Immune system

awesomeness

Body defenses

Pathogen causes disease IF

Gains access (skin or portal)

Attaches to host

Evades body defenses

Innate defense

1st - external - skin & mucus ***respiratory, urinary, reproductive system***

2nd - internal - blood & protective cells

Adaptive defense

3rd - lymphocytes

Skin

1st defense (skin & mucus) *activates* the 2nd defense

Epidermis has **dendritic phagocytic cells**

Dermis has ***antimicrobial peptides*** triggered by sugar & protein that
punch holes in cell walls or block enzyme signals
Sweat glands + sebum oil
Lysozyme destroy bacteria cell walls

Mucus Membrane has epithelial (phagocytic dendritic cells)
Stem cells replace mucus cells

Lacrimal apparatus makes & drains tears

Normal microbiota antagonizes microbes by eating nutrients and starve out pathogens and alter the skin's pH levels

Stomach acid digests proteins and blocks pathogen growth

2nd Defense: Blood

Cells

Antimicrobial

inflammation

Blood plasma

Water, electrolytes, gases, nutrients, iron binding proteins (transferrin, ferritin, siderophores)
No clotting factor is **serum**
Complement proteins
antibodies

leukocytes

Stem cells → bone marrow → erythrocytes, platelets, leukocytes

Granulocytes -

Basophils = release inflammatory chemicals
Eosinophils = kill worms & allergies, secrete extracellular toxin, phagocytize
Neutrophils
- Make NETs that trap & kill bacteria
- Release O_2- = bleach = kills pathogens
- Phagocytizes pathogens

Agranulocytes -

Monocytes that mature as traveling Macrophages

Lymphocytes

Dendritic cells:
Wait for microbes
Phagocytize them
Tell adaptive immune cells all about it

phagocytosis

Chemotaxis (chemokines)

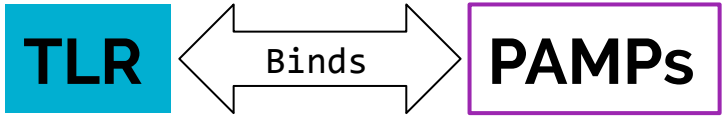
Adhesion (opsonization)

Ingestion (phagosome)

Maturation (phagolysosome)

Killing

Elimination



Protein, a warning system that triggers body immune response

If TLR fails then immune system fails

Initializes defense response

Interferons
Apoptosis
Inflammation
Adaptive immune response

interferons

Non-specific proteins that **block viral replication**

Type 1 = (IFN-**alpha**) made by **macrophages**

= (IFN-**beta**) made by cartilage, **tendons & bone**

Type 2 = (IFN-**gamma**) made by activated T cells & NK cells, regulates the immune system!!!

Complement System proteins = **opsonins** & *indirectly* triggers inflammation + fever

Classical pathway = MAC → lysis

Alternative pathway = factor B, D, P

Lectin pathway = lectin bind to sugar molecule mannose triggering cascade

Adaptive Immunity
3rd defense

Adaptive immunity
5 attributes

Specific action against pathogens

Specific activated response

Cloning of cells

Unresponsive to self (no harm to body)

memory

(ribs + hips)

Lymphocytes resting state = small WBC
Recognize specific pathogens
"Intercellular communication among immune cells"

Bone marrow → mature → B cells — Antibody production

Bone marrow → mature → thymus T cells — Cell mediated immune response

Travels the lymph & blood to move to lymph nodes & spleen

Lymphatic system

1000 lymph nodes
Home to B and T cells (lymphocytes) that attack antigens

Vessels & Cells that move **lymph** 1 way to circulatory system

Lymph plasma fluid from blood vessels moves toxins & pathogens

MATURED lymphocytes from bone & thymus wait for antigens then move to **2nd system**

Lymph nodes

Filter lymph, house lymphocytes, survey & attack invaders

Outer node replicates B cells

spleen

Filter & cleans blood

Deletes bacteria, viruses, toxins

Stores Iron

Tonsils & MALT *(mucus-associated lymphatic tissues)*

trap microbes

Antigens & Epitopes

3D shape foreign microbes, virus, allergens etc that bind to **Lymphocytes** that determine immune response

Antigen Types

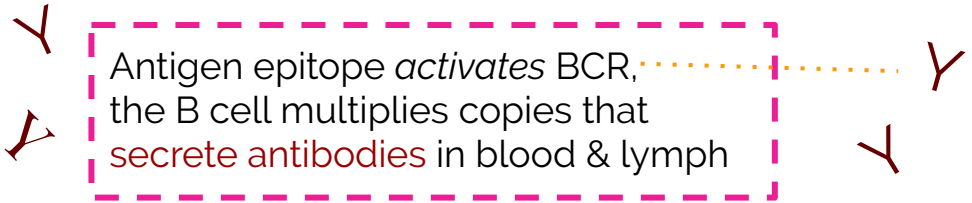
Exogenous = toxins secreted

Endogenous = antigens INSIDE cell

Autoantigen = normal cell process

B Lymphocytes (B cells)

Home = spleen, MALT, lymph nodes and function is to secrete antibodies



B cell randomly makes single BCR in bone marrow (all are identical) BCR recognizes only 1 epitope

B cells fight *particular* epitopes with B Cell Receptors (BCRs) = surface proteins

BCRs are like locksmiths that have every possible copy of a key to fit all locks

Antibody functions

Activate Complement System - IgM binds C1 = Classical pathway ↠ inflammation

Neutralization - IgA neutralizes toxins

Opsonization = antibody action that stimulates **phagocytosis**, IgG binds to antibodies

Oxidation

Agglutination = binding 2+ antigens to basic antibody, ready for phagocytosis or spleen filtering

Antibody Dependent Cell Cytotoxicity (ADCC)
= antibodies bind to NK cells which secrete perforin & granzyme causing apoptosis

Antibody classes

IgM Initial stages of immune response, activates Complement System inflammation

IgG Most common & long lasting, does all functions. Crosses the placenta wall

IgA Made by tear ducts, mammary glands & mucus membrane. Protects GI, respiratory, urinary, etc

IgE Signal molecule that attaches to eosinophils and triggers basophils to release histamine

IgD Not secreted but are antigen receptors on B cells, much like BCR

Thymus Cells

TCR randomly select parts of DNA to make new gene

TCR binds to shapes (epitopes) with MHC protein

T cell attack antigens directly = cell mediated immune response

Types

Cytotoxic T (CD8) - directly kill viruses & cancer cells

Helper T cells (CD4) - assist B cell regulation, help cytotoxic T cells with signals & growth factors and secrete **cytokines** proteins that regulate immune response

Regulatory T cells - repress immune response, block autoimmune disease

Clonal deletion of T Cells

Body eliminates self-reactive lymphocytes

Young T cells spend a week in the thymus and are exposed to all of body's natural epitopes

IF T cells don't identify the body's MHC proteins
Then
apoptosis

If they do, they get stamp of approval for recognizing antigens

Leave thymus and travel blood & lymph

Clonal deletion of B Cells

B cells in bone marrow

Self reactive B cells may be

Inactive which then get killed by apoptosis

or

Change BCR which then get killed by apoptosis

Self tolerant B cells leave the bone and move to the spleen for maturity then travel blood & lymph

Mature B & T cells travel the blood & lymph checking for antigens communicating by **cytokines**

Cytokine proteins that act as **intercellular messengers** secreted by various leukocytes

Cytotoxic T Cells only respond to cytokines when signalled

Cytokines

5 types

Interleukins

Leukocytes signal

Interferons

Block viral replication
IFN-Gamma made by Helper T cell that phagocytizes

Growth factor

Stimulate leukocytes to divide, ensures WBC supply

Tumor necrosis factor

Made by macrophage & T cells to kill tumors & regulate immune sys

Chemokines

Signal leukocytes to move/ rush to inflammation site

Leukocyte 9-1-1, what's your emergency?

Adaptive immune system

The body makes MHC & antigens for the T cells to identify epitopes

MHC function is to present epitopes for T cell inspection

MHC Classes

Class 1 - present on all cells except RBC

Class 2 - antigen-presenting cells (APC)

Professional APC = B cells, macrophages, dendritic cells (skin/mucus)

Dendritic cell gets antigen, moves to lymph node to show B & T cells

Cell mediated immune response

Body initiates response in lymph nodes where APCs interact with lymphocytes

Cytotoxic T Cell clone activation

Antigen presentation - dendritic cells w/ virus move to lymph node, present virus with MHC 1 protein, the Cytotoxic T cell binds to dendritic cell

Helper T cells - assist in binding to the APC which then signals the cytotoxic T cell

Clonal expansion - dendritic cell makes 2nd signal which activates cytotoxic T cell, triggering cytotoxic T cell division and forms memory T cells

Self stimulation - cytotoxic T cells leave lymph node and are ready to attack infected cells

Cytotoxic T Cells protein perforin & granzyme is used by NK cells which punch holes in cell and causes cell lysis

Activated cytotoxic T cell binds to CD95 onto cytoplasm target which activates apoptosis