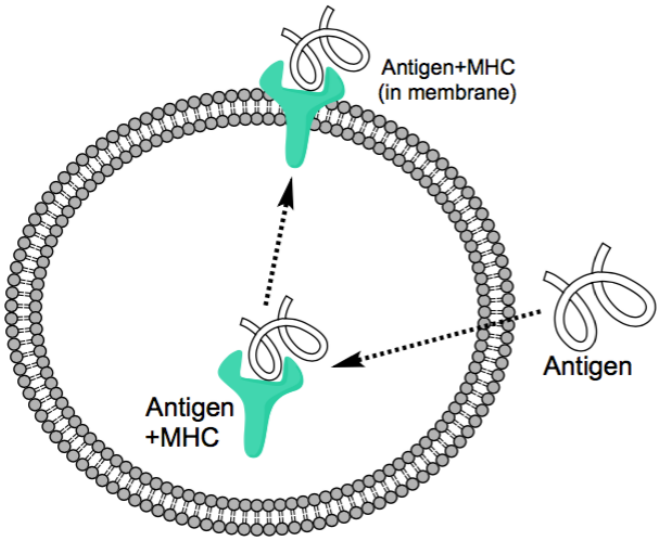
EXAMPLE:



CONCEPT: ADAPTIVE IMMUNITY

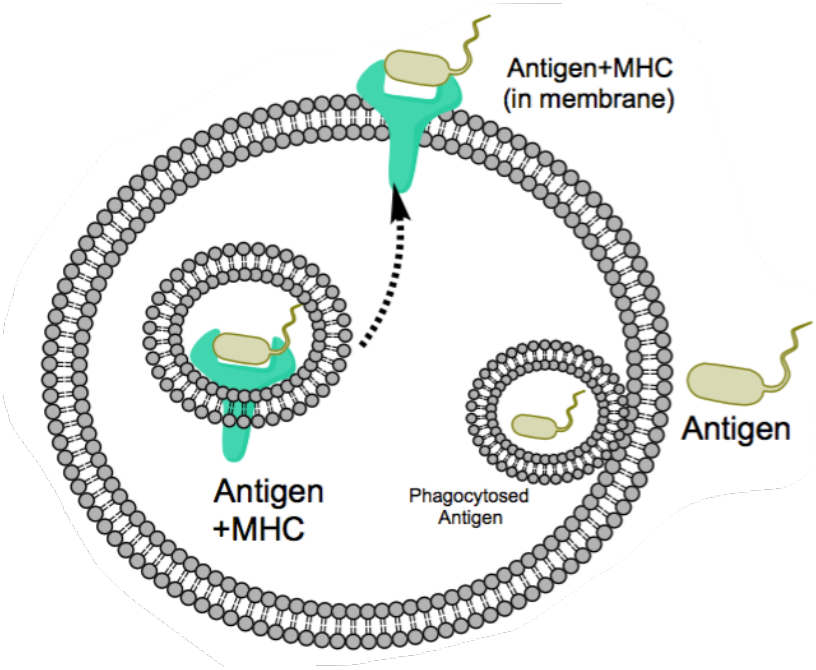
- ***Major histocompatibility complex*** (***MHC***) – cell surface proteins that display antigens
  - □ ***Antigen presentation*** – displaying antigens at cell surface using MHC proteins
  - □ ***MHC class I*** – expressed by all cells of the body to display antigens found inside the cell
    - Alerts the immune system to an infection inside a cell
    - Organ transplants are rejected by the immune system because cells display different MCH I proteins

EXAMPLE:



  - □ ***MHC class II*** – expressed by antigen presenting cells, displaying antigens found and collected outside the cell
    - ***Antigen-presenting cells*** – dendritic cells, macrophages, and B cells
- Dendritic cells link the innate and adaptive immune system through antigen presentation
  - □ Phagocytose antigens, degrade them in endosome, and present their fragments with MCH class II proteins

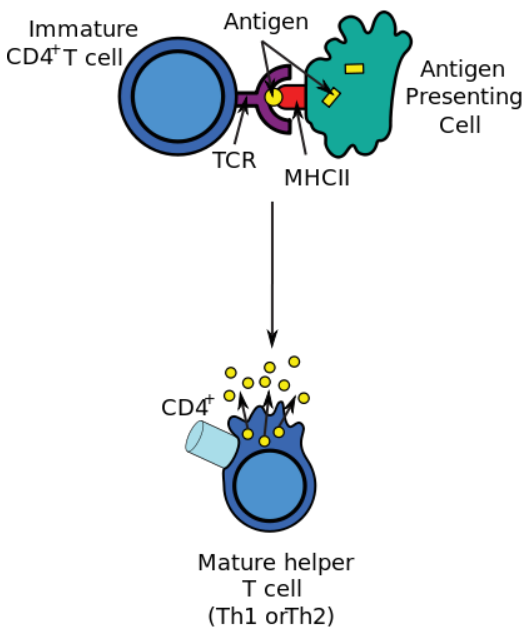
EXAMPLE:

