

# Organs and Cells of the Immune System

# Objectives

- The organs and tissues of the immune system
- Haematopoiesis and formation of blood cells
- Immune cells classes, functions and circulation
- Immune cells development and maturation

وظيفة جهاز المناعة : 1- بحمي من الإصابة بالأمراض  
2- بعمل على قتل الخلايا السرطانية  
3- بحافظ على التوازن في جسم الإنسان

\*الخلايا الموجودة بجهاز المناعة :

## 1) Innate immune cells

هي خط الدفاع الأول في الجسم (أول ما يصير invasion من بكتيريا أو ميكروبات بيحي ال innate system يكون جاهز للدفاع زي ال (skin , low ph in stomach) - اذن ال response فيها يكون سريع وبما أنه جاهز فما عنده memory cells يعني ما رح يتذكر اذا انصاب مرة ثانية بنفس البكتيريا .

في حال ما قدرت ال innate system انها تتجاوب بيحي خط الدفاع الثاني الي هي ال Adaptive cells

## 2) Adaptive immune cells

- هو (specific) لأنه بتعرف عال antigen وبكوّن أجسام مضادة خاصة فيه .  
- بكوّن memory cells (يعني إذا رجعنا تصاوبنا ب secondary exposure of the same antigen هون الاستجابة رح تكون سريعة لأنه already جسمي متعرف عليها من قبل ومجهز antibody

زي مبدأ ال vaccine بس اخده بعرض جسمي للفايروس أو البكتيريا بكون ضعيف فجسمي بكوّن antibodies وبكوّن ال memory cells زي مثلا لما يجي واحد مجدر ما بنعدي منه ليش ؟  
هلا البكتيريا بتفوت عالجسم عادي لكن جسمي بصنع antibodies بقضي عليهم .

# Anatomy of the Immune System

- **Lymphoid organs:**

1. **Primary or central lymphoid organs:** bone marrow and thymus

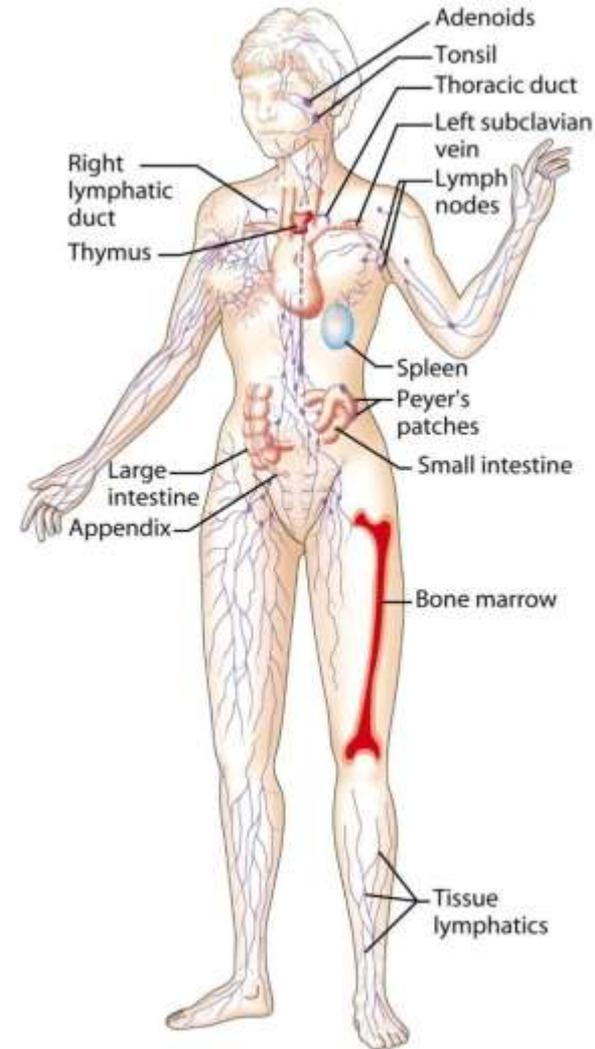
2. **Secondary or peripheral lymphoid organs:** lymph nodes, spleen, and mucosal and cutaneous immune system

- **Blood cells in the immune sys:**

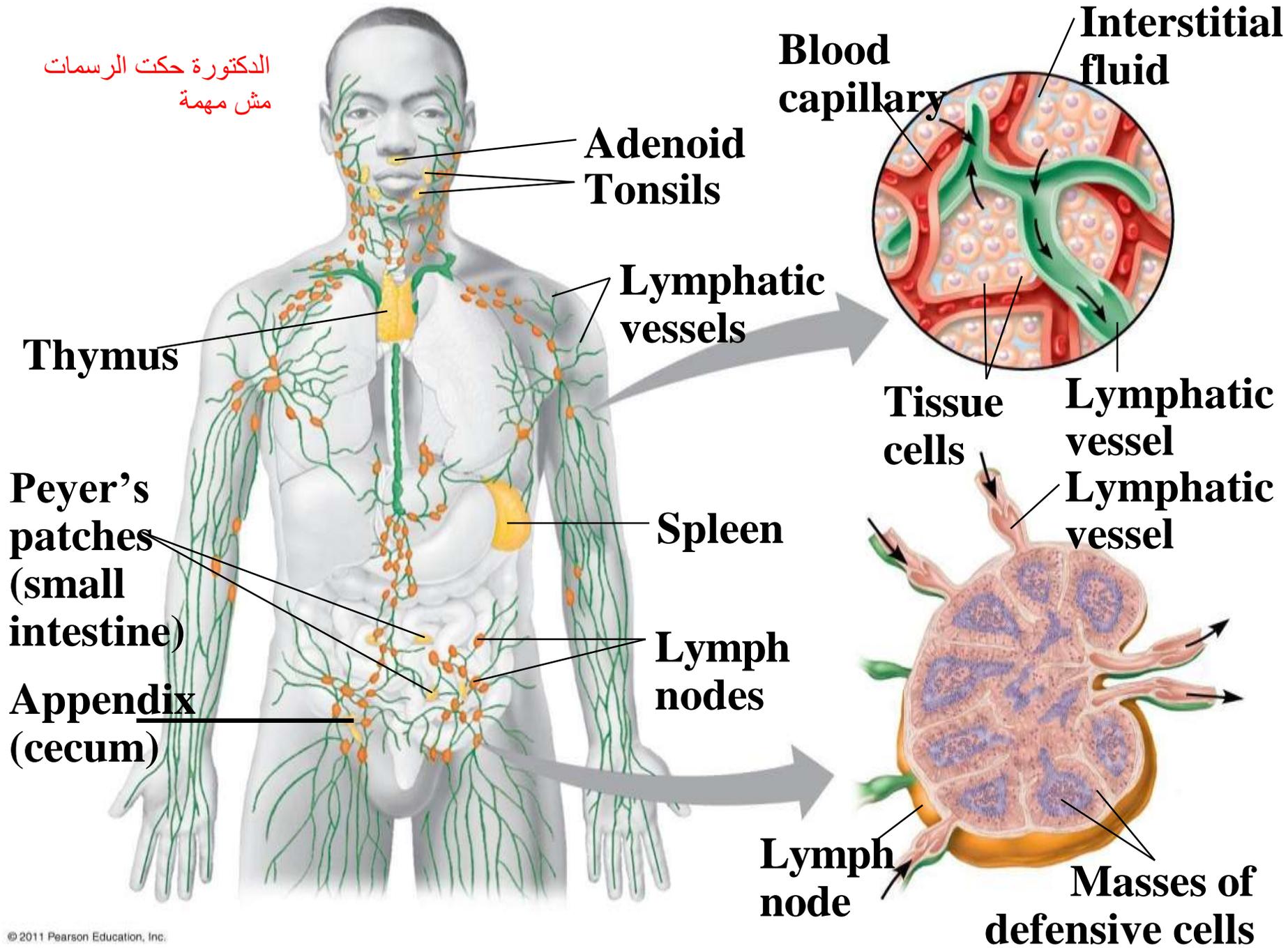
3. Innate immune cells:  
“phagocytes” macrophage, neutrophils, dendritic cells

