

Course of Basic Immunology

4th Year

Biology students

2022-2023

Lecture #1

Course specifications

Intended learning outcomes (ILOs)

A- Knowledge and understanding

- 1- Describe the mechanisms of innate immunity
- 2- Recognize the cells of the immunity
- 3- What are antigens and their characteristics
- 4- Describe the steps of cell immunity response
- 5- Describe the steps of humoral immune response
- 6- Describe complement activation and regulation
- 7- Describe Ag and Ab reaction
- 8- Explain the immunity to microbes
- 9- Describe hypersensitivity reactions
- 10- What is the immune tolerance and autoimmune diseases

B- Intellectual skills

- 1- Interpretate the results of serological tests
- 2- Make a scheme for steps of Abs and cell mediated immune responses
- 3- Make a scheme for activation of complement

C- Practical skills (Lab.)

D- Communication and transfer skills

Course contents

Lecture #1

Overview of the immune system

- 1- Definition of immunity
- 2- Difference between innate and acquired immunity
- 3- Organs of the immune system
- 4- Cells of the immune system

Lecture #2

Innate Immunity

- 1- Definition of immunity
- 2- Characters of innate
- 3- Mechanisms of innate

Lecture #3

Innate Immunity (cellular defense mechanism)

- 1- Definition of phagocytosis
- 2- Steps of phagocytosis
- 3- Natural killer cells

Lecture #4

Complement system

- 1- Definition
- 2- Activation
- 3- Function
- 4- regulation

Lecture #5

Antigens

- 1- Definition of antigen, immunogen,Hapten and epitopes
- 2- Factors that influence immunogenicity
- 3- MHC (I and II)
- 4- Importance of MHC I and II

Lecture # 6

Humoral immune response

- 1- Definition of immunoglobulins
- 2- Steps of Abs production
- 3- Structure of Ig's
- 4- Function of Ig's

Lecture # 7

Types and functions of Ig's

- 1- Types of Ig's (IgG,IgM,IgA, IgD,IgE)
- 2- Ig class switching and affinity maturation
- 3- 1ry and 2dry immune response
- 4- Monoclonal antibodies

Lecture #8

CMI

- 1- Definition of CMI
- 2- Steps of CMI
- 3- Superantigen

Course contents

Lecture # 10

Hypersensitivity reaction

- 1- Definition
- 2- Classification
- 3- Definition of type I & II
- 4- mechanism of action
- 5- Diseases of type I & II
- 6- Lab.diagnosis

Lecture #11

Hypersensitivity reaction

- 1- Mechanisms of type III and IV
- 2- Diseases of type I & II
- 3- Lab.diagnosis

Lecture # 12

Tolerance and autoimmune diseases

- 1- Difinition
- 2- Mechanisms
- 3- Examples of autoimmune diseases

Teaching and learning methods

- A- Interactive lectures between me and you by making questions**
- B- Solve problems**

Assessment methods

(25 mark theory +15 mark practical)

- A- Class activities (3 mark)**
- B-Presentation (2 mark)**
- C-Quizzes (3 mark)**
- D- Attendance (2 mark)**
- C- Written exam (15 mark)**

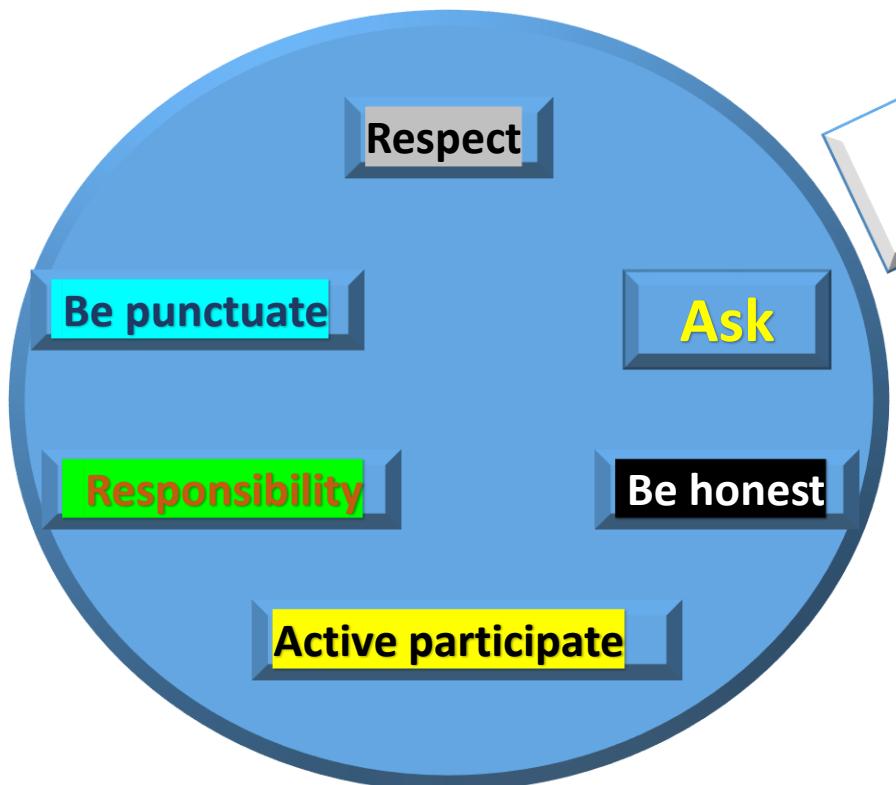
References

- A- Basic Immunology by Kuby**
- B- Basic Immunology by Abul Abbas**

Assessment methods	Marks
Attendance	2
Presentation	2
Quizzes (sudden onset)	3
Class activity	3
Written exam (short assays, MCQs, Give reasons, interpretation, labelling, Case study, solving a problem)	15
Total	25

If somebody ask a **critical question**, I will help in theory giving 5 extra marks

Don't forget general rules



If you don't understand



If you don't find the answer





Difference between active and passive lecture



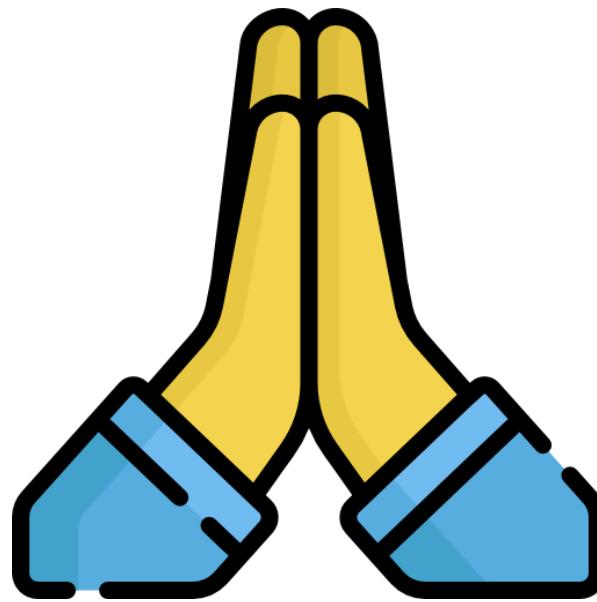
Difference between honest and dishonest



Difference between respect and insolence



Respect the time



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Lecture # 1

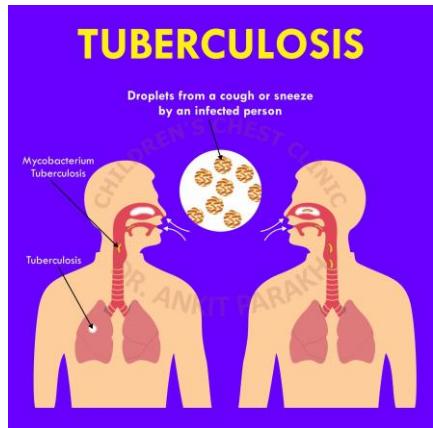
Overview of the Immune System

By the end of this lecture the students will be able to:-

- 1- Define immunity**
- 2- Make comparison between innate and acquired immunity**
- 3- Know the organs of the immune system**
- 4- Know the cells of the immune system**



Patient with severe COVID-19



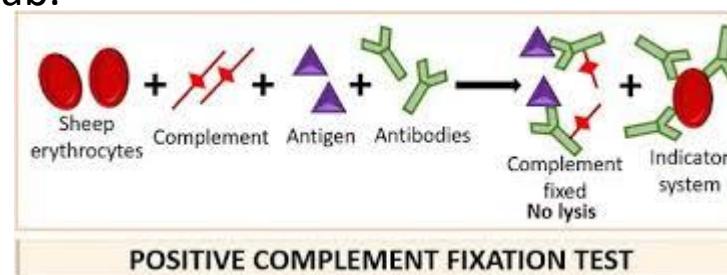
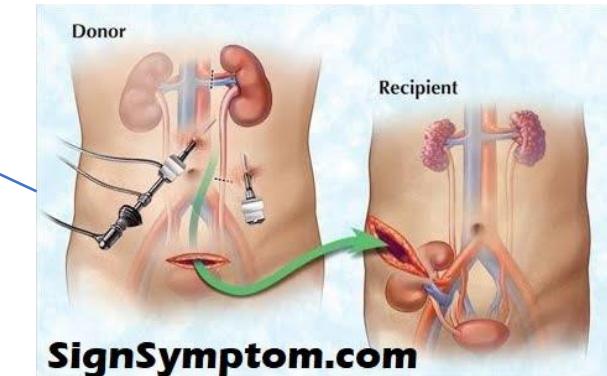
IGRA test (Interferon Gamma releasing assay)

Total IgE test

Allergy



Diagnostic Medical lab.



Autoimmune diseases
Many like Hashimotoes thyroididitis (Hypothyroididm) ,Graves disease (heprthyroidisim),.....etc

Did you infect by COVID-19?

What happened with you?

Did you checked IgG and IgM tests?

if you IgM positive and IgG negative so what is your situation?

If you positive for IgG and negative for IgM so what is your situation?

What is this type of immunity do you have?

Do you think that you have only this kind of immunity?

Do you know how you developed these antibodies?



COVID-19

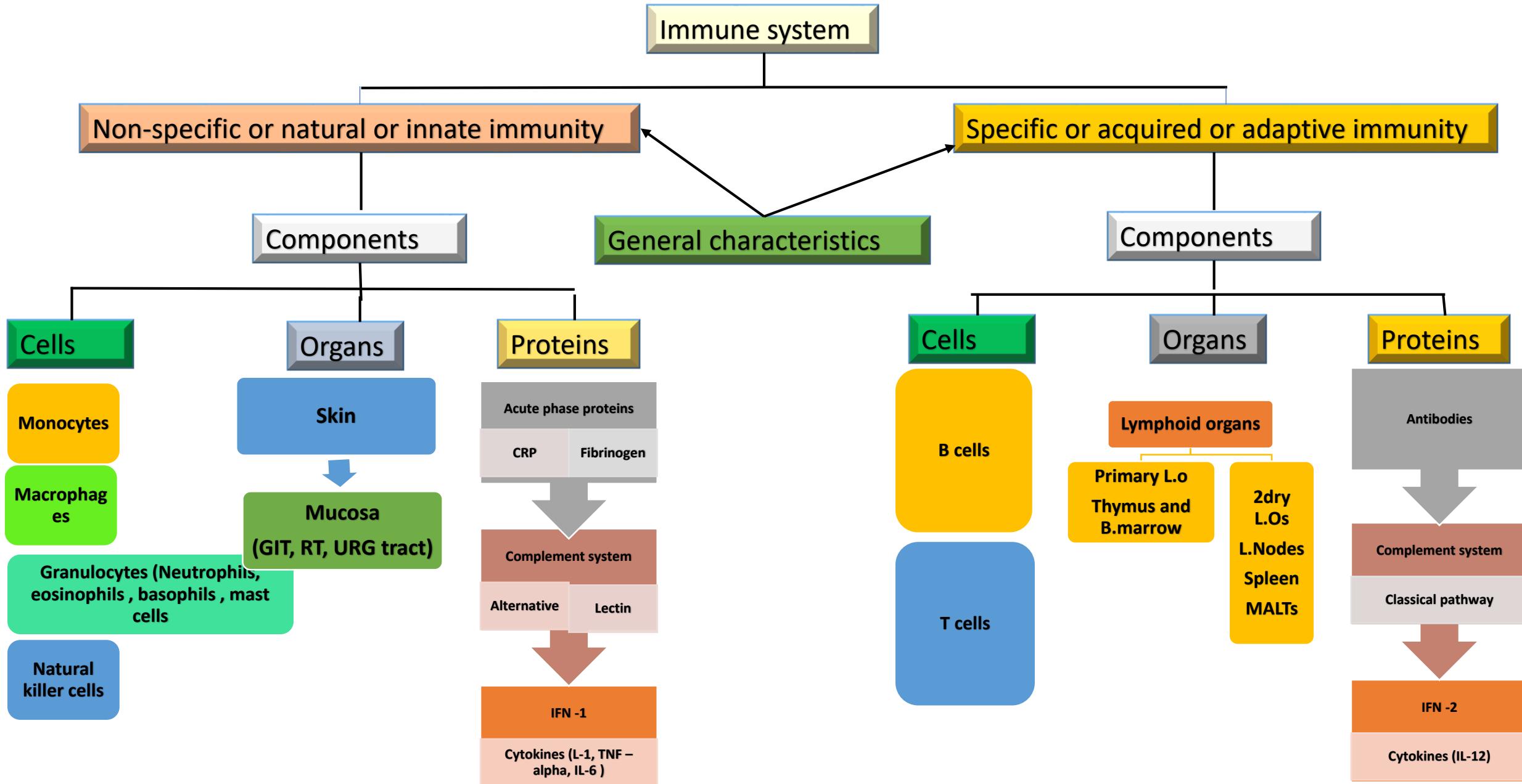
Definition of immunity: Host defense mechanisms against any foreign body (internal or external)

From this simple definition, what are the subjects that you should study in order to complete your understanding?

