BHARATHIDASAN UNIVERSITY

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Programme: M.Sc., Biomedical Science

Course Code: BM35C6

Course Title: Immunology

Unit-I

Organs of the Immune system

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Unit I:

Organs of the immune system – Primary and secondary lymphoid organs- Types of immunity – Innate and acquired immunity. Innate immunity – Cellular components - Phagocytic cells, inflammatory cells and NK cells, Acquired immunity- Cellular components of adaptive immune system – T cells - B lymphocytes –lymphocytes trafficking between lymphoid tissues. Recognition molecules and receptors of innate immune systems - PAMPs, CD1 molecule and MBL (mannose binding lectins) - Pattern recognition receptors (PRRs), TLRs, KIR, Fc gamma receptors (FcγRIa, FcγRIIa and FcγRIIIa)- Complement receptors. Recognition molecules and receptors of adaptive immune systems - MHC molecules- genomic map of MHC genes, cellular distribution and expression, Antigen processing and presentation – the cytosolic pathway and endocytic pathway- Receptors of adaptive immune system – TCR and BCR.

PRESENTATION: 1

IMMUNE SYSTEM

- The immune system is a complex network of organs, cells and proteins that defend the body against infection, whilst protecting the body's own cells.
- The immune system records every germ (microbe) it has ever defeated so it can recognize and destroy the microbe quickly if it enters the body again.
- The lymphatic system in vertebrates consists of lymphoid organs, lymphatic vessels and lymphoid tissues.
- They form an important part of the immune system and complement the circulatory system.

Organs of the immune system

- Primary lymphoid organs
- Secondary lymphoid organs

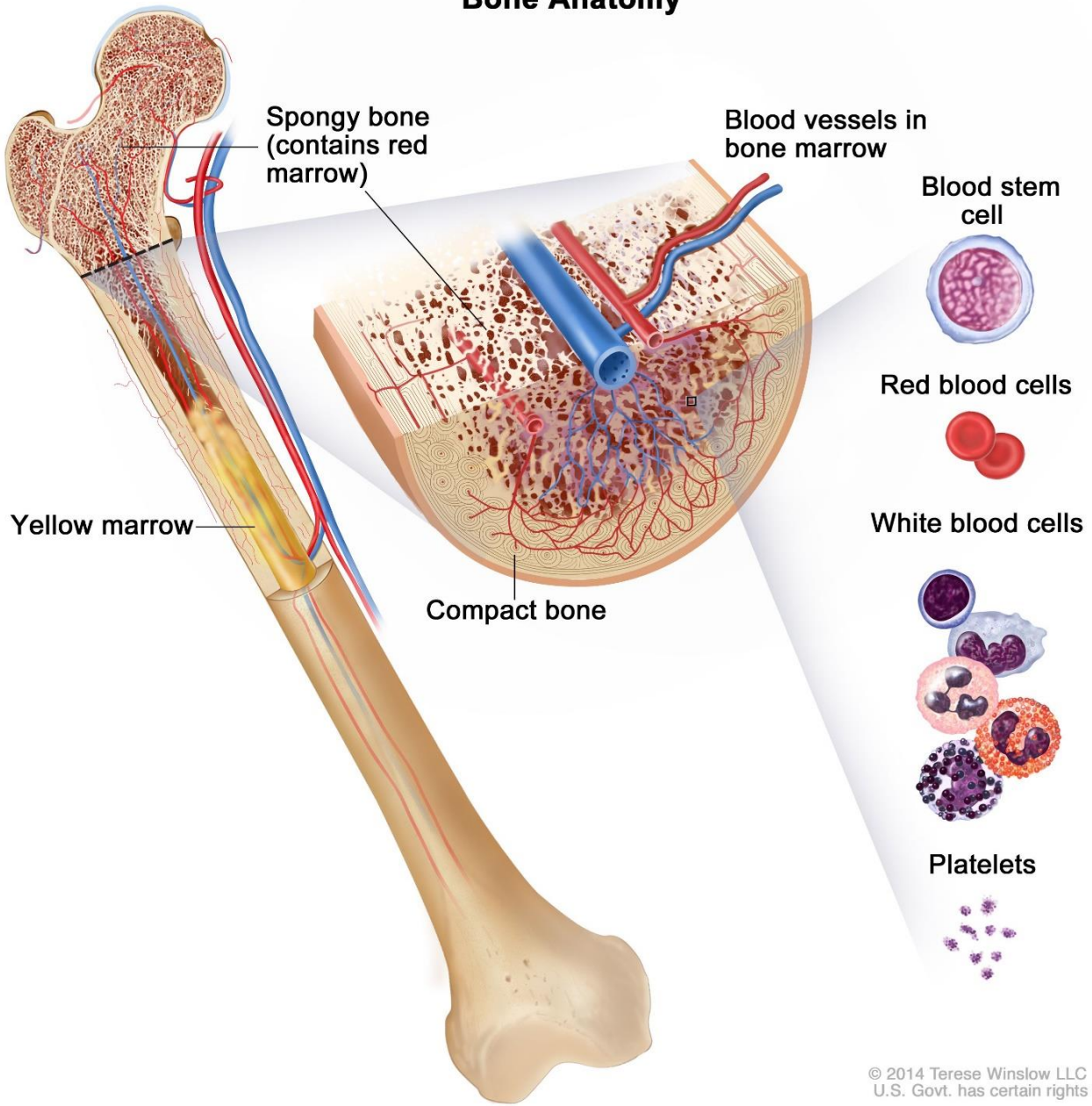
Primary lymphoid organs

- The organs in which the **production of the cells** of the immune system occurs are known as primary lymphoid organs.
- They are also known as **central lymphoid organs**.
- They include the **bone marrow and the thymus**.

Bone Marrow:

- Bone marrow, a primary lymphoid organ, is a spongy tissue found in the bones.
- It is the site for the **production of precursors of T cells, and production and maturation of B cells.**
- These cells are then transported to other organs and tissues via blood to carry out their function.
- The red bone marrow is found in abundance during the time of birth and it actively produces immune system cells, but over time, the red bone marrow converts to fatty tissues.
- The B cells that are produced and matured in the bone marrow immediately travel to the circulatory system in search of pathogens.
- T cells travel to the thymus for maturation and they join B cells in the circulatory system in search of pathogens.

Bone Anatomy



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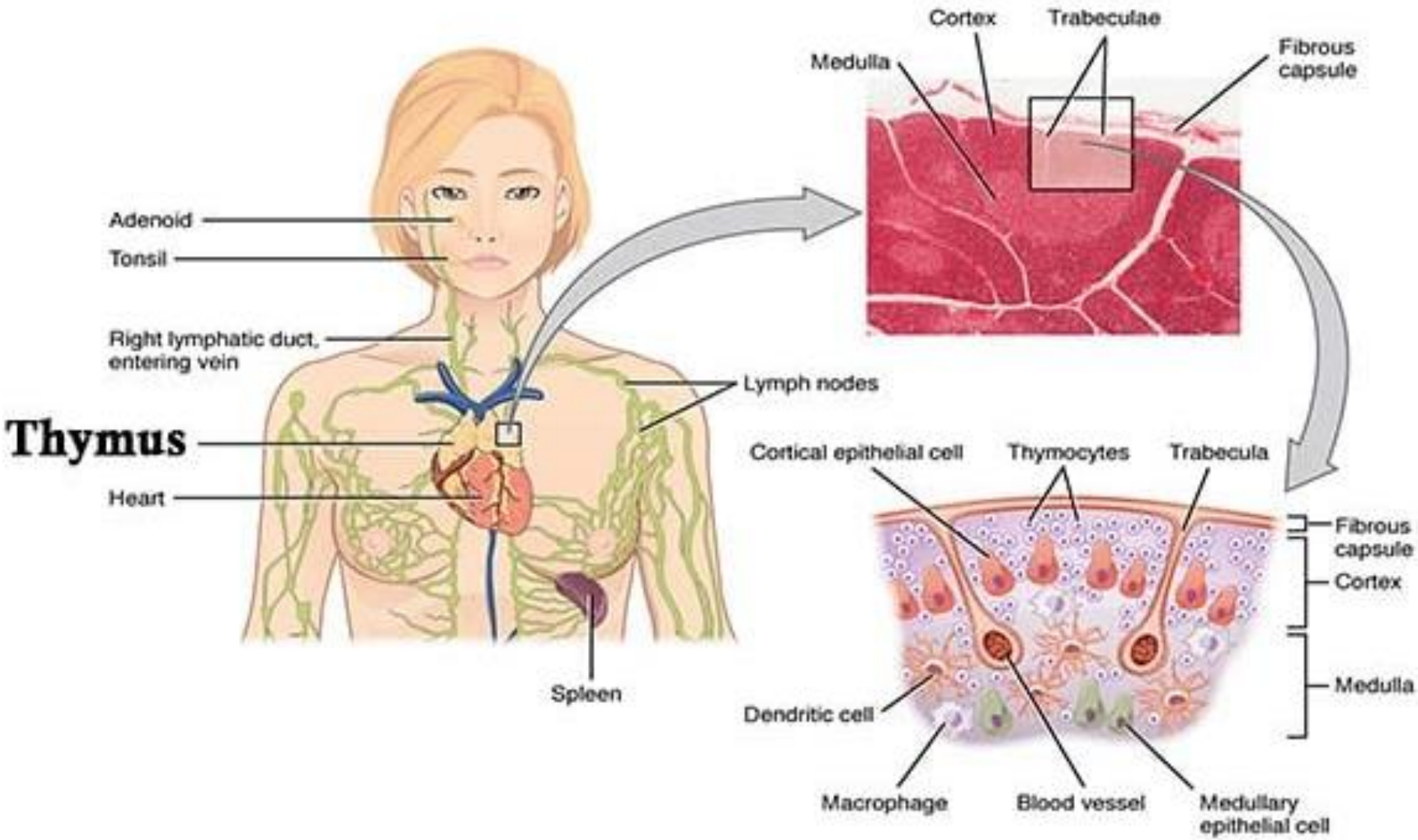
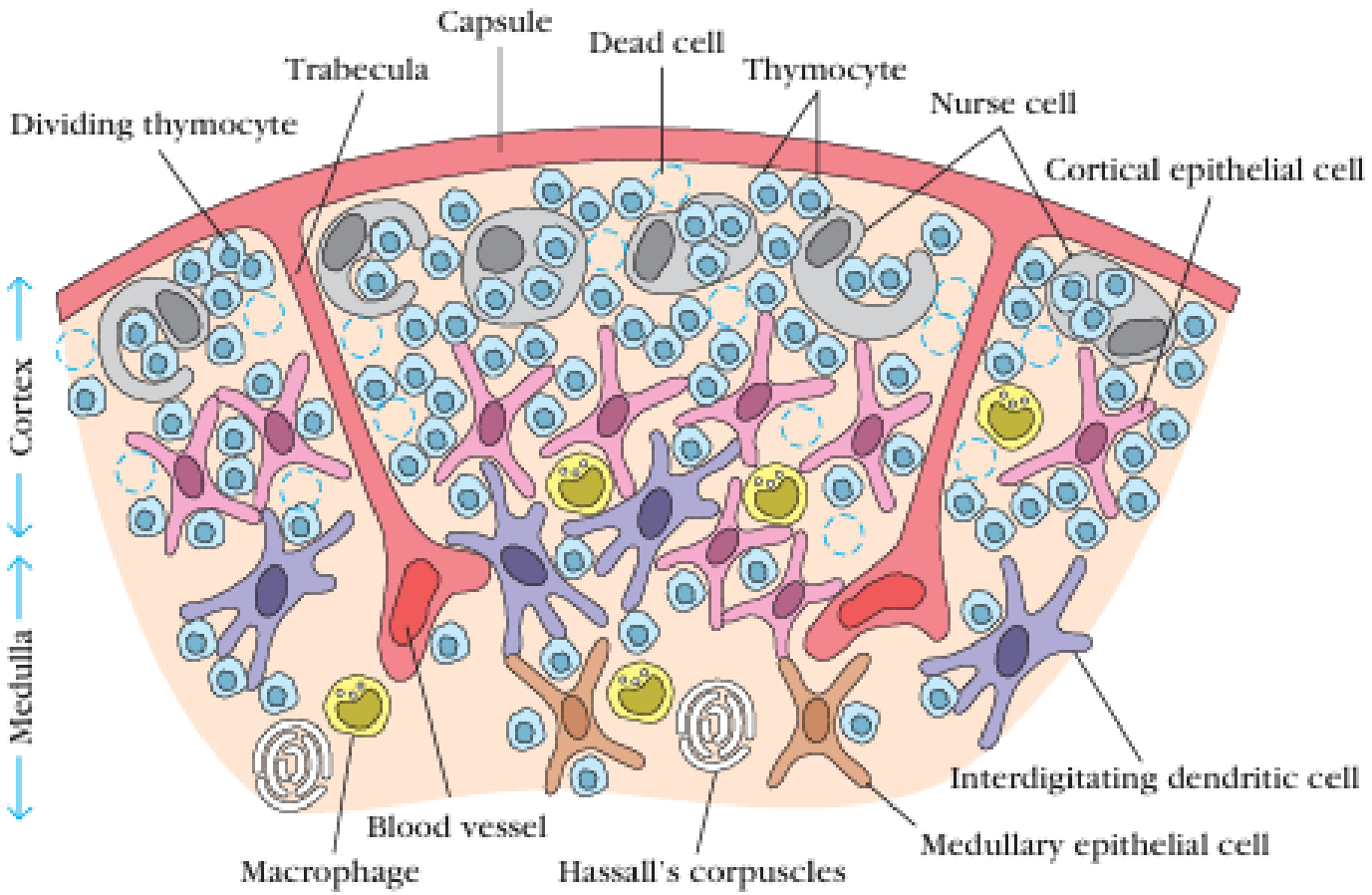
Thymus

- The thymus is a gland-like organ that is situated at the back of the heart and above the breastbone.
- It is the site for the maturation of thymus cell lymphocytes, also known as T cells.
- The thymus gives a suitable environment for the production of T cells from hematopoietic progenitor cells.
- This gland reaches its full maturity during childhood.
- As adulthood commences, it is replaced by fatty or adipose tissue.
- The T cells coordinate the innate and adaptive immune systems.


Adenoid
Tonsil
Right lymphatic duct, entering vein
Thymus
Heart
Spleen
Lymph nodes
Cortex
Trabeculae
Medulla
Fibrous capsule
Cortical epithelial cell
Thymocytes
Trabecula
Fibrous capsule
Cortex
Medulla
Dendritic cell
Macrophage
Blood vessel
Medullary epithelial cell

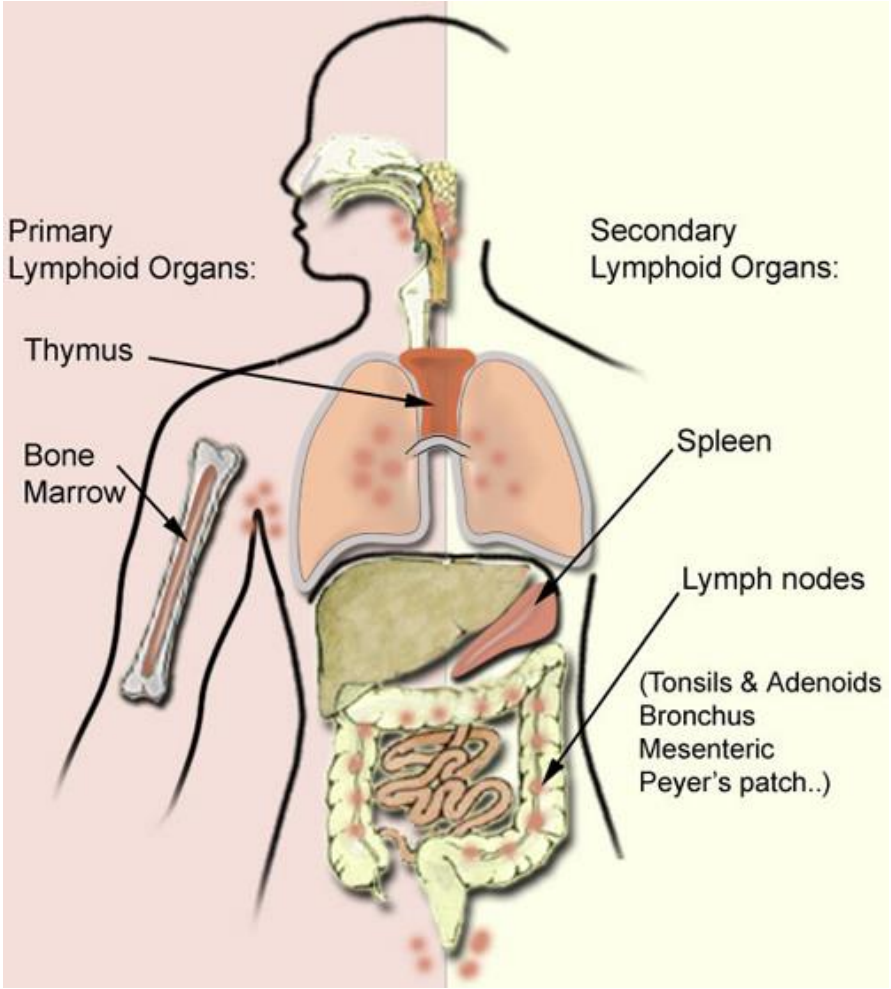
Cross section of Thymus



Secondary lymphoid organs

- The secondary lymphoid organs are also known as **peripheral lymphoid organs**.
- The function of secondary lymphoid organs is the activation of immune cells and to start a fight against foreign substances in our body.
- It includes **spleen, lymph nodes, tonsils and various mucosal membranes.**

Primary and Secondary lymphoid organs



SPLEEN

- The Spleen is an organ found in virtually all **Vertebrates**.
- The spleen is an organ located in the left side of the **Abdominal cavity** under the **Diaphragm**, the muscular partition between the **Abdomen** and the **Chest**.
- Similar to a Lymph node, it acts **primarily as a blood filter**.
- Old **RBCs are recycled** in the Spleen.
- **Platelets and WBCs are stored** in Spleen.
- The spleen also **helps to fight against certain kinds of bacteria** that cause Pneumonia and Meningitis

STRUCTURE OF SPLEEN

- The spleen **varies in size and shape** between people, but it's commonly **Ovoid shaped and Reddish brown in colour**.
- The spleen, in healthy adult humans, is approximately **7 cm (2.8 in) to 14 cm (5.5 in) in length.** It usually weighs between **150 g and 200 g**.
- The spleen is surrounded by a **Capsule** that extends a number of projections **(Trabeculae)** into the interior to form a compartmentalized structure.

- The compartments are of two types, the **(i) Red pulp & (ii) White pulp**, which are separated by a diffuse marginal zone.

STRUCTURE OF SPLEEN

- The splenic **Red pulp** consists of a network of sinusoids populated by **Macrophages and numerous RBCs and few Lymphocytes**. It is the site where **old and defective red blood cells are destroyed and removed**.

STRUCTURE OF SPLEEN

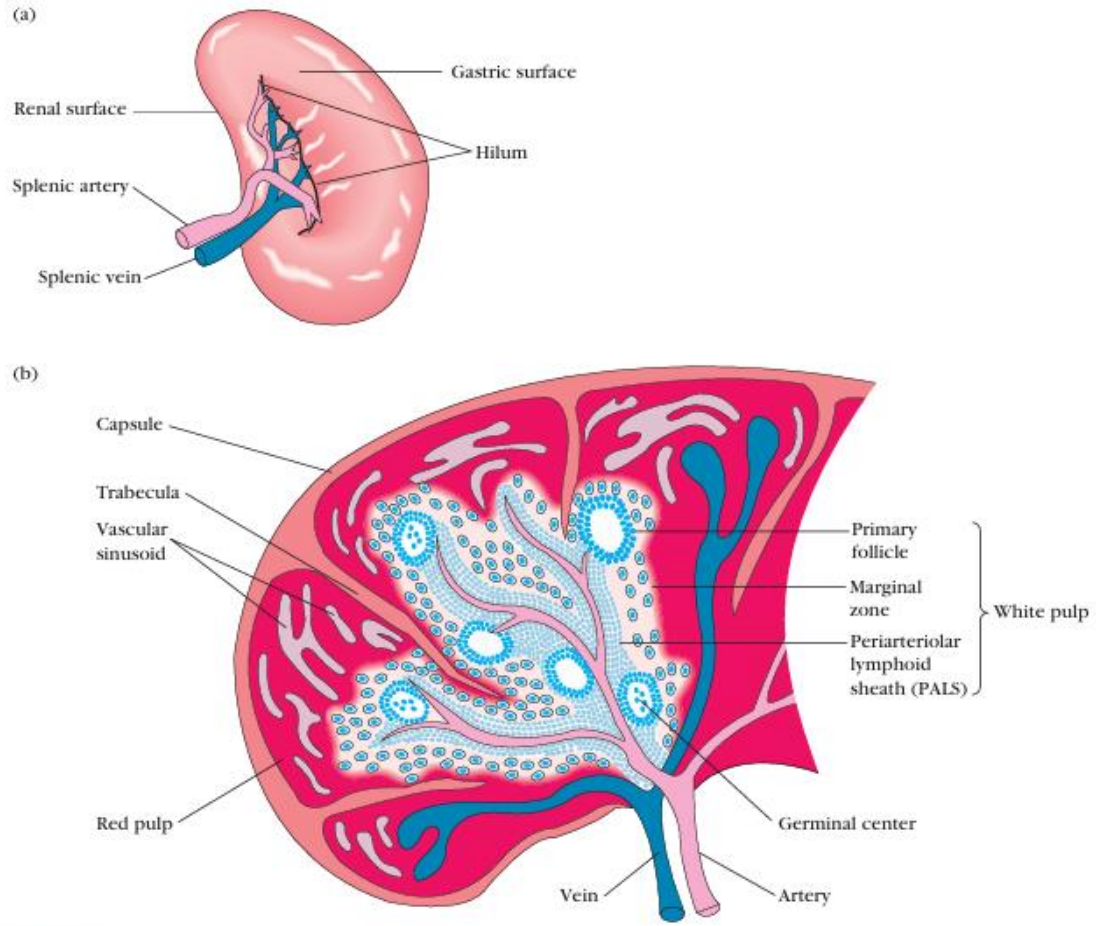


FIGURE 2-19 Structure of the spleen. (a) The spleen, which is about 5 inches long in adults, is the largest secondary lymphoid organ. It is specialized for trapping blood-borne antigens. (b) Diagrammatic cross section of the spleen. The splenic artery pierces the capsule and divides into progressively smaller arterioles, ending in vascular sinusoids that drain back into the splenic vein. The erythrocyte-filled red pulp surrounds the sinusoids. The white pulp forms a sleeve, the periarteriolar lymphoid sheath (PALS), around the arterioles; this sheath contains numerous T cells. Closely associated with the PALS is the marginal zone, an area rich in B cells that contains lymphoid follicles that can develop into secondary follicles containing germinal centers.

LYMPH NODE

- Lymph nodes are a group of **small, bean-shaped organs (2.6 cm in length) found mainly in the neck and trunk** of the human body.
- They play vital roles in the **filtration of antigens and debris from Lymph** (circulating colourless watery fluid) and in the **generation of immune responses to pathogens**.

STRUCTURE OF LYMPH NODE

- The **Capsule** is made of **Collagen** and has a sub-capsular **Sinus**.
- The Lymph flows into the Sinus carrying **Lymphocytes, Antigen processing macrophages and Dendritic cells** to the node Cortex, Paracortex and Medulla.
- Morphologically, Lymph node can be divided into 3 roughly concentric regions: (1) Cortex, (2) Paracortex and (3) Medulla.

- The outermost layer, Cortex contains **Lymphocytes (mostly B - cells), Macrophages and Follicular dendritic cells** arranged in **Primary follicles.**
- The Primary follicles enlarge into **Secondary follicles**, each containing a **Germinal center.**
- Beneath the cortex is the Paracortex, which is populated largely by **T - lymphocytes** and also contains **Interdigitating dendritic cells** thought to have migrated from tissues to the node.
- The innermost layer of a lymph node, the Medulla is more sparsely populated with **Lymphoid-lineage cells** of those present, many are **Plasma cells** actively secreting antibody molecules.
- The Medulla in the **core of the lymph node** mainly **processes T - lymphocytes**.

STRUCTURE OF SPLEEN

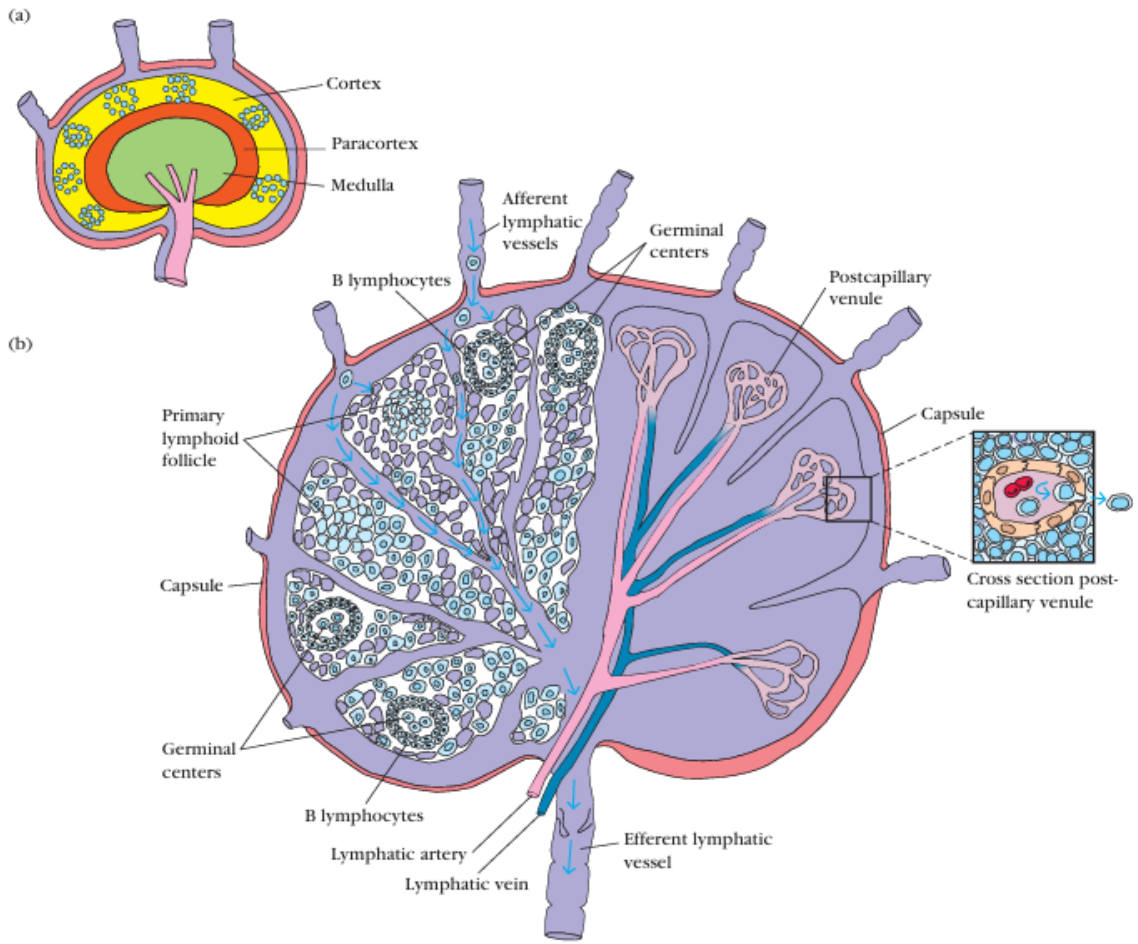
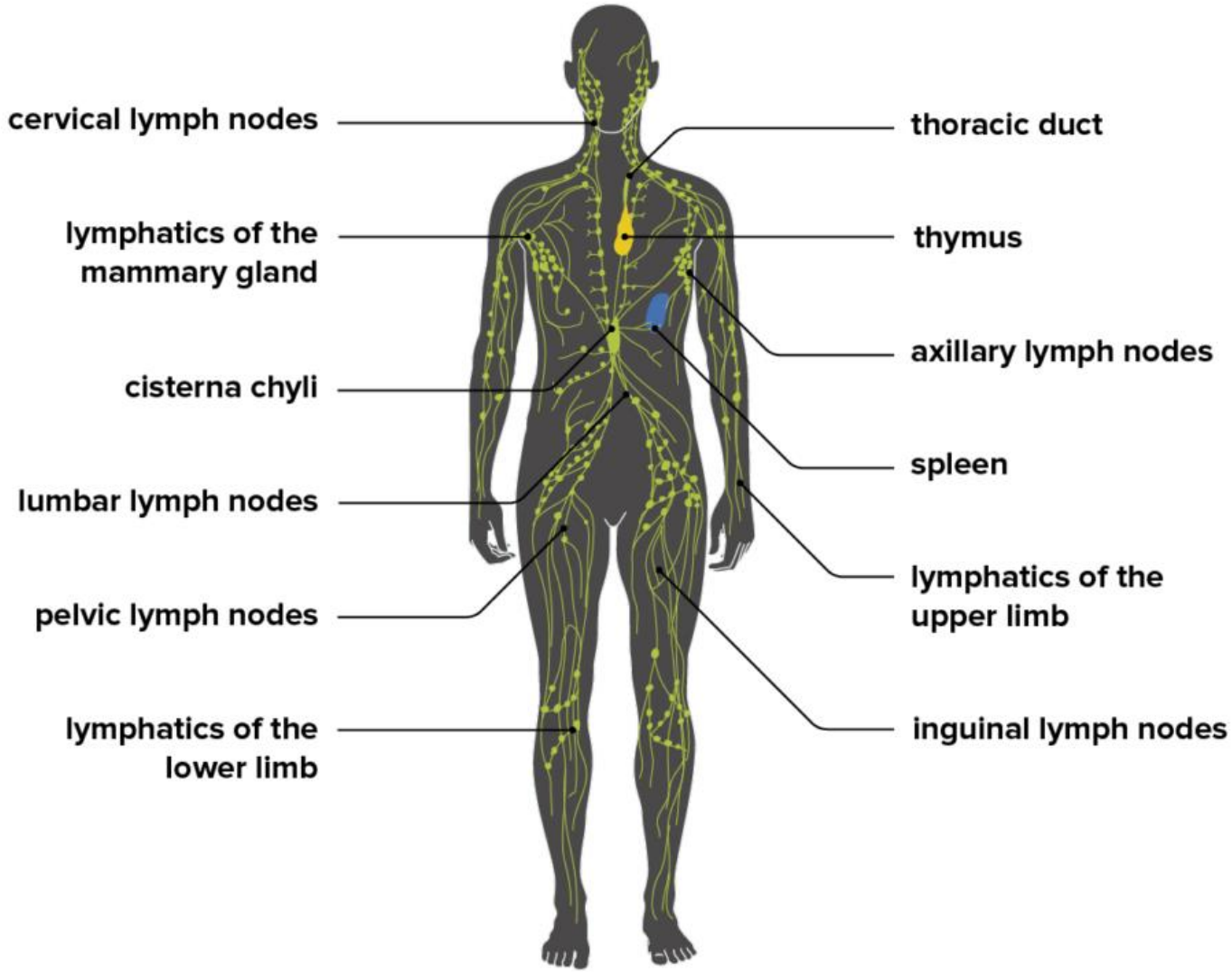


FIGURE 2-18 Structure of a lymph node. (a) The three layers of a lymph node support distinct microenvironments. (b) The left side depicts the arrangement of reticulum and lymphocytes within the various regions of a lymph node. Macrophages and dendritic cells, which trap antigen, are present in the cortex and paracortex. T_H cells are concentrated in the paracortex; B cells are located primarily in the cortex, within follicles and germinal centers. The medulla is populated largely by antibody-producing plasma cells. Lymphocytes circulating in the lymph are carried into the node by afferent lymphatic vessels; they either enter the reticular matrix of the node or pass through it and leave by the efferent lymphatic vessel. The right side of (b) depicts the lymphatic artery and vein and the postcapillary venules. Lymphocytes in the circulation can pass into the node from the postcapillary venules by a process called extravasation (*inset*).

LYMPHATIC SYSTEM

understanding lymph nodes in the body



MEDICALNEWSTODAY

FUNCTIONS OF LYMPH NODE

- Drainage of fluid from blood stream into the tissues.
- Filtration of the lymph at the lymph nodes.
- Filtering blood.
- Raise an immune reaction and fight against microbial infections.

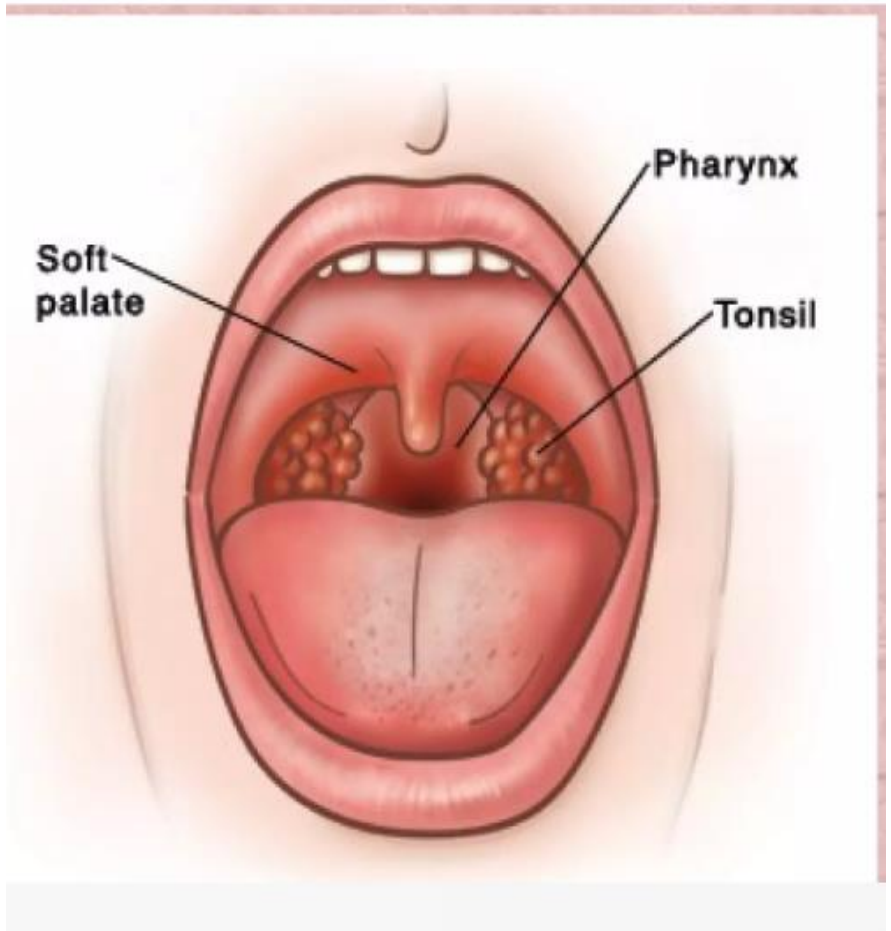
MALT

- The mucous membranes lining the digestive, respiratory, and urogenital systems have a combined surface area of about 400 m2 and are the major sites of entry for most pathogens.
- These vulnerable membrane surfaces are defended by a group of organized lymphoid tissues mentioned earlier and known collectively as Mucosal-associated lymphoid tissue (MALT).
- MALT can be further classified as Gut-associated lymphoid tissue (GALT) or Bronchus-associated lymphoid tissue (BALT).

Tonsils

- Tonsils are collections of Lymphoid tissue facing into the Aerodigestive tract.
- The Tonsils play a role in protecting the body against Respiratory and Gastrointestinal infections.
- Each tonsil consists of a network of crypts (pits) that store cells used to fight infection.
- The tonsils contain B & T- cells, that fights against infections.
- Tonsils also produce Antibodies against Polio, Streptococcal pneumonia, Influenza, and numerous infections.

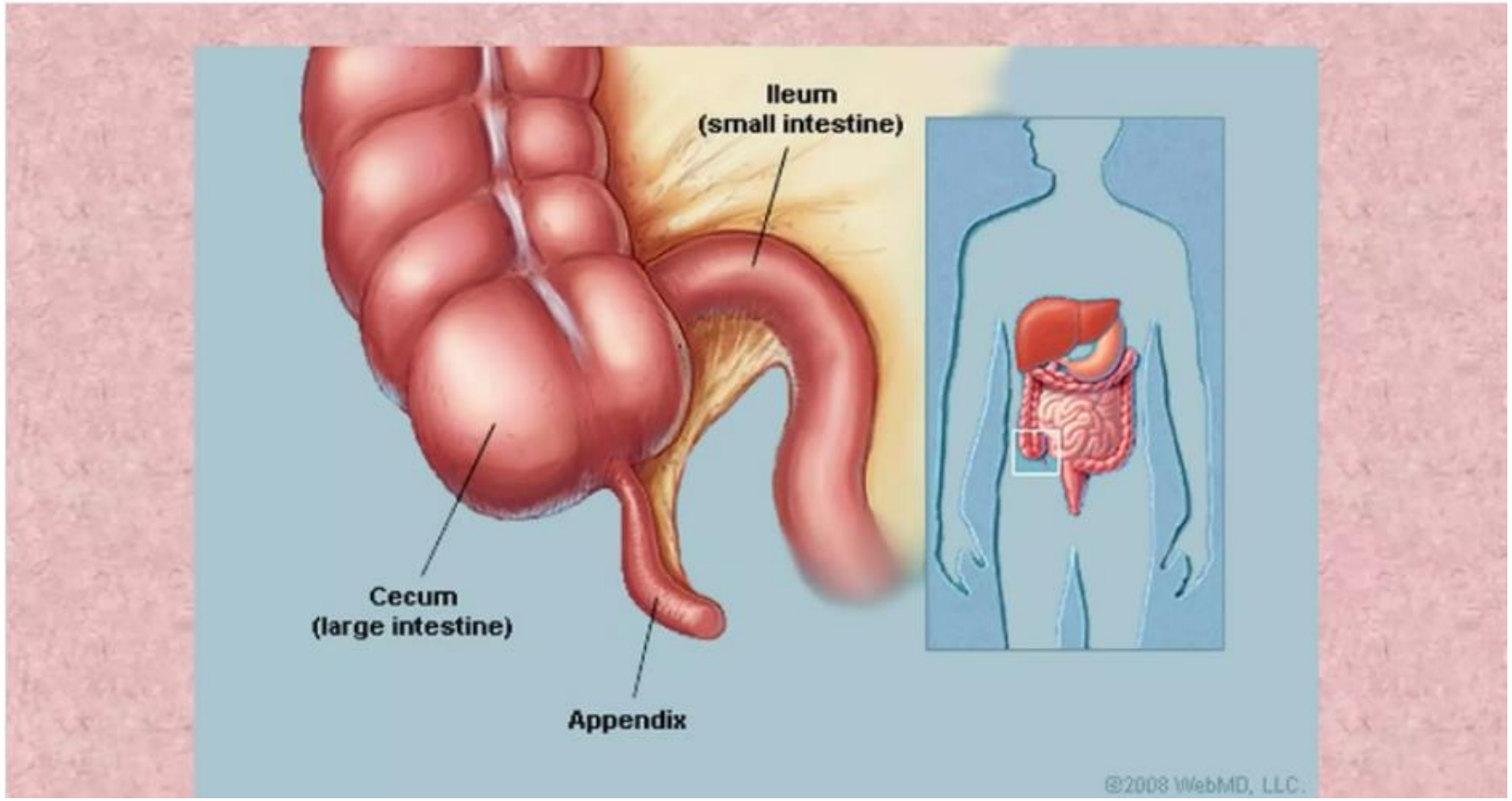
- Tonsillitis occurs when bacterial or viral organisms cause inflammation of the Tonsillar tissue. This results in fever, difficulty swallowing, sore throat, ear pain, loss of voice and throat tenderness.



Appendix

- Appendix - Blind - ended tube connected to the Cecum.
- The Cecum is a pouch like structure of the Colon, located at the junction of the Small and the Large intestines.
- The human appendix averages 9 cm in length but can range from 2 to 20 cm. The diameter of the appendix is usually between 7 and 8 mm.
- Appendicitis – Inflammation of Appendix.

- Functions of Appendix - 1) Maintaining Gut flora, 2) Important component of Mucosal immune function and 3) Storehouse for good bacteria, "rebooting" the digestive system after diarrheal illnesses.
- Surgical removal of the appendix causes no observable health problems.


Ileum
(small intestine)
Cecum
(large intestine)
Appendix
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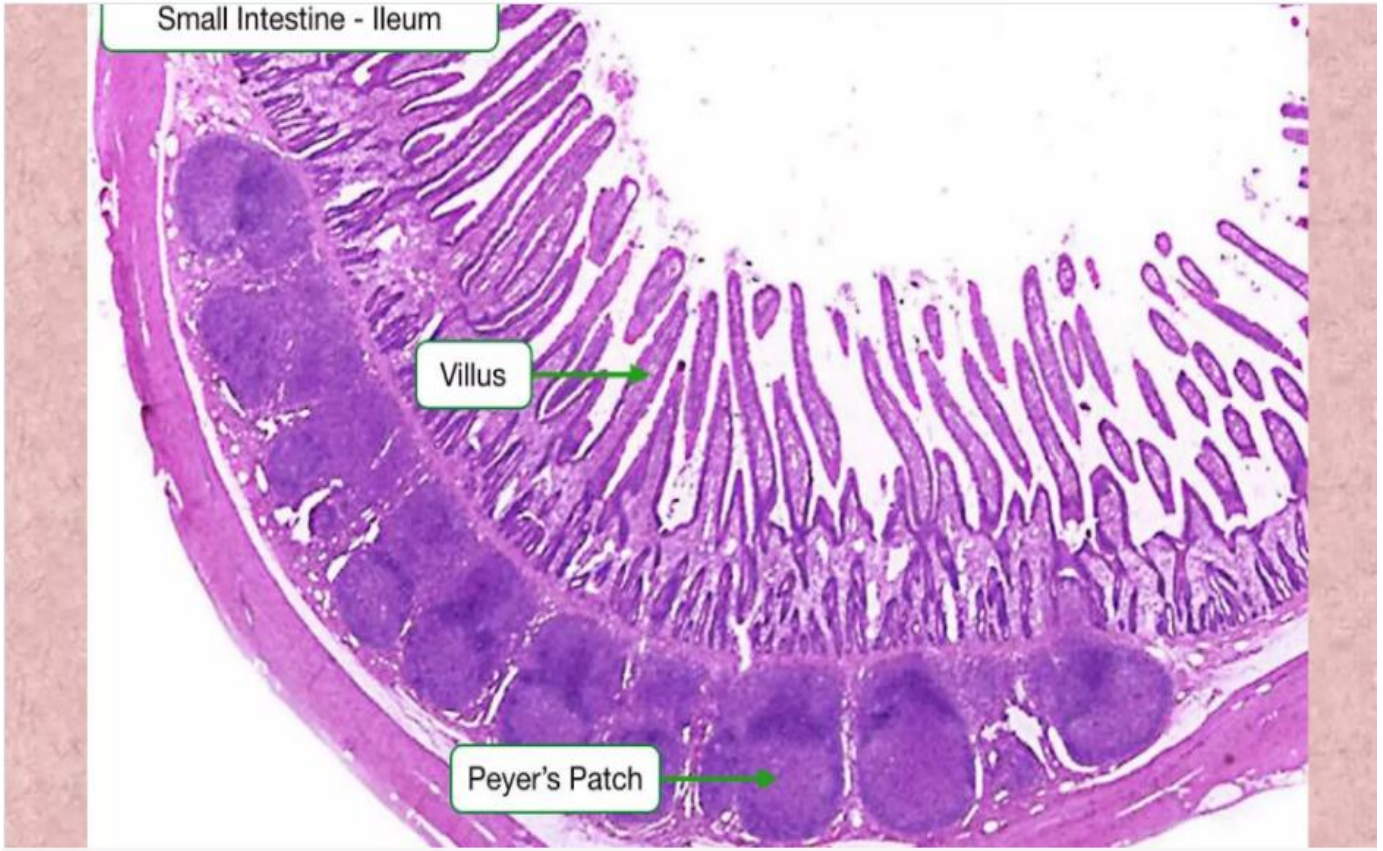
Peyer's Patches

- Peyer's patches are small masses of lymphatic tissue found throughout the Ileum region of the Small intestine.
- Peyer's patches are roughly egg-shaped lymphatic tissue nodules that are similar to lymph nodes in structure, except that they are not surrounded by a connective tissue capsule.
- Important part of the immune system by monitoring intestinal bacteria populations and preventing the growth of pathogenic bacteria in the intestines.
- Peyer's patches also playing an important role in traping antigens from pathogens and destroying them.

STRUCTURE OF PEYER'S PATCH



STRUCTURE OF SPLEEN

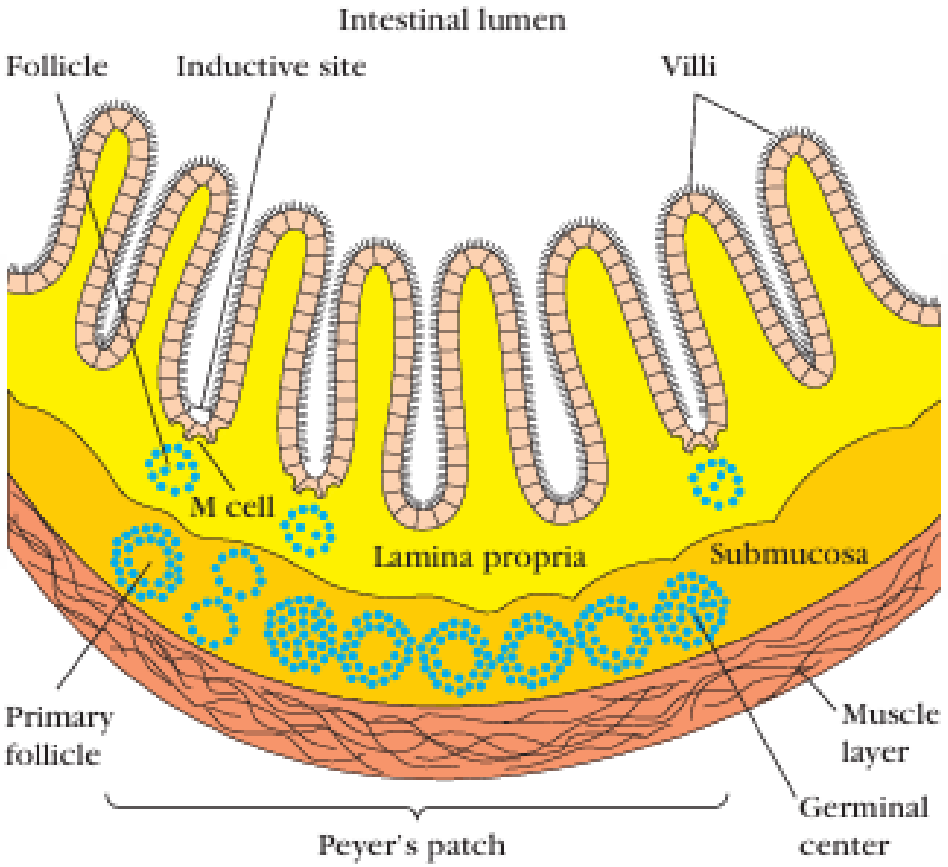
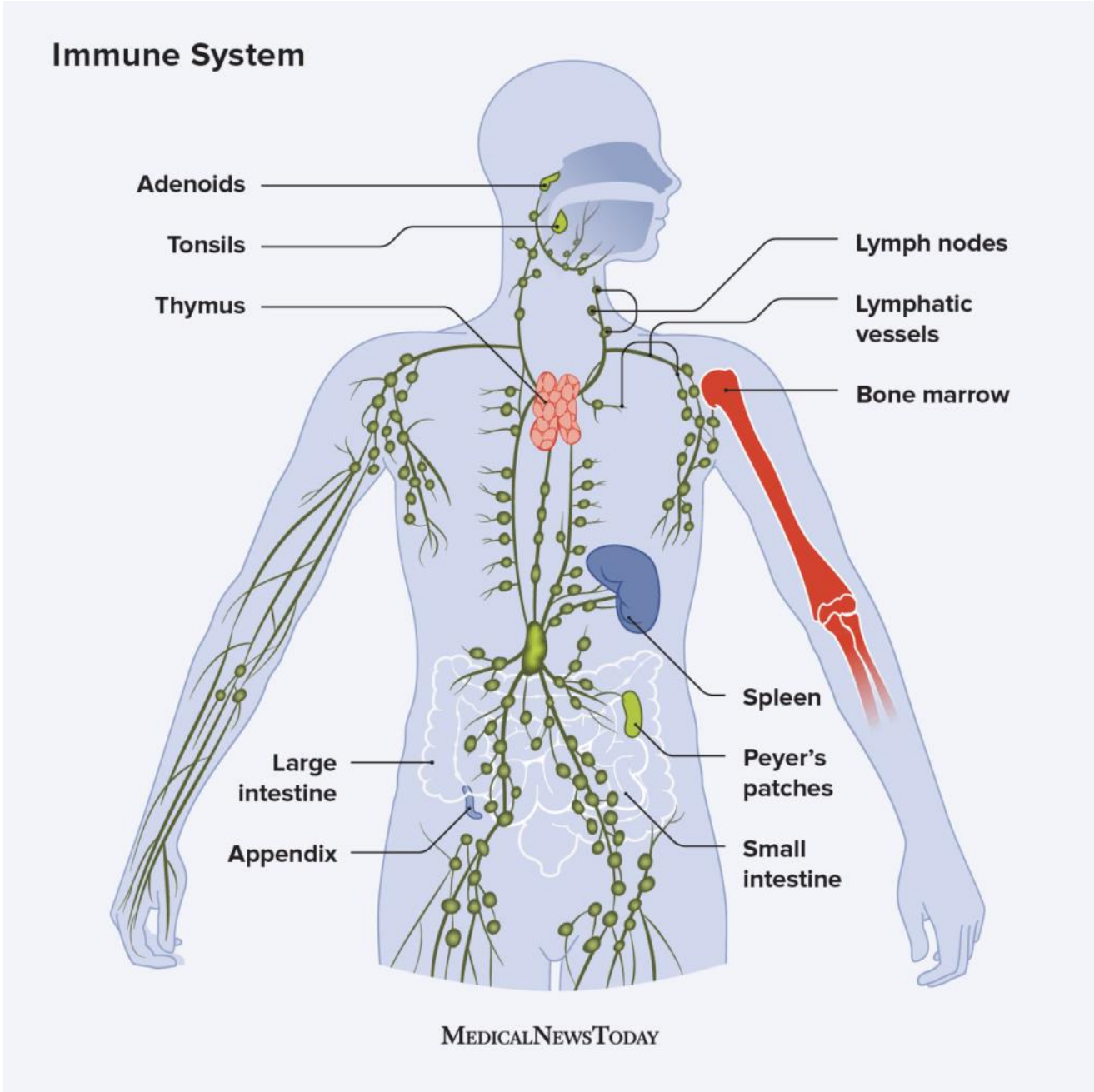


FIGURE 2-21 Cross-sectional diagram of the mucous membrane lining the intestine showing a nodule of lymphoid follicles that constitutes a Peyer's patch in the submucosa. The intestinal lamina propria contains loose clusters of lymphoid cells and diffuse follicles.


Immune System
Adenoids
Tonsils
Thymus
Lymph nodes
Lymphatic vessels
Bone marrow
Spleen
Peyer's patches
Small intestine
Large intestine
Appendix
MEDICALNEWSTODAY

TYPES OF IMMUNITY

What is Immunity?

- Immunity is the ability of the body to defend itself against disease-causing organisms.
- Everyday our body comes in contact with several pathogens, but only a few results into diseases.
- The reason is, our body has the ability to release antibodies against these pathogens and protects the body against diseases.
- This defense mechanism is called immunity.

Types of Immunity

There are two major types of immunity:

1.Innate Immunity or Natural or Non-specific Immunity.

2.Acquired Immunity or Adaptive Immunity.

Innate Immunity

- This type of immunity is present in an organism by birth.
- This is activated immediately when the pathogen attacks.
- Innate immunity includes certain barriers and defense mechanisms that keep foreign particles out of the body.
- This immunity helps us by providing the natural resistance components including salivary enzymes, natural killer cells, intact skin and neutrophils, etc. which produce an initial response against the infections at birth prior to exposure to a pathogen or antigens.
- It is a long-term immunity in which our body produces the antibodies on its own.
- Our body has few natural barriers to prevent the entry of pathogens.

Types of Barriers (4 types)

1. Physical barrier

- These include the skin, body hair, cilia, eyelashes, the respiratory tract, and the gastrointestinal tract.
- These form the first line of defense.
- Our skin acts as a physical barrier to the entry of pathogens.
- The mucus coating in our nose and ear is a protective barrier which traps the pathogen before it gets inside.

2 Physiological barriers

- We know that our stomach uses hydrochloric acid to break down the food molecules.
- Due to such a strongly acidic environment, most of the germs that enter our body along with the food are killed before the further process is carried on.
- Saliva in our mouth and tears in our eyes also have the antibiotic property that does not allow the growth of pathogens even though they are exposed all day.

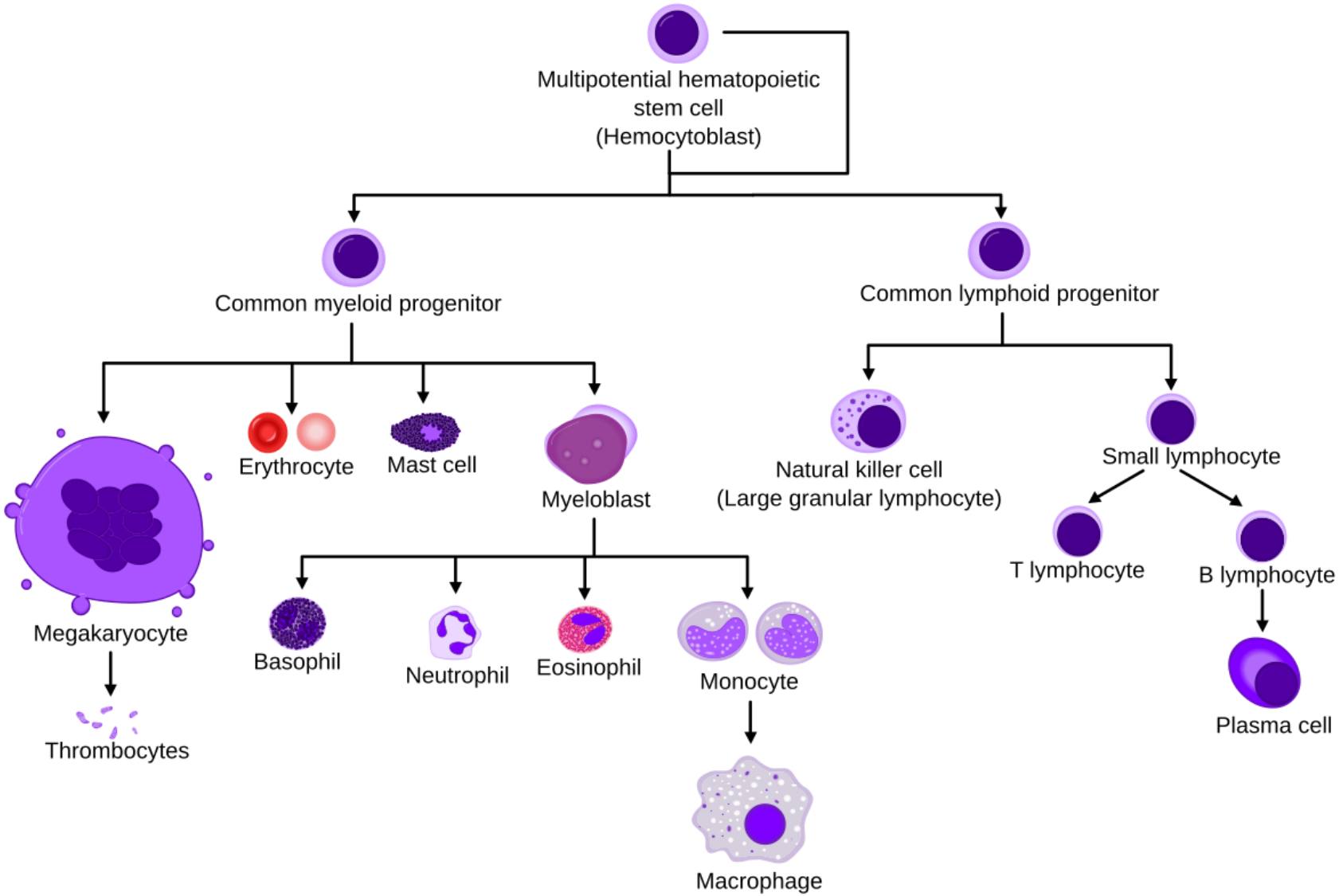
3. Cellular barriers

- In spite of the physical and physiological barriers, certain pathogens manage to enter our body.
- The cells involved in this barrier are leukocytes (WBC), neutrophils, lymphocytes, basophil, eosinophil, and monocytes.
- All these cells are all present in the blood and tissues.

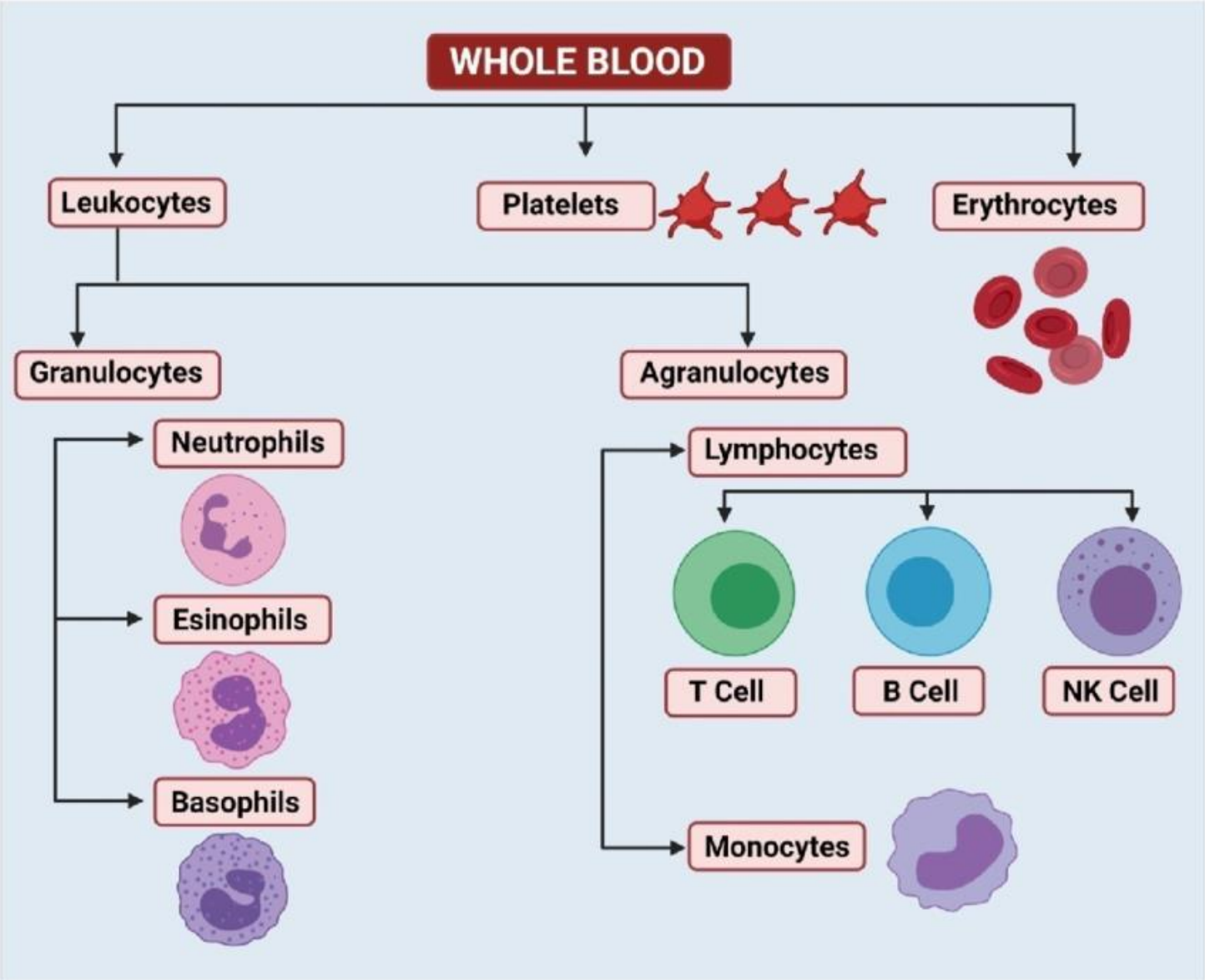
4. Cytokine barriers

- The cells in our body are smarter than we give them credit for.
- For instance, in case a cell in our body experiences a virus invasion, it automatically secretes proteins called interferons which forms a coating around the infected cell and prevents the cells around it from further infections.

Haematopoiesis



Composition of blood



Cells Involved In Innate Immunity

Macrophages:

- Macrophages (monocytes in tissue are called macrophages), they reside in tissues and can differentiate into specialized forms based on their environment.
- Phagocytosis (engulfing and digesting pathogens), antigen presentation to T cells, and production of pro-inflammatory cytokines (to recruit other cells at the site of infections).
- These have the ability to move across the walls of the circulatory system.

Neutrophils:

- Neutrophils are short-lived cells that are abundant in the bloodstream and can migrate quickly to infection sites.
- They are the first responders to sites of infection, they perform phagocytosis and release enzymes and reactive oxygen species to kill pathogens.
- These are important for healing wounds and defense against infections.

Mast Cells:

- Reside in connective tissues and mucosal surfaces, playing a role in both innate immunity and allergic responses.
- Release histamine and other mediators during allergic reactions and in response to pathogens, contributing to inflammation.
- These contain granules that are toxic in nature and kill any pathogen that comes in contact.

Eosinophils:

- Primarily found in tissues, they are involved in the response to parasitic infections and asthma.
- Combat multicellular parasites and contribute to allergic reactions by releasing cytotoxic granules.

Basophils:

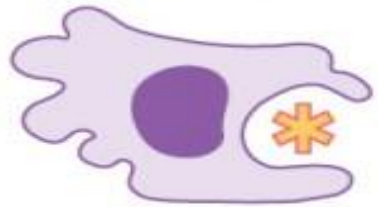
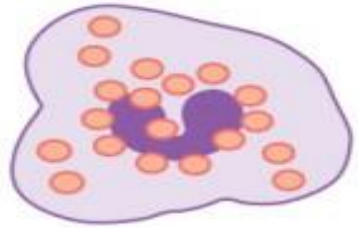
- The least common type of granulocyte, they play a role in the defense against parasites and in allergic responses.
- Combat multicellular parasites and contribute to allergic reactions by releasing cytotoxic granules.
- These attack multicellular parasites.
- Like the mast cells, these release histamine.

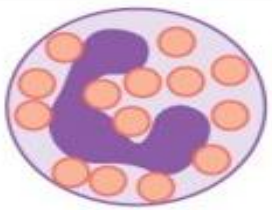
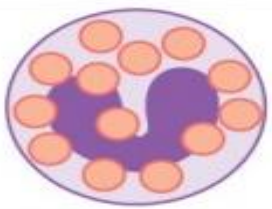
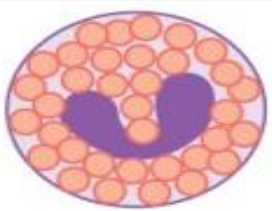
Natural Killer Cells:

- They do not require prior sensitization and can recognize stressed cells through the absence of MHC I molecules.
- Recognize and kill virus-infected cells and tumor cells by inducing apoptosis (programmed cell death).
- These stop the spread of infections by destroying the infected host cells.

Dendritic Cells:

- Found in tissues and lymphoid organs, they are critical for initiating the adaptive immune response.
- Act as antigen-presenting cells (APCs) that capture, process, and present antigens to T cells, bridging innate and adaptive immunity.

Cell type	Characteristics	Location	Image
Mast cell	Dilates blood vessels and induces inflammation through release of histamines and heparin. Recruits macrophages and neutrophils. Involved in wound healing and defense against pathogens but can also be responsible for allergic reactions.	Connective tissues, mucous membranes	
Macrophage	Phagocytic cell that consumes foreign pathogens and cancer cells. Stimulates response of other immune cells.	Migrates from blood vessels into tissues.	
Natural killer cell	Kills tumor cells and virus-infected cells.	Circulates in blood and migrates into tissues.	
Dendritic cell	Presents antigens on its surface, thereby triggering adaptive immunity.	Present in epithelial tissue, including skin, lung and tissues of the digestive tract. Migrates to lymph nodes upon activation.	

Cell type	Characteristics	Location	Image
Monocyte	Differentiates into macrophages and dendritic cells in response to inflammation.	Stored in spleen, moves through blood vessels to infected tissues.	
Neutrophil	First responders at the site of infection or trauma, this abundant phagocytic cell represents 50-60 percent of all leukocytes. Releases toxins that kill or inhibit bacteria and fungi and recruits other immune cells to the site of infection.	Migrates from blood vessels into tissues.	
Basophil	Responsible for defense against parasites. Releases histamines that cause inflammation and may be responsible for allergic reactions.	Circulates in blood and migrates to tissues.	
Eosinophil	Releases toxins that kill bacteria and parasites but also causes tissue damage.	Circulates in blood and migrates to tissues.	

Acquired Immunity:

Acquired immunity, also known as adaptive immunity, is a type of immunity that develops over time as the immune system is exposed to and learns to recognize specific pathogens.

- It provides a targeted and long-lasting response against infections.
- Unlike innate immunity, this is not present by birth.
- The ability of the immune system to adapt itself to disease and to generate pathogen-specific immunity is termed as acquired immunity.
- An individual acquires immunity after birth, hence the acquired immunity.
- It is specific and mediated by antibodies or lymphocytes which make the antigen harmless and prevent future attack.

Features of Acquired Immunity

•**Specificity**:

Our body has the ability to differentiate between different types of pathogens, whether it is harmful or not, and devise ways to destroy them.

•**Diversity**:

Our body can detect vast varieties of pathogens, ranging from protozoa to viruses.

•**Differentiate between self and non-self**:

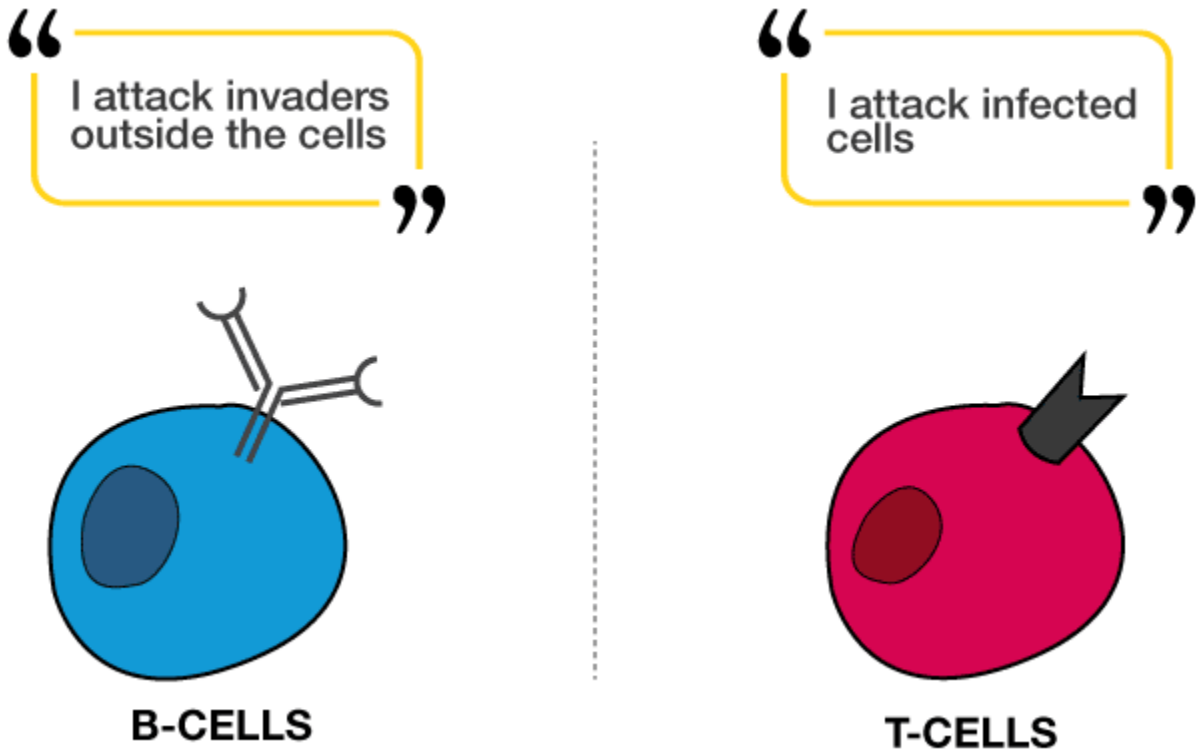
Our body has the unique ability to differentiate between its own cells and foreign cells. It immediately starts rejecting any foreign cell in the body.

•**Memory**:

Once our body encounters a pathogen, it activates the immune system to destroy it. It also remembers what antibodies were released in response to that pathogen, so that, the next time it enters, a similar procedure is followed by the body to eliminate it.

Cells Involved in Acquired Immunity

The acquired immunity involves two types of cells: B-cells and T-cells



There are two main types of Acquired immunity:

1. **Active immunity**
2. **Passive immunity**

1. Active Immunity

Active immunity is when the body's immune system is actively involved in producing a response to a pathogen. This type of immunity can be further divided into two categories:

a. Natural Active Immunity

- **Natural Infection**: Occurs when a person is exposed to a live pathogen, develops the disease, and recovers. During the infection, the immune system learns to recognize the pathogen, creating memory cells that provide long-term protection.

b. Artificial Active Immunity

- **Vaccination**: Involves the introduction of a weakened or inactivated form of a pathogen, or a piece of the pathogen (such as a protein), into the body. This stimulates the immune system to produce a response without causing the disease, leading to the creation of memory cells that provide immunity.

2. Passive Immunity

Passive immunity is when antibodies are transferred from one individual to another, providing immediate but temporary protection. This type of immunity can also be divided into two categories:

a. Natural Passive Immunity

- **Maternal Antibodies**: Antibodies are passed from mother to baby through the placenta during pregnancy and through breast milk after birth. These antibodies provide the infant with protection against infections during the early months of life.

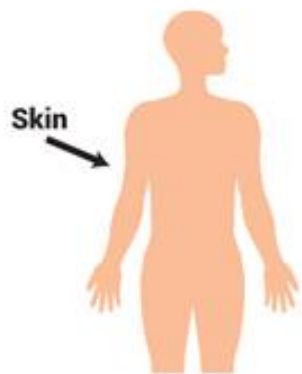
b. Artificial Passive Immunity

- **Immunoglobulin Therapy**: Involves the administration of pre-formed antibodies, often obtained from the plasma of immune individuals, to a person who needs immediate protection against a specific pathogen. This can be used for post-exposure prophylaxis or treatment of certain infections.

Types of Immunity

Innate Immunity

Organs, tissues, and cells of the immune system that you are born with, e.g., skin



Acquired Immunity

Immunity that develops during your lifetime

Active Immunity

Develops in response to an infection or vaccination

Passive Immunity

Develops after you receive antibodies from someone or somewhere else

Natural

Antibodies developed in response to an infection

Artificial

Antibodies developed in response to a vaccination

Natural

Antibodies received from mother, e.g., through breast milk

Artificial

Antibodies received from a medicine, e.g., from a gamma globulin injection or infusion

Types of Acquired Immune Response

1. **Humoral Immune Response**
2. **Cell-mediated Immune Response (no production of antibodies)**

Humoral Immune Response:

- The antibodies produced by B-lymphocytes are present in the blood cells and they are transported all over the body. This is why it is called the humoral immune response as it consists of an antibody produced by the lymphocytes.
- When an antibody on a B-cell binds with an antigen, humoral immunity comes into play. The antigen is internalized by the B cell and presented on the helper T cell. This activates the B-cell.
- The activated B cells grow and produce plasma cells and memory cells.
- These plasma cells release antibodies in the bloodstream, whereas the memory B cells retain the information about the pathogen to prevent any disease caused by that pathogen in the near future.

Cell-mediated Immune Response (no production of antibodies)

- Cell-mediated immunity is a crucial component of the immune system that involves the activation of certain immune cells to combat pathogens and infected cells.
- This type of immunity is primarily mediated by T cells, which are a subset of lymphocytes.

1.T Cells:

These are the central players in cell-mediated immunity and include various types such as helper T cells (Th cells), cytotoxic T cells (Tc cells), and regulatory T cells (Tregs).

2. Antigen Presentation:

For T cells to recognize and respond to pathogens, antigens (foreign molecules) must be presented to them. This is done by antigen-presenting cells (APCs) such as dendritic cells, macrophages, and B cells. These cells process the pathogen and present its antigens on their surface using major histocompatibility complex (MHC) molecules.

3. Helper T Cells (Th cells):

These cells are activated when their T-cell receptors (TCRs) recognize and bind to antigens presented by MHC class II molecules on APCs. Once activated, helper T cells secrete cytokines that help activate other immune cells, including B cells and cytotoxic T cells.

4. **Cytotoxic T Cells (Tc cells)**:

These cells are activated when their TCRs recognize antigens presented by MHC class I molecules, typically on infected or cancerous cells. Upon activation, cytotoxic T cells can directly kill these infected or abnormal cells by releasing perforin and granzymes that induce apoptosis (cell death).

5. Memory T Cells:

After an immune response, some T cells differentiate into memory T cells, which persist long-term in the body. These cells enable a faster and more efficient response if the same antigen is encountered again in the future.

6. Regulatory T Cells (Tregs):

These cells help maintain immune tolerance and prevent autoimmune responses by suppressing the activity of other immune cells.

CELLULAR COMPONENTS OF INNATE IMMUNITY

- **Phagocytic Cells-** Macrophages, Neutrophils, Dendritic Cells
- **Inflammatory Cells-** Mast Cells, Basophils, Eosinophils, Monocytes
- **Natural Killer (NK) Cells-** Cytotoxic Activity, Cytokine Production

1. Phagocytic Cells

- Phagocytic cells are a type of white blood cell that engulf and digest pathogens, dead cells, and other debris. Key phagocytic cells include:

1. **Macrophages**: These cells are found in almost all tissues and play a major role in detecting, engulfing, and destroying pathogens and apoptotic cells. They also stimulate other immune cells by presenting antigens and secreting cytokines.
2. **Neutrophils**: These are the most abundant type of white blood cells and are usually the first cells to arrive at the site of infection. They rapidly ingest and destroy bacteria and fungi.
3. **Dendritic Cells**: These cells are key in antigen presentation. They process antigen material and present it on their surface to T cells, thus bridging the innate and adaptive immune systems.

2. Inflammatory Cells

- Inflammatory cells are involved in the inflammation process, which is the body's response to infection or injury. They include:

1. **Mast Cells**: These cells release histamine and other substances during inflammatory and allergic reactions, contributing to inflammation.
2. **Basophils**: Similar to mast cells, basophils release histamine and play a role in the inflammatory response, especially in allergic reactions.
3. **Eosinophils**: These cells are involved in combating multicellular parasites and certain infections. They also play a role in allergic reactions and asthma.
4. **Monocytes**: These cells circulate in the blood and migrate into tissues where they differentiate into macrophages or dendritic cells to partake in immune responses.

3. Natural Killer (NK) Cells

- NK cells are a type of lymphocyte that play a major role in the rejection of tumors and cells infected by viruses.
- They are part of the innate immune system and can recognize stressed cells in the absence of antibodies and MHC, allowing for a faster immune reaction. NK cells are capable of:

1. **Cytotoxic Activity**: They can induce apoptosis in infected or cancerous cells by releasing granules containing perforin and granzymes.
2. **Cytokine Production**: They secrete cytokines like IFN-γ, which enhance the immune response by activating other immune cells.

Cellular components of Acquired immunity

1. **Lymphocytes**
2. **Antigen-Presenting Cells (APCs)**
3. **Memory Cells**:

Cellular components of Acquired immunity

1. Lymphocytes:

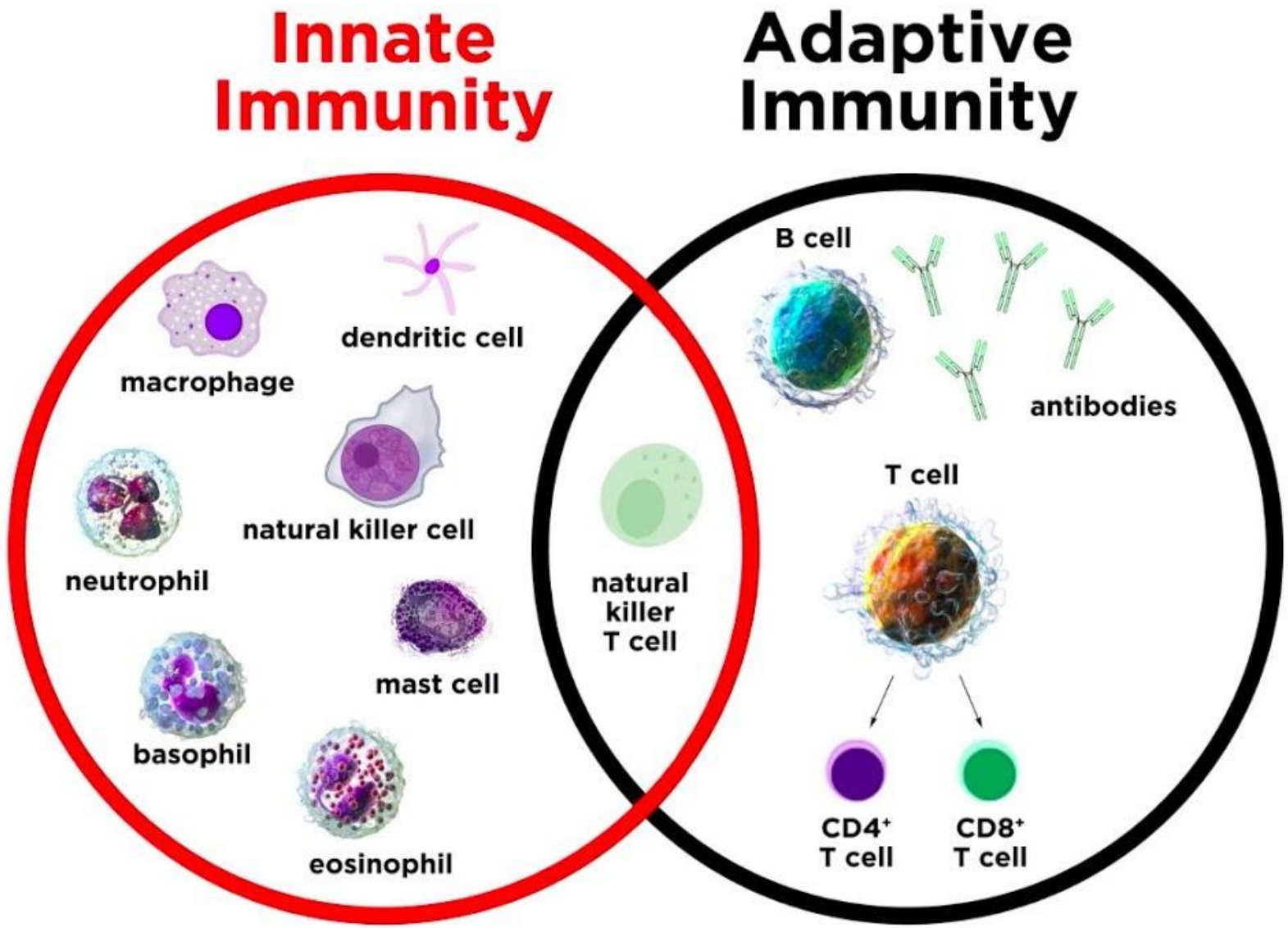
- **B cells**: Produce antibodies that target specific antigens. Upon activation, B cells differentiate into plasma cells, which secrete large quantities of antibodies, and memory B cells, which provide long-lasting immunity.
- **T cells**:
  - **Helper T cells (CD4+ T cells)**: Activate other immune cells, including B cells and cytotoxic T cells, by releasing cytokines.
  - **Cytotoxic T cells (CD8+ T cells)**: Destroy infected cells by recognizing antigens presented by Major Histocompatibility Complex (MHC) class I molecules.
  - **Regulatory T cells (Tregs)**: Help maintain immune tolerance and prevent autoimmune responses by suppressing the activation of other immune cells.

2. Antigen-Presenting Cells (APCs):

- **Dendritic cells**: Capture antigens from pathogens and present them to T cells, initiating the adaptive immune response.
- **Macrophages**: Engulf and digest pathogens, and present antigens to T cells to stimulate the adaptive immune response.

3. Memory Cells:

- Both B and T cells can form memory cells after an initial encounter with an antigen. These cells persist in the body and respond more rapidly and effectively upon subsequent exposures to the same antigen.


Innate Immunity
Adaptive Immunity
macrophage
dendritic cell
natural killer cell
neutrophil
mast cell
basophil
eosinophil
natural killer T cell
B cell
antibodies
T cell
CD4+ T cell
CD8+ T cell

DIFFERENCE BETWEEN B CELLS AND T CELLS

B-cells	T-cells
•They develop in the bone marrow. •These cells are activated on their encounter with foreign agents. These foreign particles act as foreign markers. •The B-cells immediately differentiate into plasma cells which produce antibodies specific to that foreign particle or so-called antigen. •These antibodies attach to the surface of the antigen/foreign agent. •These antibodies detect any antigen in the body and destroy it. •The immunity dependent on B-cells is called humoral immunity.	•They originate in the bone marrow and develop in the thymus. •T-cells differentiate into helper cells, cytotoxic cells, and regulatory cells. These cells are released into the bloodstream. •When these cells are triggered by an antigen, helper T-cells release cytokines that act as messengers. •These cytokines initiate the differentiation of B-cells into plasma cells which release antibodies against the antigens. •The cytotoxic T-cells kills the cancer cells. •Regulatory T-cells regulate immune reactions.

LYMPHOCYTES TRAFFICKING

- **Lymphocytes trafficking** refers to the movement of lymphocytes between different lymphoid tissues in the body.
- This process is essential for the immune system to monitor and respond to pathogens effectively.
- This process involves the movement of lymphocytes (T cells, B cells, and natural killer cells) from one lymphoid tissue to another, allowing them to encounter antigens, proliferate, and differentiate into effector cells.

Features of Lymphocyte Trafficking

1.Dynamic Movement:

Lymphocytes move continuously between the bloodstream, lymphatic system, and various lymphoid organs (such as lymph nodes, spleen, and thymus). This dynamic movement is essential for surveillance and rapid response to infections.

2. Chemokine Guidance:

The movement of lymphocytes is directed by chemokines, which are signaling proteins that create gradients that lymphocytes follow. Specific receptors on lymphocytes bind to these chemokines, guiding them to their target tissues.

3. Adhesion Molecules:

Lymphocyte trafficking involves interactions with endothelial cells lining blood vessels. Adhesion molecules (e.g., selectins and integrins) on lymphocytes facilitate their attachment to the endothelium, allowing them to exit the bloodstream and enter tissues.

4. Lymphatic System Role:

The lymphatic system plays a crucial role in transporting lymphocytes from peripheral tissues to lymph nodes, where they can encounter antigens and become activated.

5. Recirculation:

After activation in lymph nodes, lymphocytes can recirculate back into the bloodstream and home to sites of infection or inflammation, where they exert their effector functions.

Mechanisms of Lymphocyte Trafficking

1. Spleen and Lymph Node Homing:

Lymphocytes express specific receptors that enable them to home to secondary lymphoid organs. For example, naive T cells express CCR7, which directs them to lymph nodes via the lymphatic vessels.

2**. Activation and Differentiation:**

Upon encountering antigens in the lymph nodes, lymphocytes can differentiate into effector cells (such as cytotoxic T cells or antibody-secreting B cells) and migrate to sites of infection.

3. Exit from Lymphoid Organs:

Activated lymphocytes exit lymph nodes through efferent lymphatic vessels, returning to the bloodstream via the thoracic duct. This process is influenced by changes in adhesion molecule expression and chemokine receptor signaling.

4. Inflammatory Response:

During inflammation, the expression of adhesion molecules on endothelial cells increases, promoting the recruitment of lymphocytes to inflamed tissues. This process is enhanced by local cytokine production.

5. Memory Cell Trafficking:

Memory T and B cells have distinct trafficking patterns, allowing them to quickly respond to previously encountered antigens. They can migrate to peripheral tissues and remain poised for rapid activation upon re-exposure to the same pathogen.

Steps of Lymphocyte Trafficking

1.Lymphocyte Development:

1. **B cells** mature in the bone marrow.
2. **T cells** mature in the thymus.

2.Lymphocyte Entry into the Bloodstream:

1. Mature lymphocytes enter the bloodstream and circulate through the body.

3.Homings to Lymphoid Tissues:

1. **Chemokines**: These are signaling molecules that attract lymphocytes to specific tissues.
2. **Adhesion Molecules**: Proteins on the surface of lymphocytes and endothelial cells of blood vessels help lymphocytes adhere to the vessel walls in the lymphoid organs.
3. **High Endothelial Venules (HEVs)**: Specialized blood vessels in lymph nodes that allow lymphocytes to exit the bloodstream and enter the lymph node.

4. **Surveillance and Activation**:

1. In the lymph nodes and other secondary lymphoid tissues, lymphocytes survey for the presence of antigens (foreign substances).
2. **Antigen Presentation**: Dendritic cells and other antigen-presenting cells (APCs) present antigens to lymphocytes, leading to their activation.

5. **Recirculation**:

1. After activation, lymphocytes leave the lymphoid tissues and re-enter the bloodstream or lymphatic system to travel to sites of infection or inflammation.
2. **Efferent Lymphatic Vessels**: Transport activated lymphocytes out of the lymph nodes.

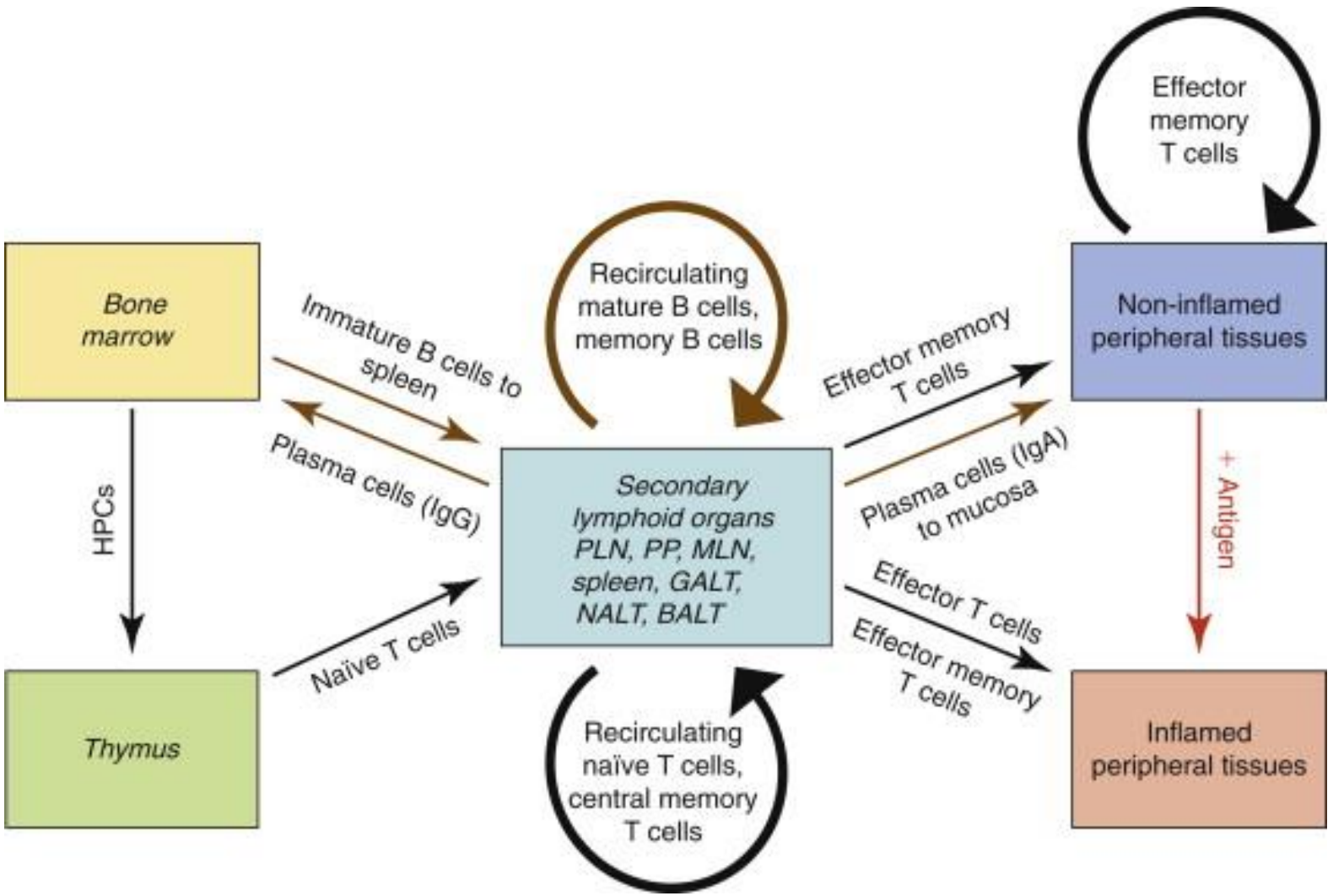
6. **Migration to Sites of Infection**:

1. Activated lymphocytes migrate to tissues where they are needed to fight infections.
2. **Inflammatory Signals**: Cytokines and other signals at the site of infection attract lymphocytes.

Importance of Lymphocyte Trafficking

- **Immune Surveillance**: Allows lymphocytes to monitor the body for pathogens continuously.
- **Efficient Immune Response**: Ensures that activated lymphocytes can quickly reach sites of infection or injury.
- **Homeostasis**: Maintains a balance of lymphocytes in different tissues.

Lymphocyte Trafficking



HPSCs- Haematopoietic Progenitor cells

PLN-Peripheral Lymph Nodes

PP- Peyer's Patch

MLN-Mesenteric Lymph Nodes

GALT-Gut Associated Lymphoid Tissue

NALT-Nasal Associated Lymphoid Tissue

BALT-Bronchus Associated Lymphoid Tissue

ACKNOWLEDGEMENT

- The presentation is being used for educational and non-commercial purposes.
- Thanks are due to all the original contributors and entities whose pictures were used to create this presentation.