2. Adaptive immune cells:  
“lymphocytes” T cells, B cells

- **Lymphatic and blood circulation**



الدكتورة حكمت الرسومات  
مش مهمة



كل خلايا جهاز المناعة بتقضي معظم وقتها بال lymphoid organs وبتيجي من ال primary lymphoid  
organs (bone marrow, thymus) بعدين بتتحرك من ال primary لل secondary ( lymph )  
antigen مع ال antigen أما بال primary ما بتحتك بال antigen لأنه مافي  
antigen أصلا

- The cells of the immune system spend much of their time in lymphoid organs. They develop (arise) in primary lymphoid organs, and they interact with antigens in secondary lymphoid organs.
  - **T**hymus: primary lymphoid organ for **T** cell development
  - **B**one marrow: primary lymphoid organ for **B** cell development
  - Lymph nodes: collect antigens from tissues
  - Spleen: collects antigens from blood stream

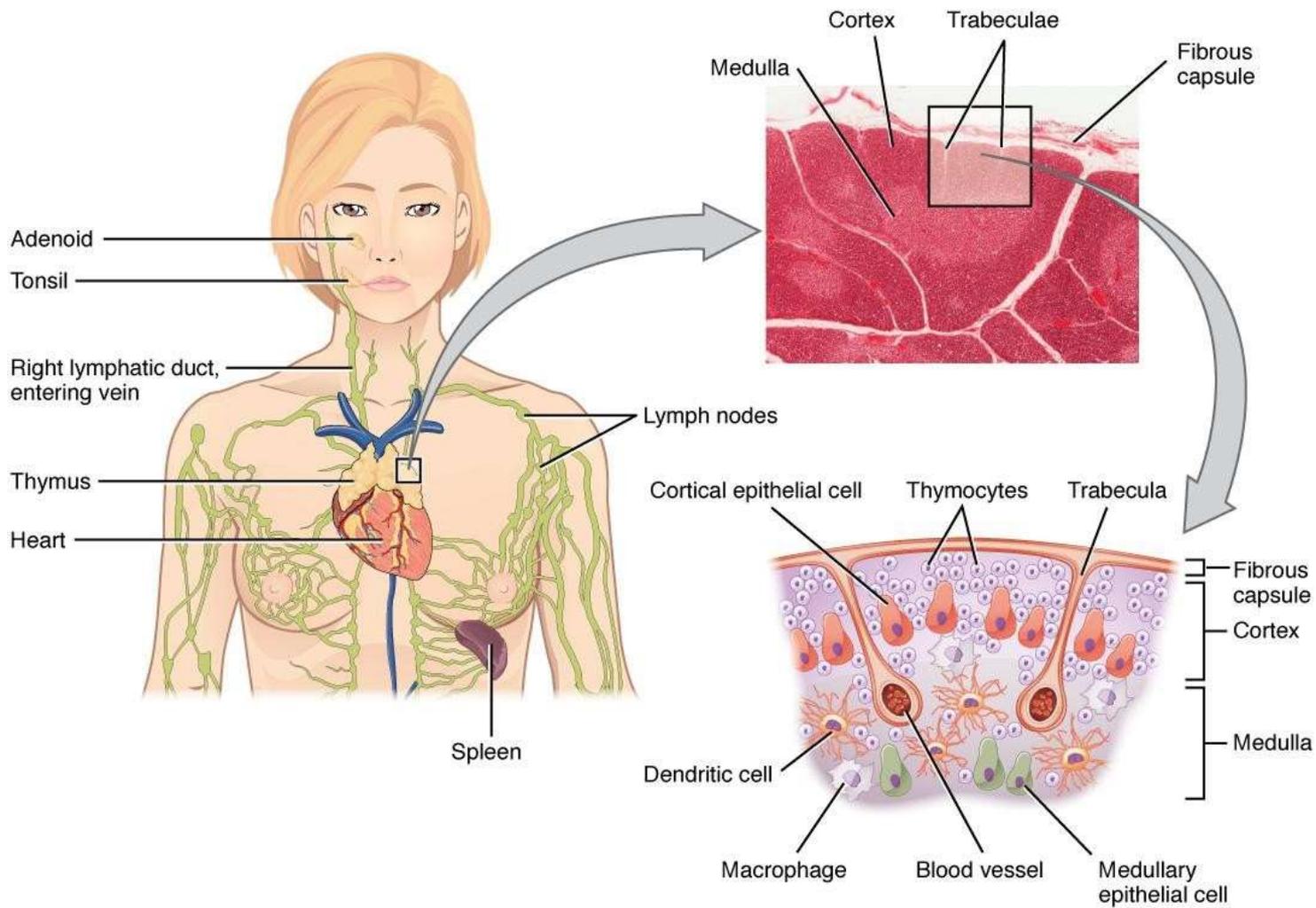
هدول التنتين وظيفتهم يجمعوا ال antigen لكن ال lymph node بجمع ال antigen من  
ال tissue عن طريق ال lymph بفوت عليها و بجمع ال antigen أما ال spleen بجمع  
ال antigen من ال blood هل بفوت عليه lymph ؟ لا  
بفوت عليه ال blood و بجمع ال antigen .

# Lymphoid Organs

## 1. Thymus

المسؤول عن ال development وال preparation لل T cells

- Flat bilobed organ **situated above the heart**
- Each lobe is surrounded by a capsule and divided into lobules separated by connective tissues called trabiculae
- The thymus reach its maximum size at puberty and then atrophies بس يوصل لل 35 يكون 20% من وظيفته لكن بس يوصل لل 65 almost يبطل يشتغل بصير atrophy (بضمجل)
- The thymus generation of T cells drop with time. By the age of 35 thymus generation of T cells drop to 20% and by the age of 65 it drop to 2% of newborn levels
- Play critical role in formation and maturation of **T cells**



بشكل 4% من وزن الإنسان + مصنع ال B cells

## 2. Bone Marrow

مسؤول عن تصنيع كل خلايا الدم الحمراء اسم العملية : haematopoiesis  
تقريبا مصنع 500 billion خلية باليوم

- Bone marrow is the flexible tissue in the interior of bones
- On average, bone marrow constitutes 4% of the total body mass of humans
- There are two types of bone marrow: red marrow (also known as myeloid tissue) and yellow marrow.
- Bone marrow is the site of haematopoiesis and the origin of B cells in human
- The hematopoietic component of bone marrow produces approximately 500 billion blood cells per day

فتخيلوا لما نحكي انه في حدا مصاب بسرطان النخاع العظمي اديش رح يكون الحجم بالتصنيع  
ال therapy الجديدة الي يعملوها هي bone marrow transplant

بجمع ال antigen الي جاي من ال tissue

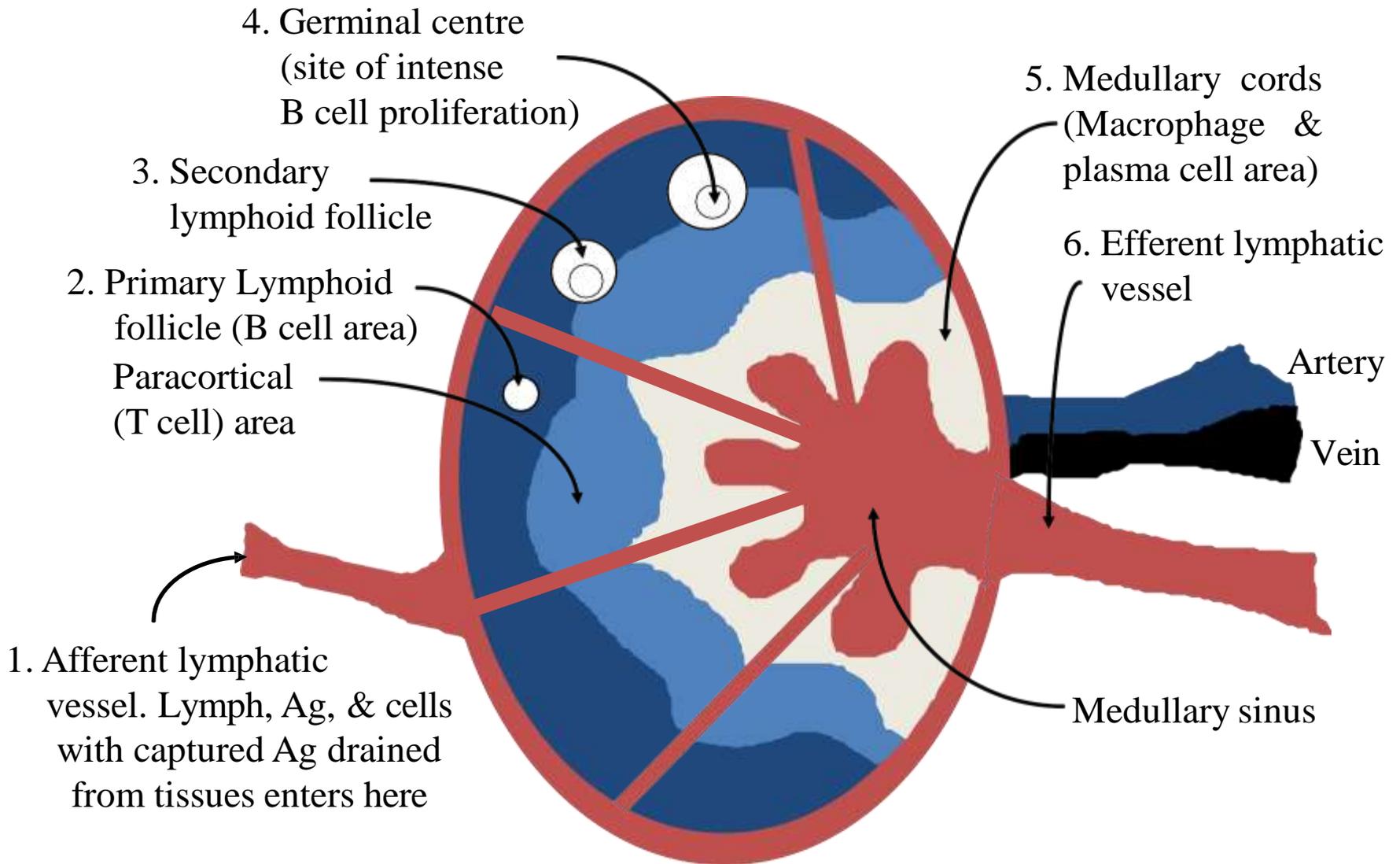
## 3. Lymph Nodes

عبارة عن :

- Lymph nodes are a nodular aggregates of lymphoid tissue located a long lymphatic channels through out the body
- As the lymph pass through the lymph nodes immune cells sample the antigens of microbes that might enter the body
- Antigens that might enter the body became concentrated and captured in the lymph nodes

لما يشخصوا سرطان الثدي يكون في كثير عقد ليمفاوية بمنطقة ال under arm فييجوا بشيكوا انه ما يكون واصلها السرطان

# Lymph node



**Trabecula**

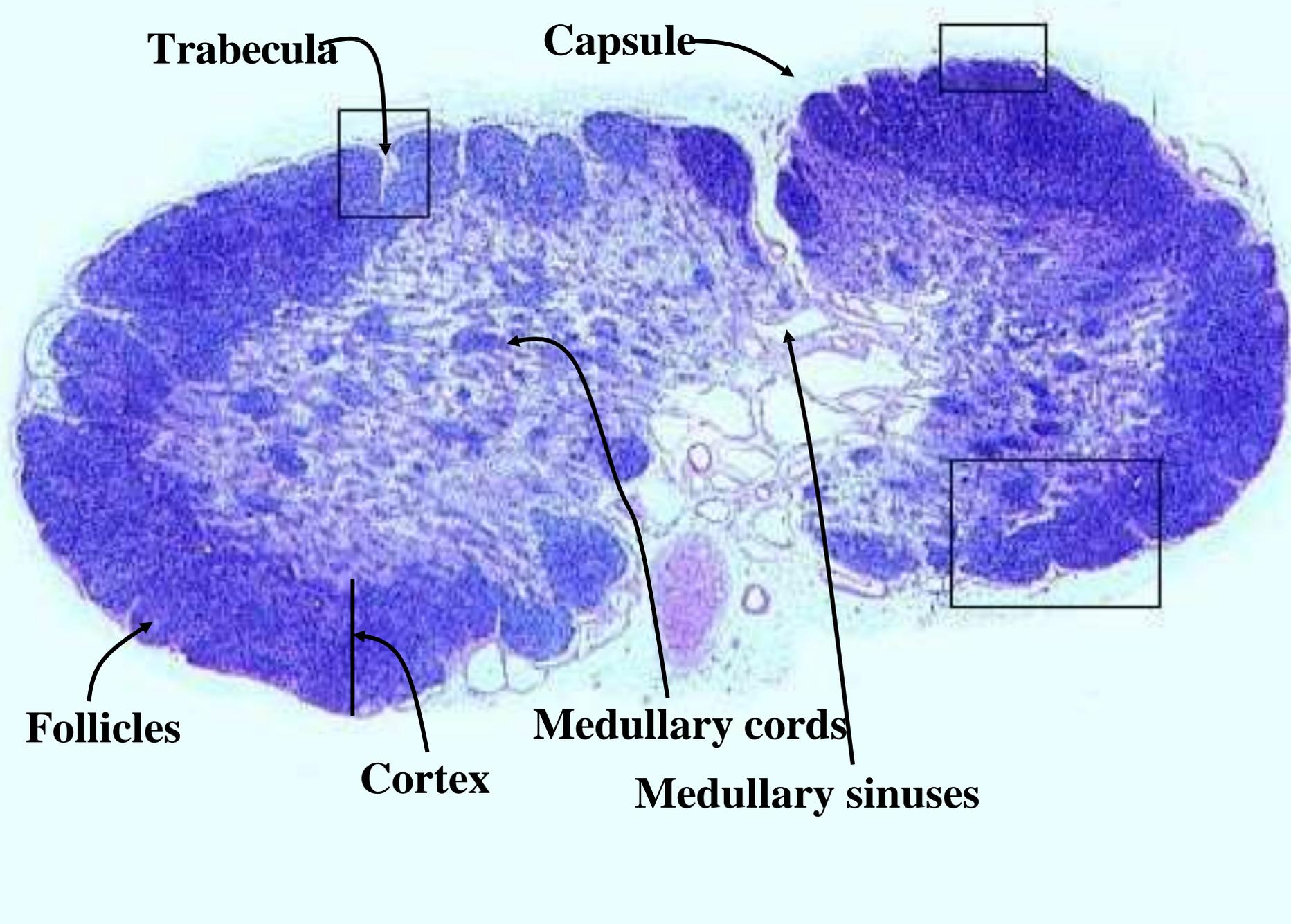
**Capsule**

**Follicles**

**Cortex**

**Medullary cords**

**Medullary sinuses**



# 4. Spleen Abdominal organ

موجود بالبطن منسقيه مقبرة الدم يدخل عليه الدم والدم يكون محمل بالantigen فييجي  
السpleen بجمع الantigen ويعمله concentrated فيها

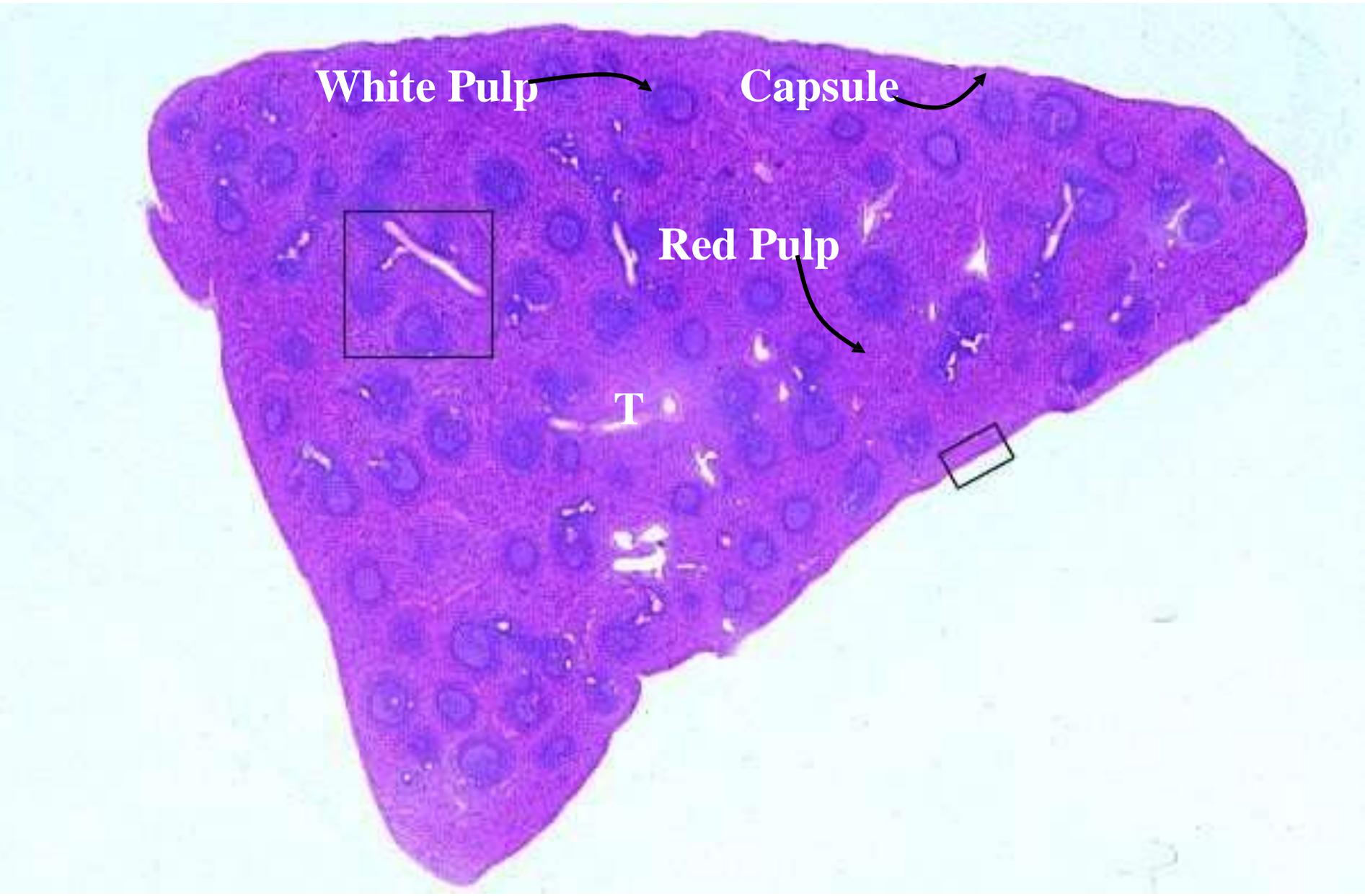
- Abdominal organ that serve as a big lymph node
- Unlike the lymph nodes the spleen is not supplied by lymphatic vessels
- The spleen had two main compartment the red pulp and the white pulp separated by diffuse marginal zone
- Blood enter the spleen through a network of channels called sinusoids
- Blood-borne antigen are trapped and concentrated in the spleen
- Immune cells in the spleen identify, ingest and destroy microbes

**White Pulp**

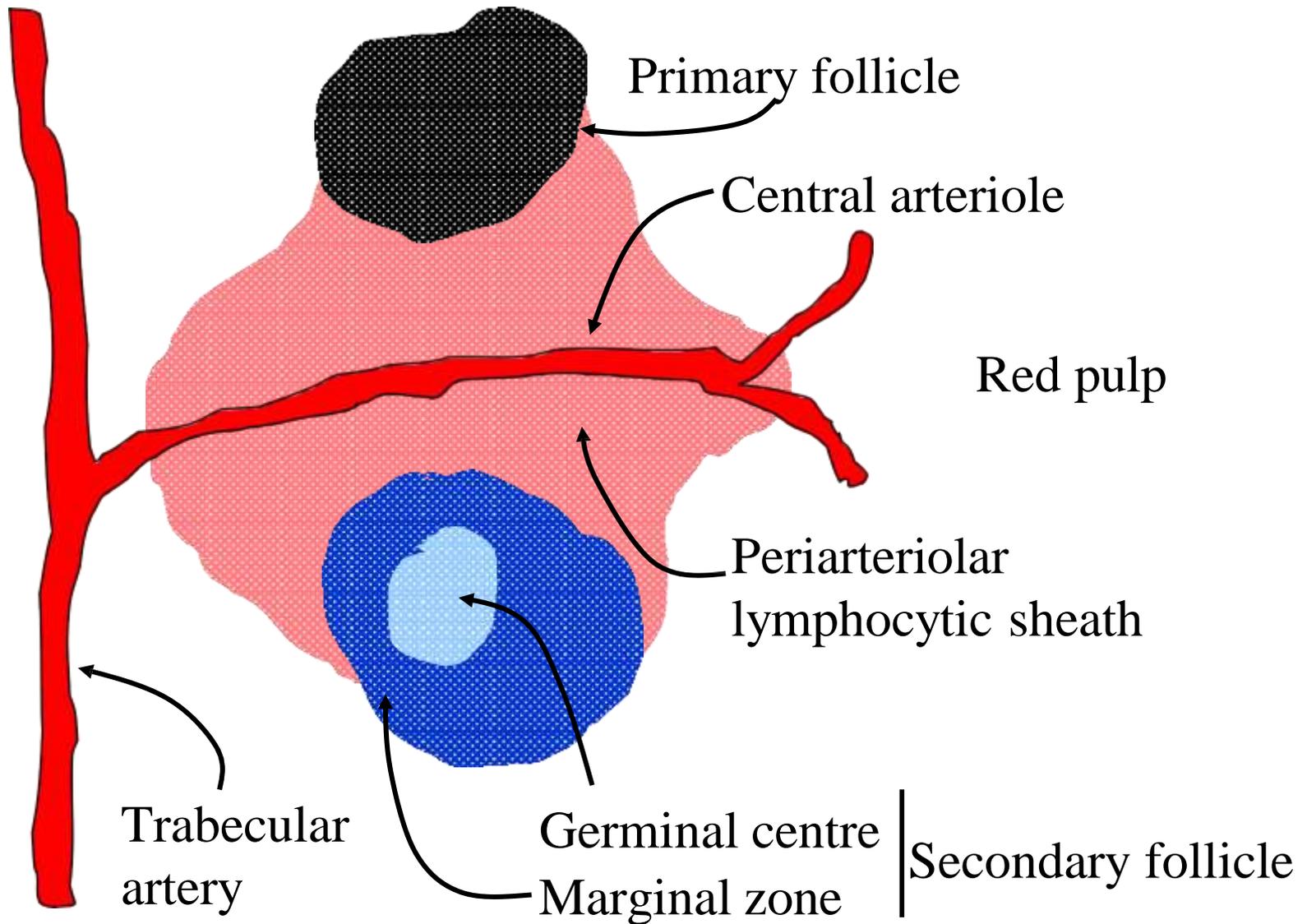
**Capsule**

**Red Pulp**

**T**



# Spleen



# 5. Cutaneous and Mucosal Lymphoid Organs

- Located under the epithelia of the skin, GIT and respiratory tracts. It includes: pharyngeal tonsils, adenoids, appendix and peyer's patch
- Sites of immune response to microorganisms that breach epithelia

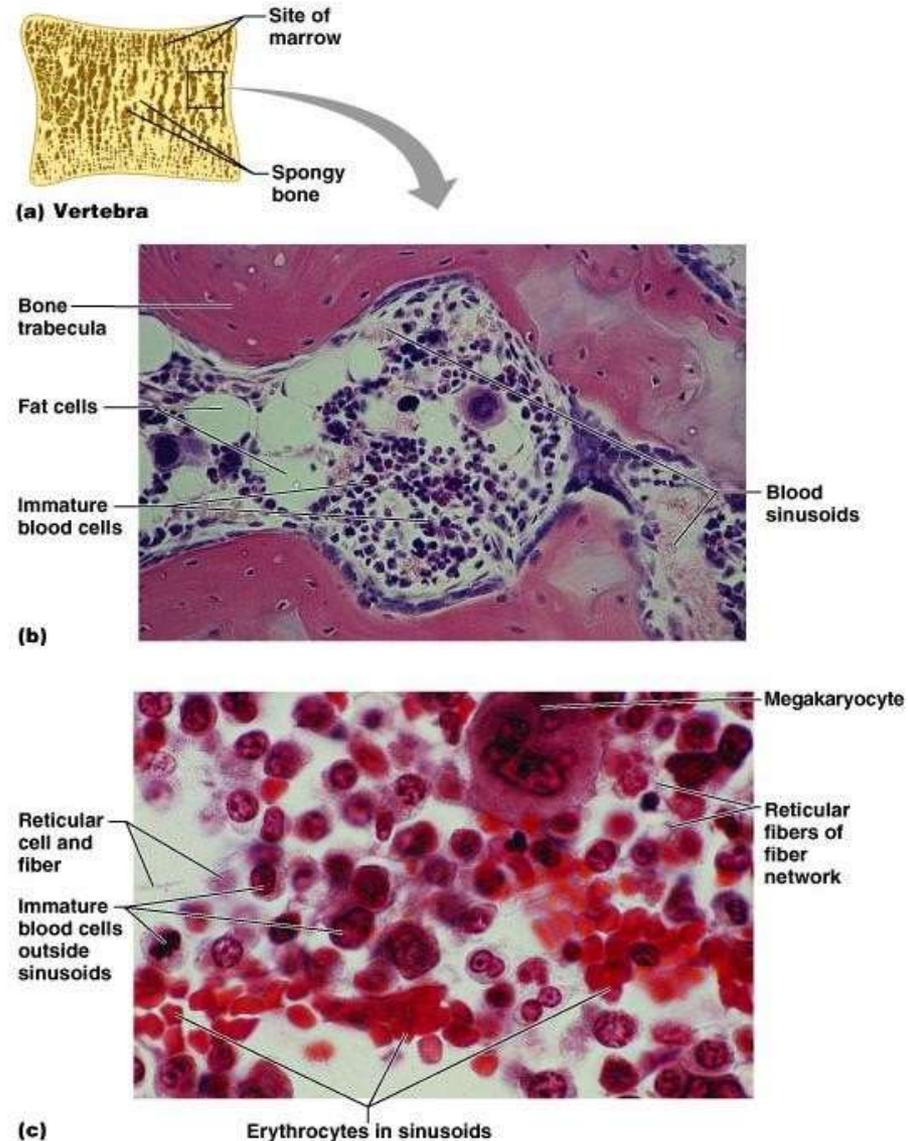
زي ما حكينا قبل لما نتعرض لوخزة ابرة طبعا الابرة اكيد مش معقمة يعني فيها MO فلما اخترقت الجلد عملت damage لل cell فبالتالي يتم إفراز mediator بتتحفز ال mast cell وبصير لها stimulation بتعمل Histamine release لل حرارة بالمنطقة وبرضو بزيد ال blood flow للمنطقة وبصير swelling طيب ليش بزيد ال blood flow ؟  
عشان يعمل dilution لل toxin

وبرضو بزيد ال permeability حتى تتمكن ال phagocyte انها تهاجر من ال plasma وتروح لل site of infection ( ال phagocyte وال macrophage الثنتين يشتغلوا زي مكنسة الكهرباء ببلعوا ال microbes ).

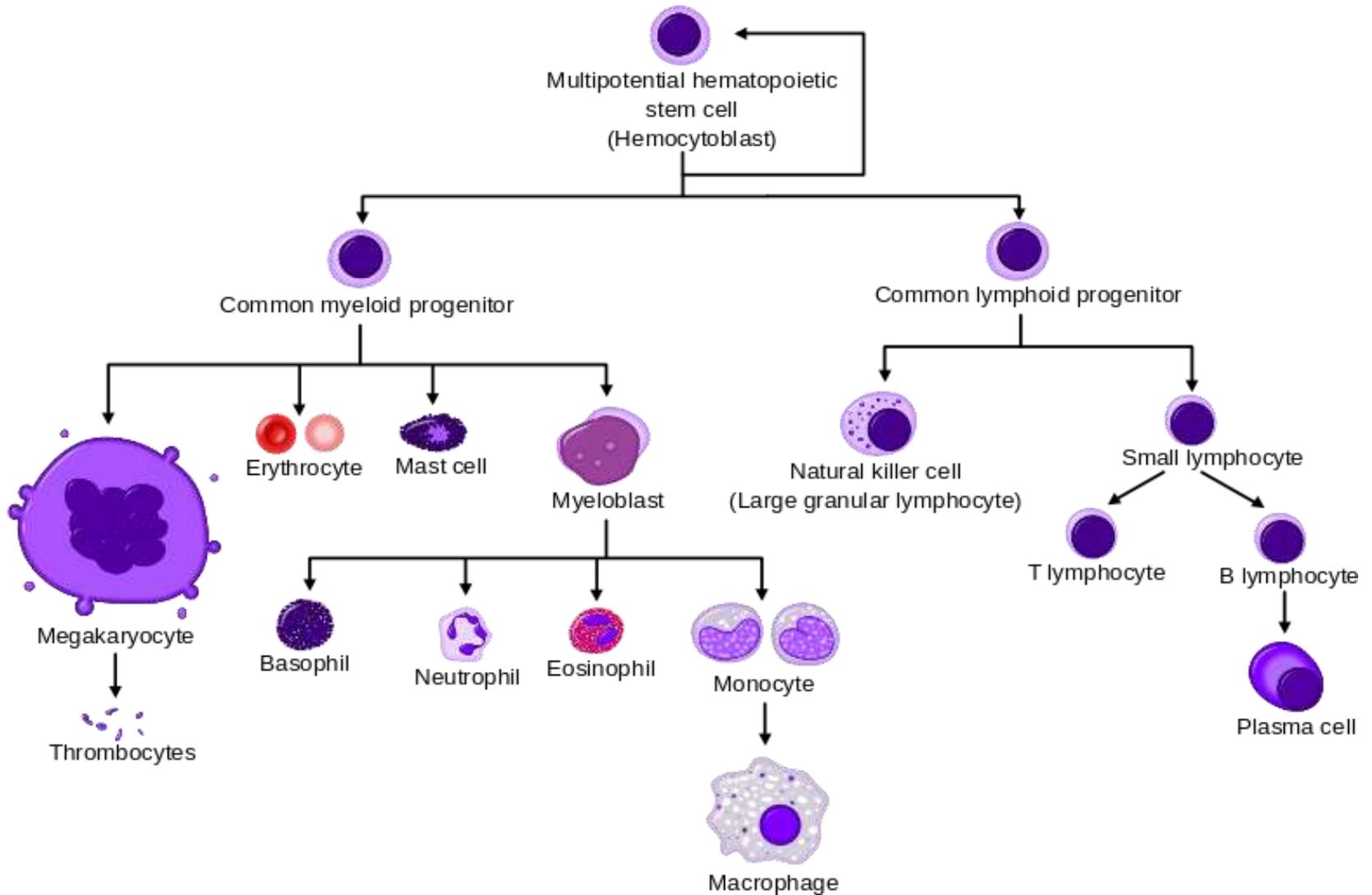
# Hematopoiesis

- Formation of blood cells
- Occurs mostly in red bone marrow
- All cells arise from same **blood stem cell**  
(pluripotent hematopoietic stem cells)

هاي الخلية الجذعية الأم الي  
بنتمايز لأي نوع من أنواع الخلايا



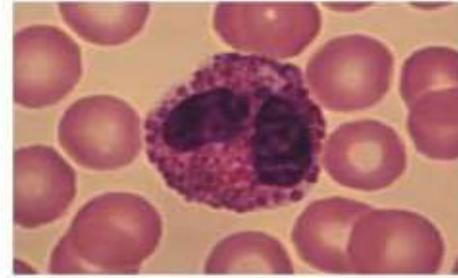
# Formation of Blood Cells



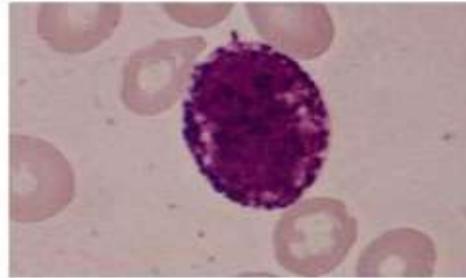
# Leukocytes



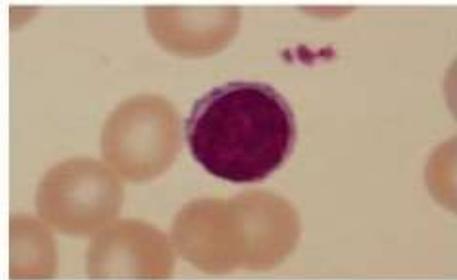
(a) neutrophil



(b) eosinophil



(c) basophil



(d) small lymphocyte



(e) monocyte

# Leukocyte Types

بتحتوي على granules

- Artificial division into **granulocytes** and

**agranulocytes** ما بتحتوي على granules

- Granulocytes: neutrophils, eosinophils, basophils (according to how stain)

- Granules
- Lobed nuclei
- All are phagocytic

هاي ال granules بتحتوي على إنزيمات وهاي الإنزيمات بتساعد على ال digestion والقضاء على الميكروبات اذن ال granulocytes الي بتحتوي على granules الها خصائص وظيفية انها بتعمل phagocytosis

- Agranulocytes: lymphocytes, monocytes

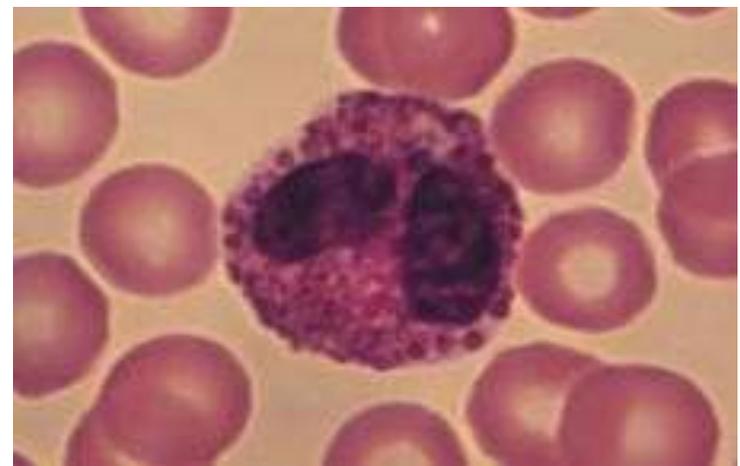
# 1. Neutrophils

معظم الـ WBCs هي عبارة عن neutrophils  
وبتحتوي على granulocyte



- 60% of all WBCs
- Other names: Polymorphonuclear cells (PMNs, polys, segs)
- Appearance: pink granules in cytoplasm, nucleus has 3-5 lobes  
لكنها مش الوظيفة الوحيدة
- Function: **Phagocytosis of bacteria**
  - Granules have enzymes
  - Can damage tissue if severe or prolonged
  - Form pus

## 2. Eosinophils



- 1-4 % of leukocytes
- Bilobed and contain eosinophilic granules which have digestive enzymes
- Role in ending allergic reactions and in fighting parasitic infections

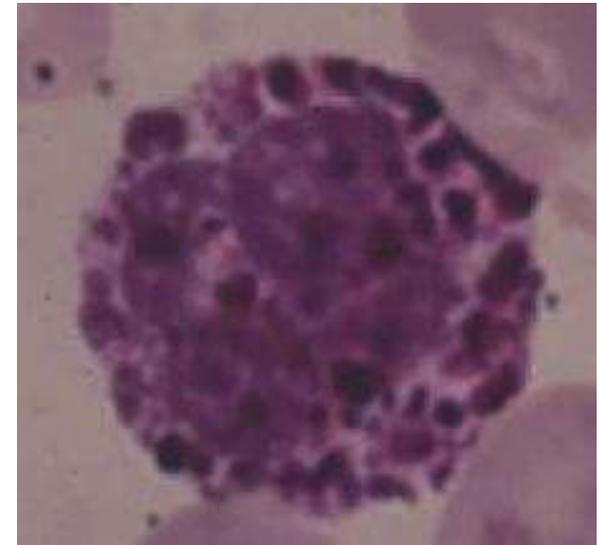
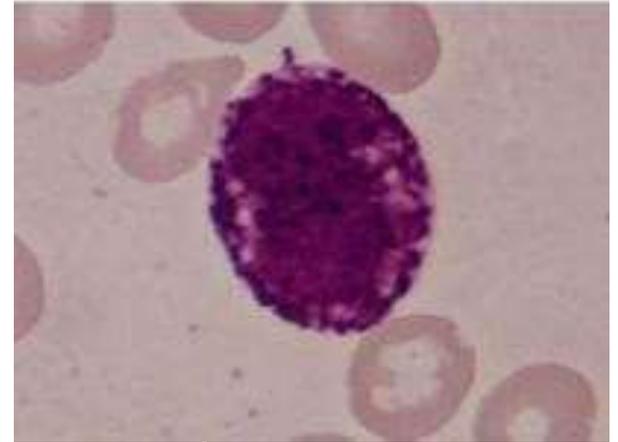
فيها granules

وظيفتها :



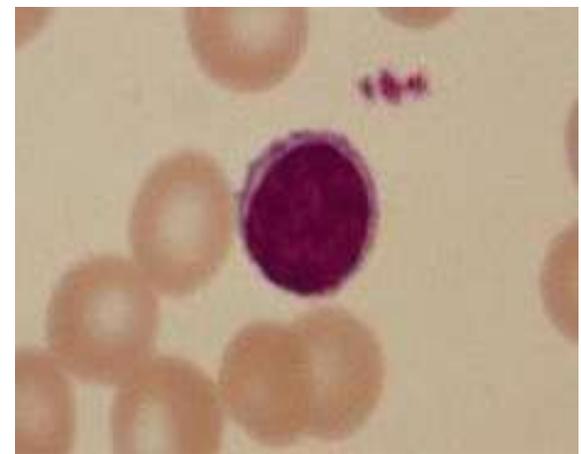
## 3. Basophils

- Rarest WBC, <1% WBC
- **Bilobed** nucleus
- **Dark purple granules** (basophilic granules)
- Granules contain: histamine and heparin
- IgE receptors - Involved in allergy



ما فيها granules وحجمها كثير صغير

## 4. Lymphocytes



- Most important WBC 20-45%
- Small (same size as RBCs)
- Mostly present in lymphoid connective tissue, e.g. lymph nodes, tonsils, spleen
- Nucleus occupies most of the cell volume (**little visible cytoplasm**) and no specific granules
- Two main types attack antigens in different ways
  1. T cells
  2. B cellsplus “natural killer cells”

يادوب منكون شايفينه

بصنعه الbone marrow

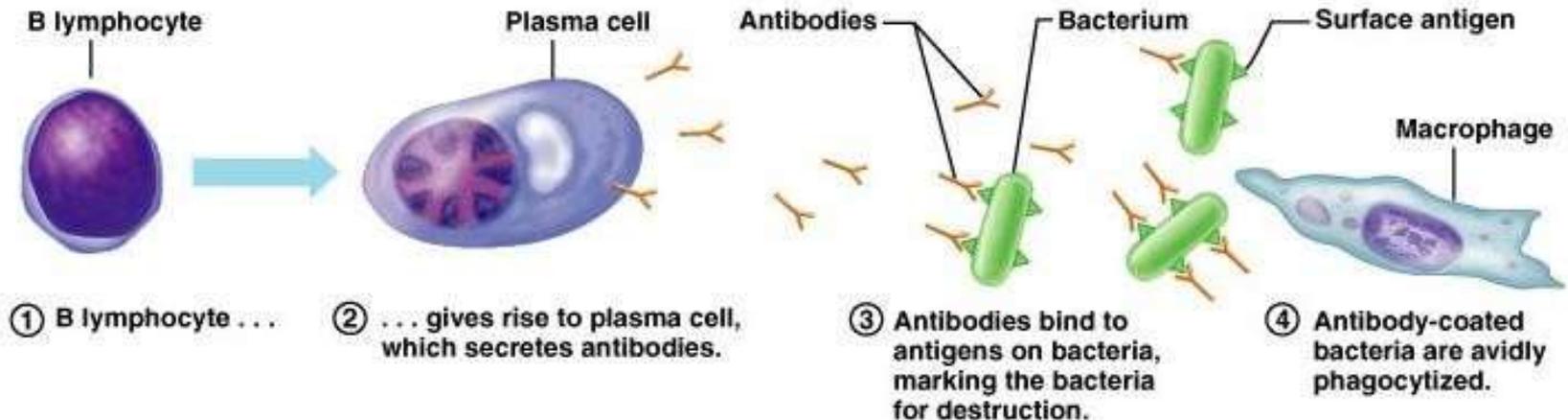
# B cells

- Formed and mature in the bursa of Fabricius in birds and in bone marrow in mammals
- Differentiate into plasma cells that secrete antibodies or become a **memory cells** that live longer

ما لها أي activity بتضل silent بتشتغل زي الحرس

- B cells also display **antibodies** on their

بتشتغل زي الred flag بتأشر للmacrophage انها تيجي وتعمل engulfment للantigen



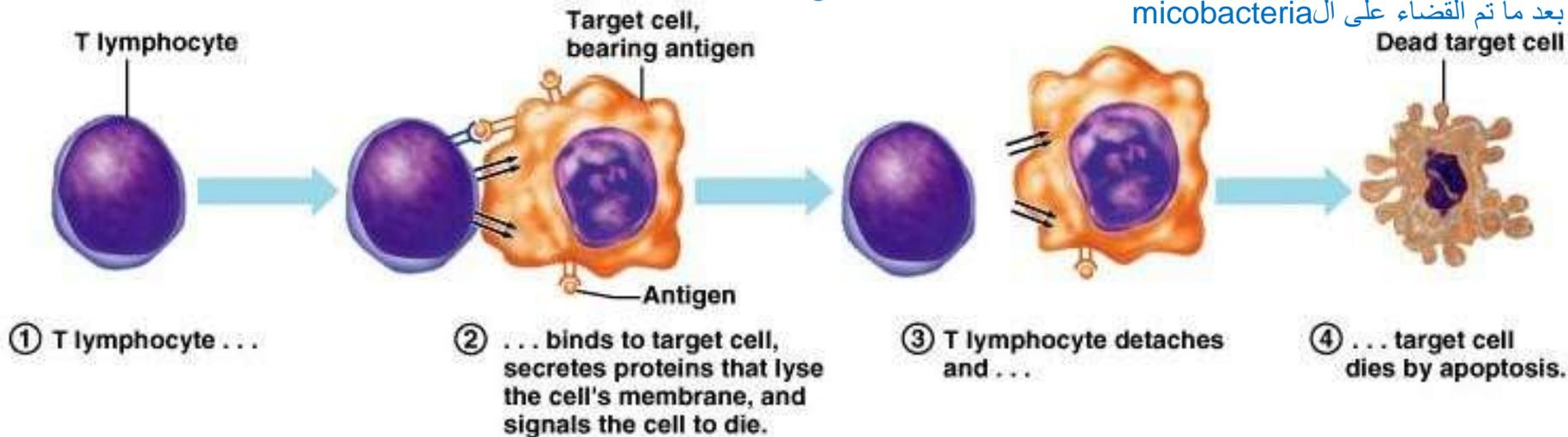
# T cells

- T lymphocyte mature in thymus
- T cells antigen binding molecule called T cell receptor
- T cells are subdivided into 3 main groups: **Helper T cells**, **Cytotoxic T cells**, and **regulatory**

بتساعد جهاز المناعة يشتغل أكثر

بتعمل killing للخلايا

بتساعد جهاز المناعة ليرجع لوضعه الطبيعي  
بعد ما تم القضاء على الـ micobacteria



# 5. Natural Killer Cells (NK)

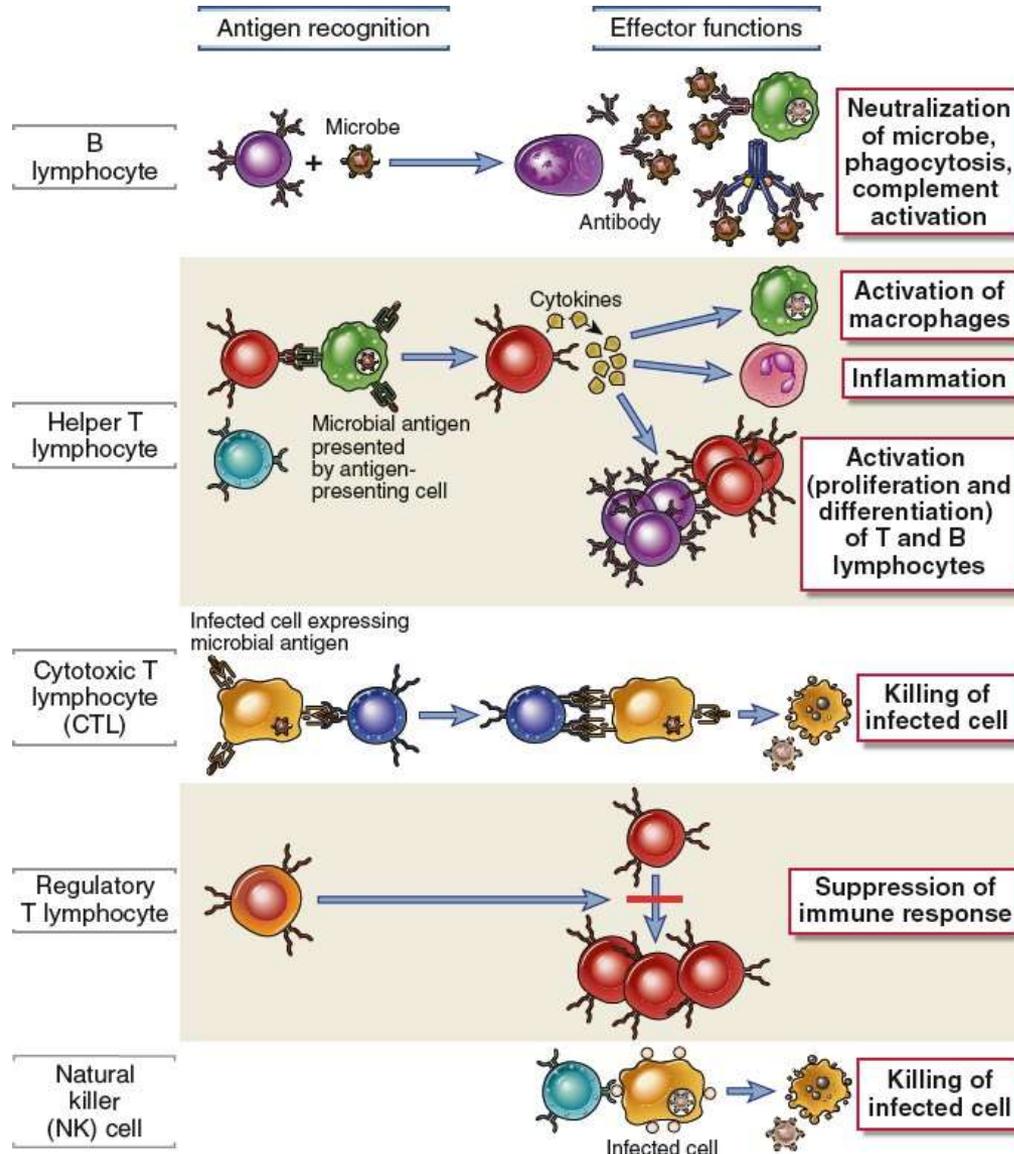
بتقضي على tumor cells وأي خلية بصيرلها infection بالفايروس



- Constitute 5-10% of human lymphocytes and granular cells
- Display cytotoxic activity against tumor cells and cells infected with viruses
- These cells do not have specific receptors for antigens on their surface and considered part of innate immunity
- NK cells have receptors for **antibodies** and can destroy targeted cells through a process known as **antibody-dependent cell mediated toxicity**

بترتبط بالNK cells وبتعمل destruction للtargeted cells

# Classes of Lymphocytes



# 6. Monocytes/ Macrophages



## Monocyte

- 3-8% WBC
- Monocytes circulate in blood for about 8 hours then it enlarge and migrate into tissues and differentiate into specific tissue macrophage
- Recruited to sites of inflammation

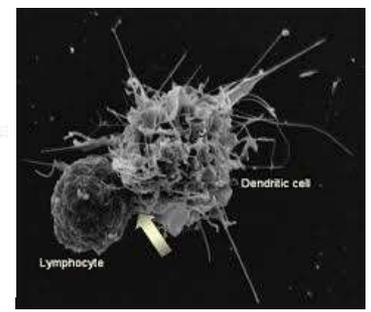
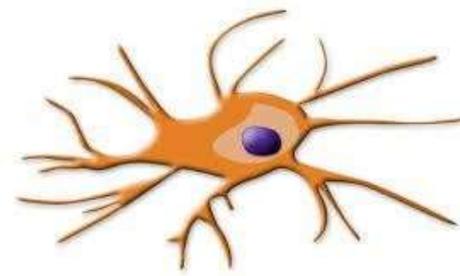
## Macrophages

- Macrophage play role in phagocytosis, bacterial killing, and antigen presentation
- Some macrophages move through the body and remain as free macrophage and some reside in particular tissue and become fixed macrophage like:
  - Peritoneal cavity: peritoneal macrophages
  - Lung: alveolar macrophages
  - Spleen: splenic macrophages
  - Liver: Kupffer cells
  - Intestinal macrophage
  - Microglial cells in brain
  - Histocytes in connective tissue

فأنا بس اجي  
أسميها بسميها  
related  
للمكان الي هي  
فيه

# 7. Dandritic Cells

سبب تسميتها :



- Acquired its name because it is covered with long membrane extensions that resemble the dendrites of nerve cells
- Dandritic cells have 4 main classes:
  - Langerhans DCs
  - Interstitial DCs
  - Monocyte-derived DCs
  - Plasmacytoid-derivied DCs
- DCs main functions are monitoring of body pathogen invasion and presentations of antigens for T cells

الدكتورة حكمت ما  
بتجيب سؤال مثلا اذكر  
الأنواع

\*لحد الان الخلايا الي بتعمل presentation للantigen :

- 1) Macrophages
- 2) Dandritic cells

# Stages of Lymphocyte Activation

بحياتها ما شافت  
أو antigen  
تعرفت عليه

لما نحكي عن حدا شو إنه نيف يعني ما عنده خبرة بالحياة أو عالبركة زي لما نحكي  
naïve patient يعني ولا عمره أخذ هاد الدواء من قبل

- **Naïve lymphocytes**
  - Mature lymphocytes that have not previously encountered antigen; function -- **antigen recognition**
  - Preferential migration to peripheral lymphoid organs (lymph nodes), the sites where antigens are concentrated and immune responses start
- **Effector lymphocytes** يعني الها effect ووظائف
  - Activated lymphocytes capable of performing the functions required to eliminate microbes (effector functions)
  - Effector T lymphocytes: cytokine secretion (helper cells), killing of infected cells (CTLs) → Cytotoxic T lymphocytes
  - B lymphocytes: antibody-secreting cells (e.g. plasma cells)
- **Memory lymphocytes** لكن لما تتعرض ل secondary exposure بنفس ال antigen الي كونها بتتمايز ال plasma cells و antibodies
  - Long-lived, functionally silent cells; mount rapid responses to antigen challenge (secondary responses)

بتتحول

plasma ل  
cells

وال plasma  
Cells بتعمل  
antibody  
secretion

# Function of Immune Cells

- Lymphocytes of the adaptive immune system
  1. T helper cells: regulate other immune cells
  2. T cytotoxic (killer) cells: kill infected cells **antigen presenting cells** هذول
  3. B cells: produce antibodies (immunoglobulin) 
- **Dendritic cells** and **macrophage**: directly kill microbes by phagocytosis and other mechanisms. They also help to activate T cells (connection between innate and adaptive immunity) **macrophages** زي ال
- Dendritic cells and other Antigen presenting cells (APCs) also play role in capturing microbes and then process and display antigens
- NK cells are lymphocytes: Recognizes and kill abnormal cells like **tumour cells**, and **virus infected cells**

# Lymphocyte Circulation

- Lymphocytes constantly circulates between tissues in such a way that
  1. naïve lymphocytes traverse the peripheral lymphoid organs where immune response are initiated
  2. the effectors lymphocytes migrates to sites of infections to eliminates microbes
- Lymph: Fluids from all epithelia, connective tissues and paranchymal organs is drained by lymphatic's

حكيما انها بتكون موجودة بال central lymphatic organ بعدين بتهاجر وبتروح لل peripheral حتى هناك تعمل recognition

antigen لى يصير لها maturation

لما تصير activated وين مافي antigen بتحاول انها تقضي عليه واذا ما واجهت antigen مارح تضل عايشة بالجسم رح يصير لها

turn over بعدين بتتحول لل effector T cells زي : helper T cells , cytotoxic T cells , regulatory T cells

# Lymphocyte Circulation

## Lymphocyte Circulation:

1. Lymphocytes & lymph return to blood via thoracic duct
2. Naïve lymphocytes enter lymph nodes from blood

**Naïve lymphocytes:** Have not seen Ag  
blood → Lymph nodes → lymphatics → thoracic duct → blood

**Small T & B lymphocytes:** Recirculating population of lymphocytes

**Effector cells:** Recognize (“seen”) Ag; Differentiate in lymph nodes

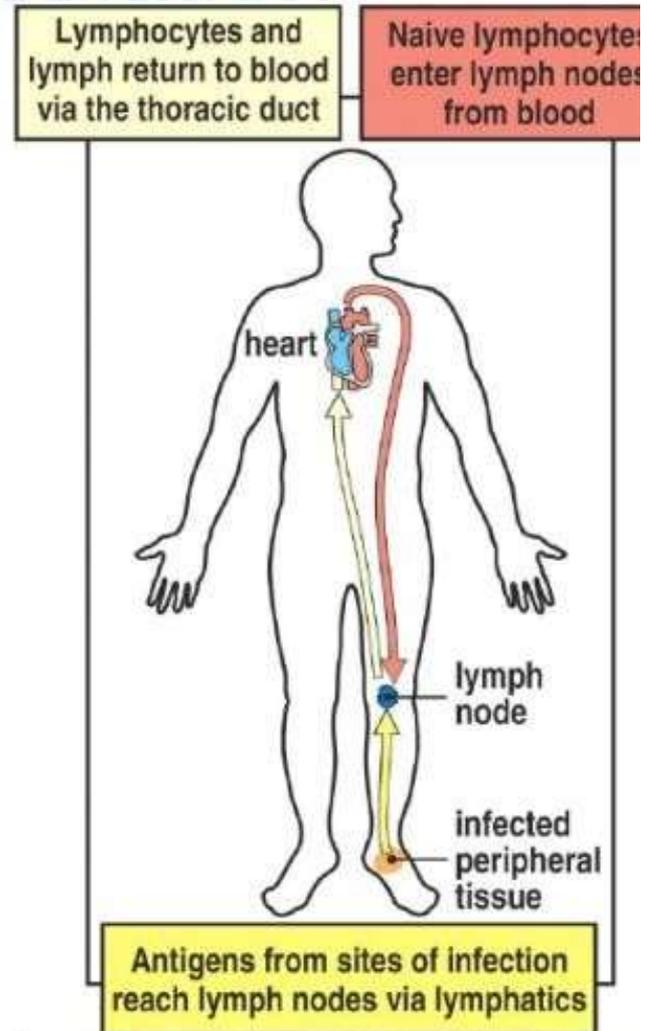


Figure 1-11 Immunobiology, 6/e. (© Garland Science 2005)

كيف قدروا العلماء يفرقوا انه هاي helper ولا cytotoxic ولا regulatory ؟

عن طريق molecule موجود عسطحها واتبعوا نظام اسمه

# The CD Nomenclature

- Structurally defined leukocyte surface molecule that is expressed on cells of a particular lineage and recognized by a group (“cluster”) of specific antibodies is called a member of a cluster of differentiation (CD)
- Used to classify leukocytes into functionally distinct subpopulations, e.g. helper T cells are CD4+, Cytotoxic T cells are CD8+, and Regulatory T cells are CD4+ and CD25+
- Often involved in leukocyte functions
- Antibodies against various CD molecules are used to:
  1. Identify and isolate leukocyte subpopulations
  2. Study functions of leukocytes
  3. Eliminate particular cell populations

\*اذن اذا انا قدرت اصنع antibodies وتروح

Helper cells specific لل CD4+ بتكون

-اذا كان على سطحها CD4+ هاي بتكون Helper

-اذا كان على سطحها CD8+ هاي بتكون Cytotoxic

-اذا كان على سطحها CD4+ و CD25+ هاي بتكون Regulatory

شَدُّوا الهِمَّةَ ، فنحن مسلمون نُعوِّلُ على البركة لا على الوقت ♡