I think 2 main subjects

So which are?





Non specific immune system
Or natural or innate like
Ministry of defense

specific immune system
Like **ministry of interior**

invader

(pathogen)

First line of defenses at the border

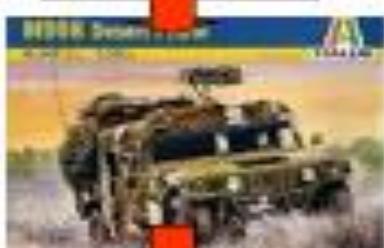
**Skin or mucus membrane
(physical barriers)**

If passed they will be killed by Chemicals, flora, cells (phagocytic) NK cells, APCs, Cytokines, complement

Those soldiers are neutrophils, dendritic cells and macrophages.
Instead of killing they will arrest the invaders and carry to the regional L.N where exposed to other cells called lymphocytes.



Invaders killed at night and took their bodies (ID unknown) but removed the threat temporarily. This task is performed by special cells at the site of entrance (Neutrophils and macrophages). This is task of innate immunity



The specific I.S will activate A new weapon called humoral or antibody I.R and another weapon called cell mediated I.R

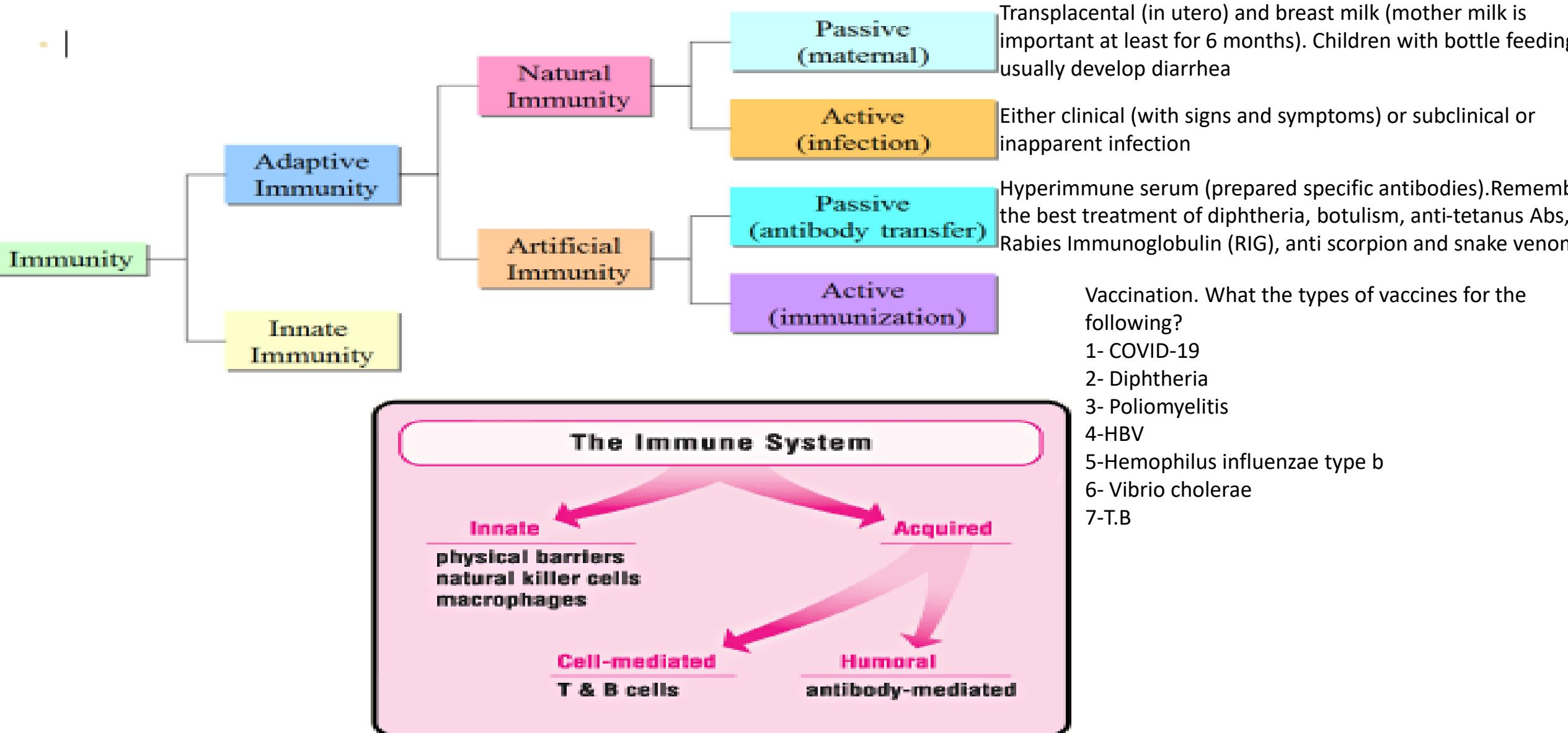


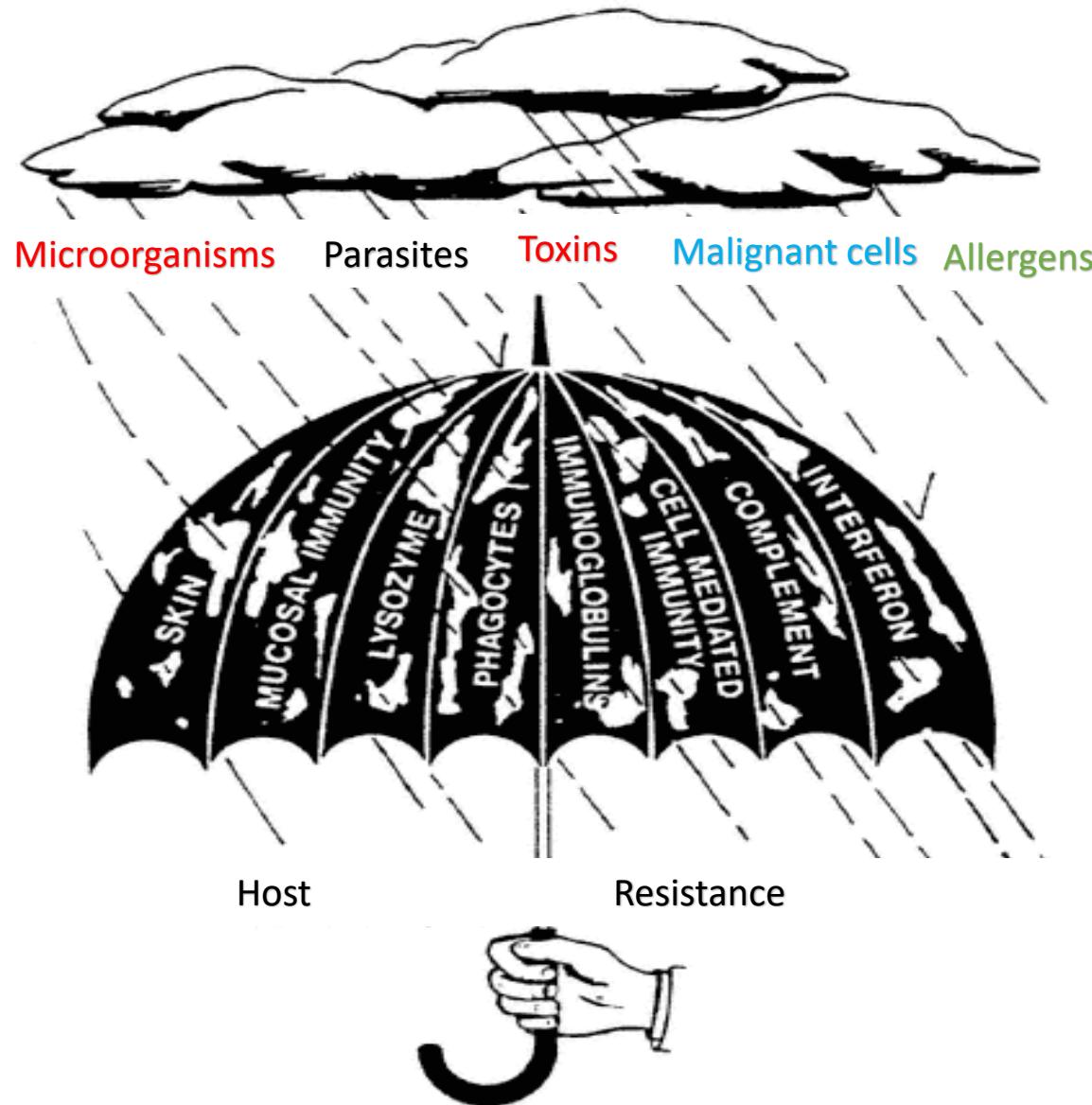
Macrophages and other cells called antigen presenting cells carry pathogens and travel through road called lymphatic vessels to the regional L.N

In L.N they will expose parts of pathogen bodies to the lymphocytes. (Now acquired or specific immune system is turn on)

The body will send copies of pathogen photos to all parts of the body to be recognized (memory) when enter the body and kill them directly without calling

Immunity and classification of the immune system





Our immune system is like a protective umbrella

	Innate immunity	Specific immunity
Origin	From birth	During life –acquired or adaptive
Immune response	Rapid in minutes	Slow in days
Prior exposure	Not required	After exposure to antigen
Specificity	Limited and targets groups of pathogens (non specific)	High and targets specific pathogen (specific)
Diversity	Limited	High
Memory	Absent	Present
2nd immune response	same	faster
Receptors	Pattern Recognition receptors (PRRS) like Toll Like receptors (TLRs). Non specific (Few)	Various BCR and TCR-Specific receptors
Components	Anatomical or mechanical barriers (skin & MM) Chemical barriers like pH of the stomach, lysozyme in saliva tears + complement system	B cells, T cells, Macrophage and dendritic cells+ Cytokines IL-1, 2,4,5 , IFN gamma + Complement, antibodies
Cells =	macrophages, neutrophils, eosinophils, mast cells, Natural killer cells	
Proteins :	Cytokines (IL-1,6,8, 12,INF alpha and beta, Inflammatory responses+ Acute phase proteins like CRP, Complement system	
Self reaction	No	Yes (autoimmune diseases)

Challenge questions of previous slide

What are the advantages of Innate immunity?

What are the advantages of adaptive immunity?

What are the disadvantages of Innate immunity?