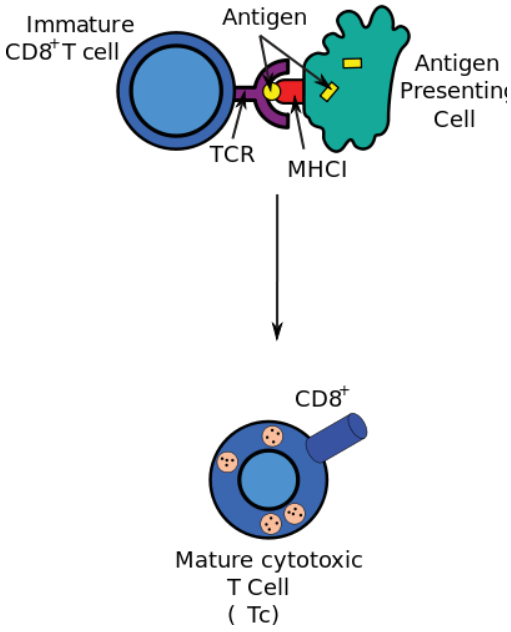


CONCEPT: ADAPTIVE IMMUNITY

- T cells are classified as $CD4^+$ or $CD8^+$ based on the presence of a CD4 or CD8 protein, respectively
  - □ ***$CD4^+$ T cells*** – interact with epitopes bound to MHC class II proteins found on antigen-presenting cells
    - Activated $CD4^+$ T cells undergo clonal expansion to form helper T cells
  - □ ***$CD8^+$ T cells*** – interact with epitopes bound to MHC class I proteins found on most cells
    - Activated $CD8^+$ T cells undergo clonal expansion to form cytotoxic T cells

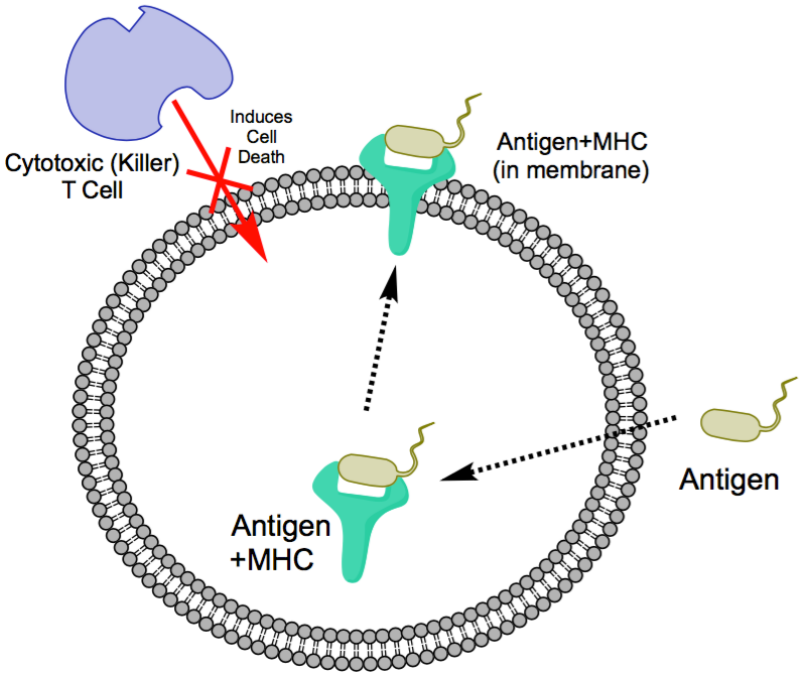
EXAMPLE:





- ***Cytotoxic T cells*** (***T_C***) – effector T cells that kill pathogen-infected cells, defensive measure against pathogen

