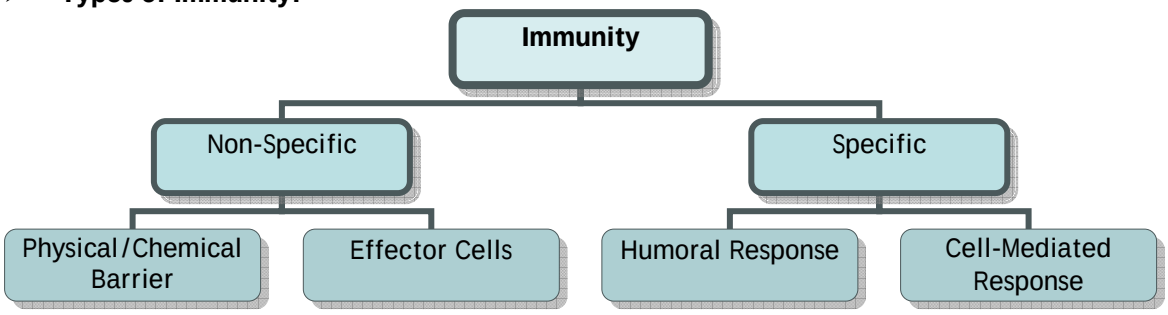
Immune Response and Nervous System

~Biology AP~

A Meridian© Study Guide by John Ho, Amy Young, and Willy Zhang

❖ Immune System

➢ **Types of Immunity:**



➢ **Antigens and Pathogens:**

Second Line of Defense: Types of Effector Cells		
Type	**Response**	**Description**
Antigen	Specific	Substance that triggers the production of antibodies. It is recognized by the acquired immune system. They are usually proteins found on the cell membrane of a pathogen.
Pathogen	Non-Specific and Specific	Any foreign object in a human body. These include viruses, bacteria, or non-organic intrusions. They may contain proteins known as *antigens* on their membranes, which the immune system uses for identification.

➢ **Non-specific:** Also "Innate Immunity". Immune response that targets all pathogens with a similar response regardless of specific identity.

- **First Line of Defense: Physical or Chemical Barriers**

Types Physical or Chemical Barrier		
Form	**Type**	**Description**
Lymphatic System	All Pathogens	Continuously filters the blood and interstitial fluid, removing foreign particles.
Skin and mucus coating		Traps or physically blocks pathogens from entering the body.

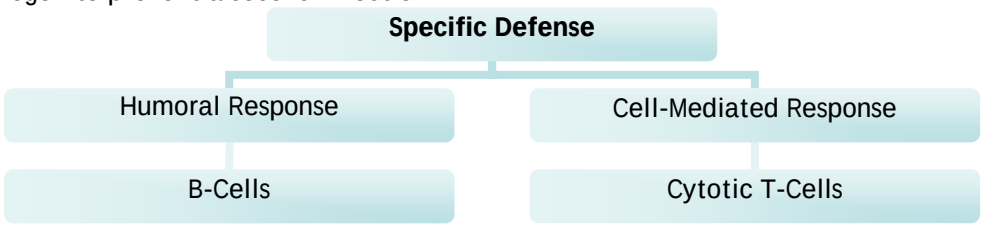
- **Second Line of Defense: Effector Cells**

Second Line of Defense: Types of Effector Cells		
Form	**Type**	**Description**
Phagocytes	All	White blood cells (or *leukocytes*) that ingest microbes and destroy them internally with lysosomes. These include: ✓ **Neutrophils:** Expend all their reserves at once after ingesting the microbe, destroying the phagocyte. ✓ **Macrophages:** Envelops pathogens and digests them.
Anti-microbial Proteins	All	Proteins that recognize pathogens through the complement system*. Recognition begins a cascade of protein activity that ultimately lyses the target cell.

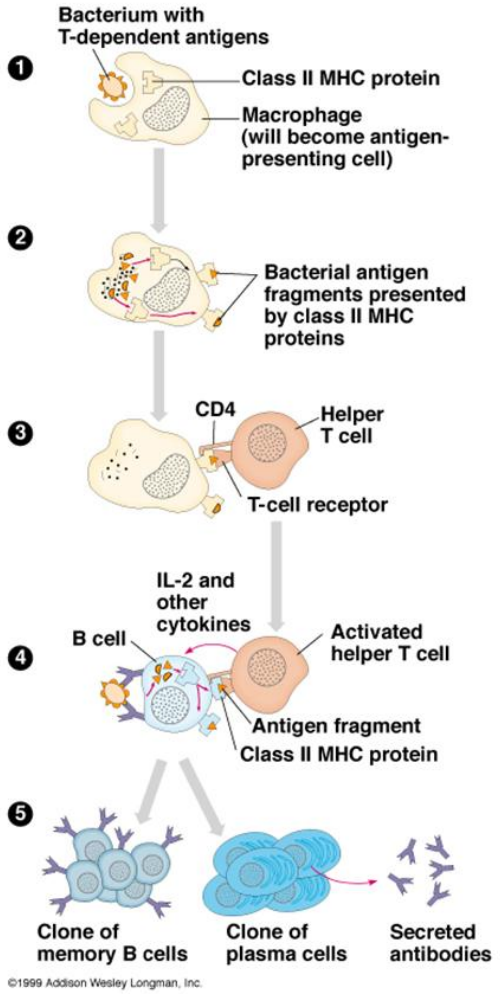
		✓ **Interferon:** Protein secreted by virus-infected cells that slow cell processes of surrounding cells, inhibiting the spread of the virus.
Inflammatory Response	All	Damaged cells release *histamine*, which causes the capillaries to expand, allowing a faster transportation of phagocytes to the area.
Natural Killer Cells	Viral and cancerous cells	Activated in response to the presence of *interferons*. The cells release *preforin*, destroying the cell membrane of the cancerous or viral-infected cell.

***Complement System:** Method anti-microbial proteins use to identify pathogens. They include: 1) Recognition of cells marked by antibodies (antigen-antibody complex), 2) Recognition when in direct contact with pathogen, 3) Recognition of cell sugars on cell membranes of pathogens.

- **Specific:** Also "Acquired Immunity". Response that produces antibodies that target a specific pathogen to prevent a second infection.



- **Humoral Response:** Production of antibodies in response to a pathogen



1. Macrophage ingests a pathogen (shown as "Bacterium" in diagram) through phagocytosis. It is then digested by lysosomes.

2. Antigens from the digested pathogen are presented by Class II MHC proteins on the cell membrane of the macrophage.

3. Helper T-Cells recognize the Class II MHC protein and bind to it. It releases cytokines which activate other Helper T-Cells (not shown).

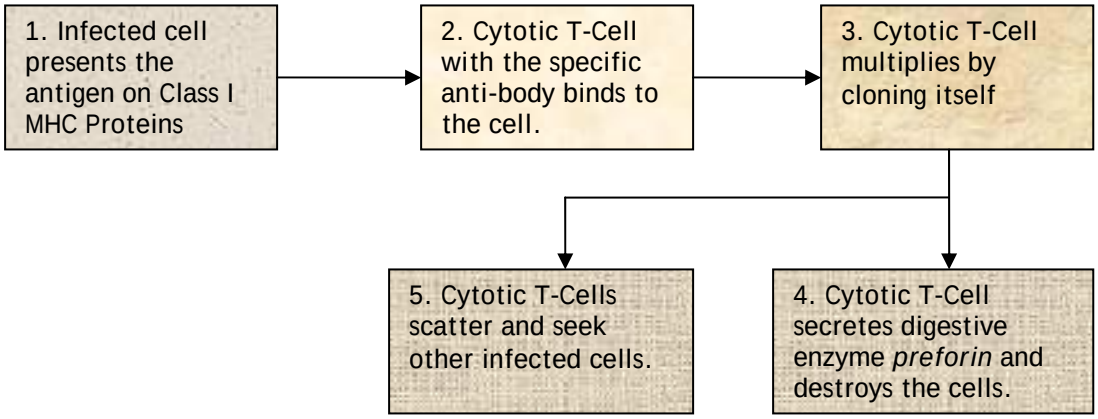
4. B-Cells with the specific antibody attach to the activated T-Cells. Cytokines are sent from the T-Cell to activate the B-Cell.

5. Activated B-Cells divide and differentiate into 1) Plasma Cells and 2) Memory B Cells

- **B-Cells:** Lymphocytes produced in the bone marrow that each have a unique antibody that will bind to a specific antigen. Floating B-Cells must find a Helper T-Cell with a matching antigen in order to differentiate.

B-Cell Differentiation	
Type	**Description**
Plasma Cells	Secrete antibodies when in contact with the specific antigen. Antibodies bind to a matching antigen, making it an easier target for phagocytes.
Memory Cells	Long-living cells which can recognize a specific antigen. It will quickly multiply into undifferentiated B-cells if it comes in contact with the antigen, creating more plasma and memory cells.

- **Cell-Mediated Response:** Utilizes Cytotic T-Cells* to eliminate 1) infected cells, 2) transplanted cells, 3) and cancerous cells. The T-Cell recognizes an infected cell and destroys it while multiplying itself.



- **T-Cells:** Lymphocytes formed in the thymus gland that each has a specific receptor that matches a specific antigen. Differentiate into Cytotic T-Cells and Helper T-Cells.

T-Cell Differentiation	
Type	**Description**
Cytotic T-Cell	"Killer" T-cells that can recognize and destroy cells with the target antigen. The release the enzyme preforin to lyse the target cell.
Helper T-Cell	Participates in the Humoral Response (see "Humoral Response Step 3"). It recognizes antigens presented by macrophages that have digested the pathogen and in turn activates B-Cells.

➢ **Primary and Secondary Response:**

Primary vs. Secondary Response		
Type	**Response**	**Description**
Primary	Humoral	The initial response to an antigen. During the response, memory cells are formed with the corresponding antibody.
Secondary	Cell-Mediated	Response to a subsequent infection of the same antigen. It is carried out by memory cells and is significantly more efficient than the primary.

➢ **Transplant Immune Response:** Transplanted cells stimulate the Cell-Mediated response.
- **Blood Types:** Red blood cells are coated with 2 types of antibodies: A and B (they may have one, both, or none). The immune system attacks non-matching types of blood, leading to "agglutination", or clumping/lysing of red blood cells.

Blood Types		
Type	**Compatibility**	**Description**
A	A, O	Has the antigen A, produces antibodies against type B.

B	B, O	Has the antigen B, produces antibodies against type A.
AB	All	The universal acceptor, no antibodies are produced.
O	O	The universal donor, its red blood cells have no antibodies and the body produces both anti-A and anti-B antibodies.

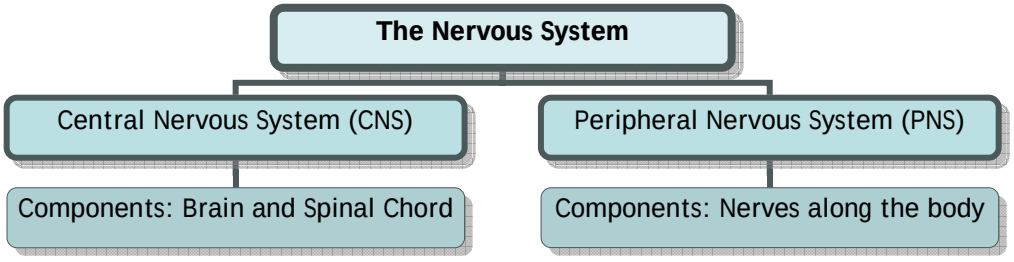
- **Immune System Disorders:**

Disorders in the Immune System		
Disorder	**Type**	**Description**
Allergies	Overreaction	Occurs when the immune system becomes overly sensitive to certain antigens. The effects are produced by the release of histamine; treatment usually involves administering anti-histamines to block the response.
Lupus	Autoimmune Disorders	*Systemic lupus erythematosus* or SLE is a chronic disease that causes the immune system to attack the body's tissues. Commonly affected areas include the kidney and the lungs.
Rheumatoid Arthritis		A chronic disease that causes the immune system to attack the bone joints of the body. The disease also affects the skin, blood vessels, heart, lungs, and muscles.
Diabetes (type I)		The body destroys B-cells in the pancreas. This reduces production of insulin. This is different from Type II diabetes where the body becomes resistant to insulin.
Multiple Sclerosis		Chronic disease affecting the brain and spinal cord. Multiple Sclerosis specifically attacks neurons by slowly destroying the myelin sheath that protects them.
Acquired Immune Deficiency Syndrome (AIDS)	Immune Deficiency	The HIV (Human Immunodeficiency Virus) damages the immune system and leaves the patient susceptible to infections or other viruses that are normally easily countered by any healthy immune system.

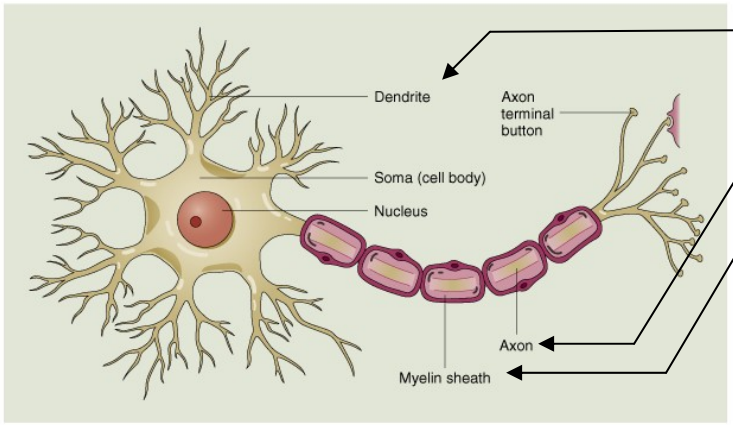
- **The ELISA Test:**

What is it?	Enzyme-linked Immunosorbent Assay (ELISA) is a technique to detect the presence of any specific disease antibody. It is most often used to determine the antibody count in serum or just to detect the presence of an antigen.
How does it work?	An antibody is a protein of the immune system that destroys antigens in the body. Each antibody created only recognizes one specific antigen, which is how ELISA detects the antibody presence. Biologically made anti-antigens are created to bind to the specific antigen present and release colors for a positive bind.

❖ Nervous System

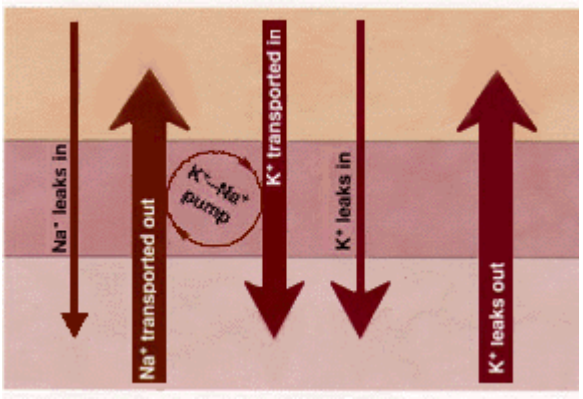


- **Neuron Structure:**



- ✓ **Dendrite:** Receiving end the neuron
- ✓ **Axon:** Carries signal away from neuron
- ✓ **Myelin Sheath:** Insulates neuron to speed signal.

- **Resting Potential:** Neurons at rest maintain a difference in voltage (-70 mV). The charge is the neuron's "ready position", where it can transmit an electrical pulse. It is at this stage *polarized*.

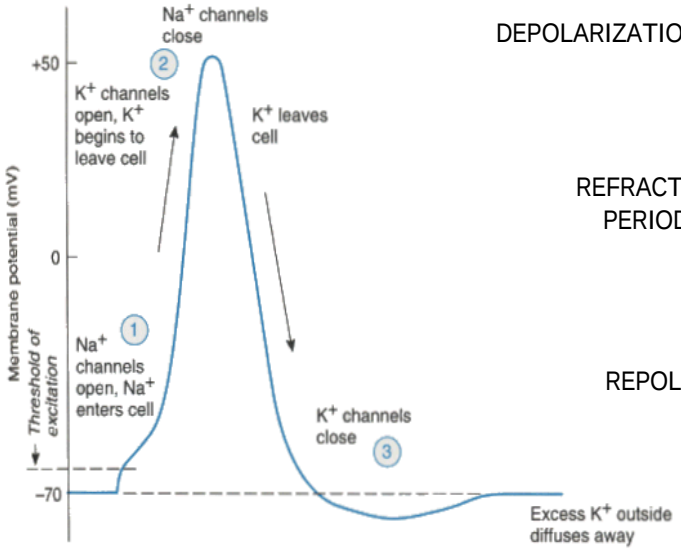


Relative Ion Concentrations		
Ion	**Inside**	**Outside**
Na^+	Low	High
CL^-	High	Low
K^+	Equal	Equal

- **Maintaining Negative Charge:** Membrane permeability and the Sodium/Potassium pump maintain a balance of ions that creates the negative charge of -70 mV.

Creating the Resting Potential		
Type	**Overall Charge**	**Description**
Na^+	Positive (+)	Cell membrane holds Na^+ until depolarization (see "Action Potential") in while the pump draws additional Na+ ions. Creates higher concentration of Na^+ in the outside.
Cl^-	Negative (-)	Enters and exits at a controlled rate, contributes to the negative interior.
K^+	None (0)	K+ is drawn in during the pumping process but is allowed to escape through the membrane. It maintains an equilibrium with the outside, not raising the charge of the neuron.

- **Active Potential:** Action where the neuron transmits the electrical pulse.



DEPOLARIZATION

1. Stimulus opens series of Na^+ channels*. Na^+ enters from outside.

REFRACTORY PERIOD

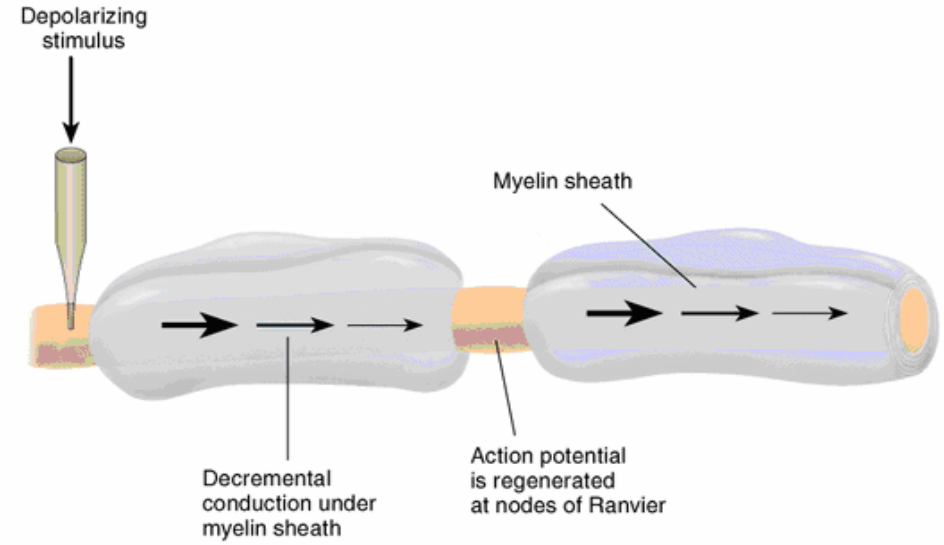
2. Na^+ channels close while K^+ channels begin to open. K^+ leaves the cell.

REPOLARIZATION

3. K^+ channels close after voltage drops. Neuron charge returns to rest.

* One Na^+ channel is opened; voltage difference causes adjacent channels to also open, creating the signal movement down the axon.

- **Saltatory Conduction:** Nerve impulse travels down the axon through transfer of action potential. The myelin sheath prevents ions from flowing outwards, allowing polarization at one Node of Ranvier to raise the voltage of surrounding cells into action potential.

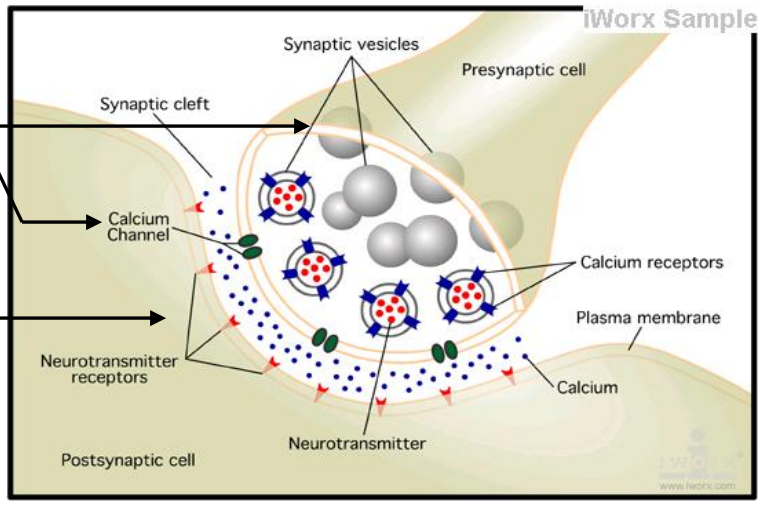


  - ✓ **Node of Ranvier:** Gaps along the myelin sheath that are not insulated. The electrical pulse jumps from one node to the other rather than to smoothly progress.

➢ **Neuron Communication:**

- **Sending the Signal:** Signal reaches the axon terminal (see "Neurons" diagram) and is transferred to another neuron.

1. Signal triggers Ca^{2+} channels to open.
2. Synaptic vesicles fuse with the membrane, releasing neurotransmitters across the synaptic cleft.
3. Neurotransmitters bind to receptors on the postsynaptic cell.
4. Na^{+} channel opens on the postsynaptic cell, triggers action potential.



- **Elimination of Neurotransmitters:** Cell must recycle the chemical signals after they move across the synaptic cleft to prevent them from stimulating the signal again.

Eliminating Neurotransmitters	
Type	**Description**
Diffusion	Chemicals diffuse away into low concentrations and are eventually broken down by proteases (enzymes).
Reuptake	Postsynaptic cell absorbs the transmitters where it is recycled and used again.
Enzyme Degradation	Once the transmitter reaches the other side of the cleft, enzymes near the membrane digest it.

✓ **Blocked Transmitters:** If the receptor is blocked, neurotransmitters are forced into the bloodstream.