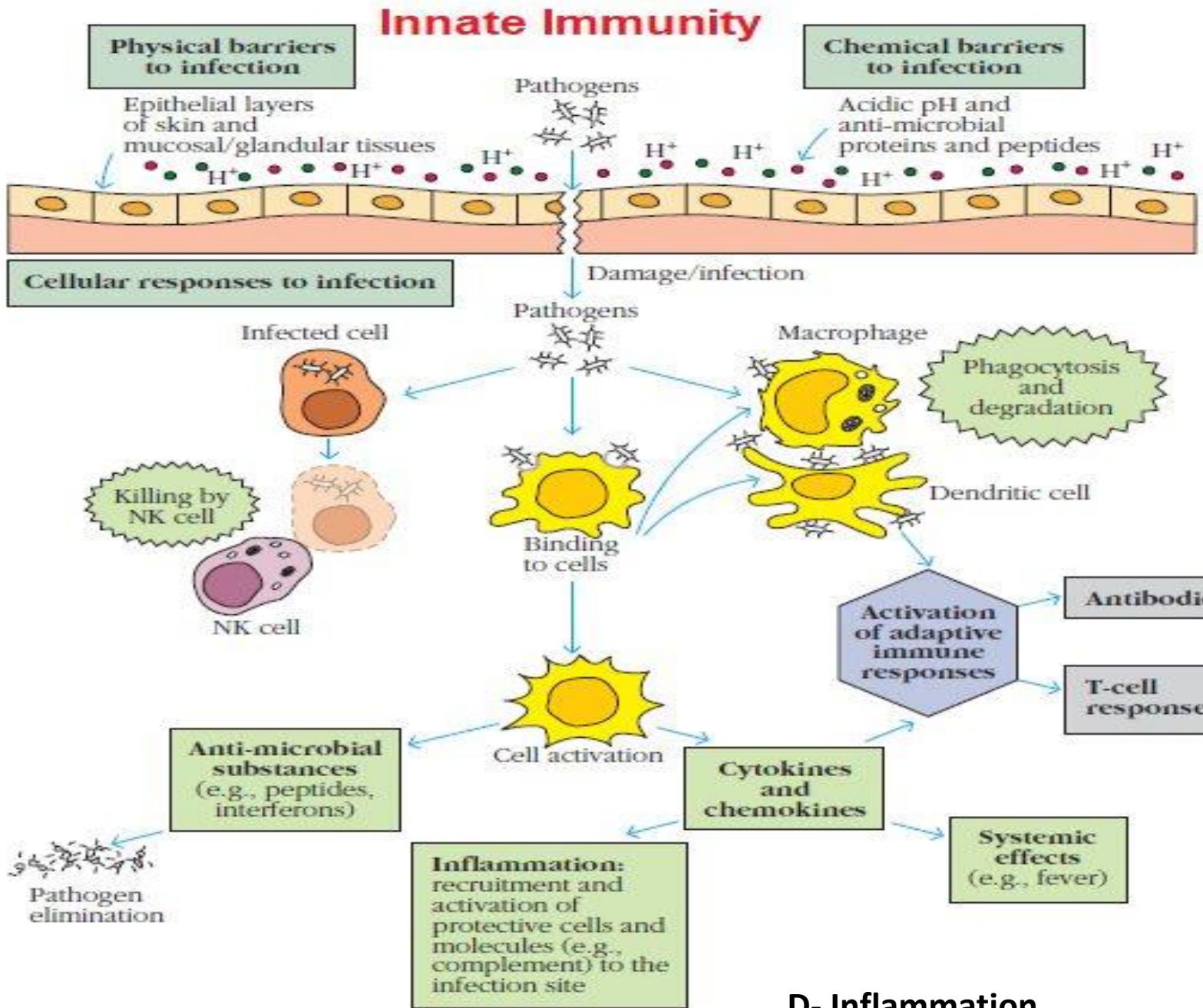
What are the disadvantages of specific immunity?

Exercise1: What are the cells of Innate immunity and Acquired immunity?

Innate Immunity	Acquired immunity
Neutrophils	B cells
Monocytes	T cells
Macrophages	
NK cells	
Mast cells	
Basophils	
Eosinophils	

Exercise2: Compare between Innate and acquired immunity

Characters	Innate	Acquired
1- Onset	Rapid	Slow
2- Main cells	Granulocytes, monocytes, Macrophages, NK cells	B and T cells
3- proteins	IFN-1, APPs, Complement	Abs, IFN-II
4- Memory	Absent	Present
5- Specificity	Non-specific	Specific
6- Efficiency	Efficient	More
7- Lines of defense	1 st line	2nd line



A- Anatomical barriers

- 1- Physical barriers
- 2- Chemical barriers

B- Cells

- 1- Neutrophils
- 2-Eosinophils
- 3-Basophils
- 4- mast cells
- 5-Monocytes
- 6-Macrophages
- 7-Natural killer cells

C- Proteins

- 1- Complement
- 2-Acute phase proteins
- 3-Cytokines and chemokines
- 4- IFN-alpha and beta
- 5-Antimicrobial substances

D- Inflammation

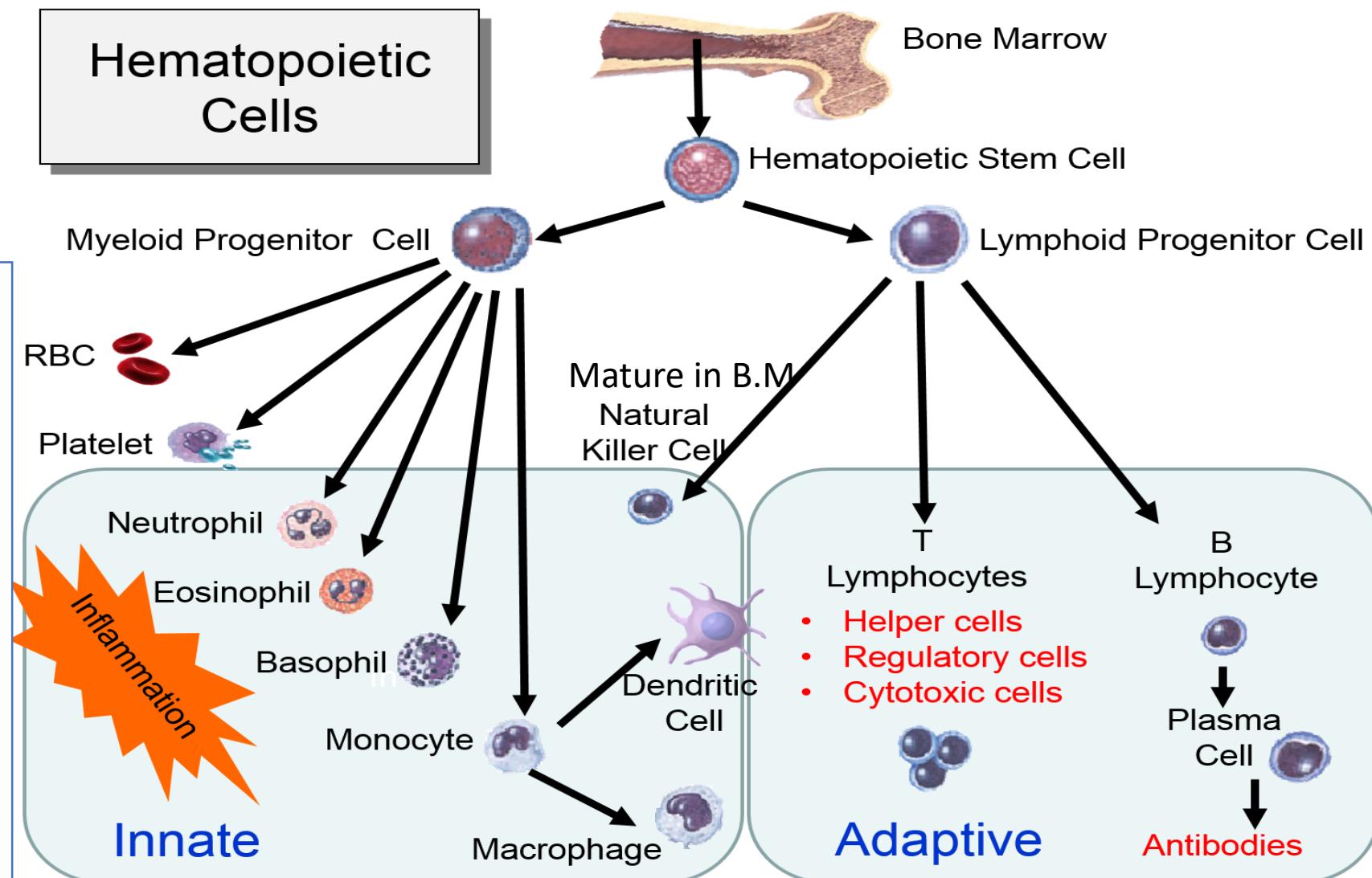
Phagocytic cells + Complement +cytokines and chemokines

Soldiers (cells) of Immune system

All cells (leukocytes and RBCs) are formed by a process called hemopoiesis in the B.M from hematopoietic stem cells (HSCs). WBCs are carried by blood and lymph and populated in secondary lymphoid organs (adaptive) or circulate in blood or distributed into tissues (innate cells).

2 kinds of stem cells
A- Embryonic SCs also called pluripotent SCs have the capacity to generate every specialized cell type in an organism.
B-Adult SCs: give rise to mature tissue-specific cells. HSC one type of adult SC. And characterized by
1- The ability to regenerate or “self-renew”.
2-The ability to differentiate into diverse cell types.

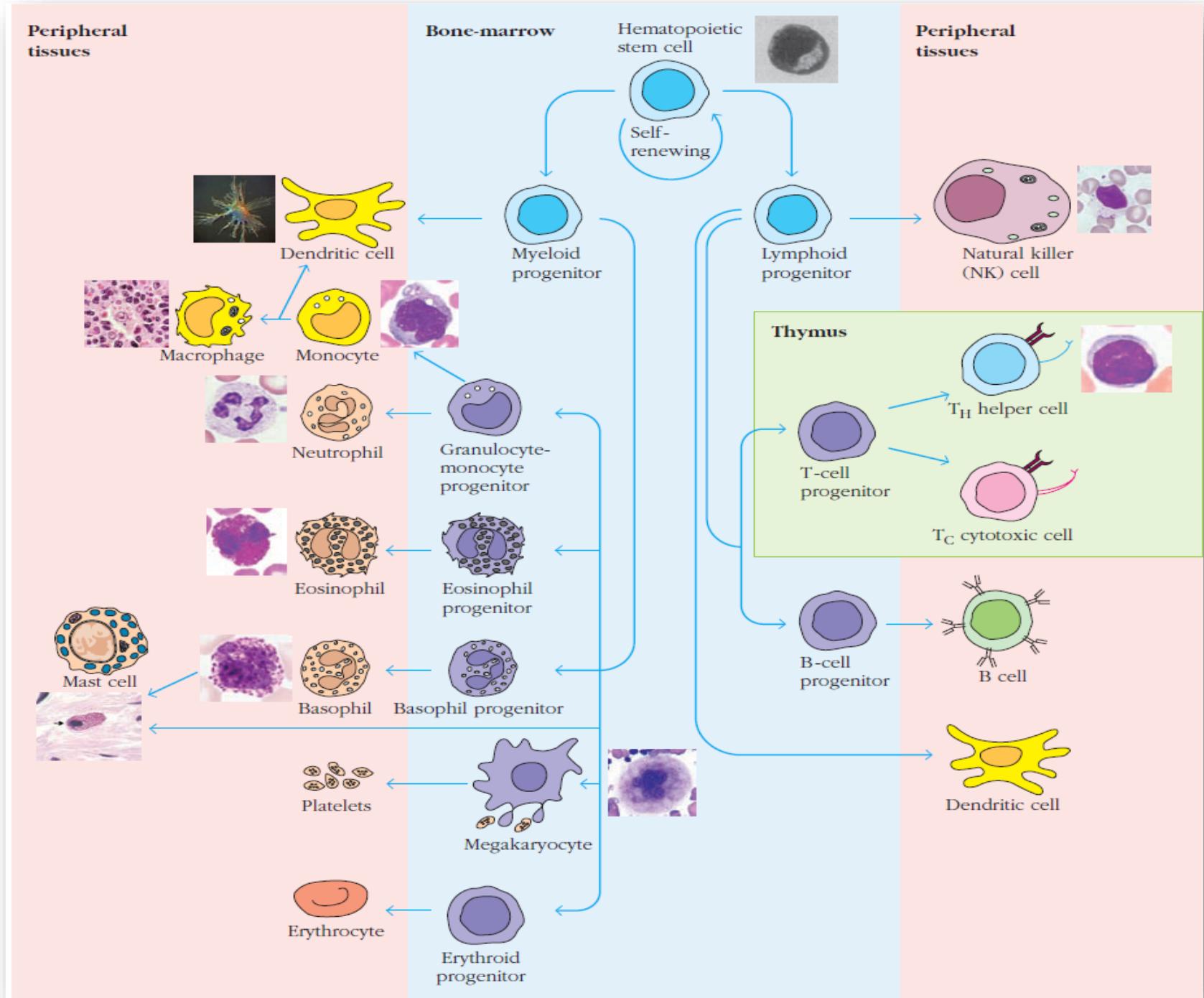
Cells of the immune system



Hematopoiesis

Nowadays immunologists can separate these Stem cells and used for therapeutic purposes

What is the strange from this figure?



Exercise 3

What are the cells of acquired immunity and where they synthesized and matured?

B and T cells are synthesized in B.M. B cells become matured and selected in B.M, while T cells in the thymus

Where the specific immune responses occur? In Secondary L.Os like spleen, L.nodes, MALT

Cells of the non specific immune system (Myeloid)

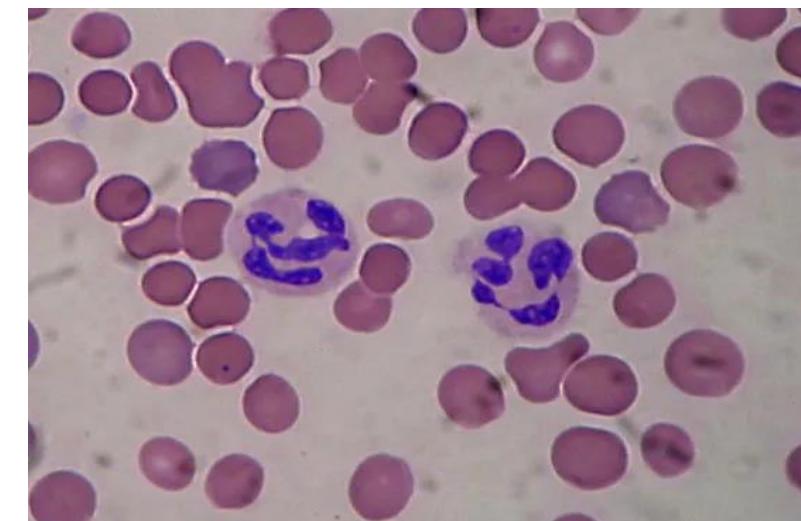
- Location
- Identification
- Function

1-Neutrophils (same staining with acid or basic dyes) (microphages)

- Most abundant
- 40-75%
- Most motile (first arrive at the site of inflammation)

Location : They are found in the **blood** and migrate to the tissue during acute inflammation (Neutrophilia)

Identified as poly lobes 3-5 lobes



If the patient with fever , leukocytosis and neutrophilia so what does this case mean?

Function of neutrophil (Cytoplasmic granules)

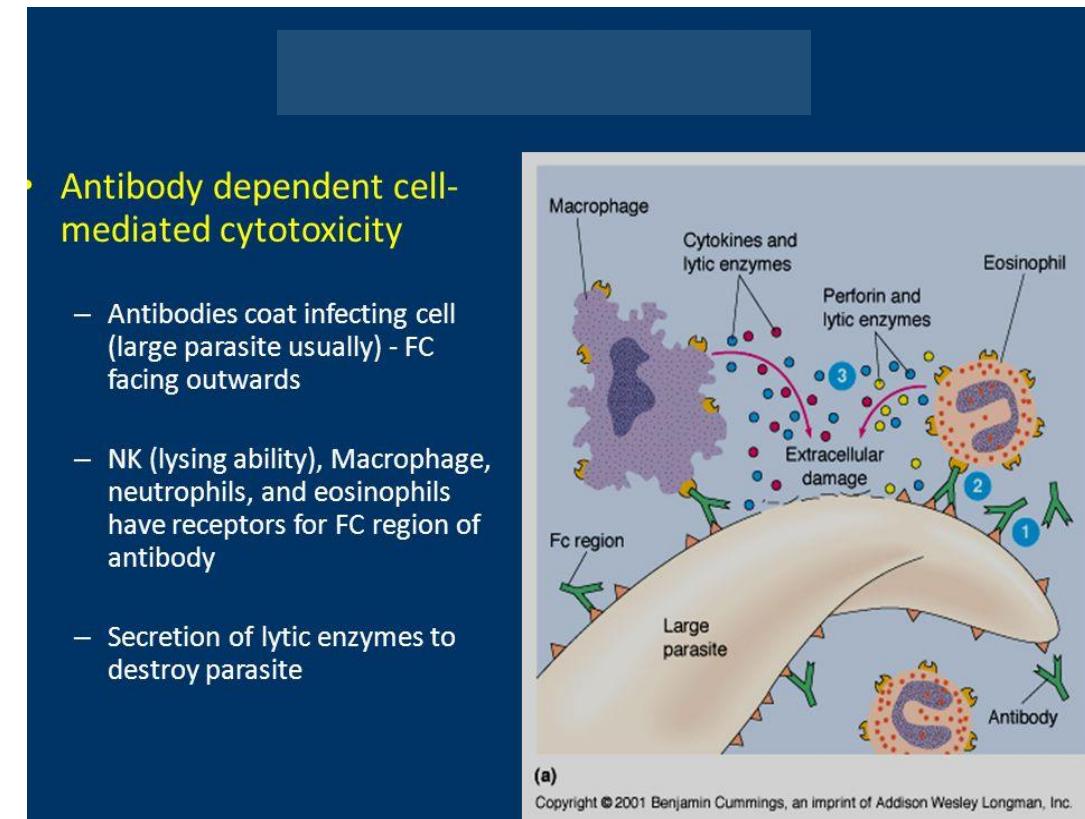
- **Lysozymes**
- **Collagenase**
- **Acid hydrolysis**
- **Myeloperoxidase**
- **Defensins**
- **Lactoferrin**
- **Hyaluronidase**

So the main functions:

- 1- **phagocytosis**
- 2- **Acute Inflammation (pus)-Neutrophilia**

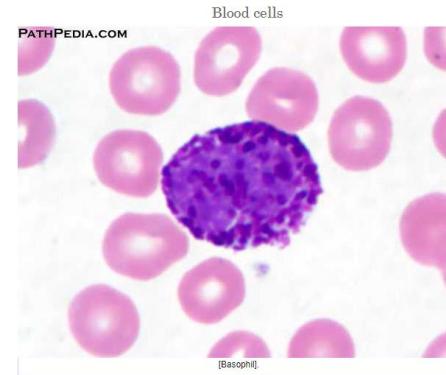
Eosinophils

- Location in blood (1-6%)**
- Identification by pink granules with bilobed nucleus**
- Function: Killing parasites (protozoa and helminths) by A process called ADCC.**
- Allergic reactions (Eosinophilia)**



Basophils

- Bilobed nucleus**
- Blue granules**
- 0-1%**
- Function: have a role in hypersensitivity**



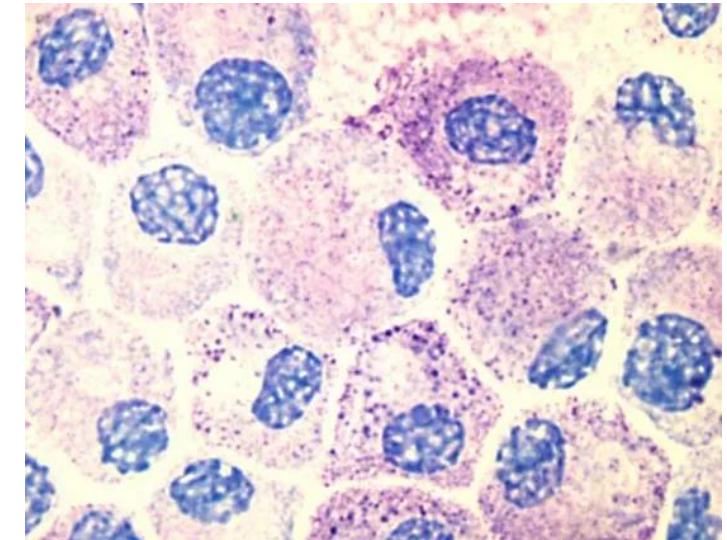
Mast cells are basophils in tissues

Location

- Skin**
- Around blood vessels**
- Mucosa of GIT**
- Mucosa of Respiratory system**

Identification

- Small nucleus**
- Blue granules**



Functions

- Similar to basophils (hypersensitivity reaction + inflammation=protective role)

Monocytes

- Large kidney or bean shaped nucleus
- Cytoplasm with vesicles and vacuoles
- CD 14
- Ruffled membrane
- Function: Phagocytosis

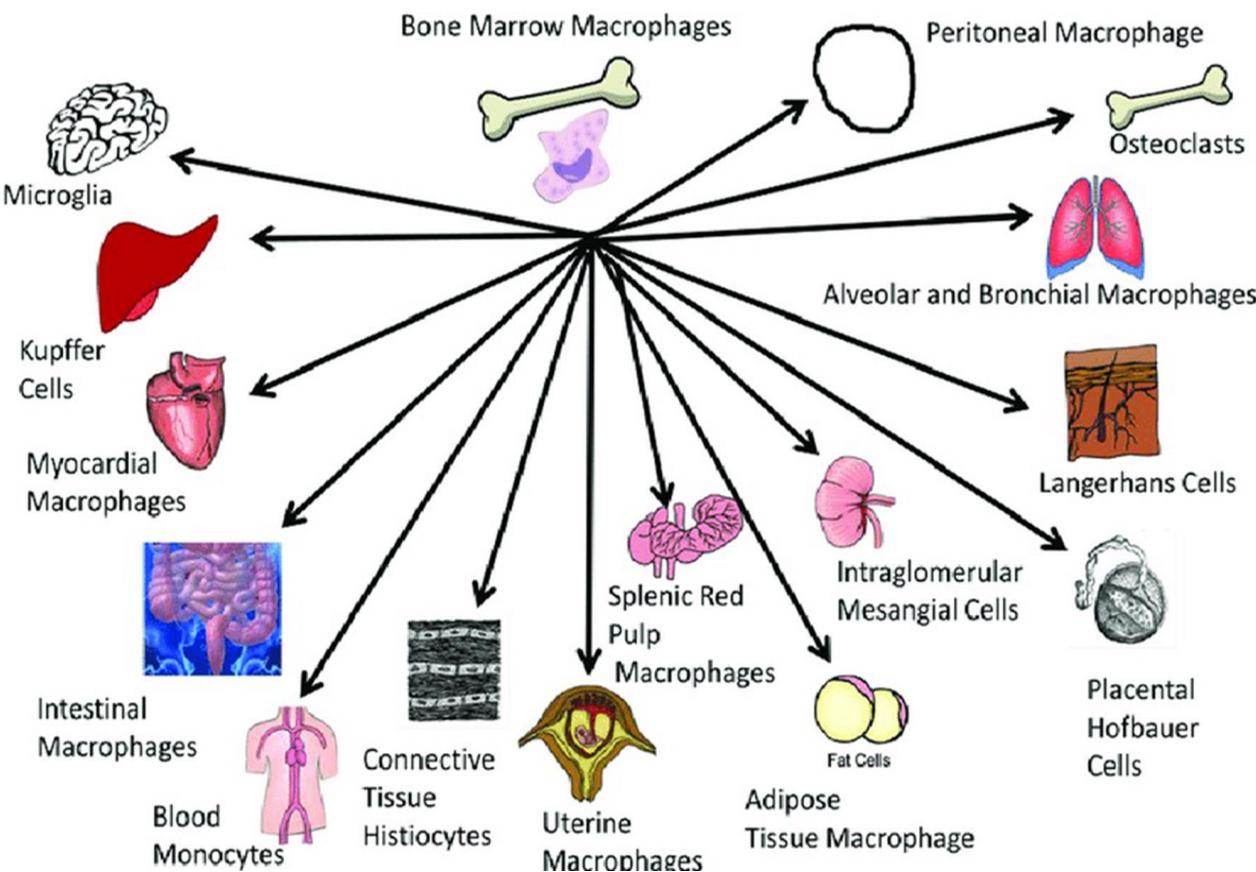
Macrophages in tissue with different names

Location: all the tissues

Function:

- 1- Phagocytosis (more effector than Neutrophils).
- 2- Act as a sentinel or patrol cells(sense or recognize the presence of the invader)
- 3- Trigger specific immunity (act as antigen presenting cells APC).
- 4- Control inflammation (good fighters)
- 5- They are responsible for wound healing
- 6- They can change into another cells called dendritic cells
(also act as APC) and can fuse to form multinucleated giant cells in case of the presence of foreign body in the tissue.