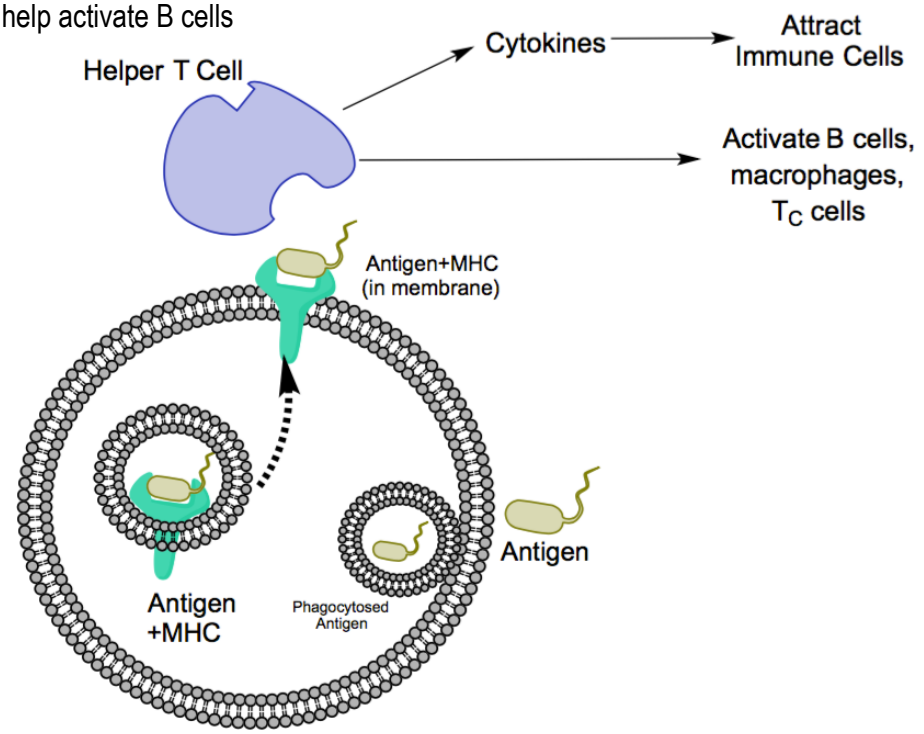
EXAMPLE:



CONCEPT: ADAPTIVE IMMUNITY

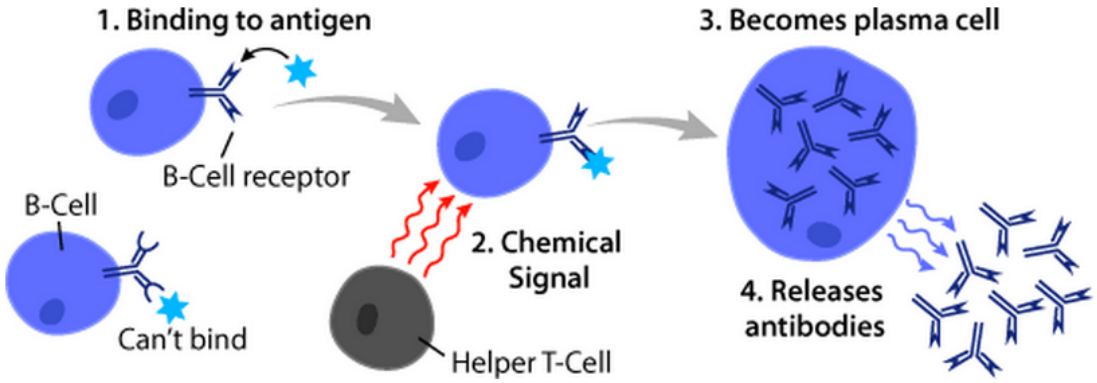
- ***Helper T cells*** (***T_H***) – effector T cells that help with the activation of other immune cells, and secrete cytokines
  - □ ***T_H1 cells*** – help activate cytotoxic T cells
  - □ ***T_H2 cells*** – help activate B cells

EXAMPLE:



- B cell activation occurs when BCRs interact with free-floating antigens in lymph or blood
  - □ Bound antigen is ingested, digested, attached to MHC class II, and transported to the cell surface
  - □ Activated T_H2 cells with complementary receptors to displayed antigen will bind to B cells
    - T_H2 cell activated by interaction with B-cell causing it to release cytokines that stimulate the B cell
  - □ Fully activated B cell replicates, generating effector and memory cells
    - Somatic hypermutation allows replicating B cells to fine tune their receptor to bind the antigen better
  - □ ***Plasma cells*** – effector B cells that produce massive amounts of antibodies and secrete them into the blood

