Varastegan

Institute for Medical Sciences

Organs of the Immune System

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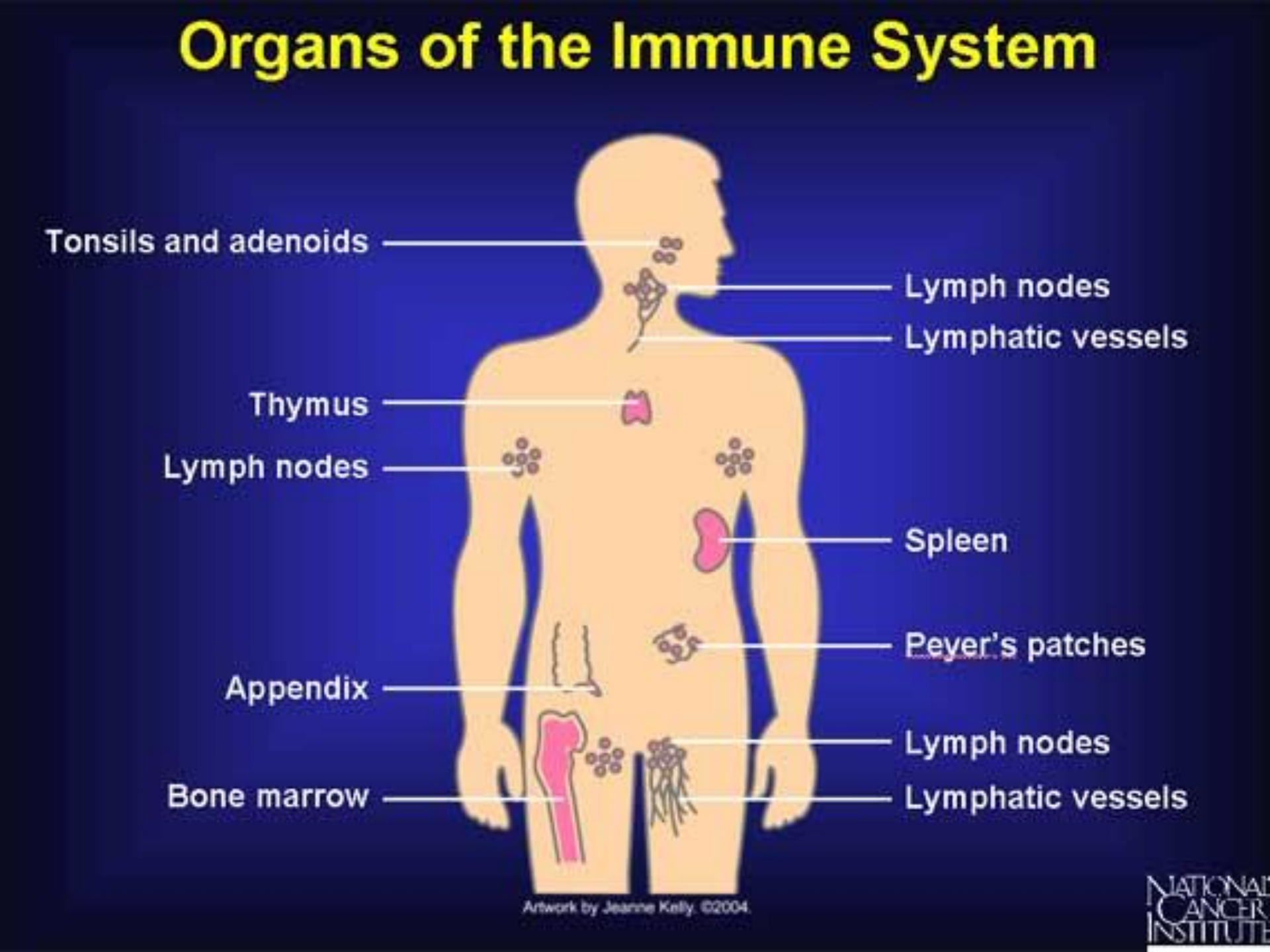
Introduction

- A number of morphologically and functionally diverse organs and tissues have various functions in the development of immune responses.

- These can be distinguished by function as the **primary** and **secondary lymphoid organs**.

Organs of the Immune System



Classification

- The **thymus** and **bone marrow** are the **primary** (or **central**) lymphoid organs, where maturation of lymphocytes takes place

- The **lymph nodes**, **spleen**, and various mucosal associated lymphoid tissues (**MALT**) such as gut-associated lymphoid tissue (**GALT**) are the **secondary** (or **peripheral**) lymphoid organs.

The role of Primary or Central lymphoid organs

- Sites where lymphocytes are generated, mature and differentiate into functional immune cells

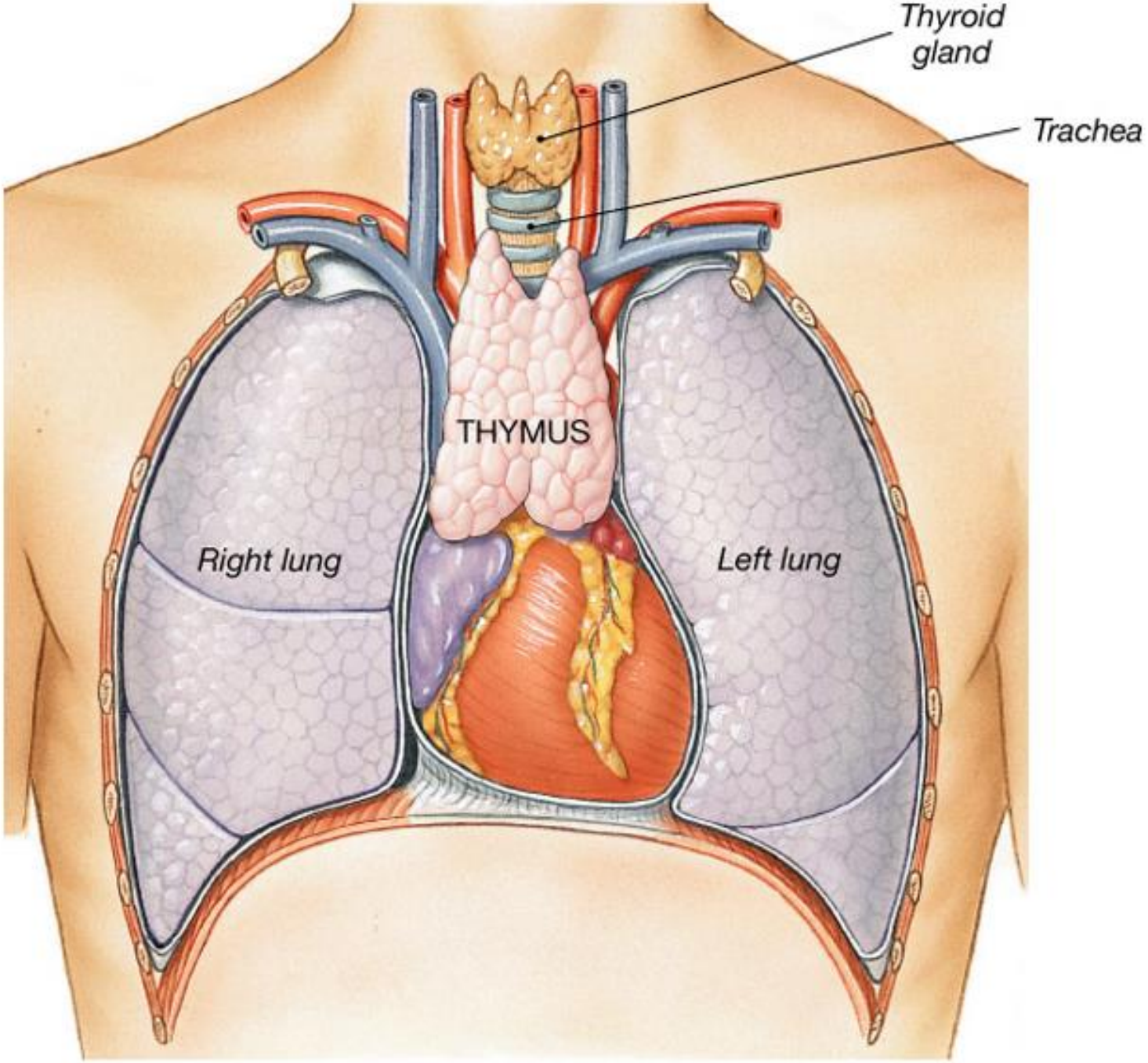
- Bone marrow: **generation** of B cells and T cell
- Thymus: T cells **maturation**
- Bone marrow-B cells **maturation**
- Bursa, B cell maturation in **birds**

The role of Secondary or Peripheral Organs function

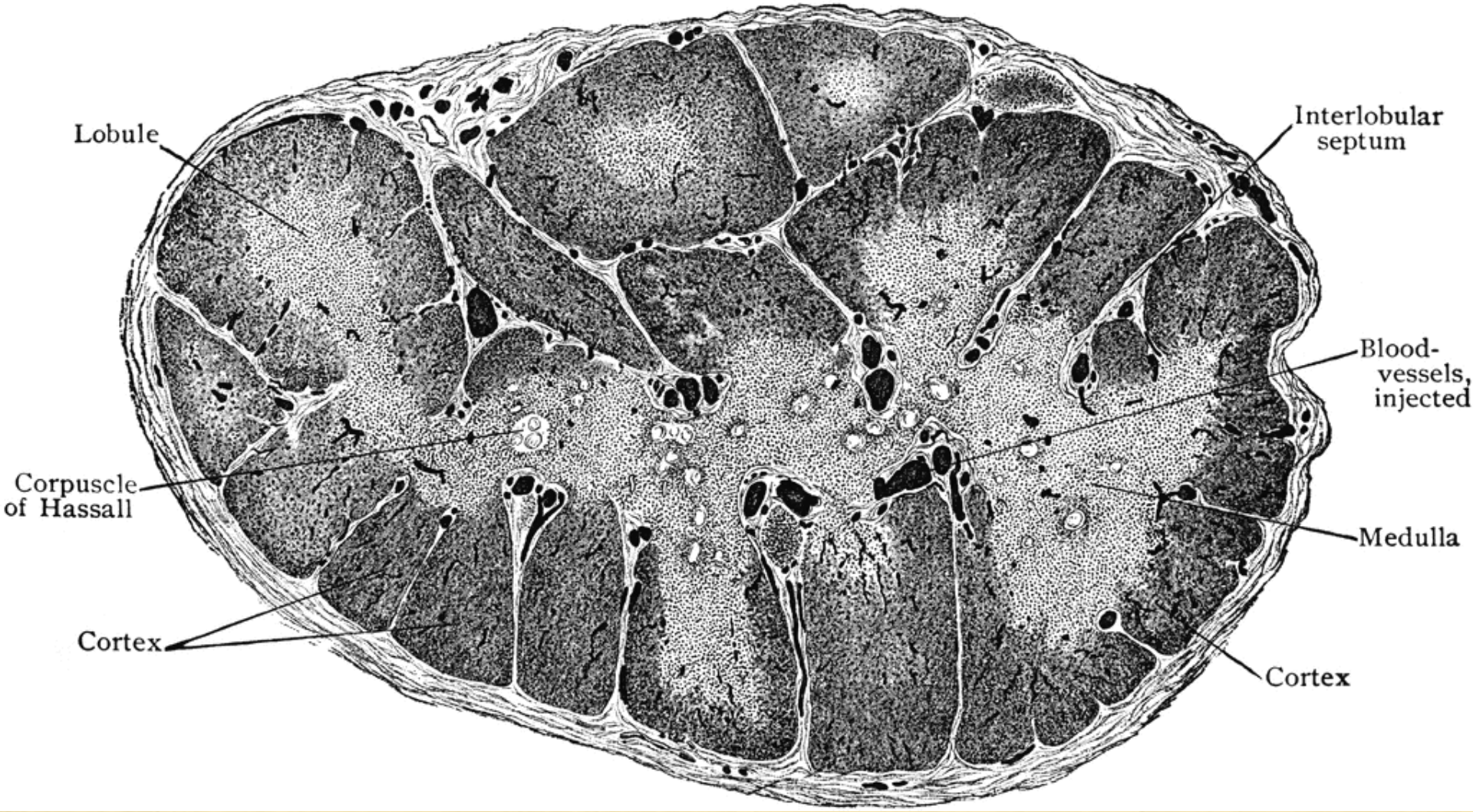
- **Filter** and **trap** antigen from blood and tissues;
- Provide **environment** for lymphocytes to find **antigen** in order to be **activated** and interact with one another

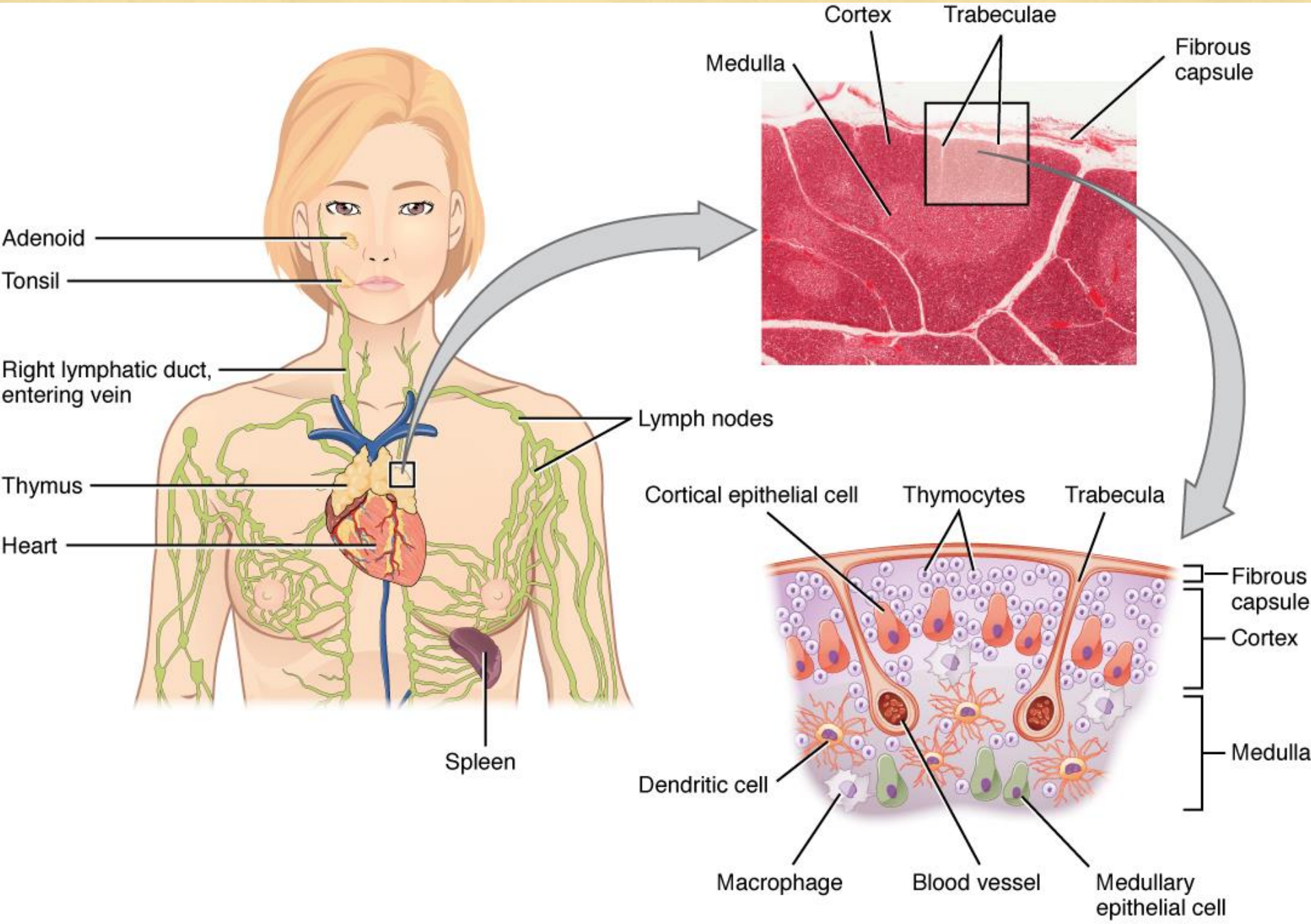
Thymus

- The thymus is the site of **T-cell** development and maturation.
- It is a flat, blobbed organ situated above the heart.
- Each lobe is surrounded by a capsule and is divided into lobules, which are separated from each other by strands of connective tissue called trabeculae.



(a) Location of thymus within thoracic cavity


Lobule
Interlobular septum
Blood-vessels, injected
Corpuscle of Hassall
Medulla
Cortex
Cortex


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

Thymus

- The function of the thymus is to **generate** and **select** a repertoire of T cells that will protect the body from infection.

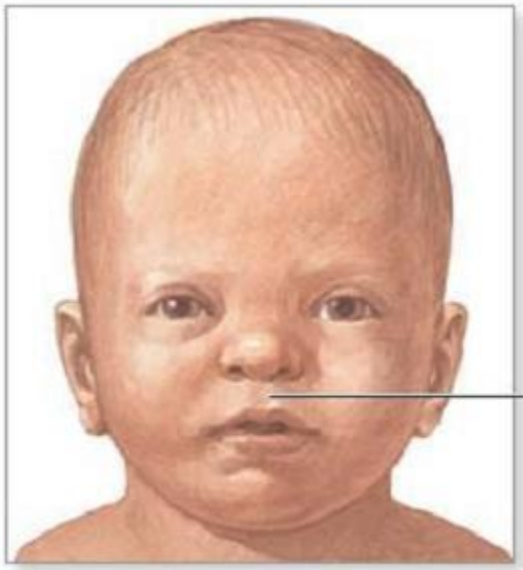
- More than 95% of all thymocytes die by apoptosis in the thymus without ever reaching maturity.

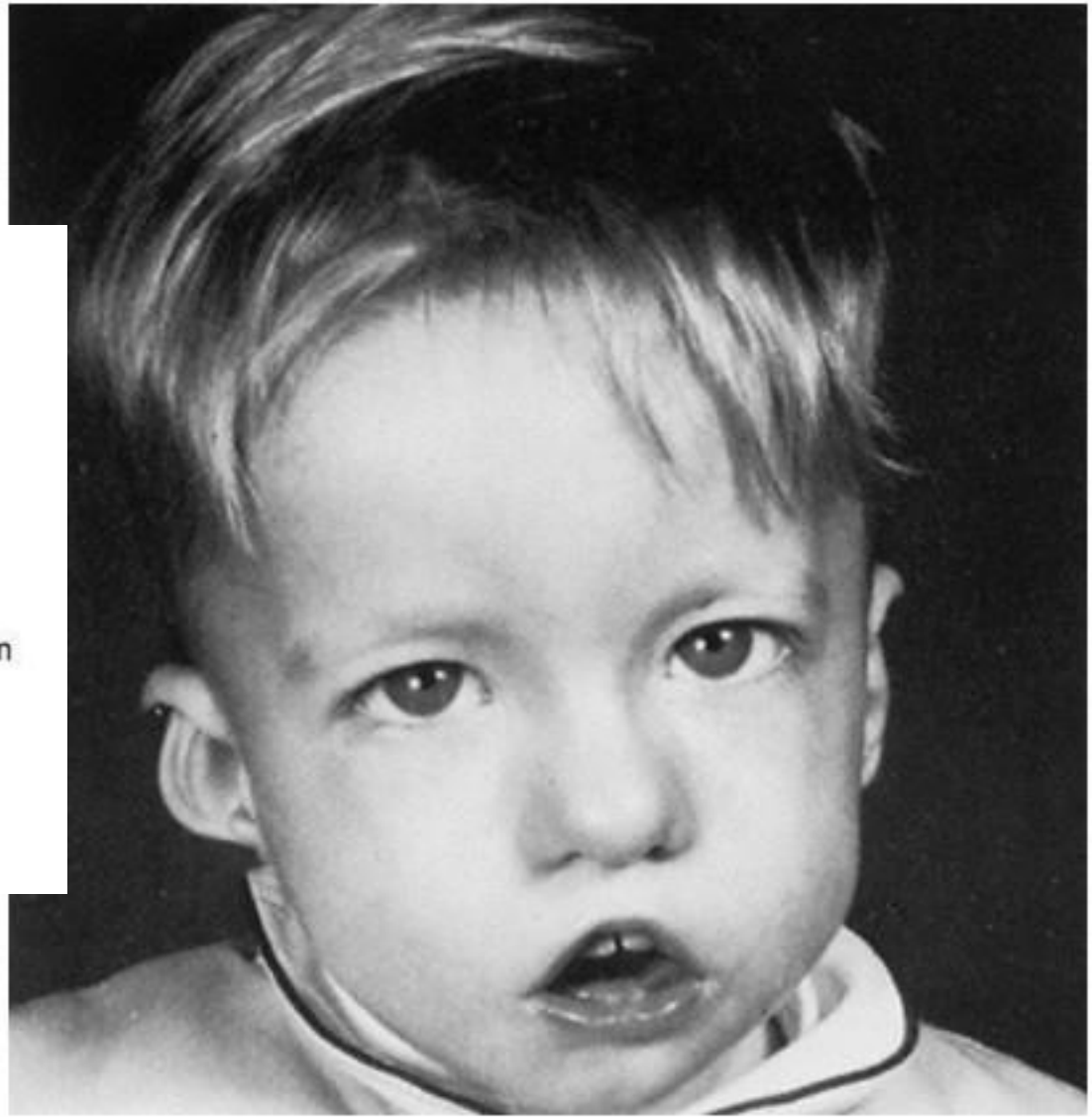
The thymus and immune function

- The role of the thymus in immune function can be studied in mice by examining the effects of neonatal thymectomy.

- Other evidence of the importance of the thymus comes from studies of a congenital birth defect in humans **(DiGeorge's syndrome)** and in certain mice **(nude mice)** in which the thymus fails to develop.

DiGeorge's syndrome



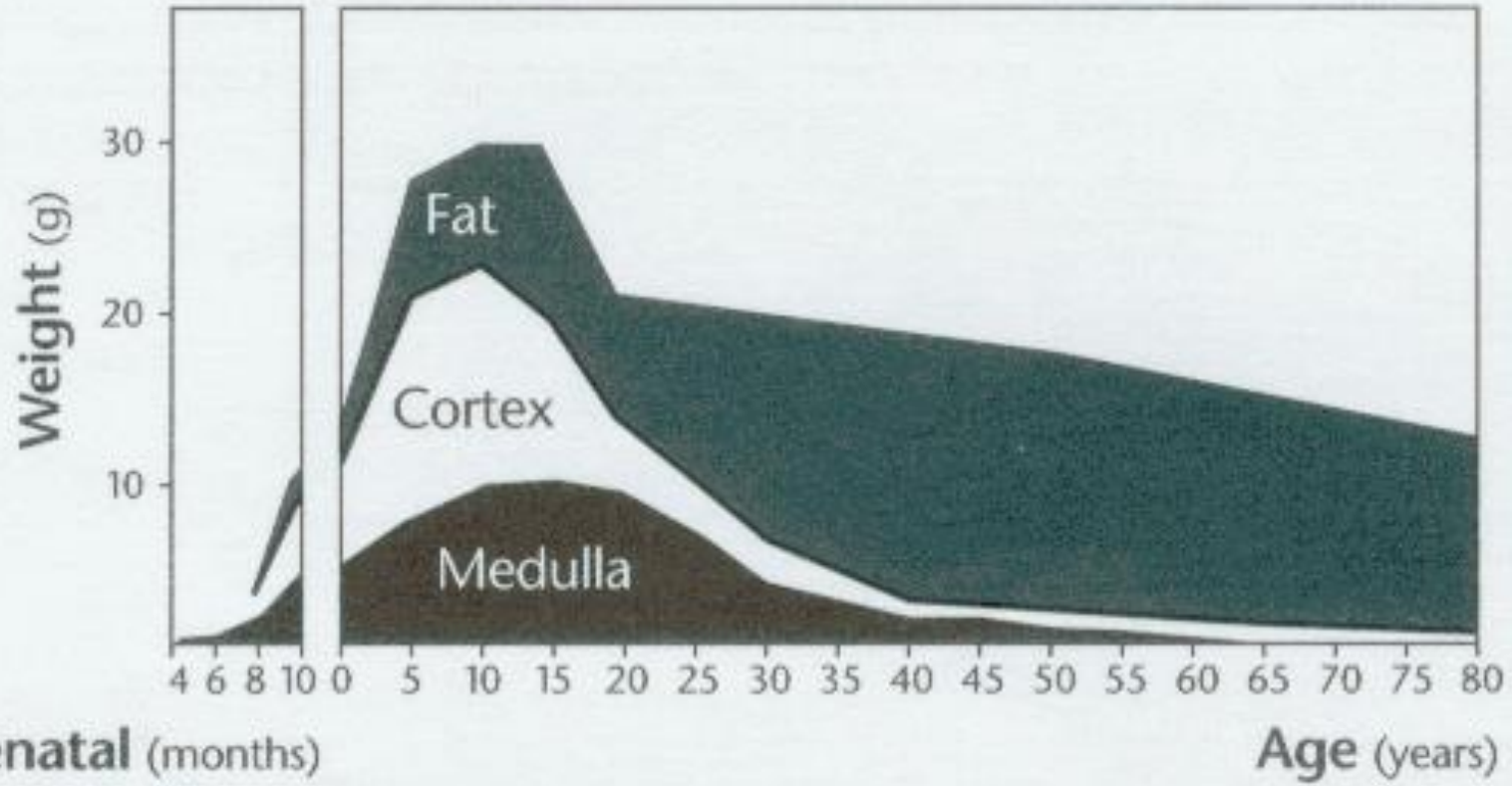


Thymus

- Aging is accompanied by a decline in thymic function.
- The thymus reaches its maximal size at **puberty** and then atrophies, with a significant decrease in both cortical and medullary cells and an increase in the **total fat** content of the organ.
- Whereas the average weight of the thymus is 20 g in infants, its age-dependent involution leaves an organ with an average weight of only 3 g in the elderly.

Figure 3

The thymic gland involutes with age



Cross section of a thymic load

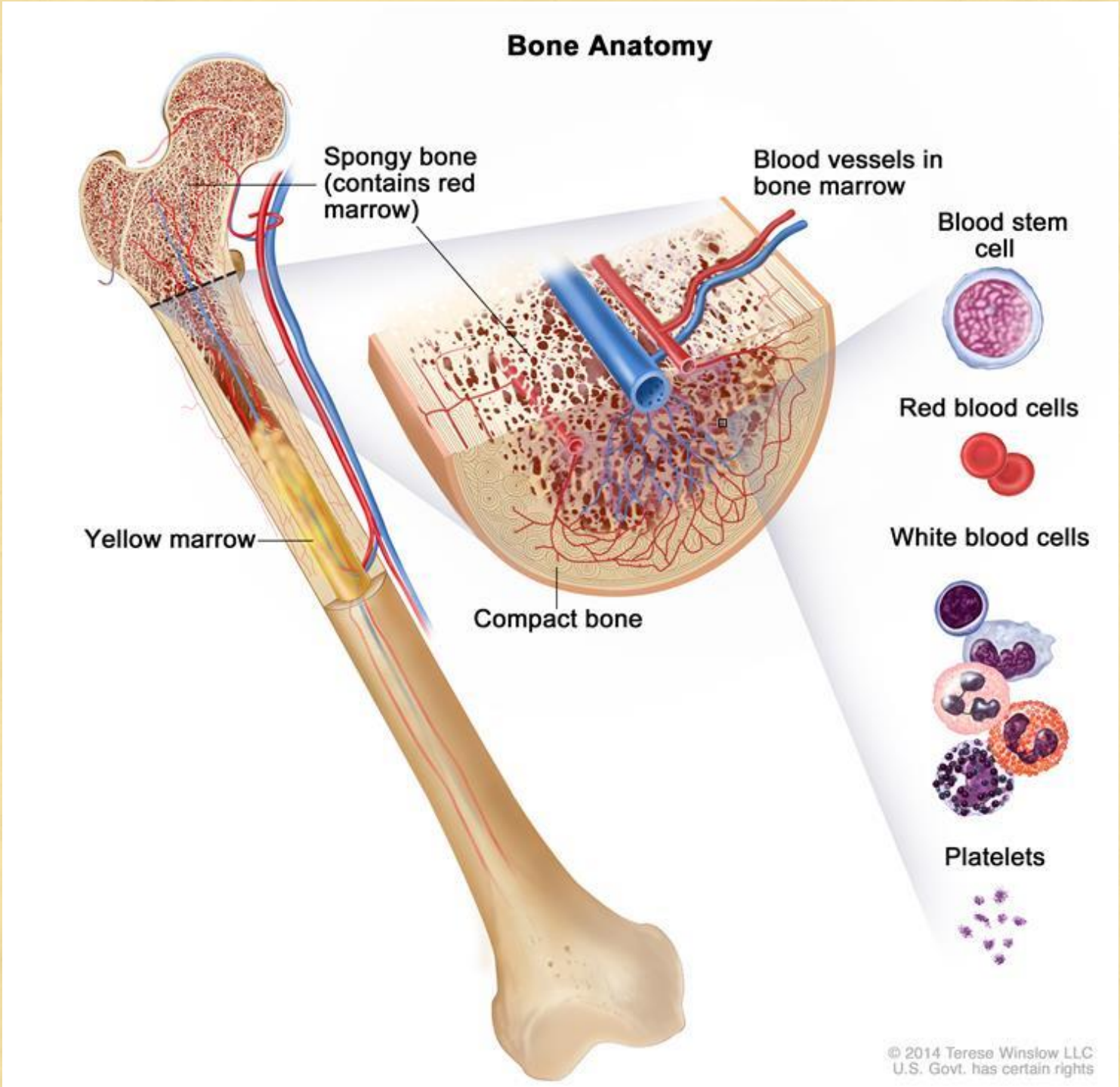
Bone Marrow

- Site of hematopoiesis,
- Generation of all blood cells
- All cell involved in immune system are produced in BM
- B cell are generated and differentiated in BM
- Different environmental factors (cell and molecule) in BM are involved in generation, differentiation, selection, education of cell

Bone marrow

- In humans and mice, bone marrow is the site of B-cell origin and development.

- Like thymic selection during Tcell maturation, a selection process within the bone marrow eliminates B cells with self-reactive antibody receptors.


Bone Anatomy
Spongy bone (contains red marrow)
Blood vessels in bone marrow
Blood stem cell
Red blood cells
White blood cells
Platelets
Yellow marrow
Compact bone
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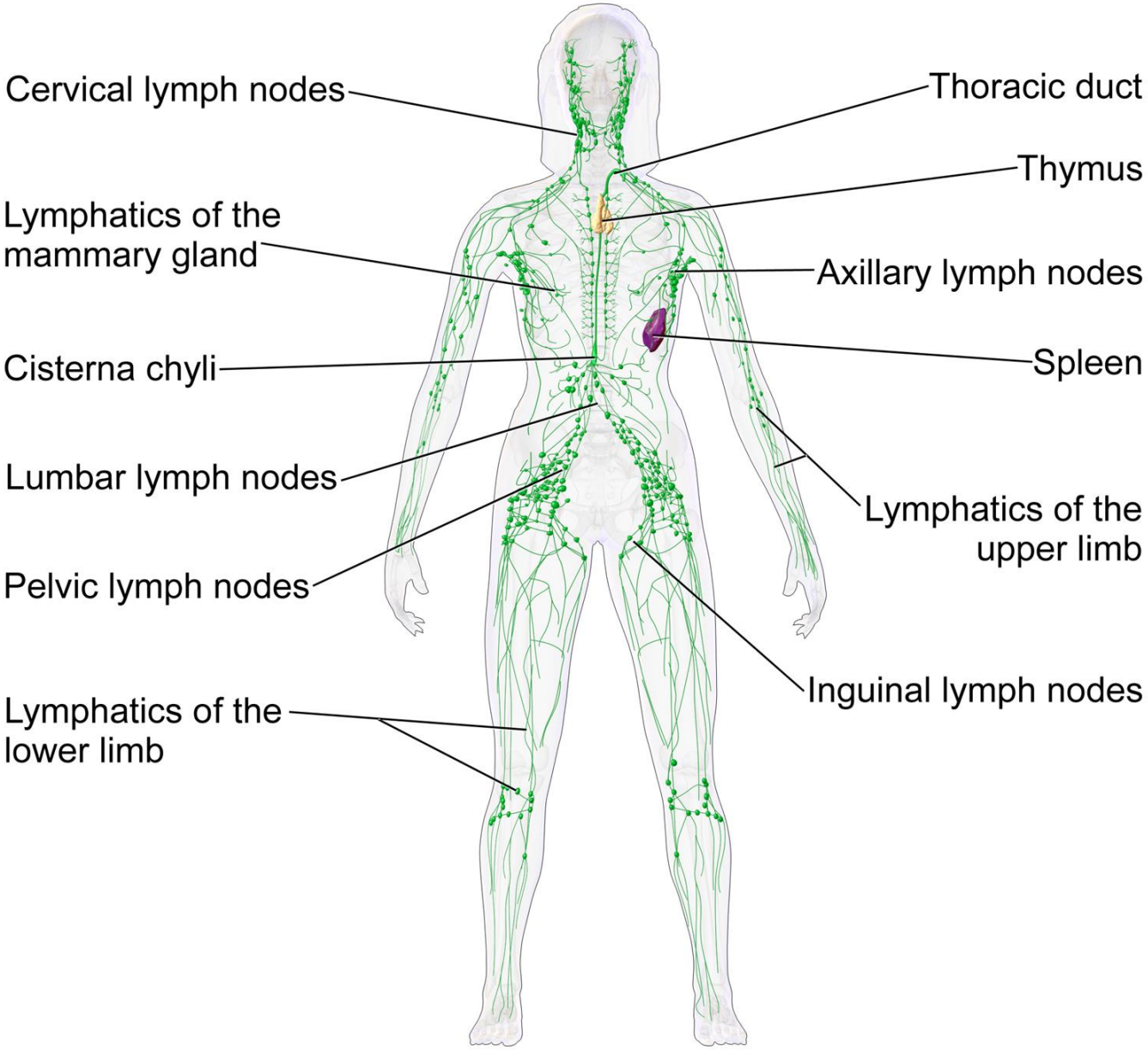
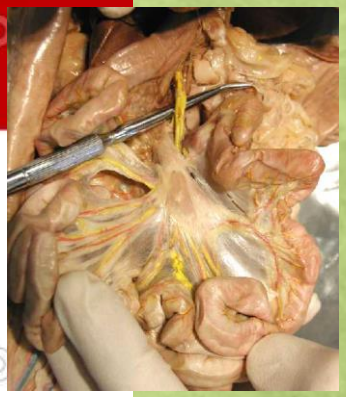
Lymphatic System

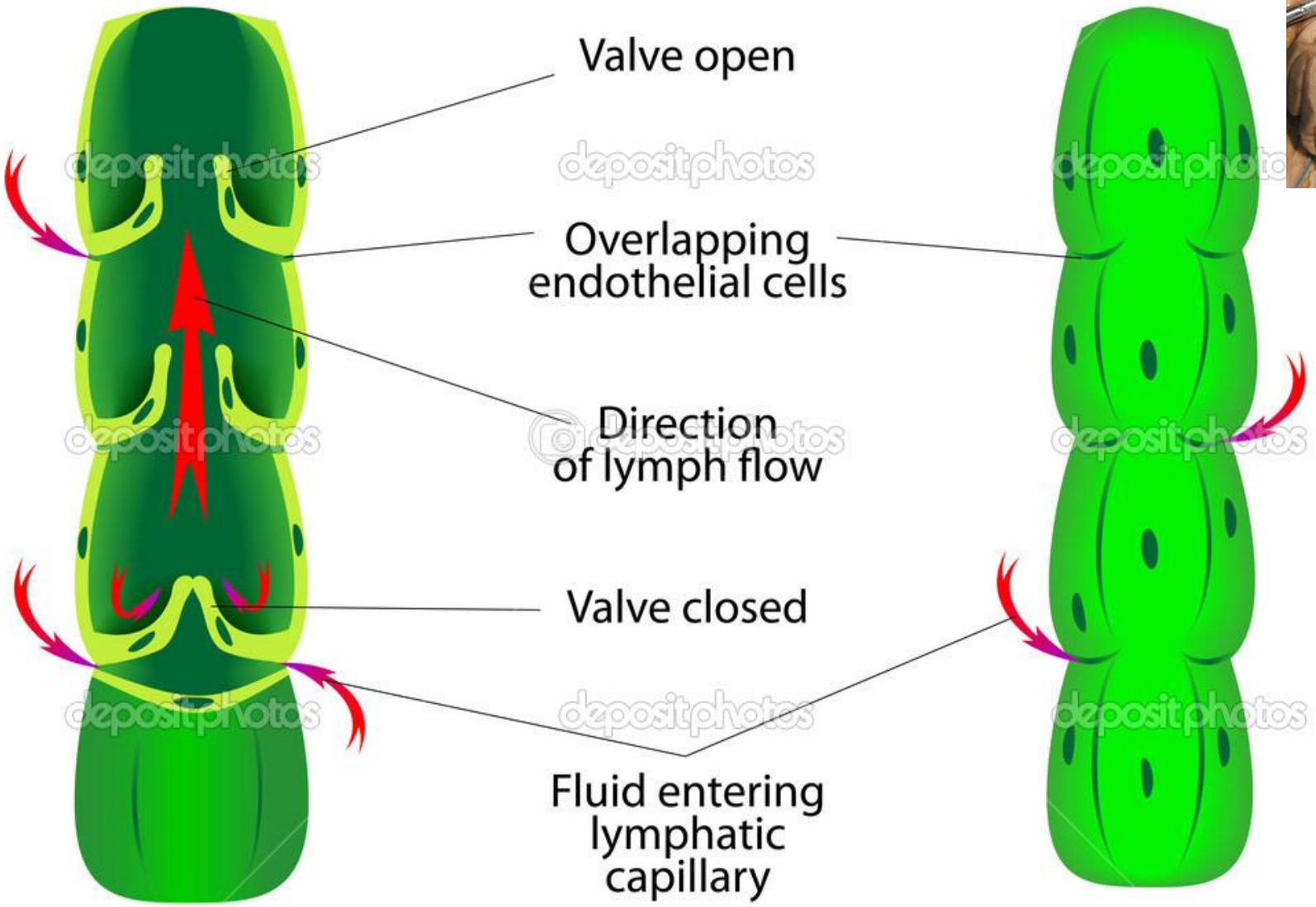
- **Lymphatic vessels** collect tissue fluid from loose connective tissue
  - *Carry fluid to great veins in the neck.*
  - *Fluid flows only toward the heart.*

The Lymphatic System



Lymphatic vessel

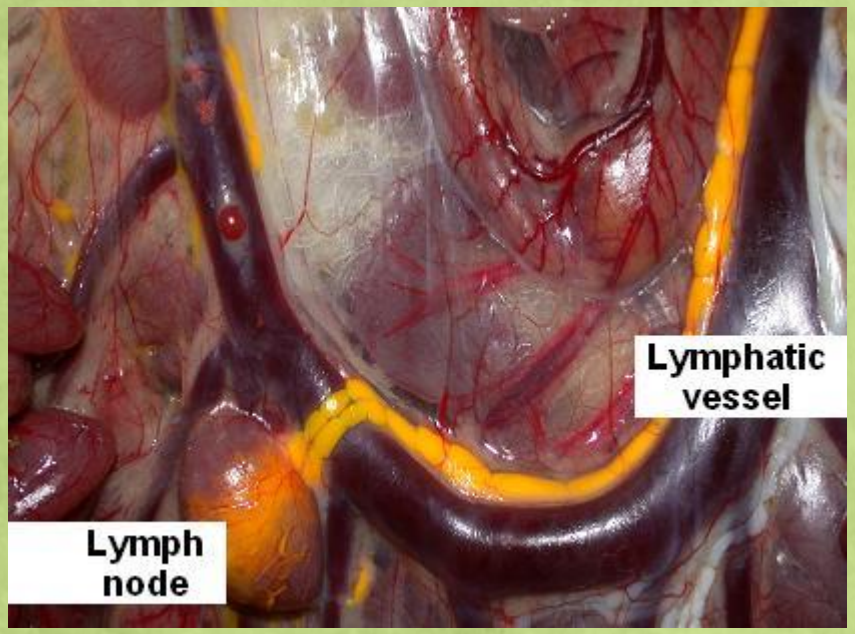


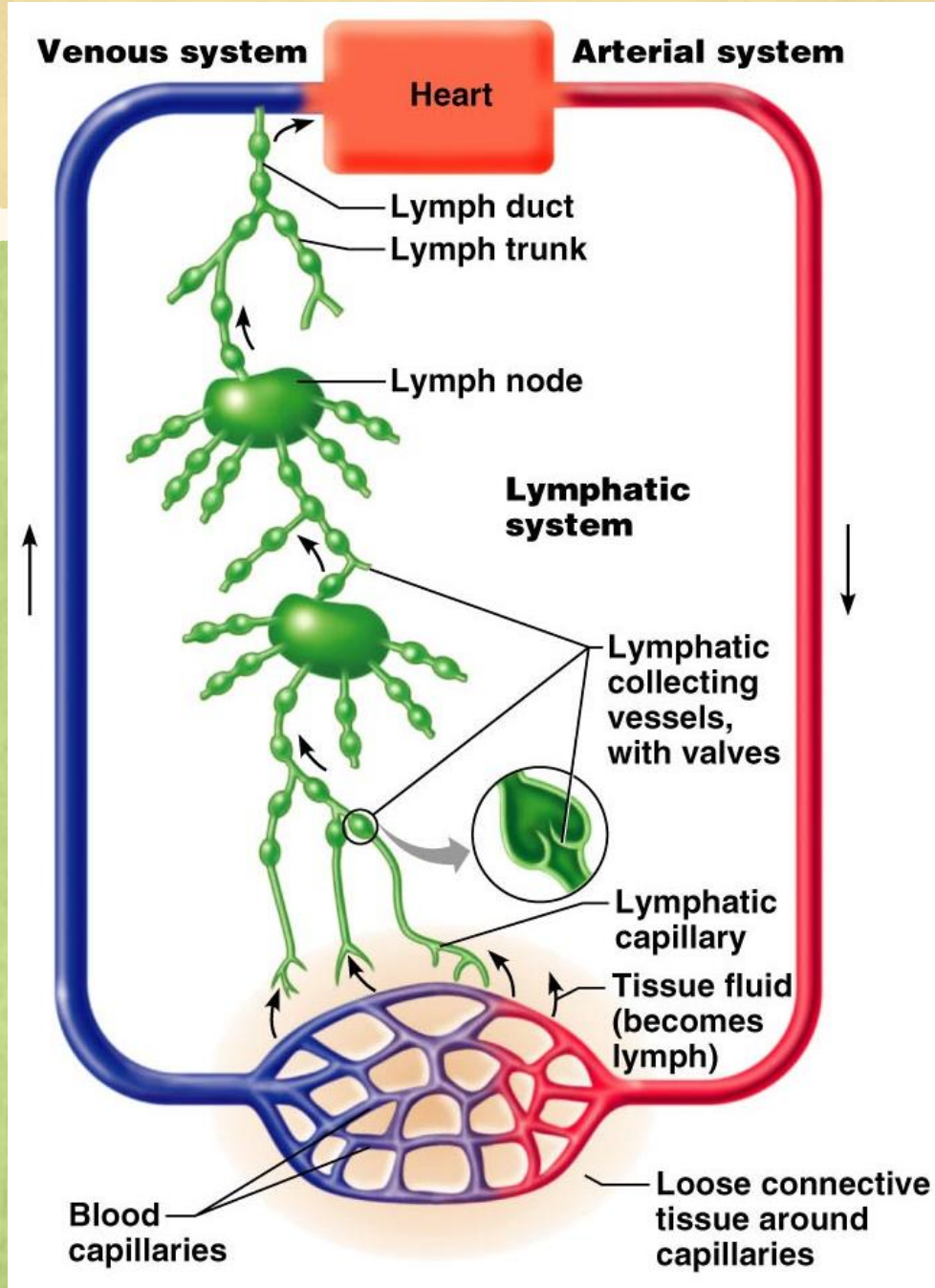


Longitudinal section

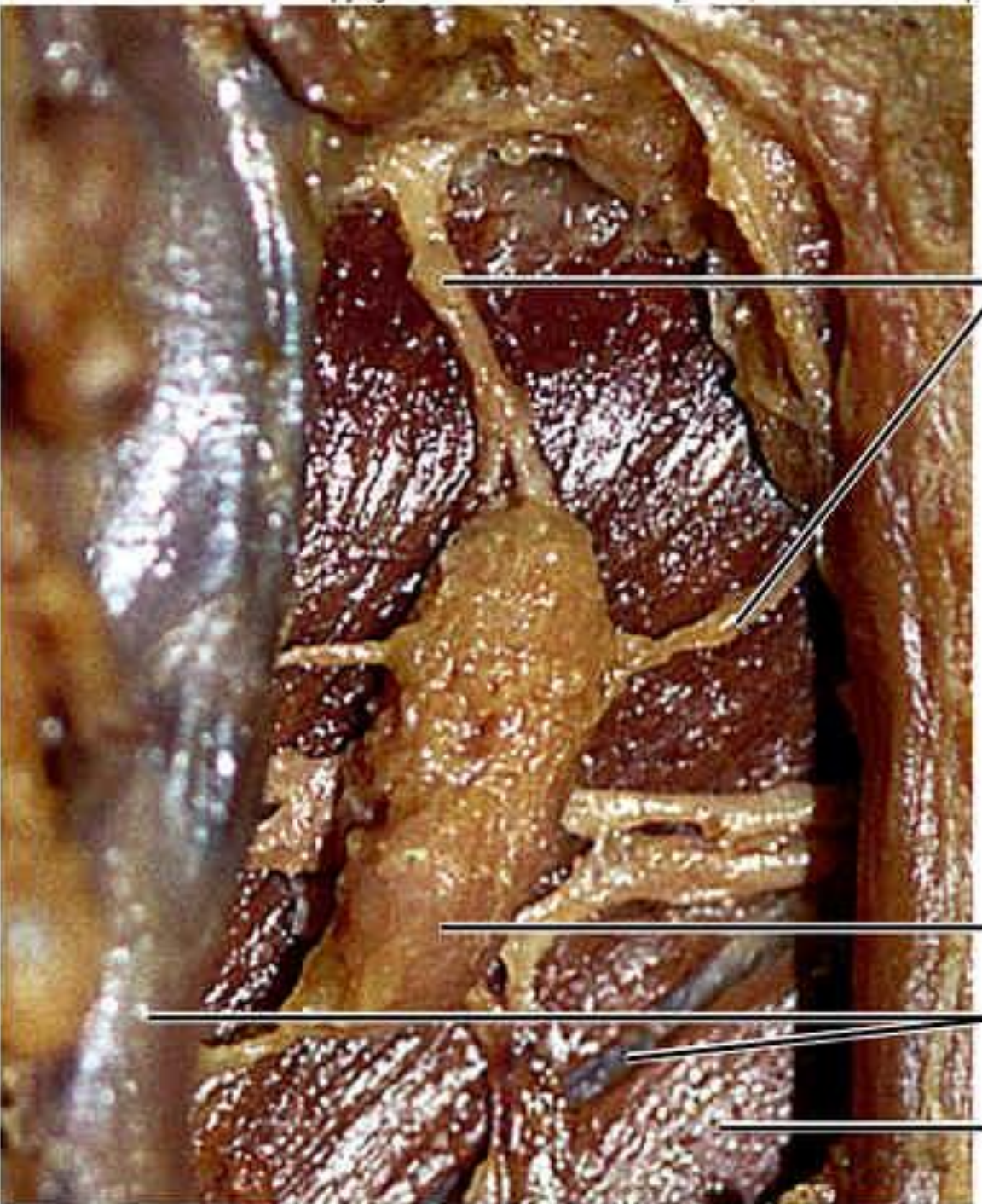
Functions of Lymphatic Vessels

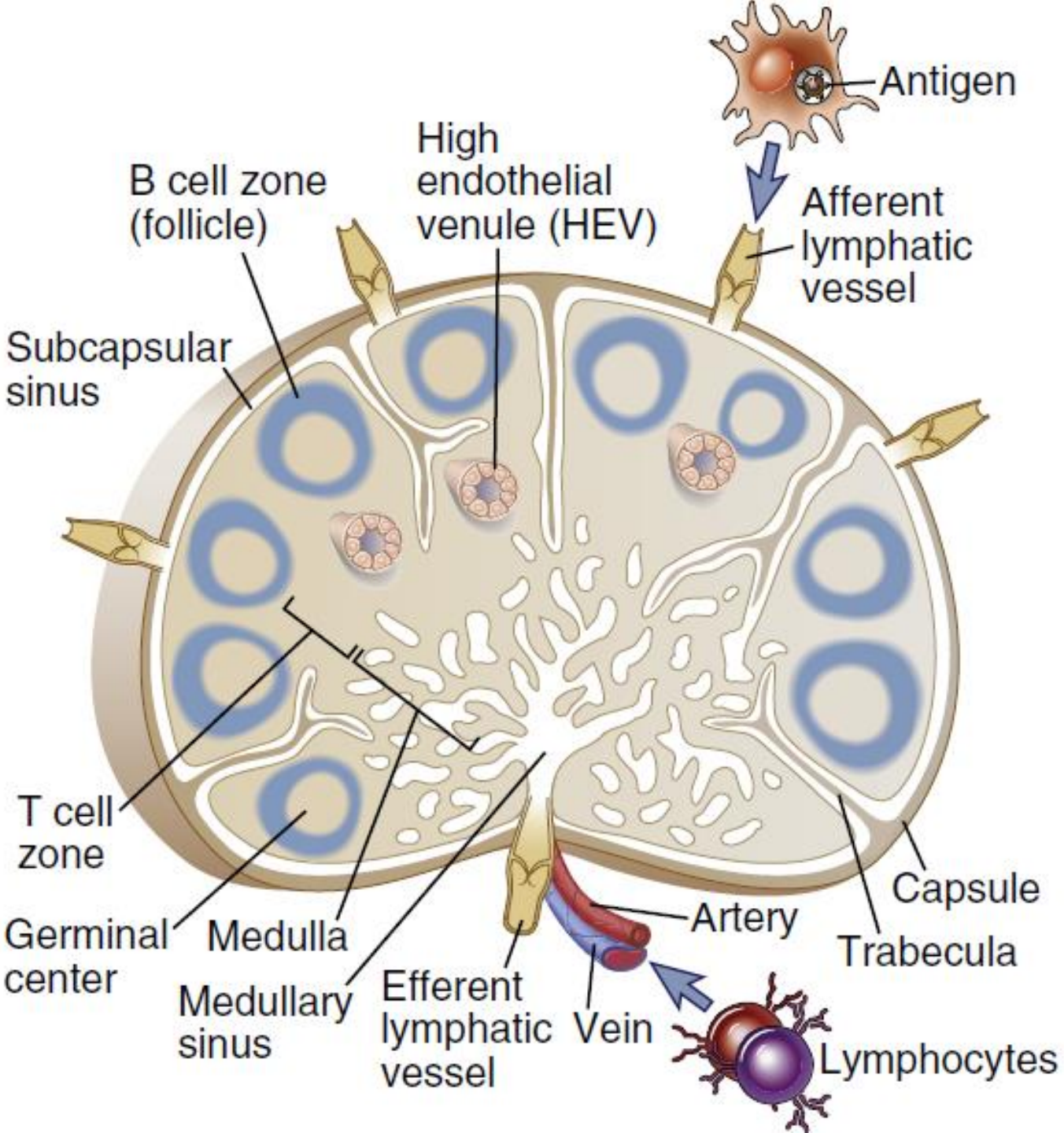
- ✓ Collect excess tissue fluid and blood proteins
- ✓ Return tissue fluid and blood proteins to bloodstream





Lymphatic Vessels

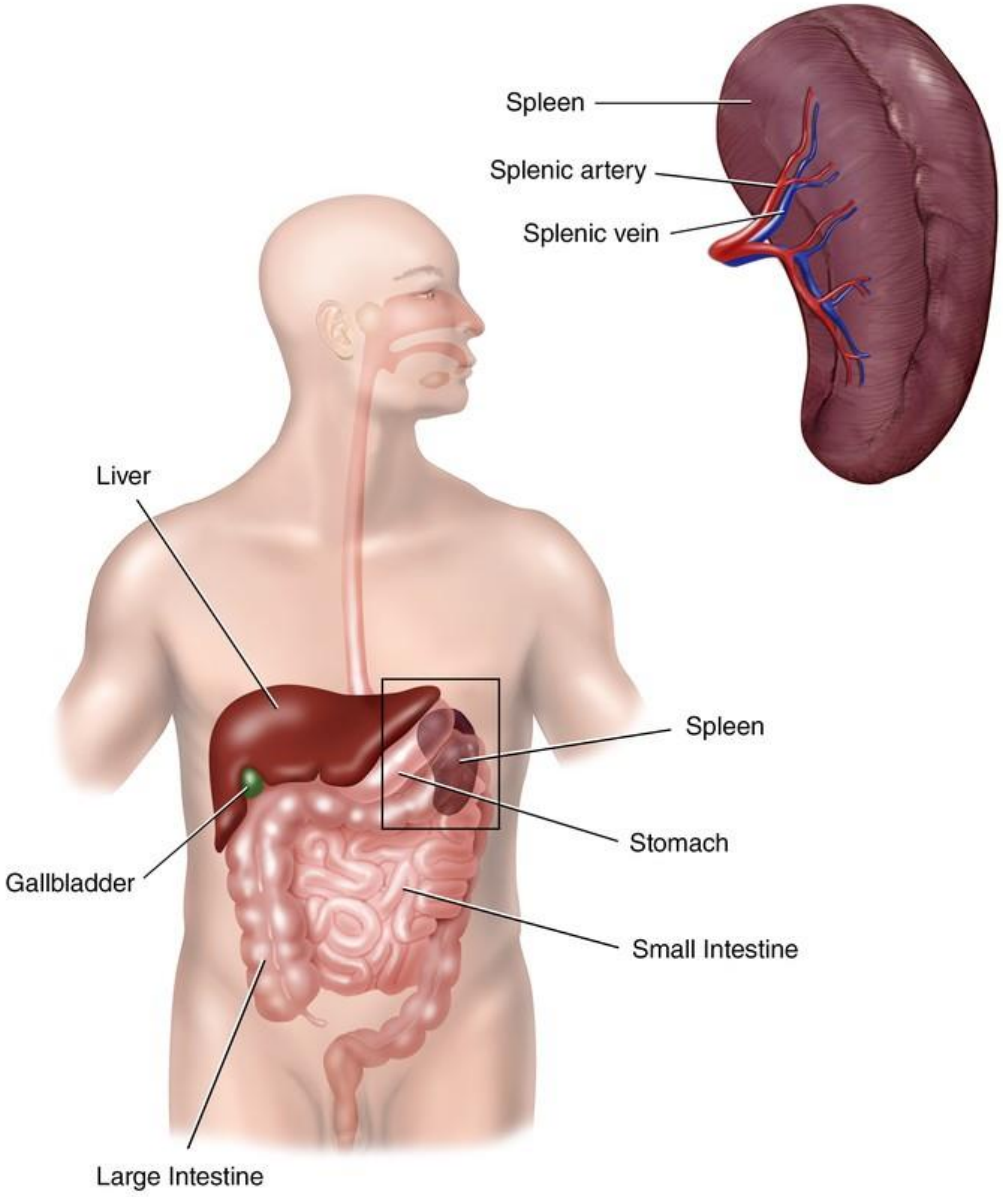



Antigen
High endothelial venule (HEV)
B cell zone (follicle)
Afferent lymphatic vessel
Subcapsular sinus
T cell zone
Germinal center
Medulla
Medullary sinus
Efferent lymphatic vessel
Vein
Artery
Capsule
Trabecula
Lymphocytes

Spleen

- Largest lymphoid organ
- Two main *blood-cleansing functions*
  - ✓ *Removal of blood-borne antigens*
  - ✓ *Removal and destruction of old or defective blood cells*
- Site of hematopoiesis in the fetus
- Site of B cell maturation into plasma cells
- Phagocytosis of bacteria and worn-out RBCs, WBCs and platelets
- Storage of platelets

Spleen

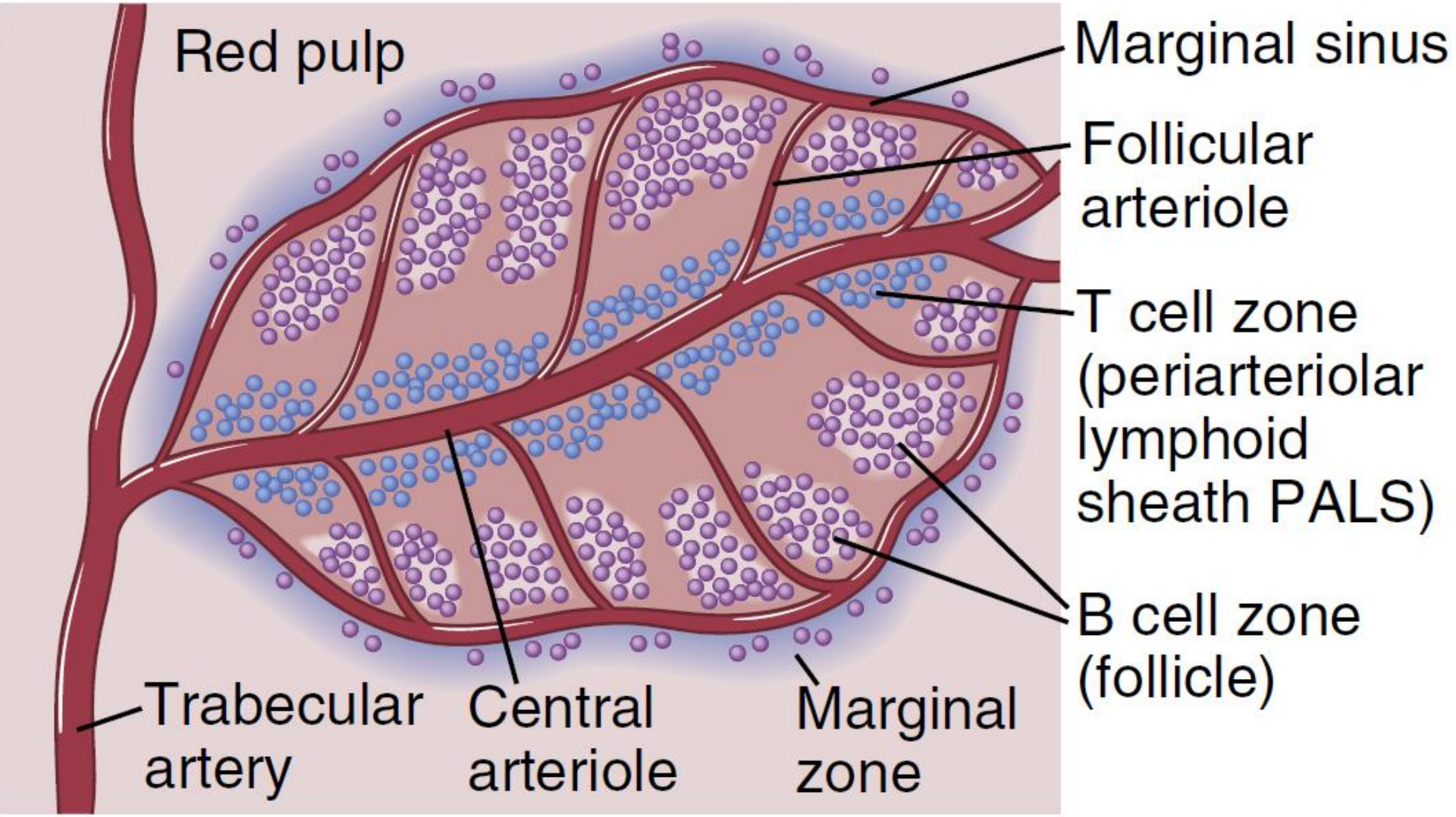


Spleen

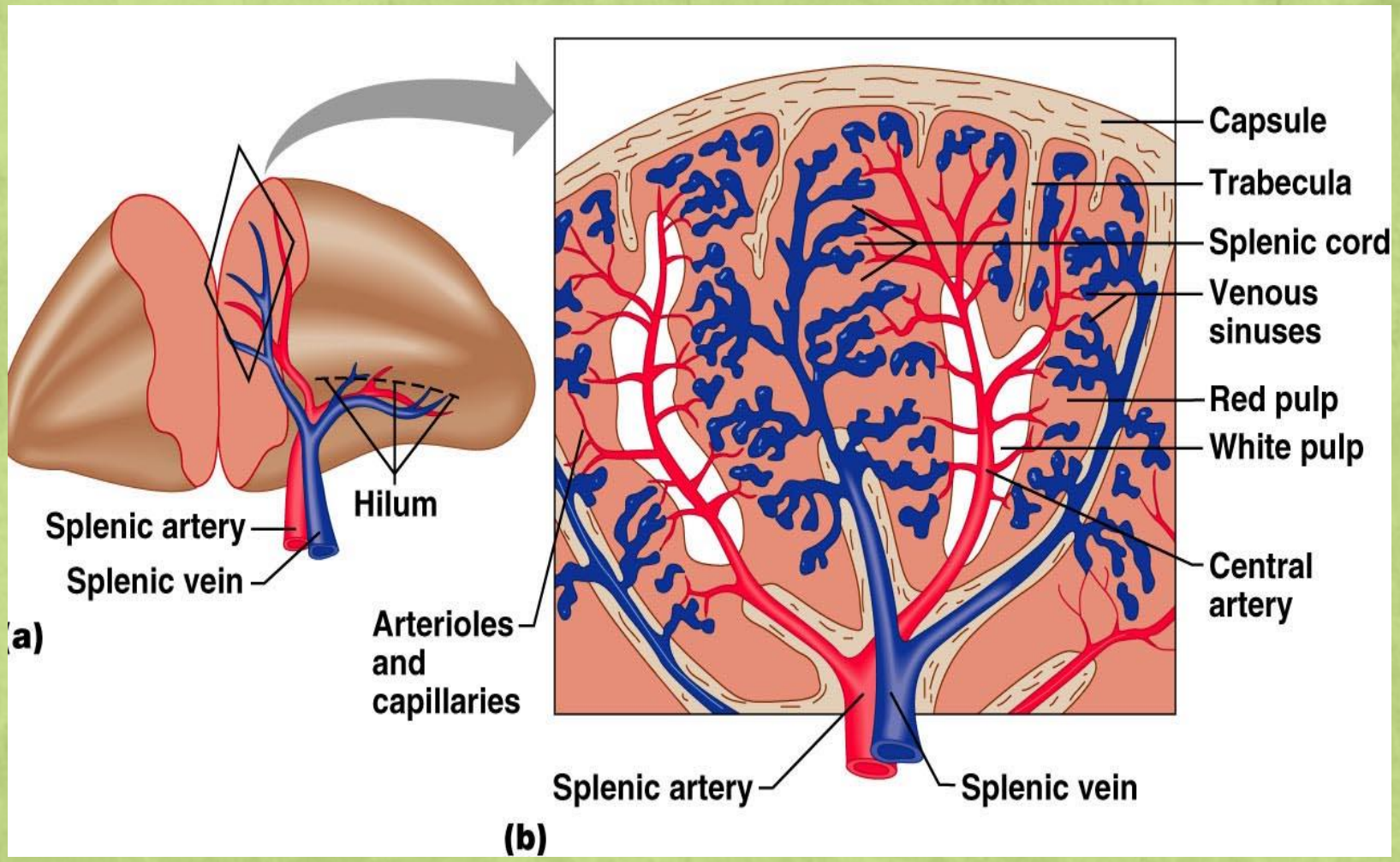
- White pulp – thick sleeves of lymphoid tissue

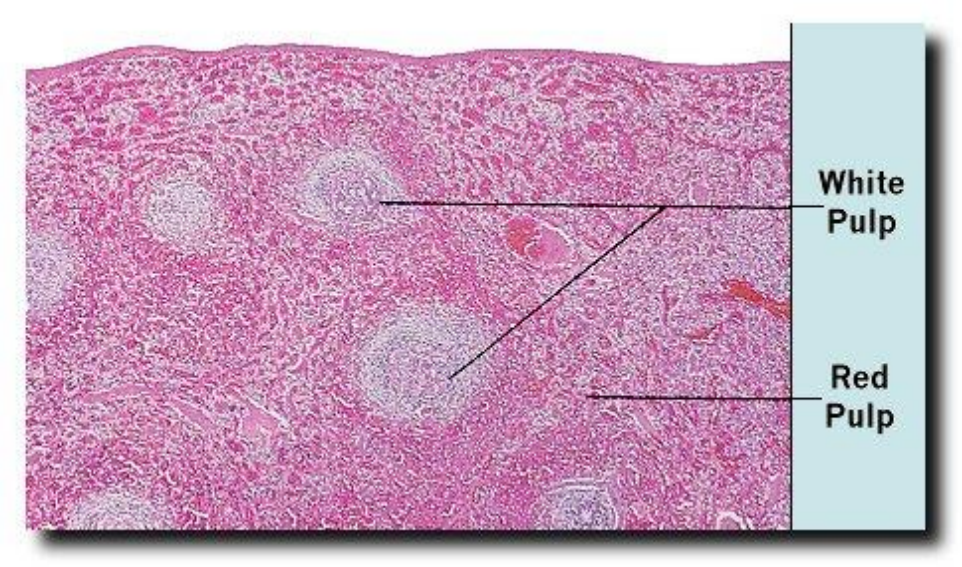
- Red pulp - surrounds white pulp

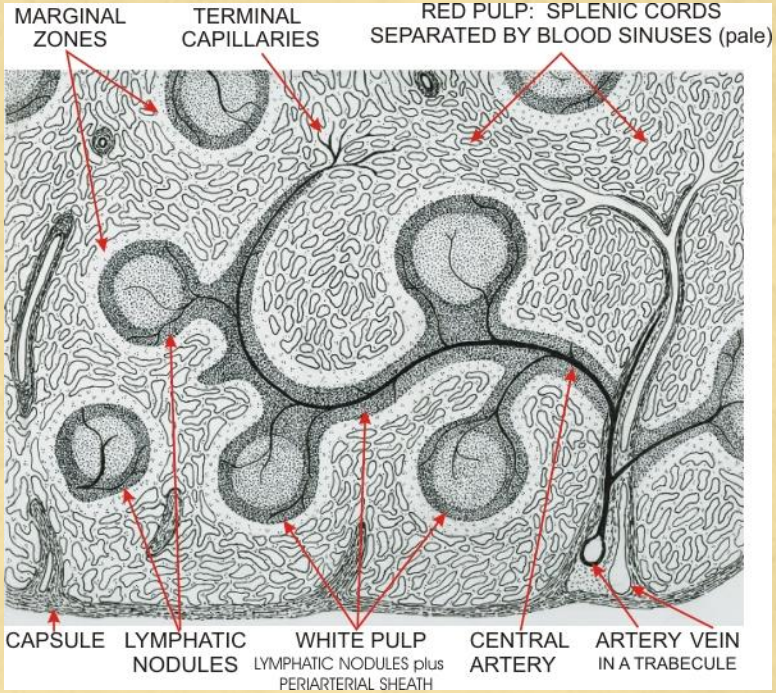
- The splenic **white pulp** surrounds the branches of the splenic artery, forming a **periarteriolar lymphoid sheath (PALS)** populated mainly by T lymphocytes.
  Primary lymphoid follicles are attached to the PALS.

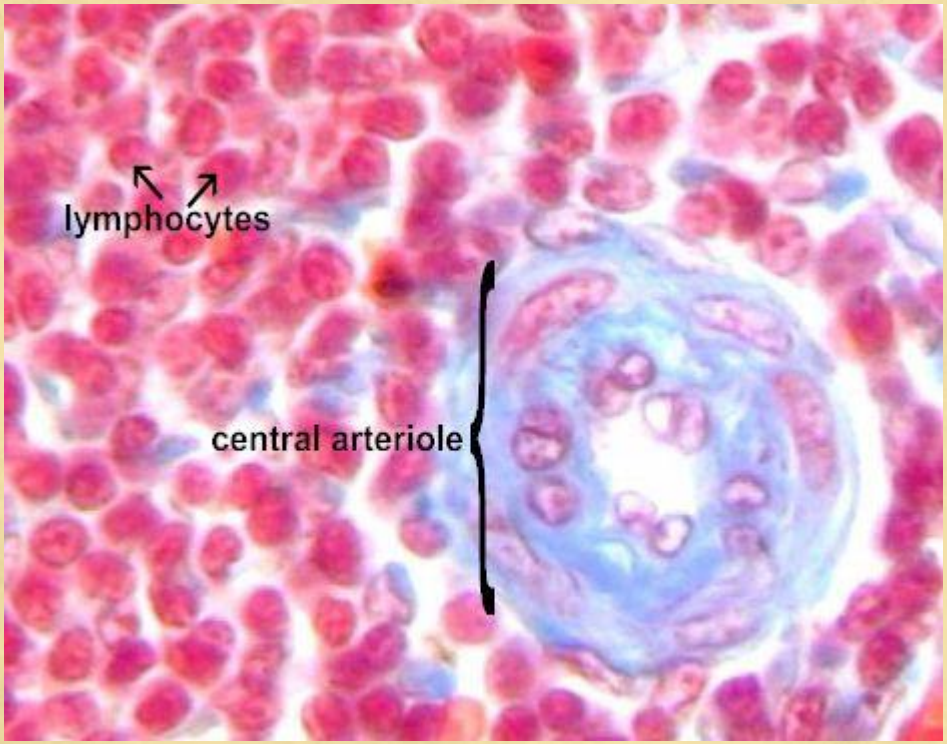

Red pulp
Marginal sinus
Follicular arteriole
T cell zone (periarteriolar lymphoid sheath PALS)
B cell zone (follicle)
Trabecular artery
Central arteriole
Marginal zone

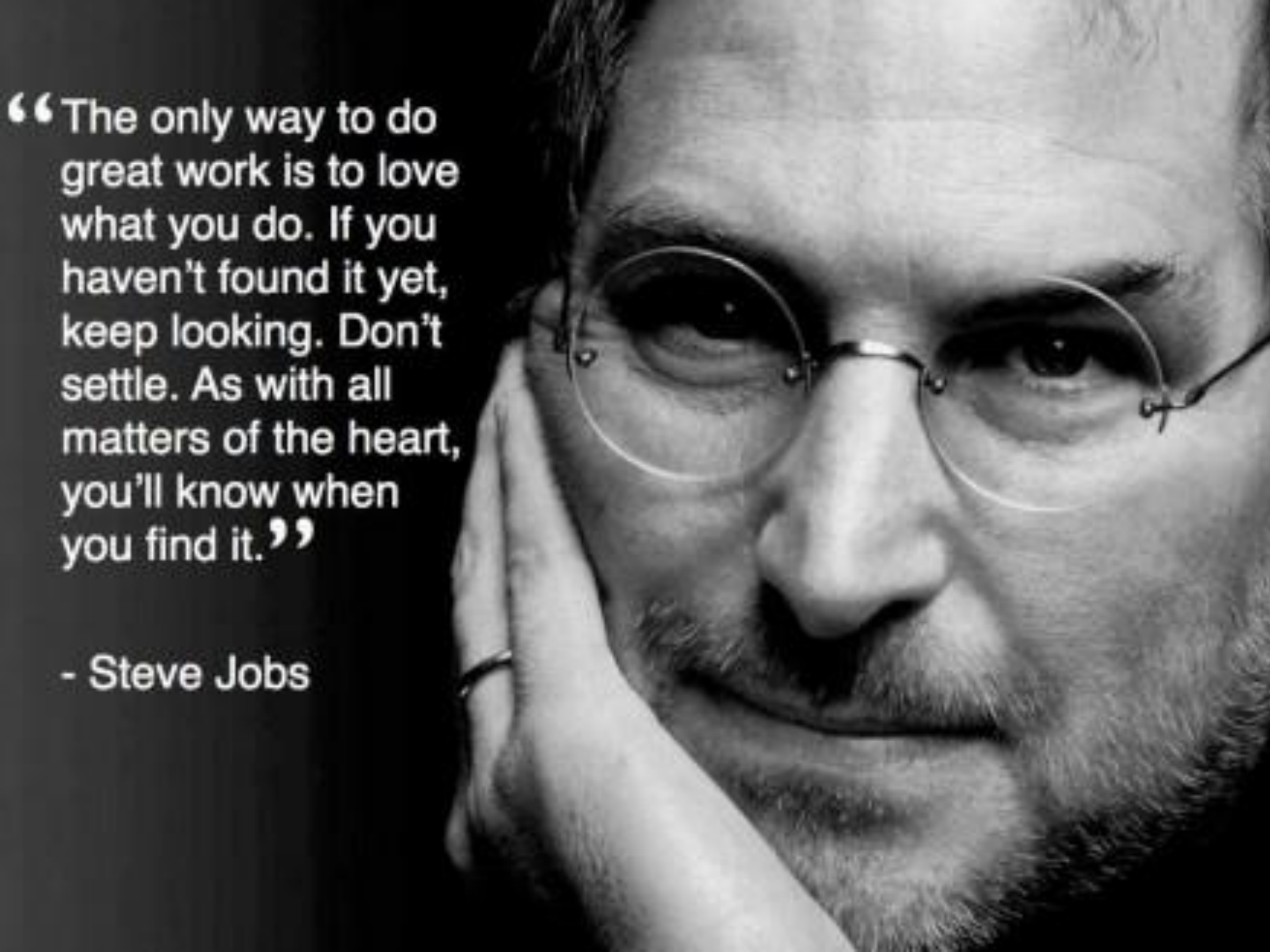
Spleen


Splenic artery
Splenic vein
Hilum
(a)
Arterioles and capillaries
Capsule
Trabecula
Splenic cord
Venous sinuses
Red pulp
White pulp
Central artery
Splenic artery
Splenic vein
(b)


White Pulp
Red Pulp


MARGINAL ZONES
TERMINAL CAPILLARIES
RED PULP: SPLENIC CORDS SEPARATED BY BLOOD SINUSES (pale)
CAPSULE
LYMPHATIC NODULES
WHITE PULP
LYMPHATIC NODULES plus PERIARTERIAL SHEATH
CENTRAL ARTERY
ARTERY VEIN
IN A TRABECULE


lymphocytes
central arteriole


“The only way to do great work is to love what you do. If you haven’t found it yet, keep looking. Don’t settle. As with all matters of the heart, you’ll know when you find it.”
- Steve Jobs