Examples of Specialized Macrophage Populations

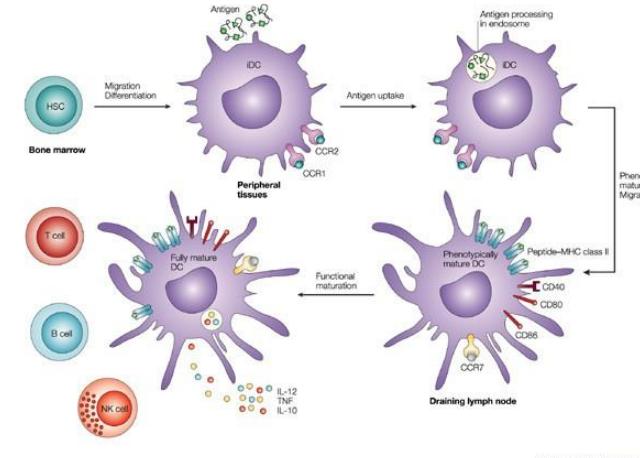


Dendritic cells

Location

- Under the skin and mucosa of the organs
- Function: Professional APC

Lymphoid progenitors (B cells+T cells+ NK cells)



B cells and T cells

Location: Blood stream and secondary lymphoid organs

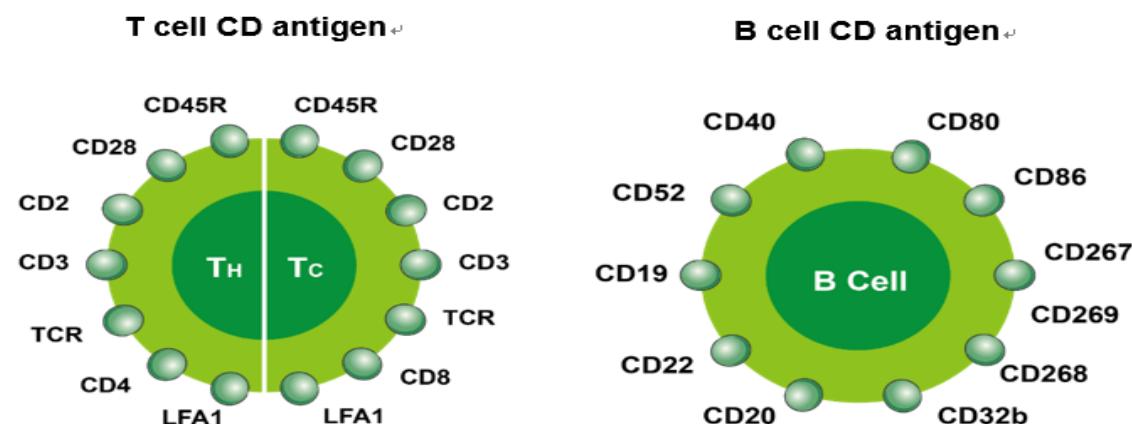
Identification: similar morphologically but can be differentiated by CD markers

B cells have CD 19,20,22 Function : Responsible for humoral immunity

T cells have CD3 (T helper cells CD4, Cytotoxic T cells have CD8)

Responsible for 1- Cell mediated immunity 2- Regulation of

Humoral and cellular immunity by CD4 cells



NK cells (Large granulocytic lymphocytes) (Innate immunity)

Location

- Blood stream 5-10% of lymphocytes

Identification

- Large cytoplasmic granules
- Surface markers : CD 16 & CD 56

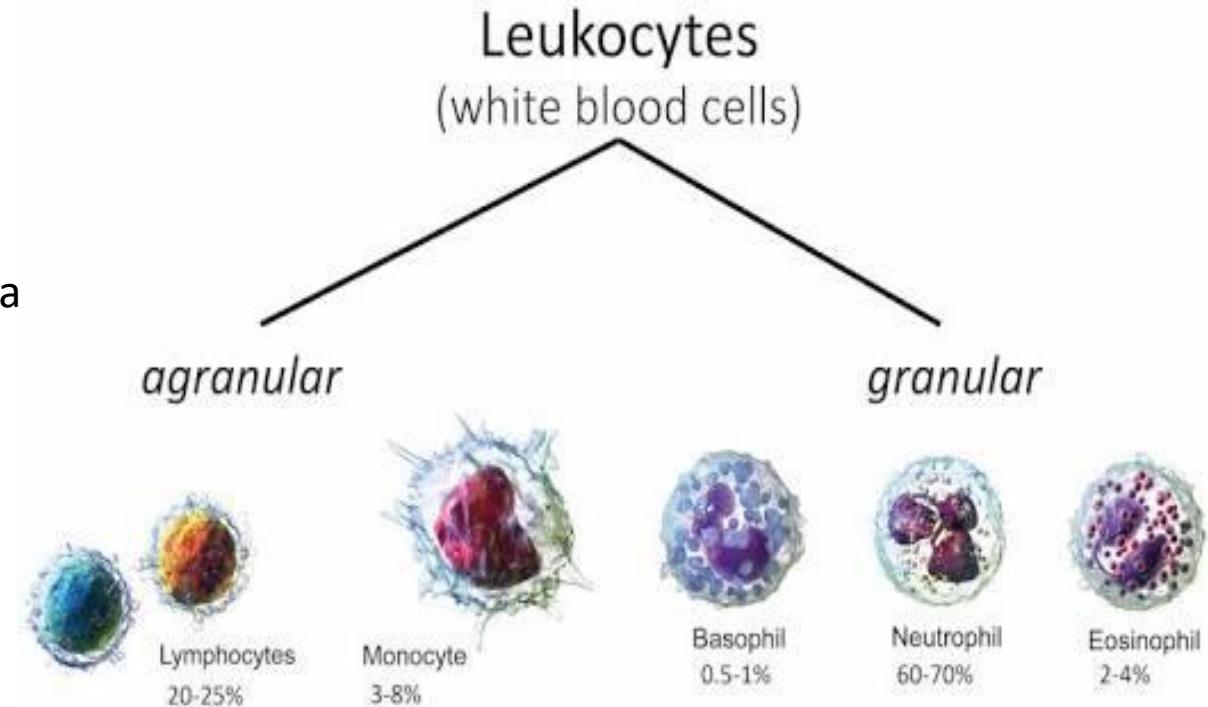
Function

1- Virally infected cells

2- Tumor cells

Normal range of WBCs:4000-11000/cu.mm

>11000 called leukocytosis and less than 4000 called leukopenia



Exercise 4

Differentiate immune cells into cells that circulating in blood, cells that residing in tissue and cells that present in both

Circulating in blood: N,M,L,E,B

Residing in tissues: Macr, Dend, Mast cells

In both : Lymphocytes

Write on the location, identification and function of 1- Macrophages, 2- Mast cells

Name	Location	Identification	
MO	Tissue	Ruffled cytoplasmic membrane, vacuoles and vesicles with bean shaped nucleus	- Phagocytosis - APC
Mast cell	Tissues around the blood vessels	Small nucleus and large blue cytoplasmic granules	- Inflammation - Type I HSR

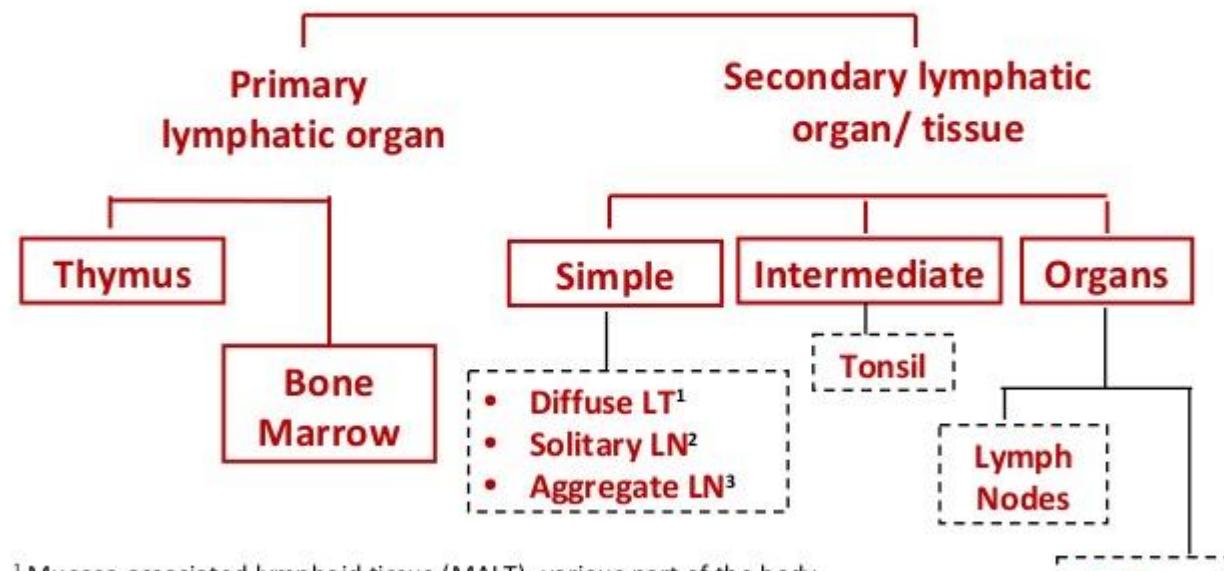
Organs of immune system

Responsible for

- 1- Maturation
- 2- Education (selection)
- 3- Residence

Immune system= organs+ tissue + Cells + intercellular communication means

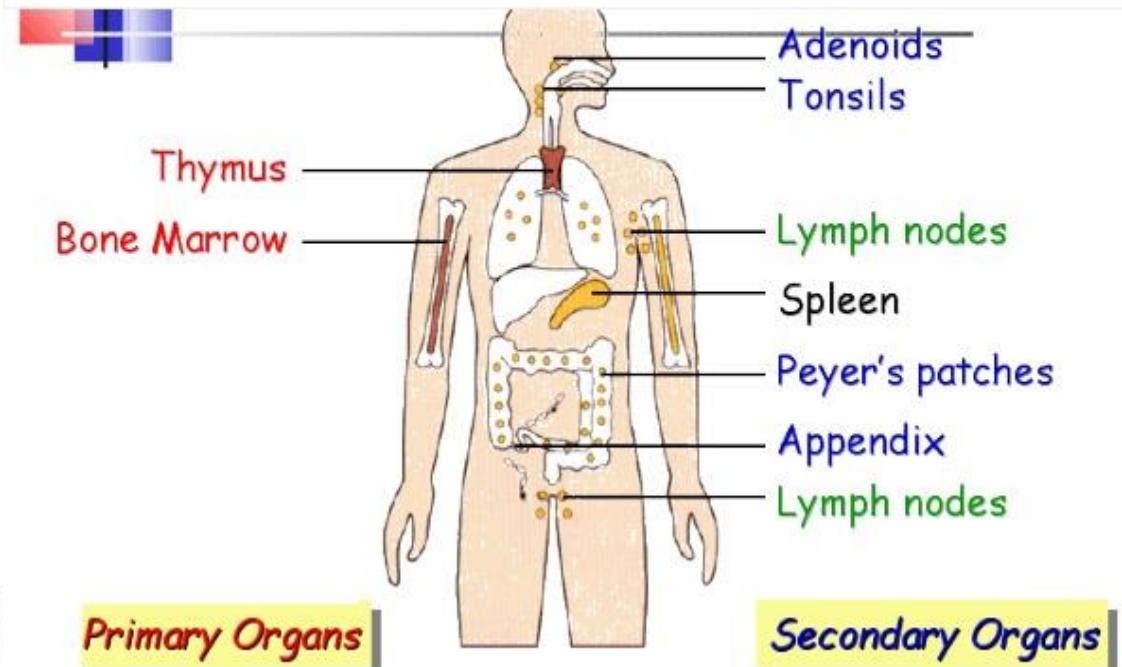
Lymphoid tissue classification



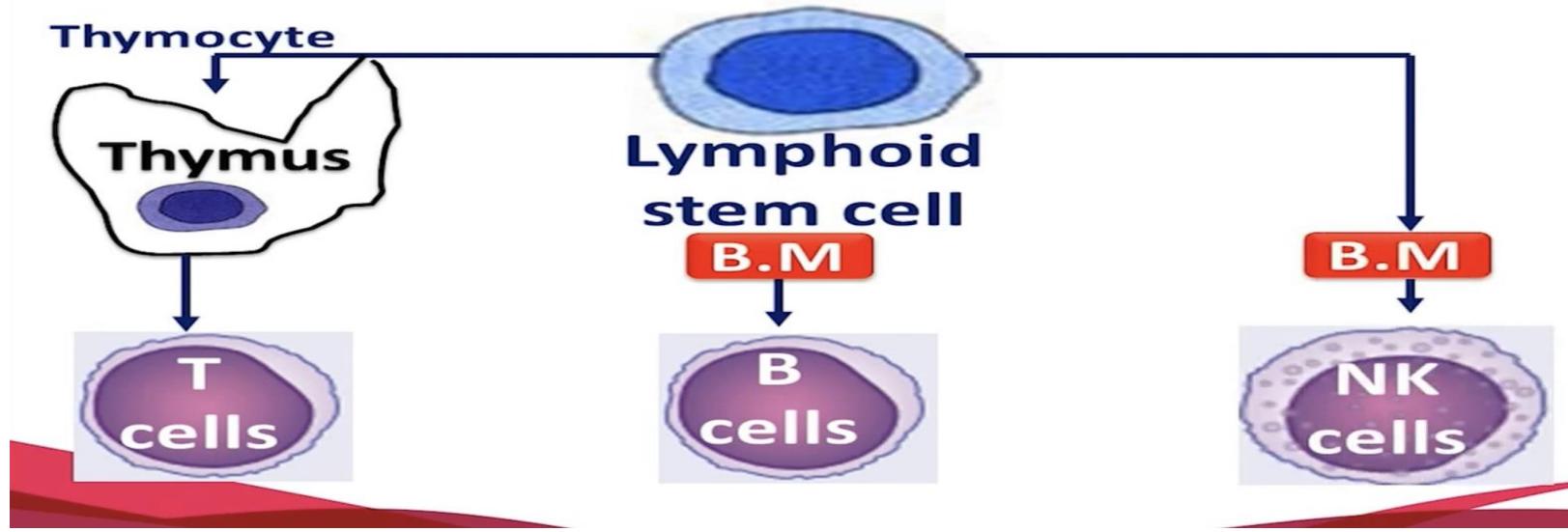
Prepared by Pratheep Sandrasaigaran

Functions of primary L.organs: Sites of development and maturation of different cells of immune system. B.M (hemopoiesis from 7th month and onward, synthesis, development and maturation of B cells). Thymus: site for development and maturation of T lymphocytes. 2ry L.O : sites of immune responses where the mature lymphocytes can interact effectively with pathogens.(L.N: Traps Ags when enter through tissues; MALT: Trap Ags when enter from mucosa; Spleen: Ags from blood)

Organ of Immune System

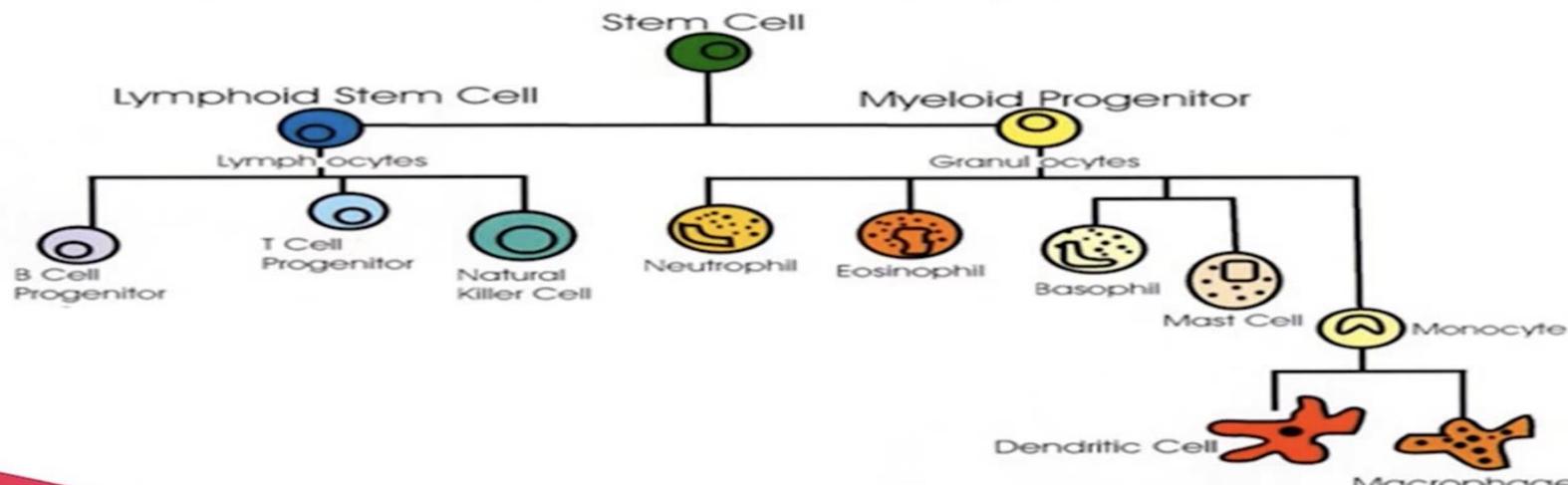


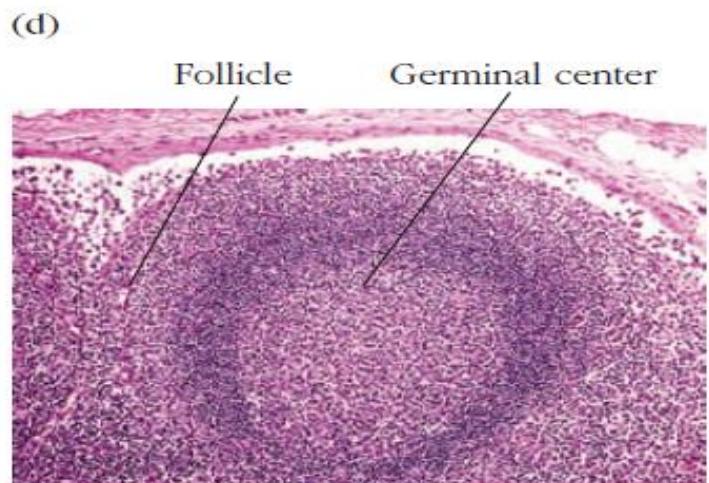
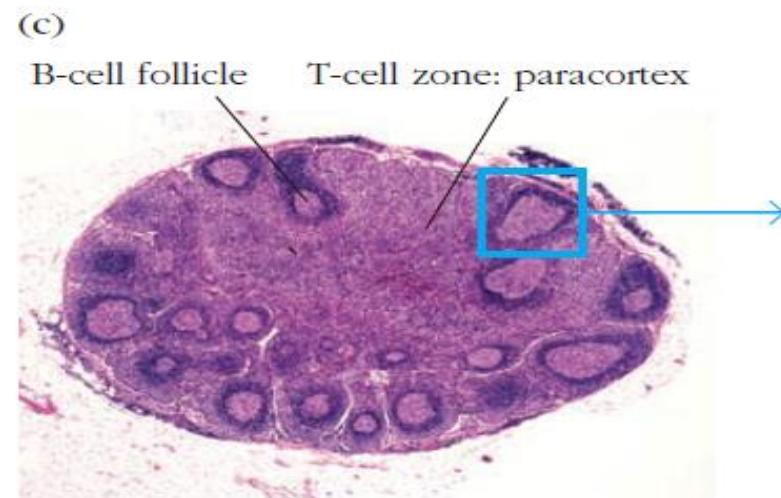
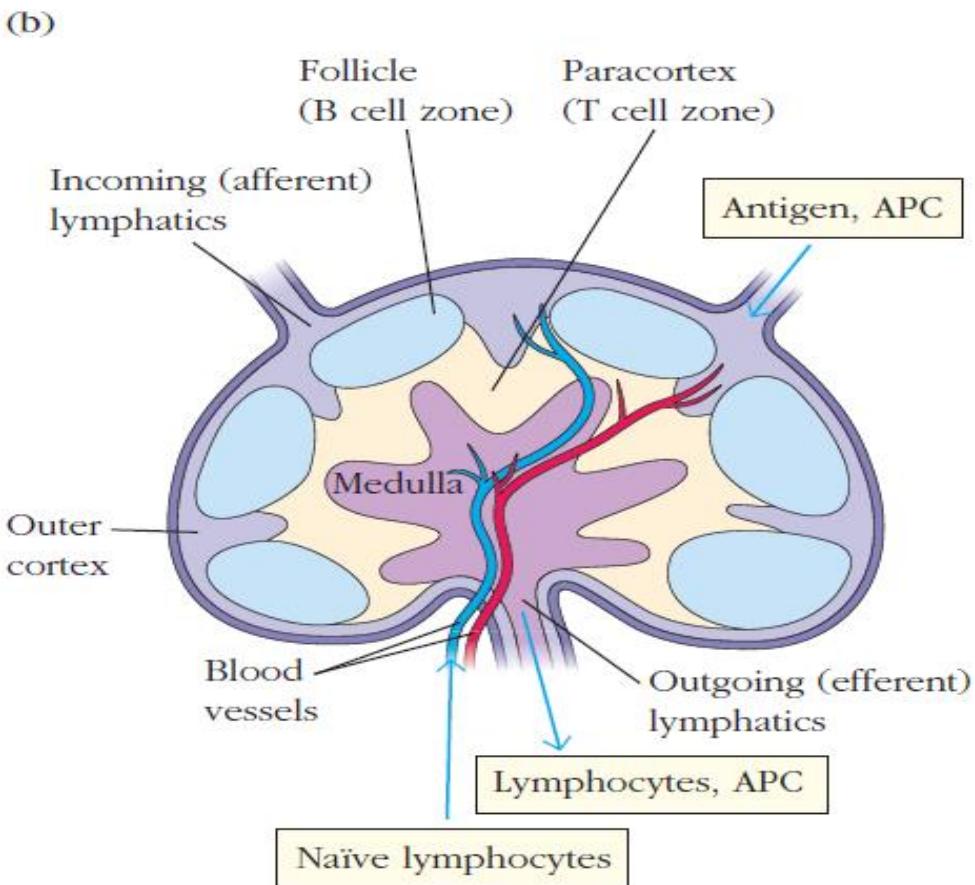
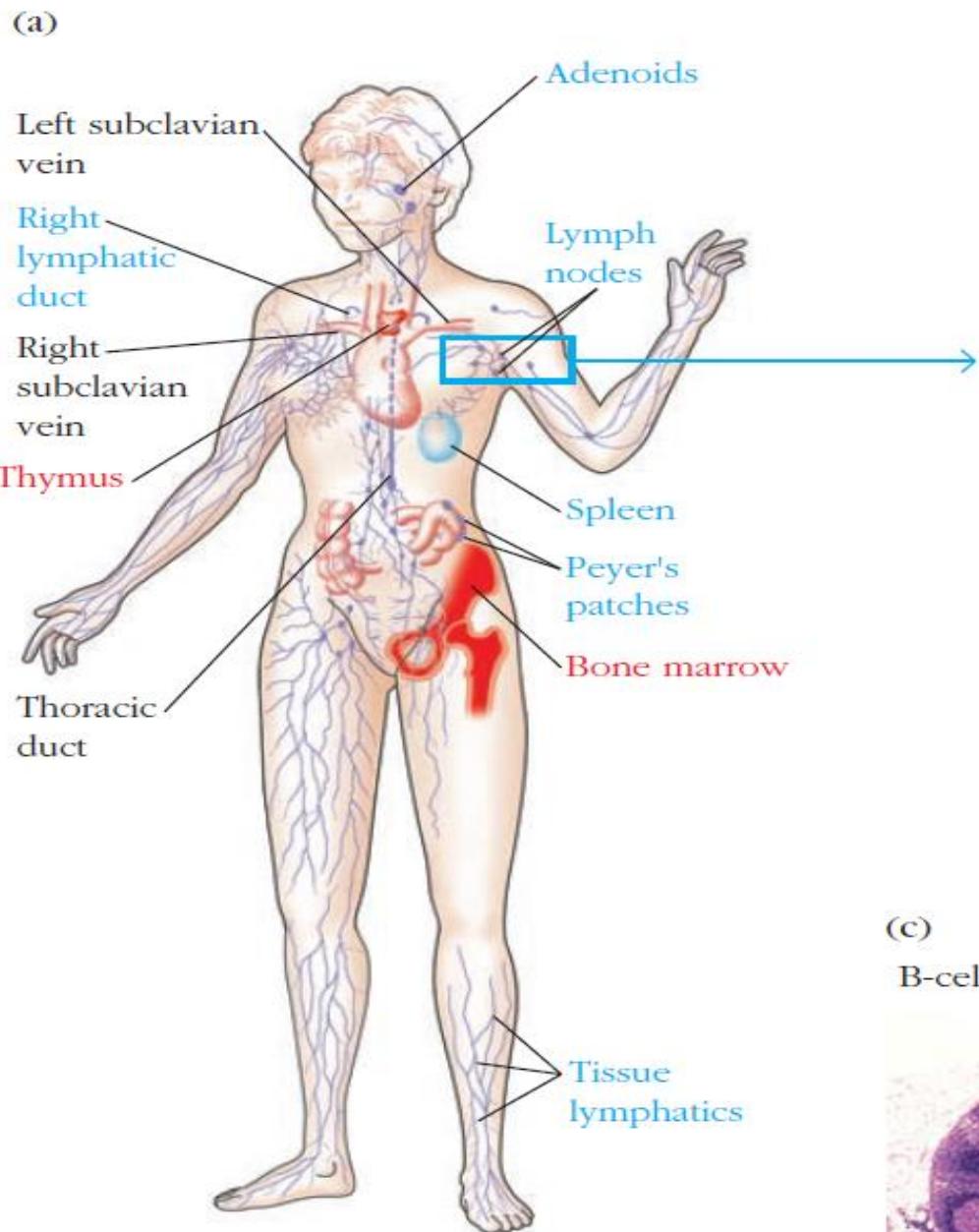
1) Primary (Central) lymphoid organs

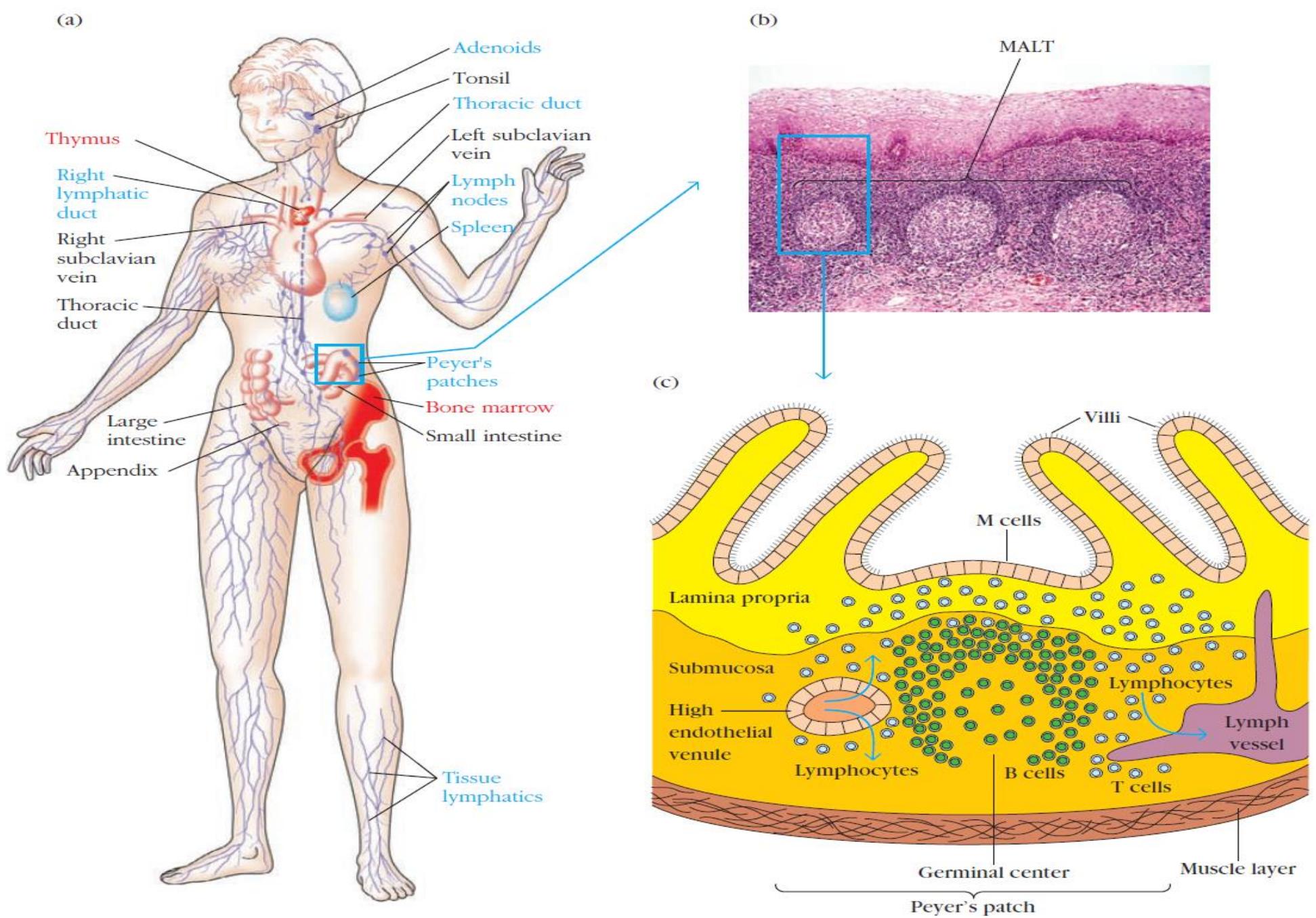


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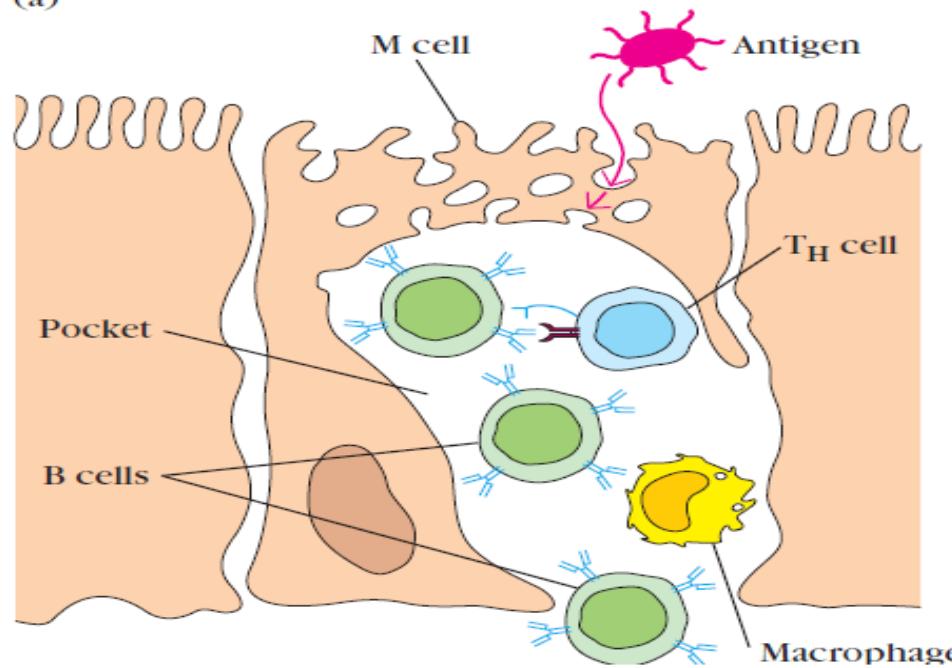
Cells of the Immune System



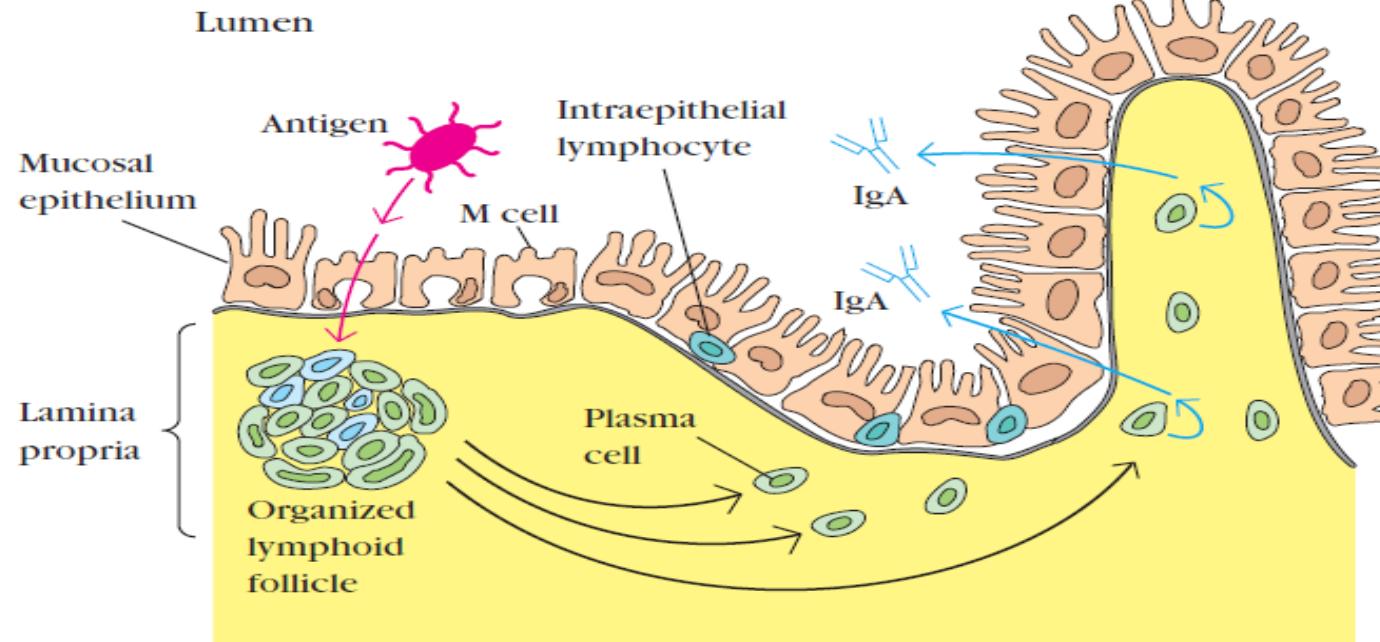




(a)



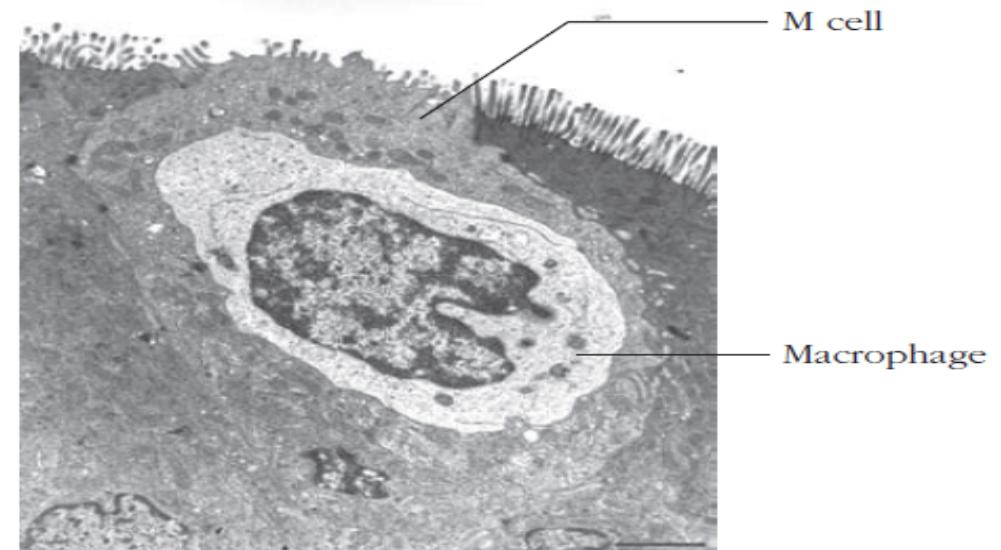
(b)



M (microfolded) cells:

- 1- Present in the mucosa of GIT
- 2- Transport antigens across the epithelium
- 3- Have no microvilli
- 4- Direct contact to the pockets rich of Macrophages, B and T cells.

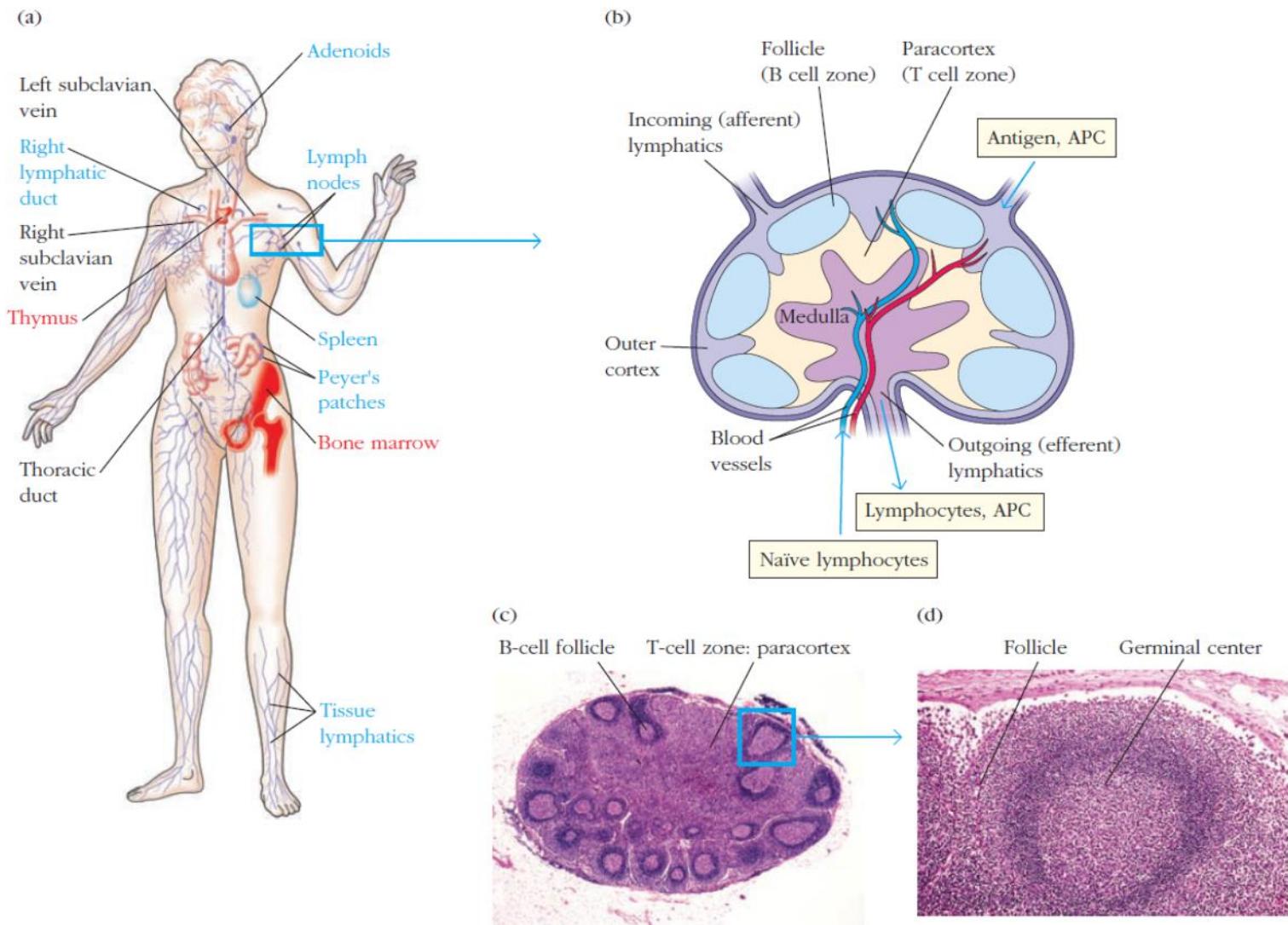
(c)



Lymph nodes found throughout body
Structure= Cortex (home of B cells) +
Paracortex (home of T cells) +Medulla site
of Plasma cells and MO

Function

- 1- Filtration of lymphatic fluid drained from tissues
- 2- The site of specific immune responses both humoral and cellular (activation of B and T cells)
- 3- Fighting against bacteria come from lymph



Spleen is the major site of immune responses to blood borne antigens

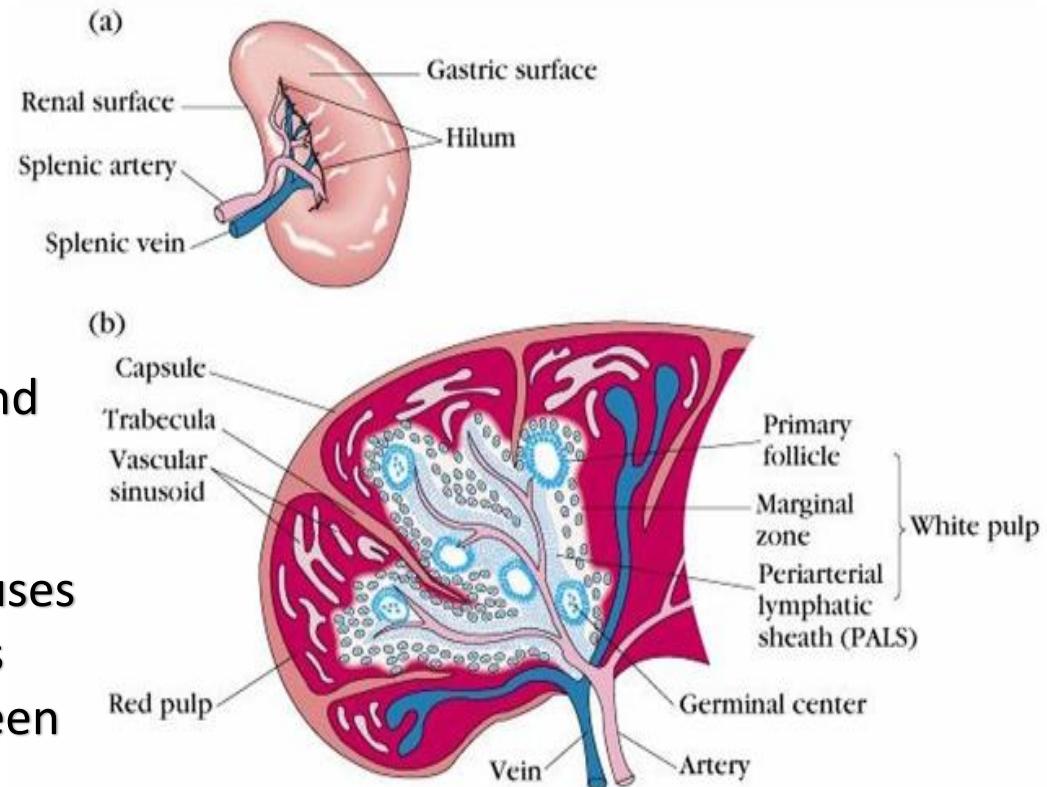
Spleen

There are two main areas, white and red pulps.

White pulp is the area of WBCs like T cells, B cells and Macrophages.

White pulp (25%) consists of periarticular lymphatic sheets (T cells), marginal zone (Macrophages mainly) and follicles (B cells).

The end arteries or capillaries do not connect with veins and do not have walls, so blood will leak to the outside space which is rich of macrophages. These macrophages are responsible for engulfing aged cells. There are venous sinuses that collect blood into splenic vein. The space with venous sinuses is called red pulp which constitutes 75% of the spleen



Test your self

What is the main function of activated B cells?

Removal of the thymus in early life will affect the function of which cell?

Which of the following is considered a primary lymphoid organ?

- L.nodes
- Thymus
- B.M
- Tonsils

Immune cells matured and educated in the primary lymphoid organ, then reside in
1- L.nodes
2-Spleen
3-Tonsils
4- Appendix

Which type of cell is increased in acute bacterial infection?

What is a characteristic of adaptive immune response and not of innate immunity?

- A- No memory
- B- Not distinguished between foreign substances
- C- Specific
- D- Fast response

The immune system prepare the immune response against m.os in
1- Blood
2-At site of infection
3-In the primary L.o
4- In the secondary L.os

Which of the following cells are responsible for allergic reaction?

- 1- Neutrophil
- 2- Basophil
- 3- Macro
- 4- Mast cell

Total WBCs : $4.0\text{--}11.0 \times 10^3/\text{cu.mm}$

Percentages of normal WBCS

Cell type	Proportion of leukocytes (%)
Neutrophil	40–75
Eosinophil	1–6
Basophil	<1
Monocyte	2–10
Lymphocyte	20–50

The main functions of immune system

Recognition phase: The ability to distinguish self from non self antigens (pathogens) or altered self cells

Effector phase: Destroy foreign invaders

Remove the infectious agents with the least possible tissue damage

The function of the immune system should be **balanced** and **highly regulated**

A Balanced Immune System

Internal Threat

Autoimmune problem

(Hashimoto's Thyroiditis, Rheumatoid Arthritis, Lupus, Inflammatory bowel disease, Type 1 Diabetes)

External Threat

Allergic Reaction

(food sensitivities, allergies, eczema, asthma, sinusitis)

Immune Over-reaction

Balanced Immune System = Optimal Effectiveness

Immune Under-reaction

Cancer

(Hepatitis, HIV, Shingles, TB)

Infection

(Bacteria, Mold/Fungus, Parasites, Viruses)

Active immunity

Developed by host immunity

Natural-Infection

Artificial- vaccines

Duration: long lasting

With lag phase

Booster doses are important

Memory present

Negative phase is present

Passive immunity

Prepared antibodies or Igs

Natural-Maternal

Artificial- Ready Igs

Duration: Short

With no lag phase

Booster doses less effective

Memory absent

Negative phase is absent

Primary I.R

First exposure to an antigen

Slow, sluggish and short lived

Lag phase 4-7 days

No negative phase

IgM with low titer

Secondary I.R

Subsequent exposure to the same antigen

Prompt, powerful and prolonged

Lag phase 1-3 days

Negative phase is present

IgG with high titer