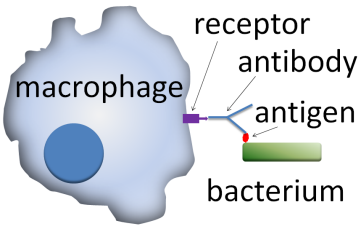
EXAMPLE:

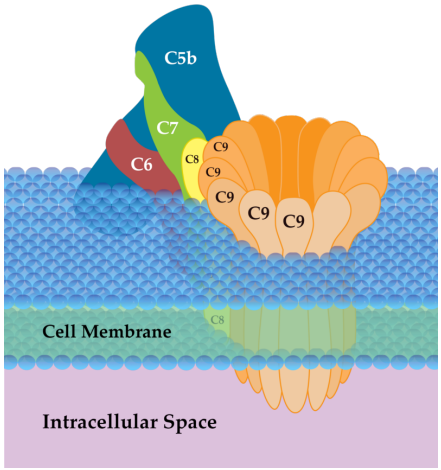


CONCEPT: ADAPTIVE IMMUNITY

- Opsonization – pathogens with bound antibodies are more easily targeted and removed by macrophages and neutrophils
- Neutralization – pathogens coated in antibodies are prevented from infecting host cells
- Agglutination – antibodies have two binding sites, and may interact with multiple pathogens, leading to clumping
- ***Compliment proteins*** – activated by antibodies and create holes in pathogen membrane

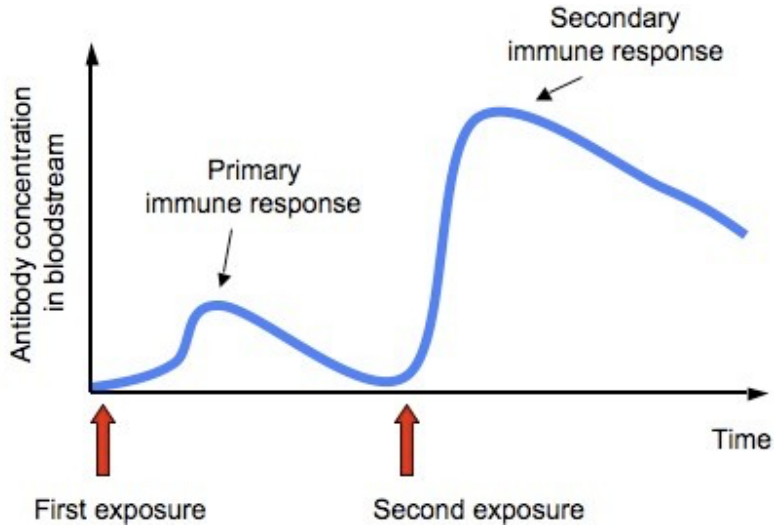
EXAMPLE:





- ***Cell-mediated response*** – occurs primarily through cell-to-cell contact, cytotoxic T cells promoted by T_H1 cells
- ***Humoral response*** – occurs in the blood and lymph, antibodies released from plasma cells promoted by T_H2 cells
- ***Primary immune response*** – first time encountering an infection antibodies are produced in response
- ***Secondary immune response*** – second time encountering an infection, memory cells are activated
    - □ Antibodies are produced more rapidly, and in greater numbers during a secondary immune response
- ***Active immunity*** – producing antibodies as part of a primary or secondary immune response
- ***Passive immunity*** – receiving antibodies produced by another individual, like from mother to fetus

EXAMPLE:



CONCEPT: ADAPTIVE IMMUNITY

- ***Immunization*** – organism's immune system gains defense against a pathogen, usually through vaccination
    - □ ***Vaccination*** – introduction of a vaccine to prime the immune system to deal with later infections of a pathogen
    - □ ***Vaccine*** – biological preparation that contains antigens, often a weakened or killed pathogen
        - Subunit vaccine – contains isolated viral proteins
        - Inactivated virus – damaged virus that contains antigens, but can't cause infection
        - Attenuated virus – infectious virus cultured in species other than host, will not infect host cells
- Monoclonal antibodies – antibodies prepared from a single clone of B cells, specific for the same epitope

EXAMPLE:

- ***Allergies*** – abnormal immune response to an antigen called an allergen
- ***Autoimmunity*** – immune response directed a self molecules and cells of the organism
- ***Human immunodeficiency virus*** (***HIV***) – virus that infects and kills $CD4^+$ T cells and macrophages
    - □ Helper T cells needed for both humoral and cell-mediated response
- ***Acquired immune deficiency syndrome*** (***AIDS***) – severe weakening of the immune system from HIV infection

EXAMPLE: