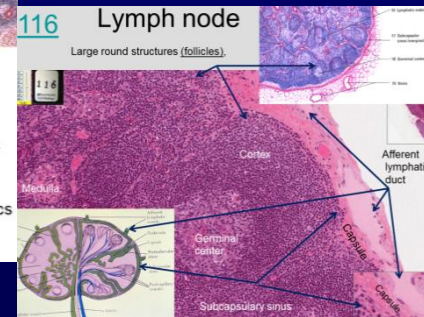
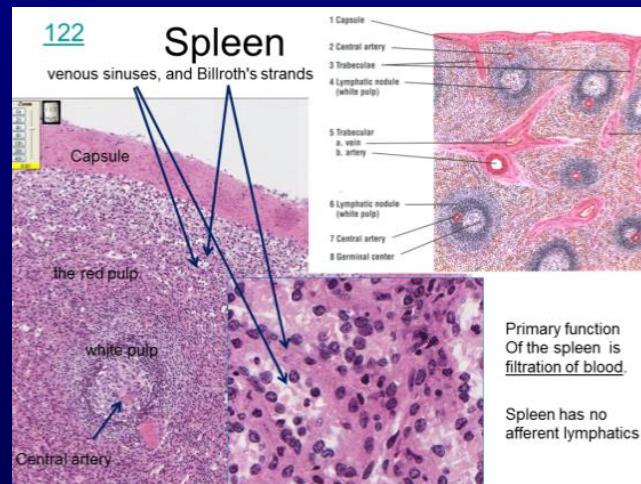
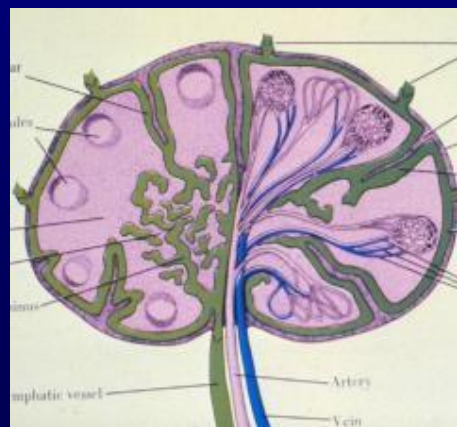
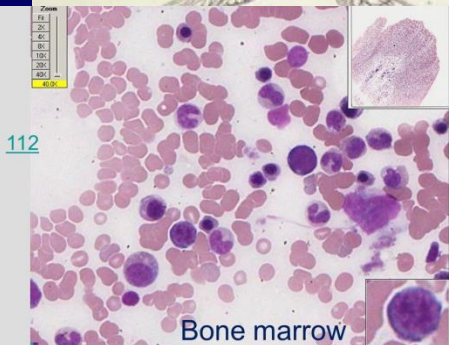
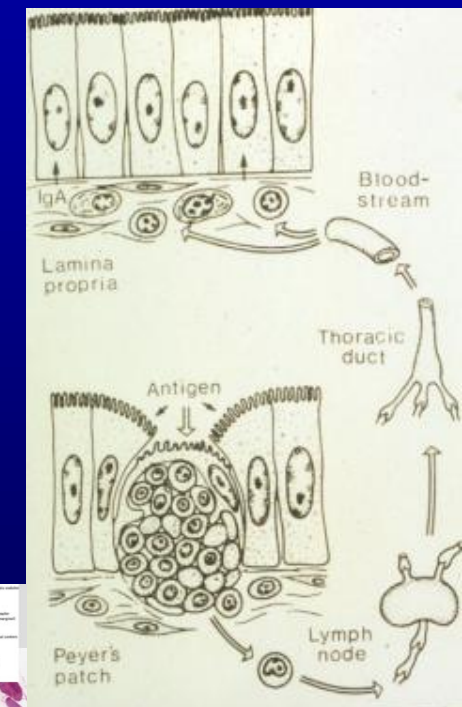
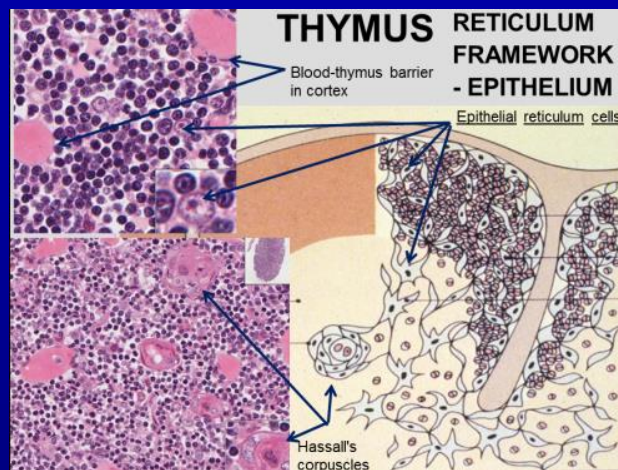
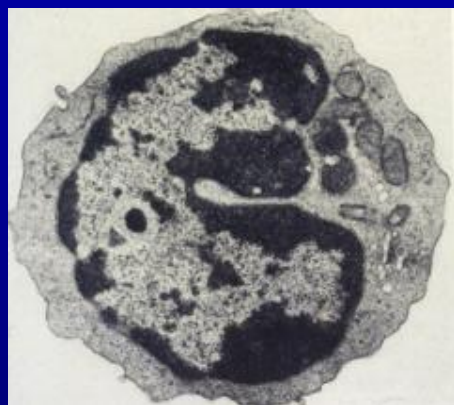
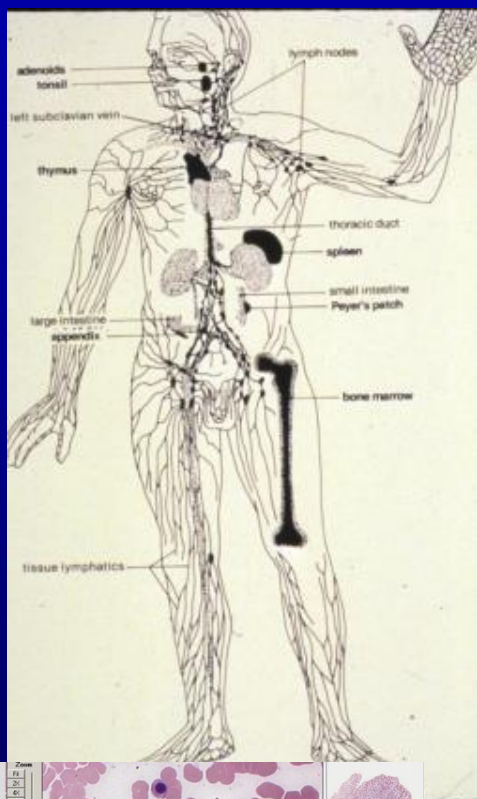


# Structure of Lymphoid System Components

Undergraduate – Graduate  
Histology Lecture Series

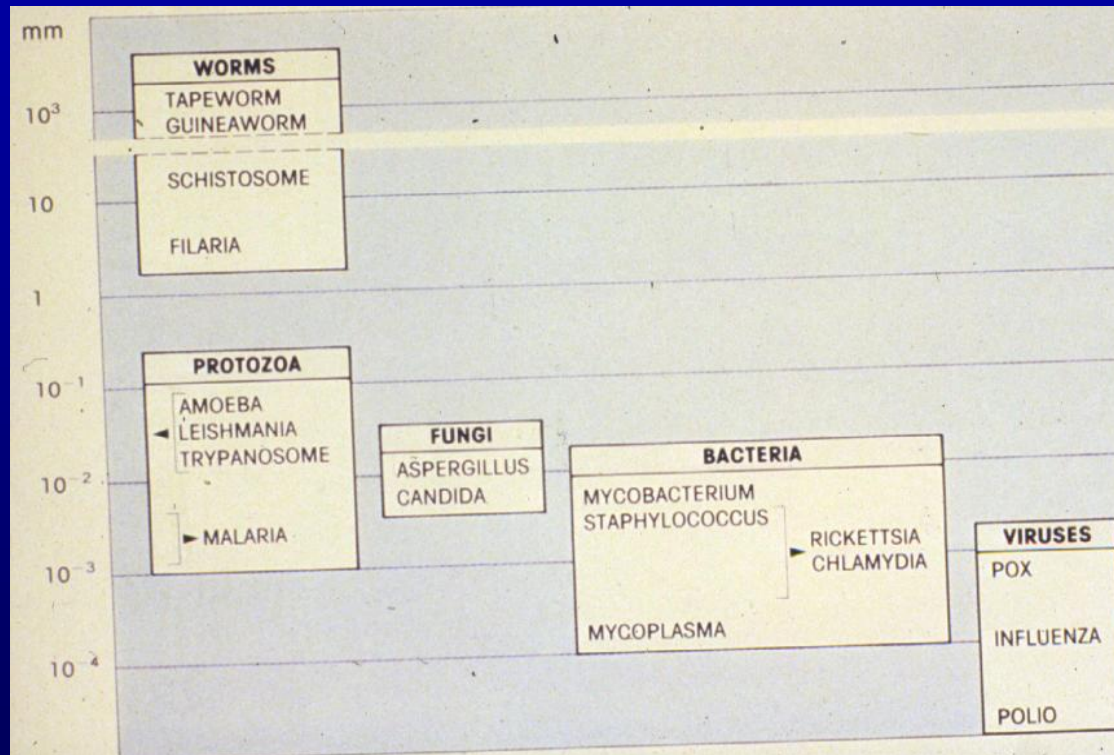
Larry Johnson, Professor  
Veterinary Integrative Biosciences  
Texas A&M University  
College Station, TX 77843



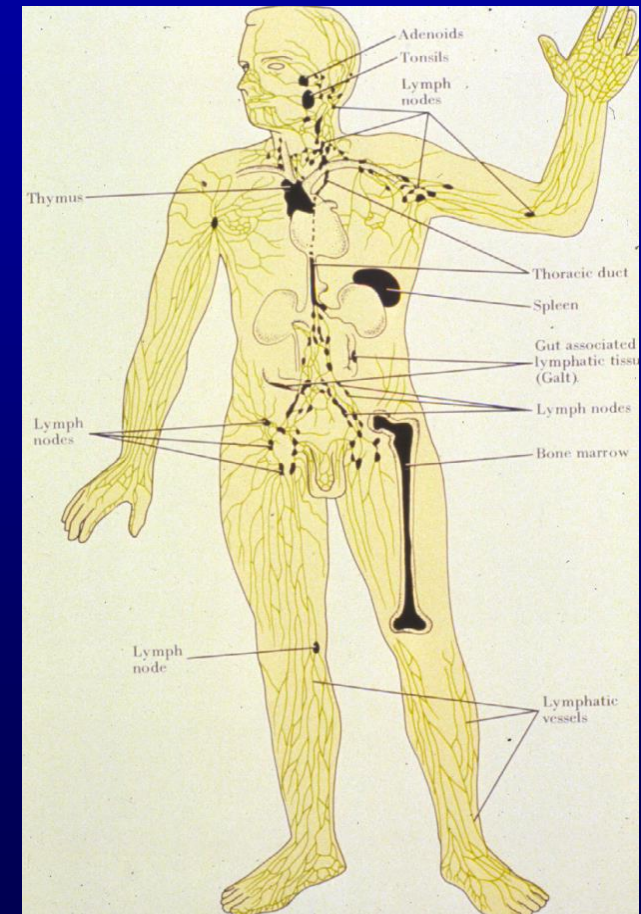


# FUNCTIONS OF THE IMMUNE SYSTEM

- PROTECTION AGAINST FOREIGN INVADERS INTO BODY

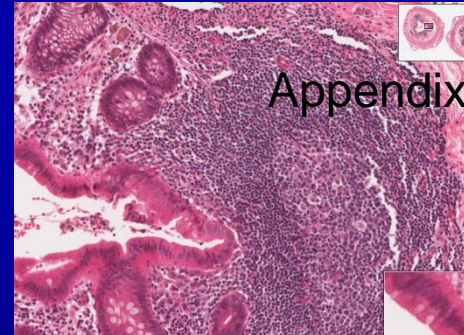


- PRODUCE / PROTECT GERM FREE ENVIRONMENT OF THE BODY



# EXAMPLES OF IMMUNE RESPONSE

- REACTION AGAINST MICROORGANISMS: BACTERIA, VIRUSES, PARASITES



- REACTION AGAINST TUMOR CELLS

- ALLERGIC REACTIONS: HAY FEVER, POISON IVY

- AUTOIMMUNE REACTION: ARTHRITIS, TYPE I DIABETES

- GRAFT REJECTION



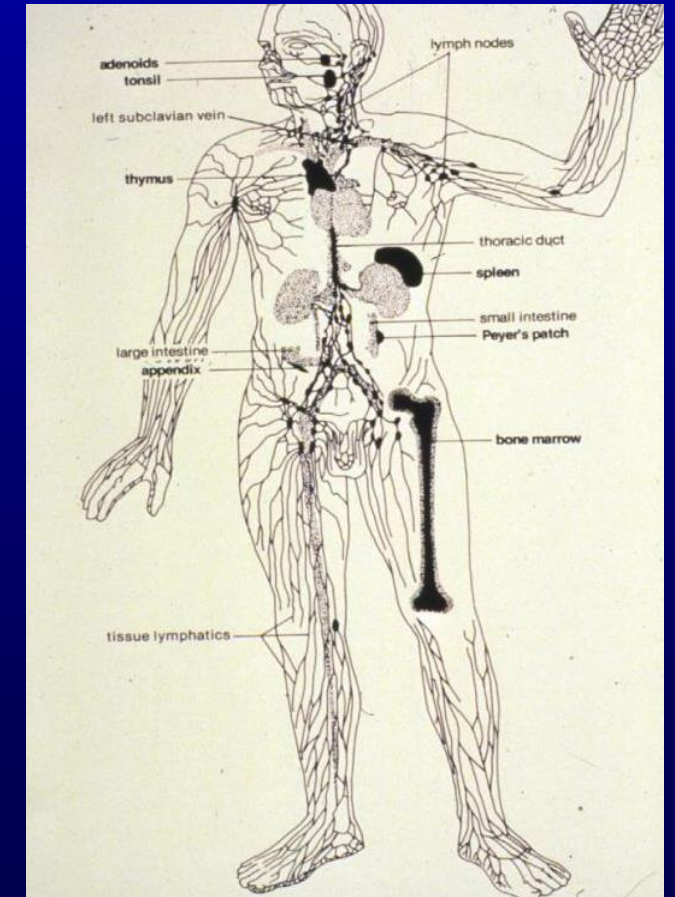
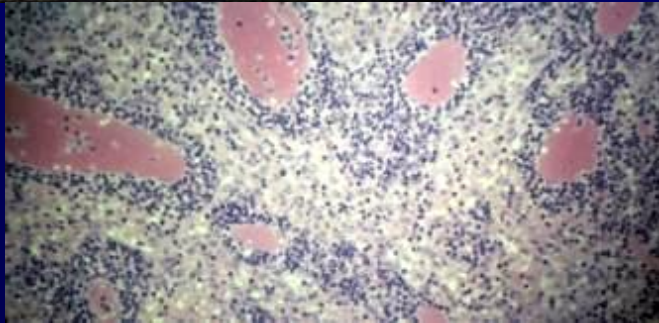
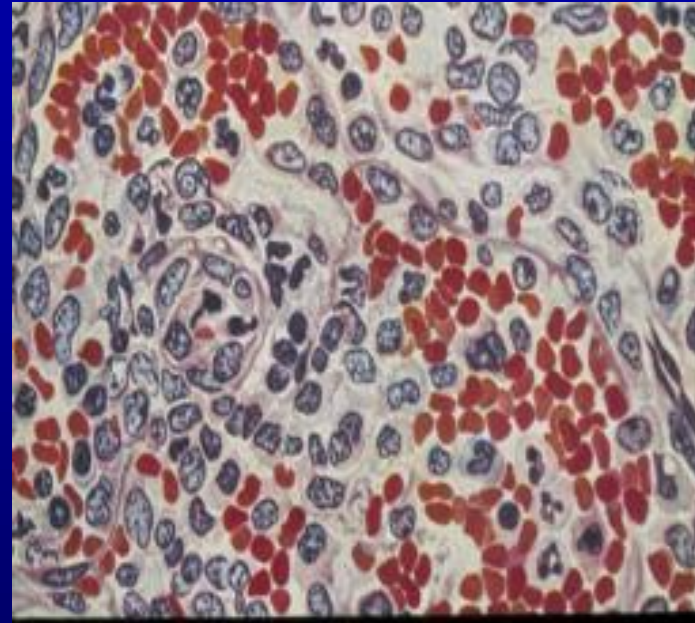


# Objective

Learn the role in immunity of

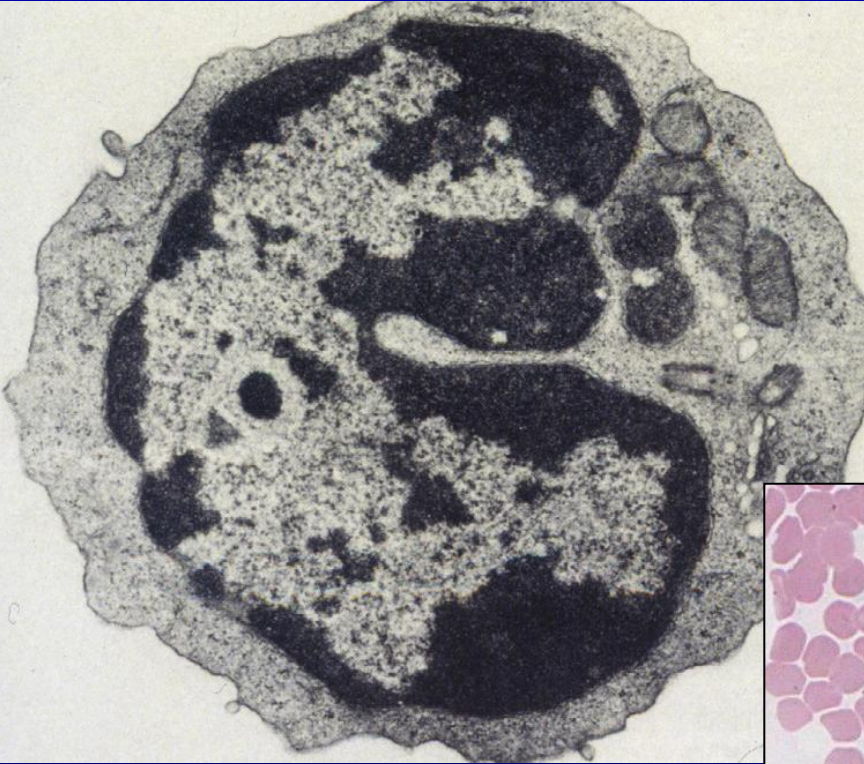
Primary organs

Secondary organs

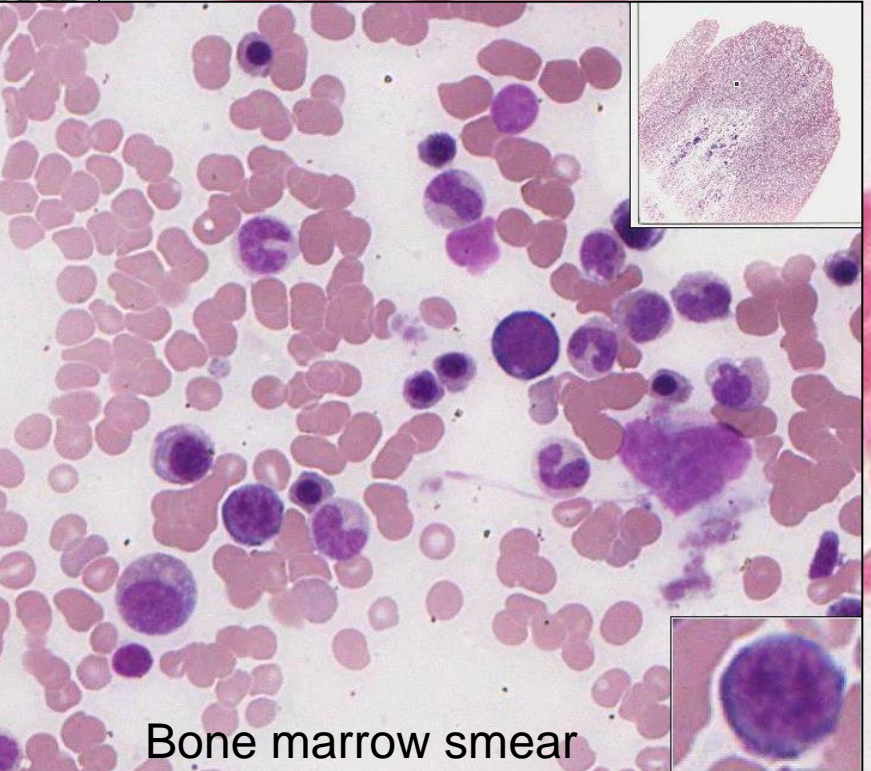




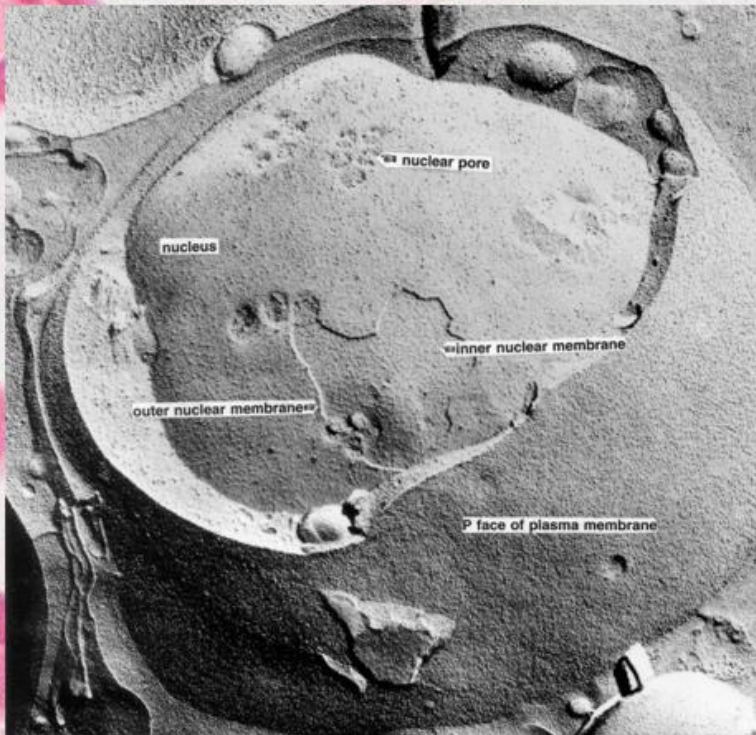
# Main Player, The Lymphocyte



Lymphocyte is a main player of immune response



Bone marrow smear



In different settings



# Life Cycle of Lymphocytes

## Fetal organs

Bone marrow

## Primary lymphoid organs

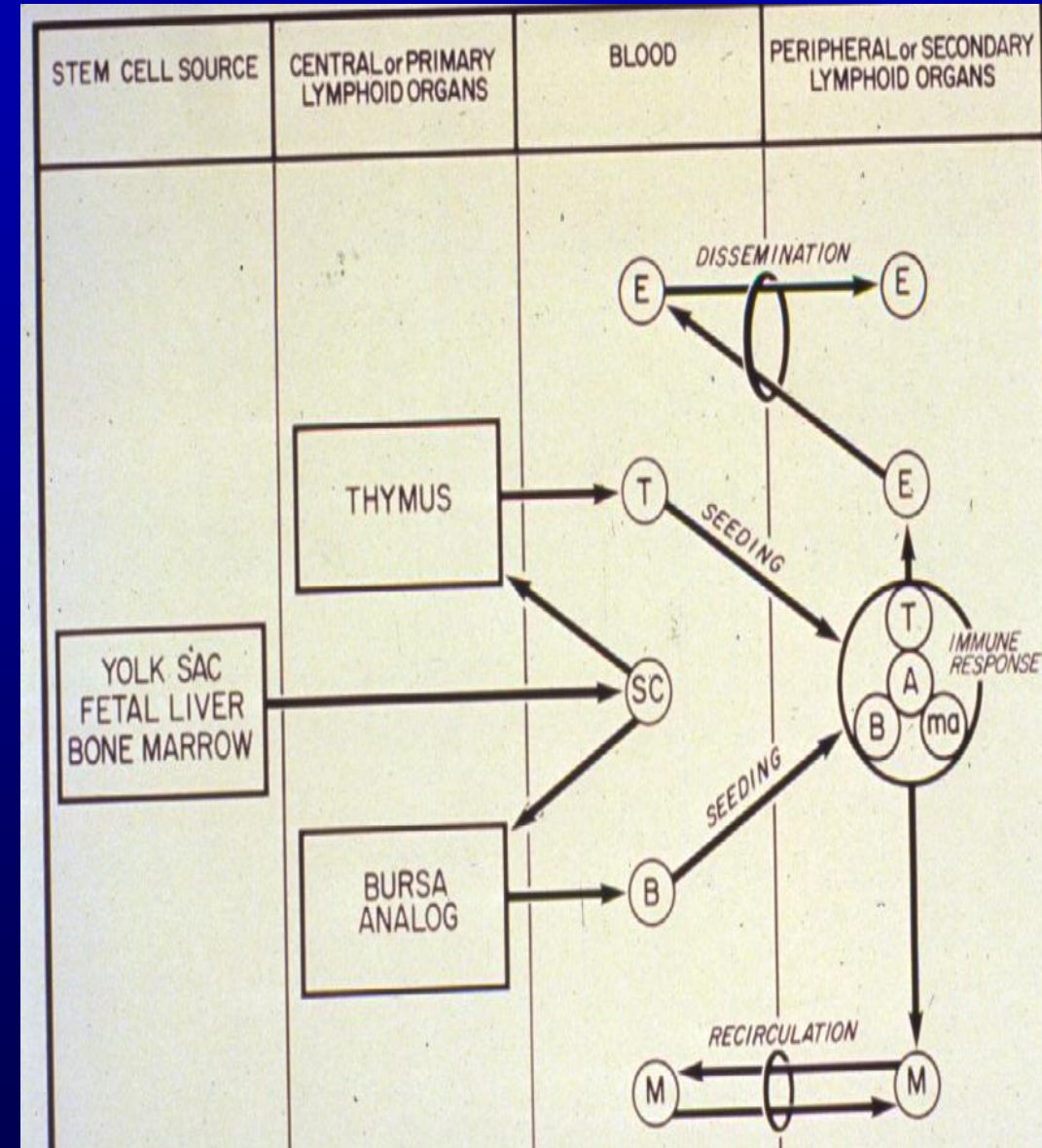
(**Antigen independent** development)

- Thymus – T lymphocytes
- Bone marrow - B lymphocytes

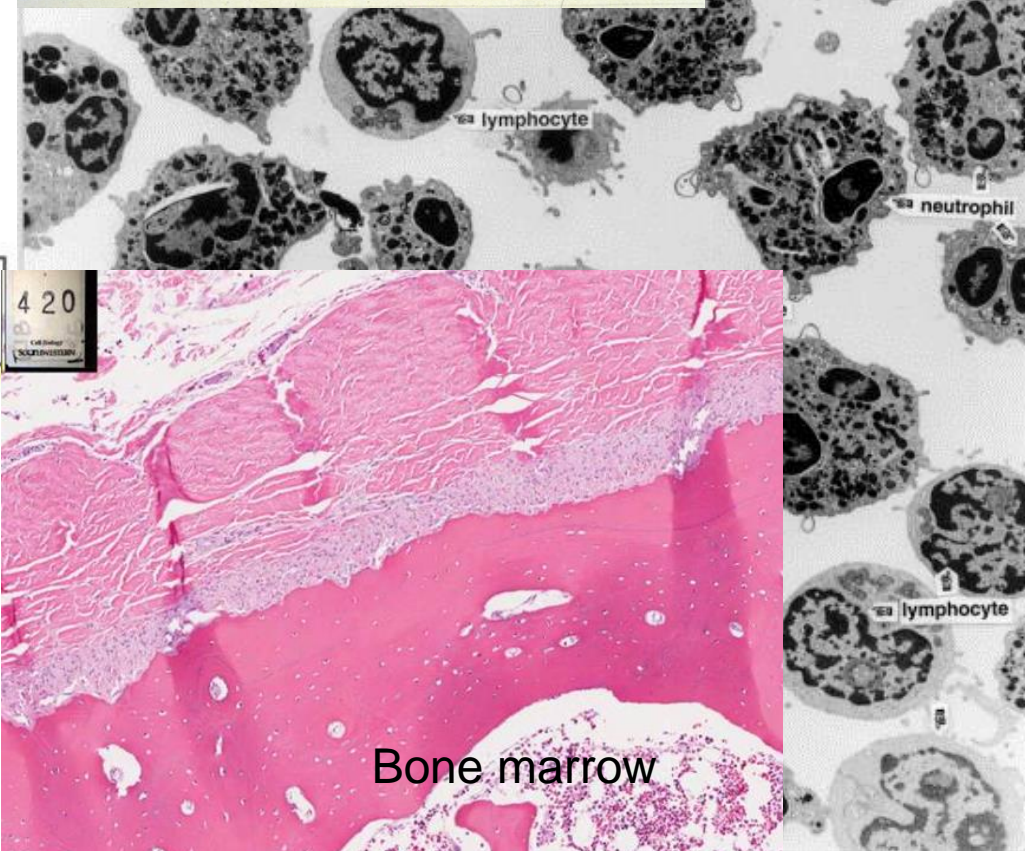
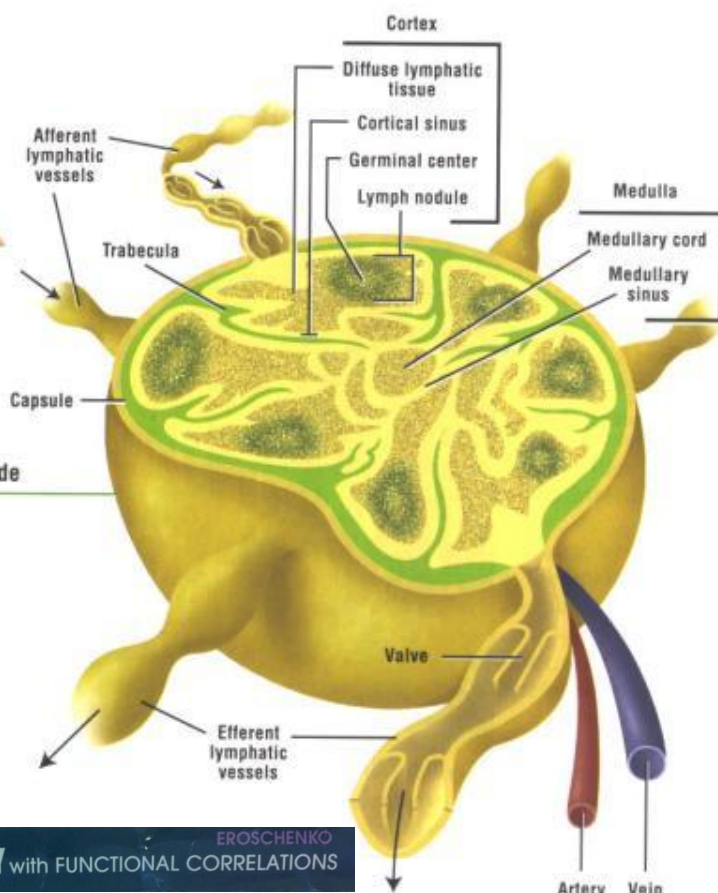
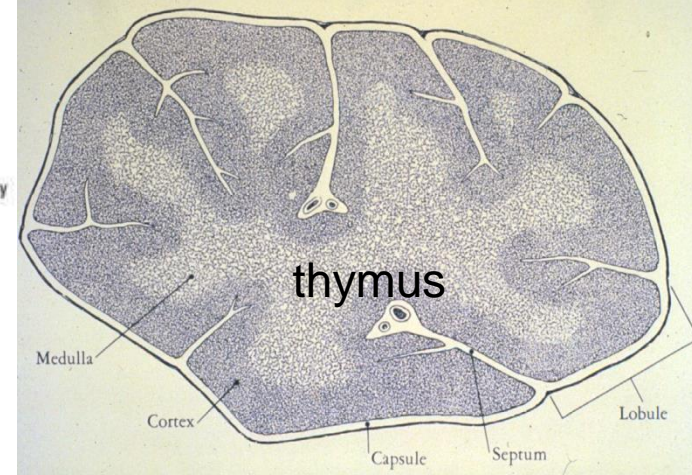
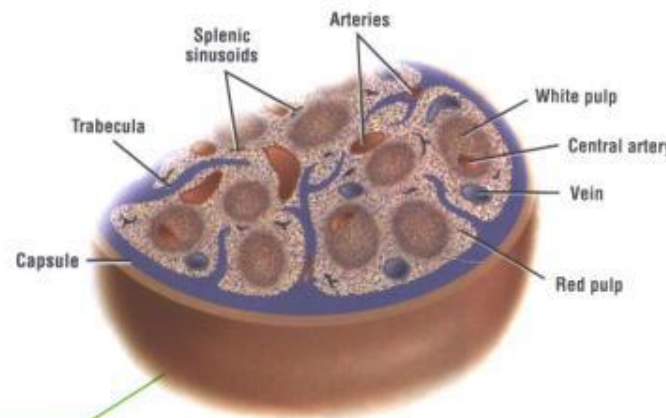
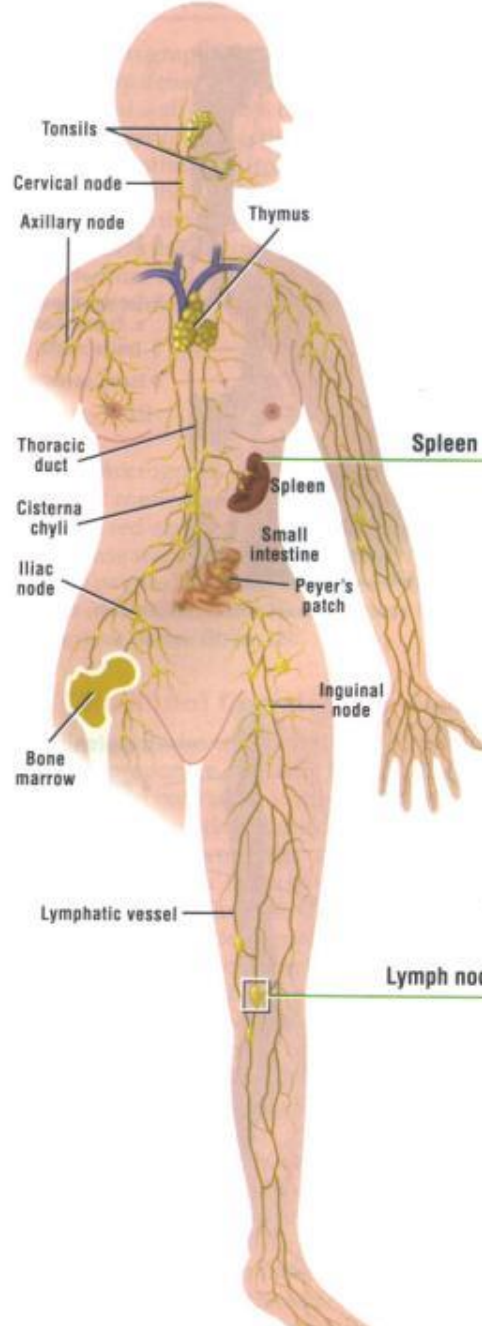
## Secondary lymphoid organs

(**Antigen dependent** development)

- Lymph nodes
- Lymphoid nodules
- Spleen





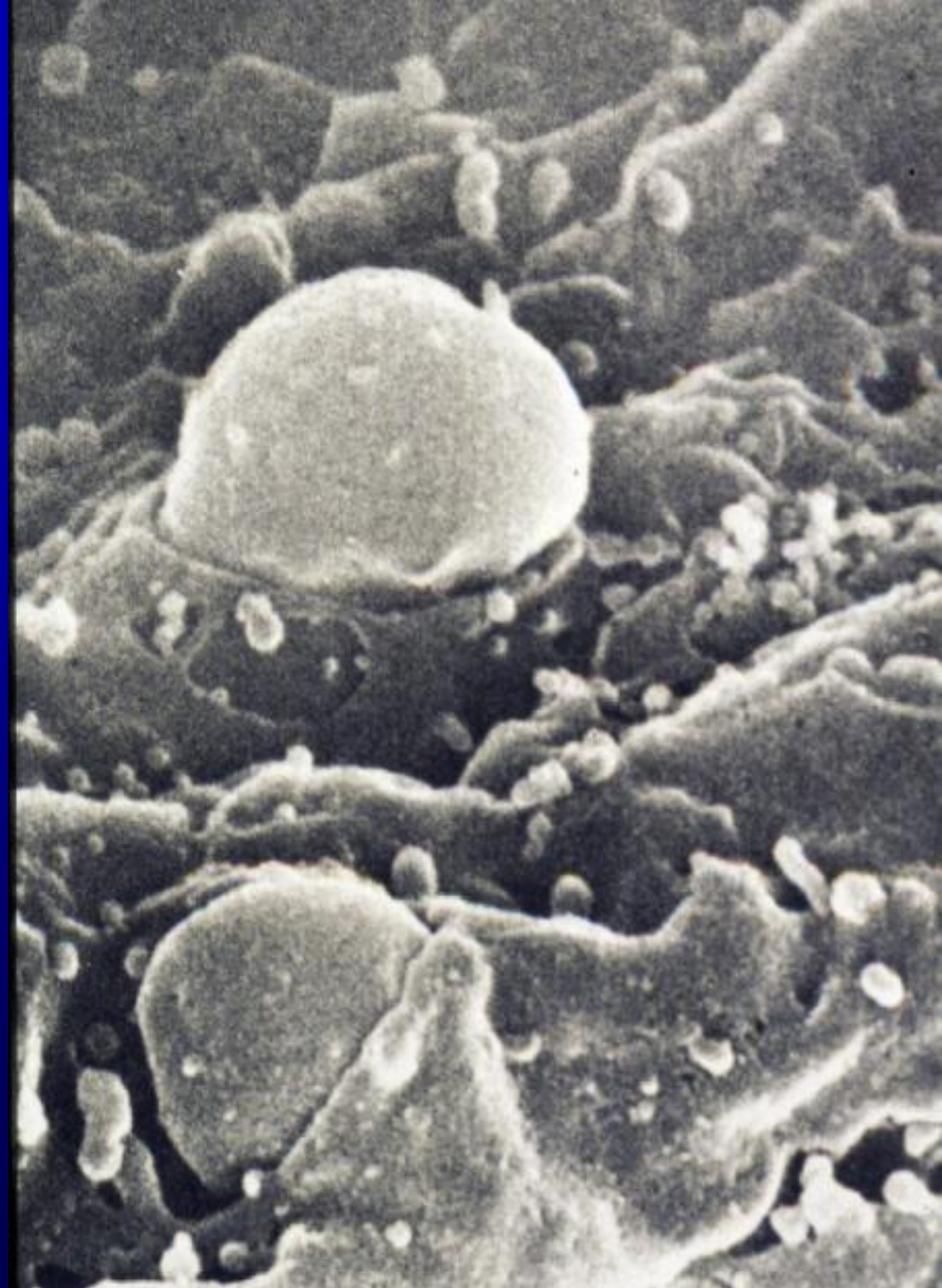




# Life Cycle of Lymphocytes

Bone marrow

Seeding primary organs





# Thymus

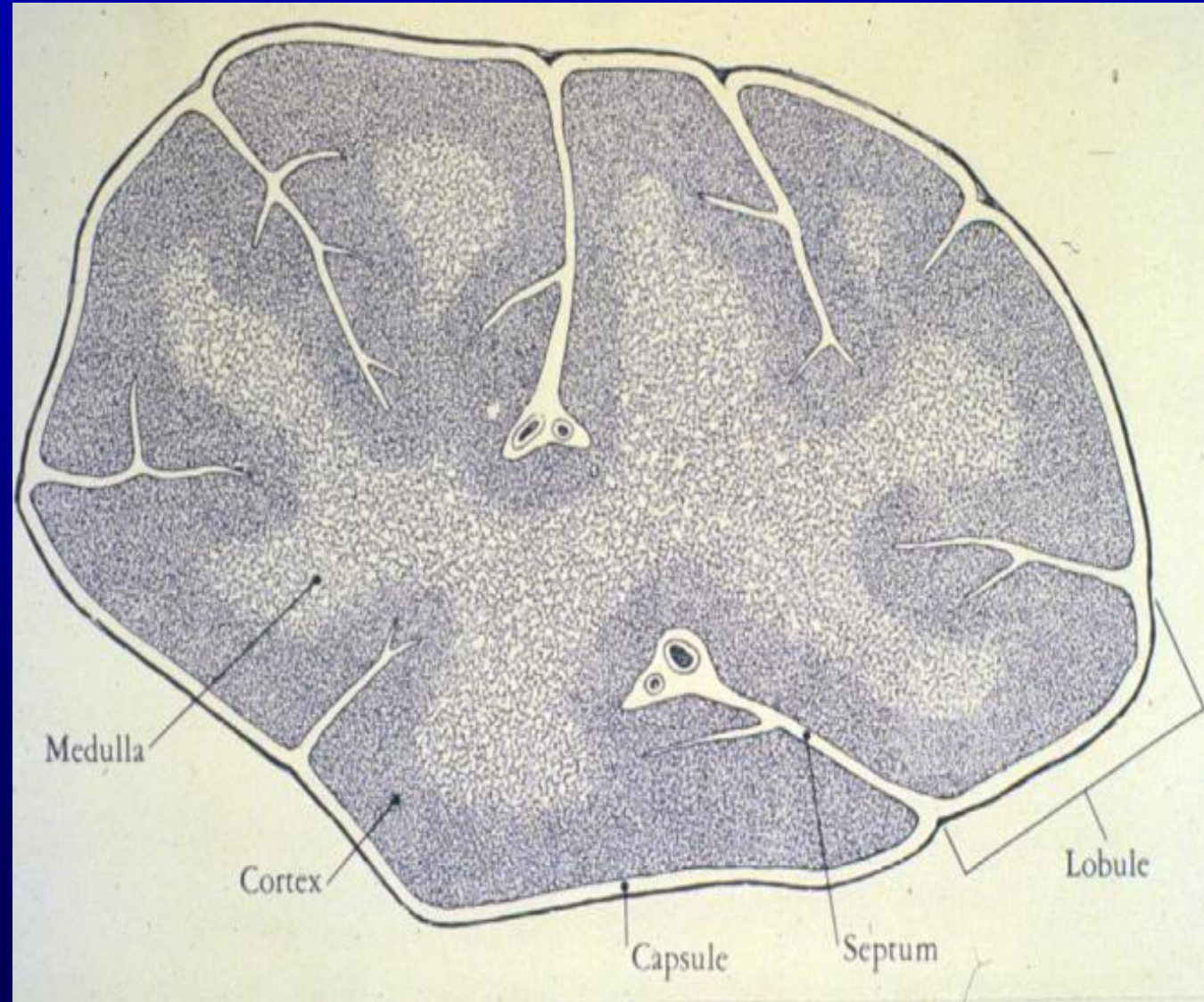
Growth pattern – regress after childhood

Reticulum framework –  
**epithelium**  
(from **endoderm**)

Cortex - absence of exogenous antigens

- Epithelial microenvironment
- Lymphopoiesis
- Blood-thymus barrier

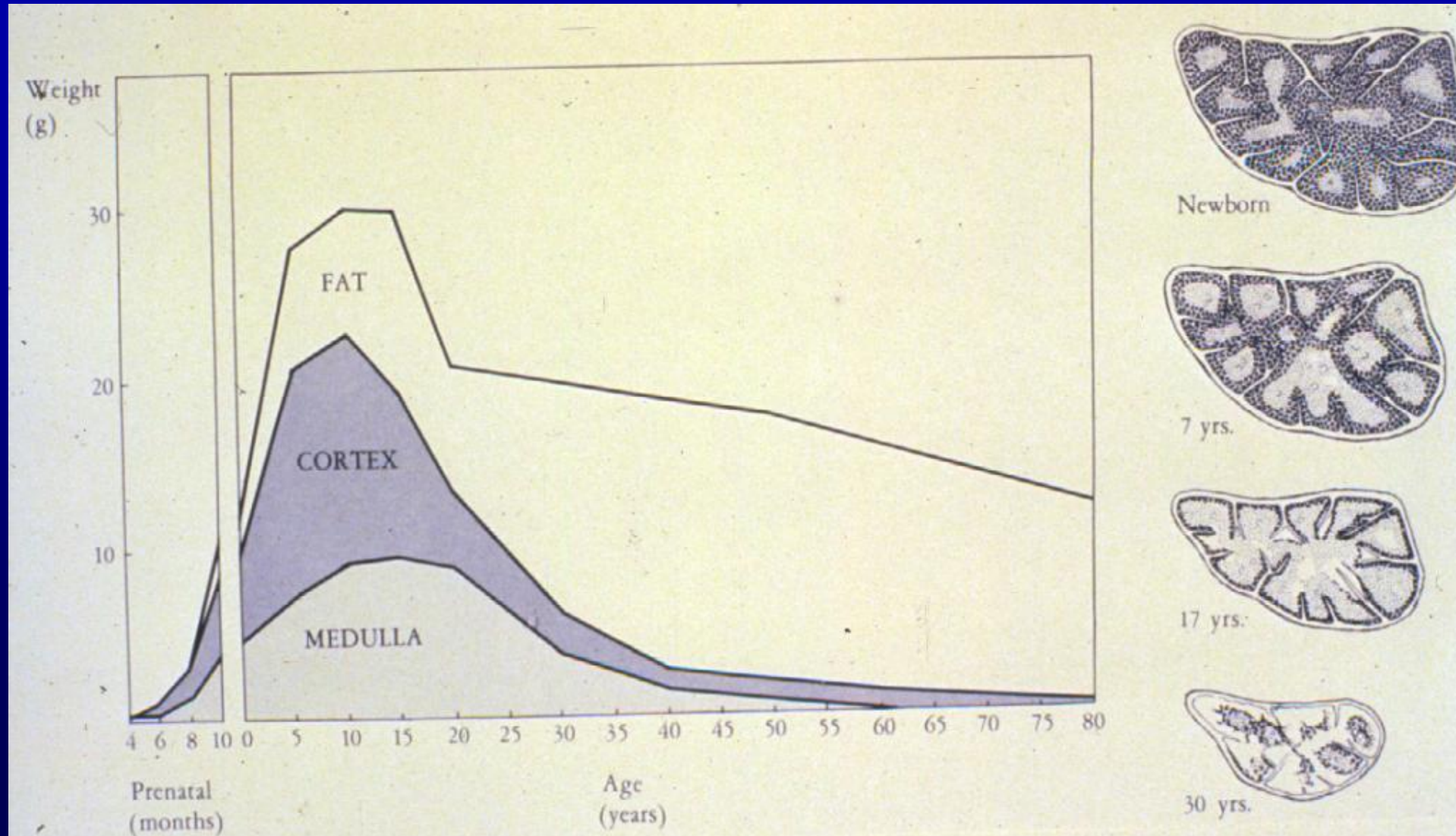
Medulla





# Thymus

Growth pattern - regress after childhood

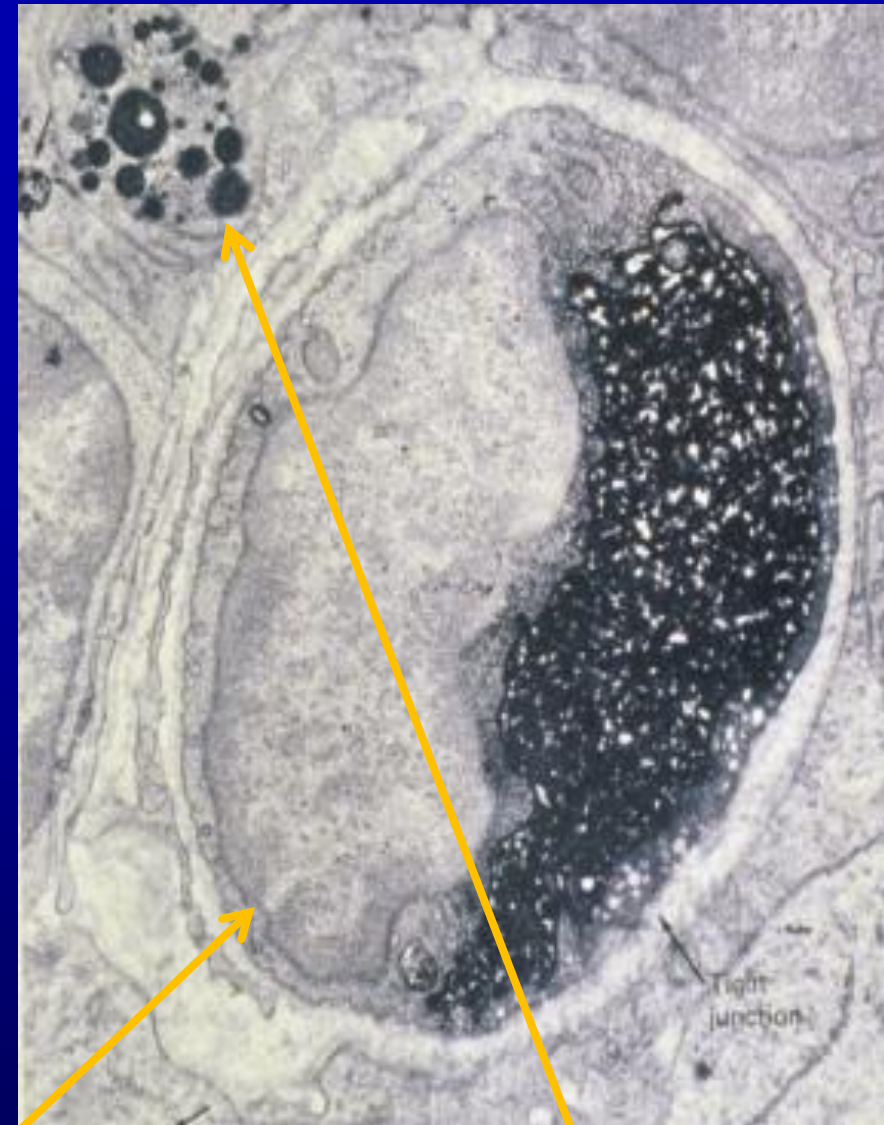
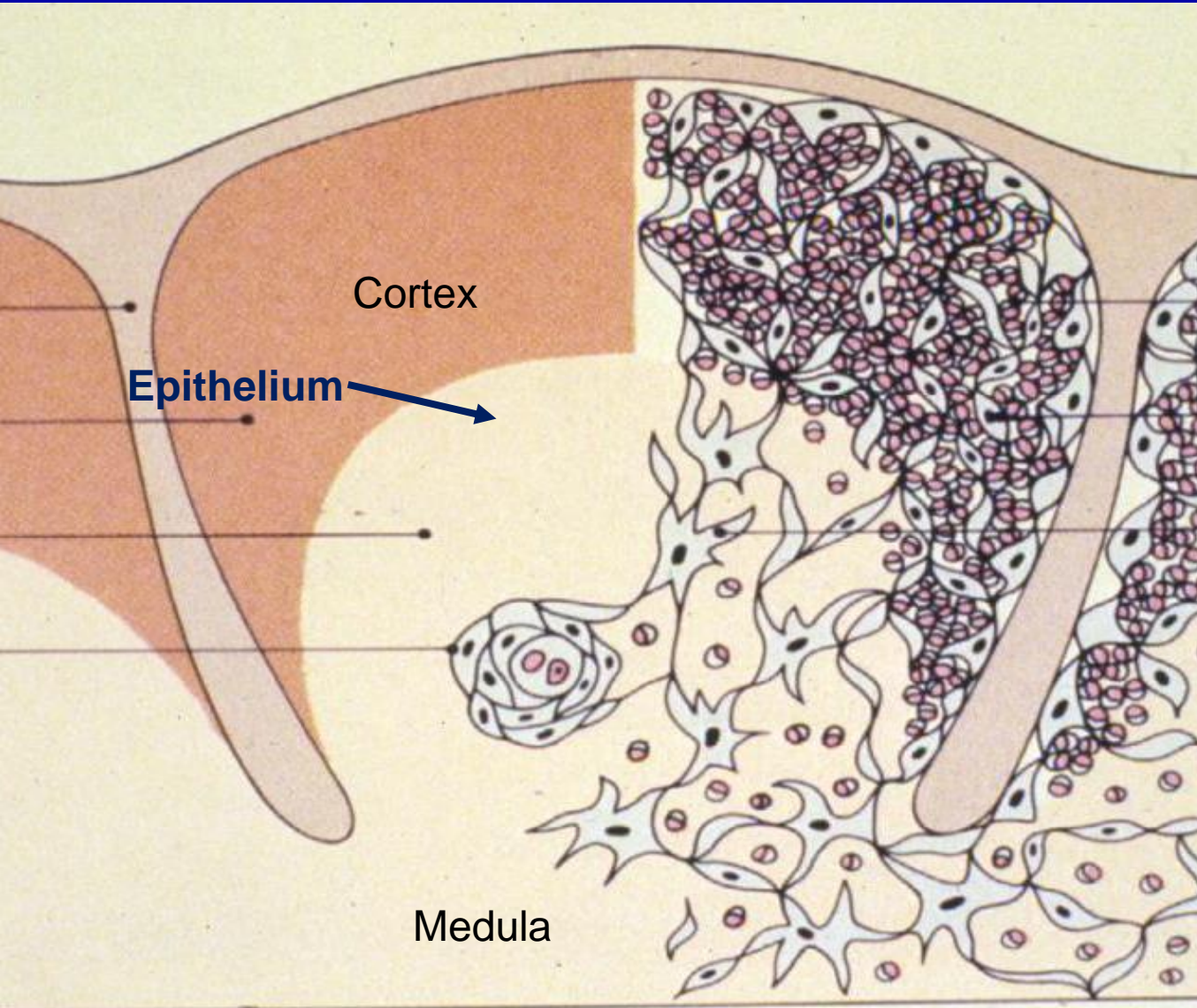




# Thymus

Blood-thymus barrier  
(cortical barrier only)

Reticulum framework - epithelium

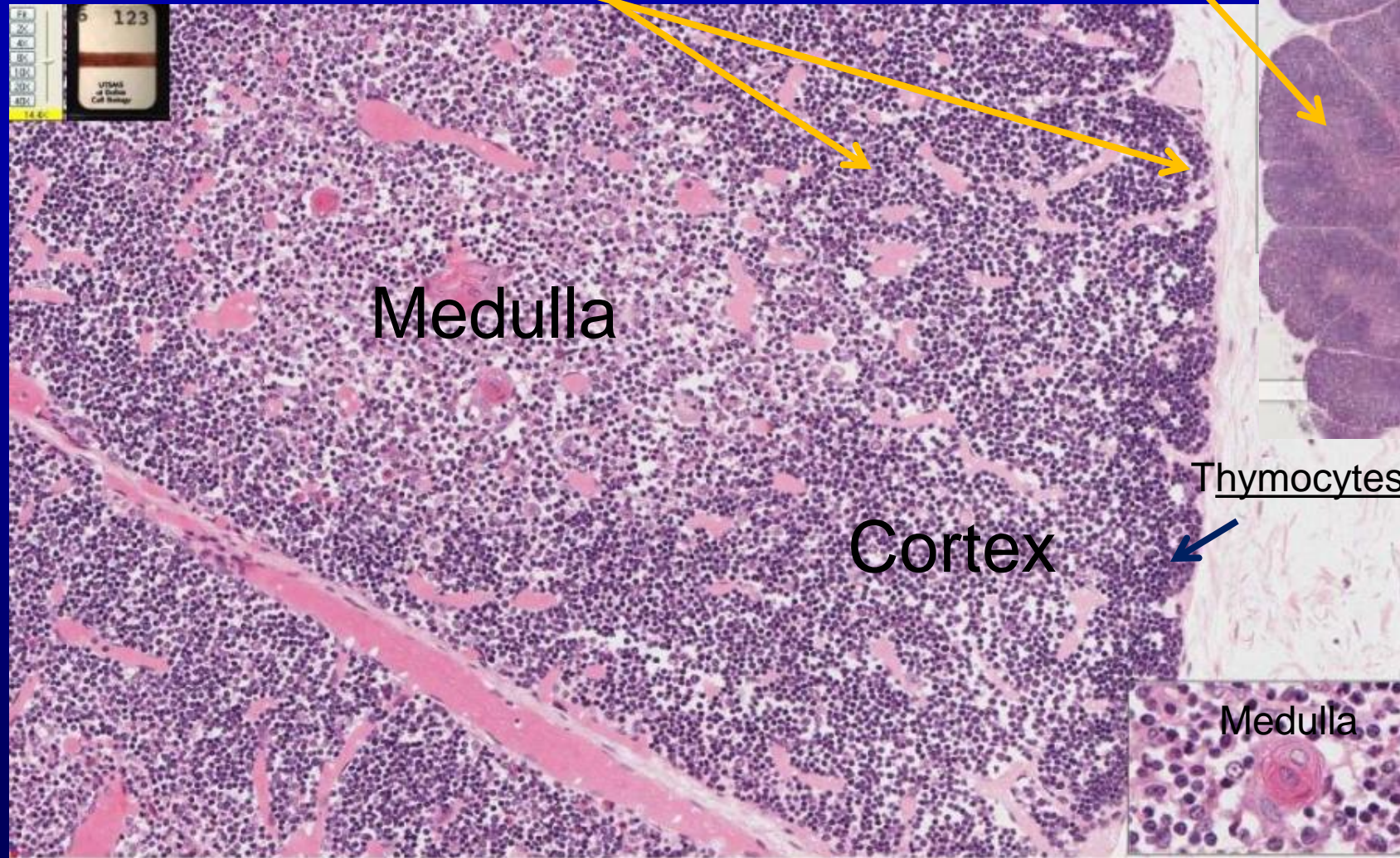


Continuous capillaries, sheathed  
by epithelial reticular cells



# 123 Thymus, newborn

Outer darkly staining areas (cortex) and lighter central areas (medulla).



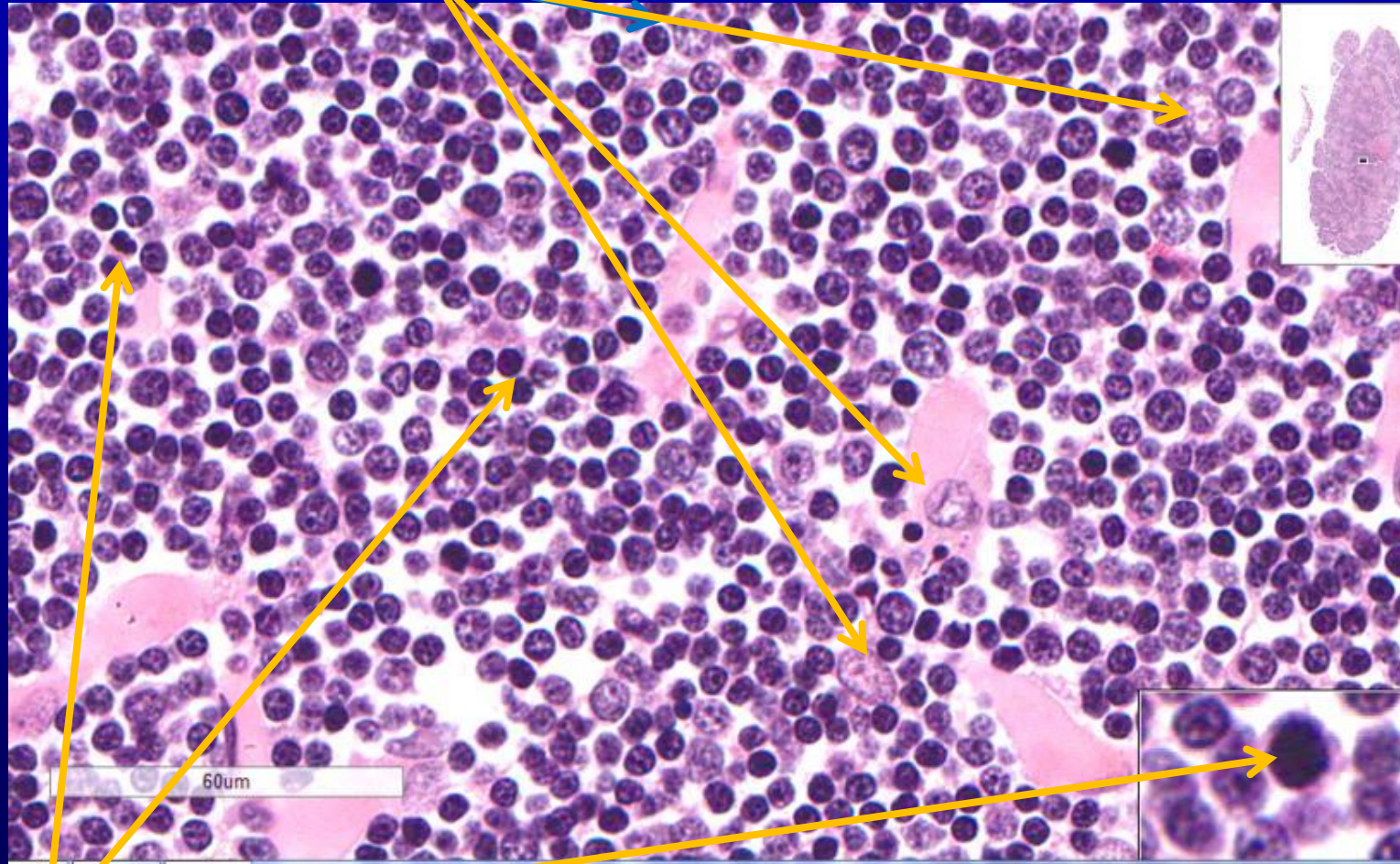
Continuous capillaries, sheathed by epithelial reticular cells around each, characterizes blood vessels in the thymus cortex and are responsible for the blood thymus barrier. Also there are no afferent lymphatics in the thymus.



# 123 Thymus, newborn

Epithelial reticulum cells

Cortex



Mitotic figures frequently, which reflect the high proliferative rate of these cells.



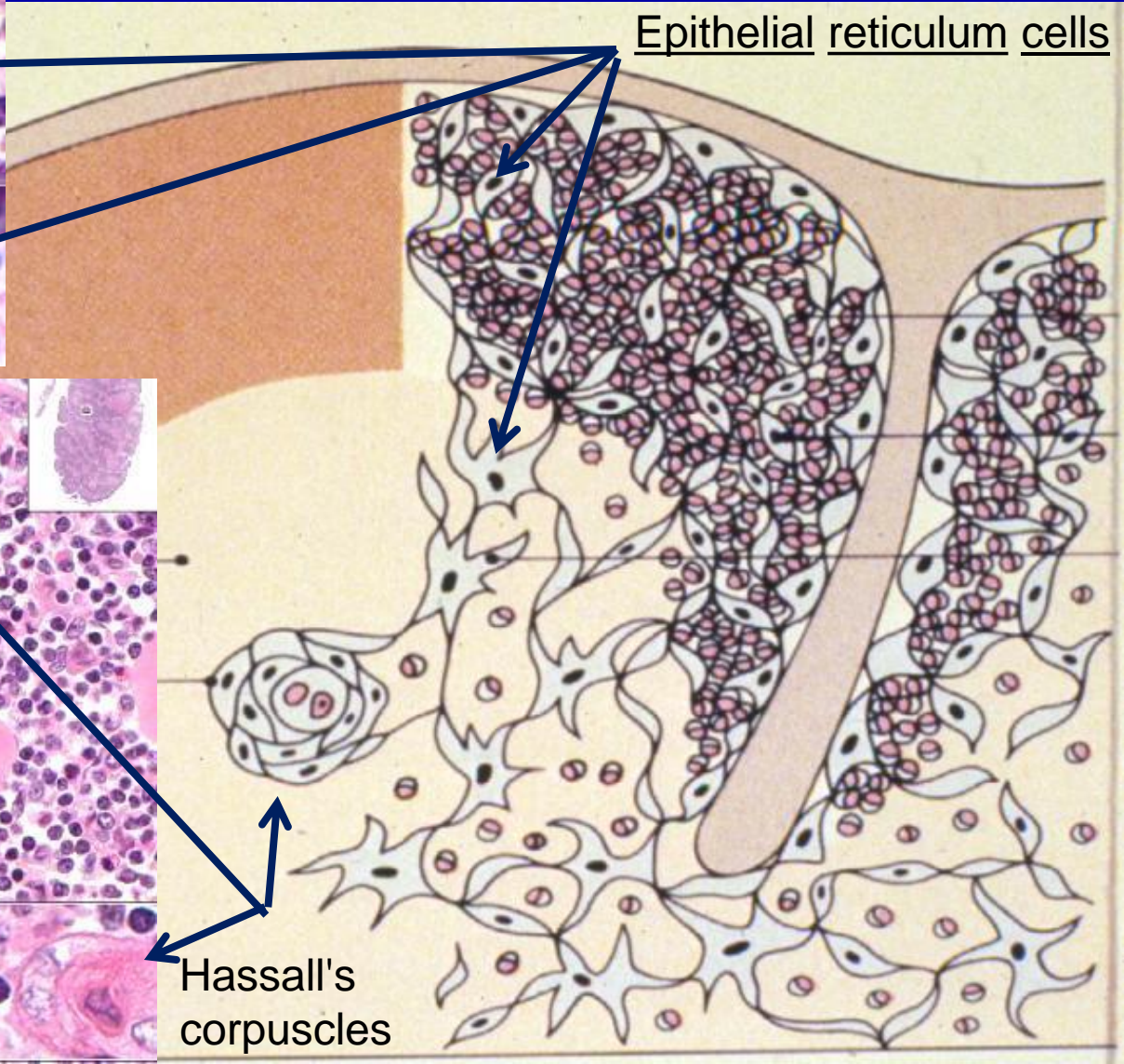
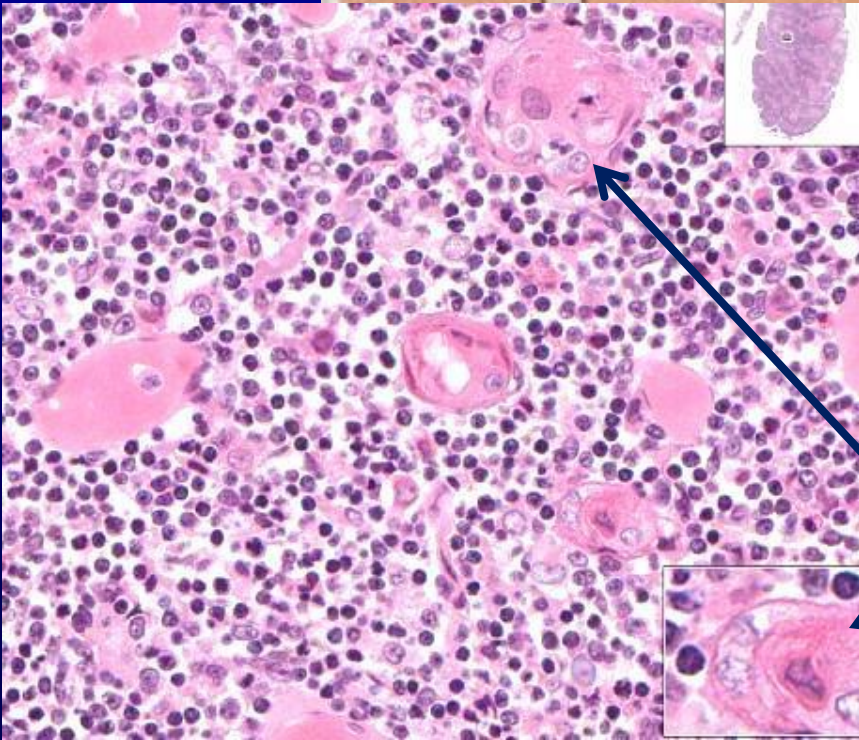
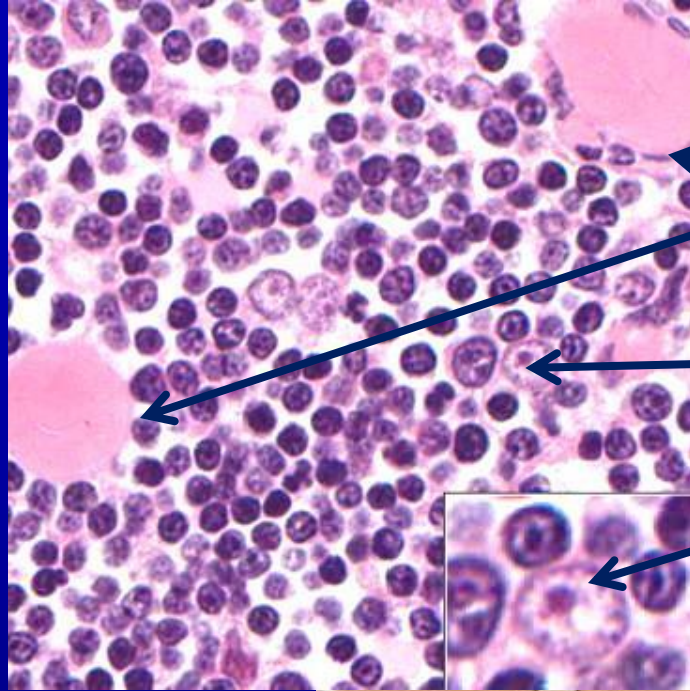
# THYMUS

## RETICULUM FRAMEWORK - EPITHELIUM

Blood-thymus barrier  
in cortex

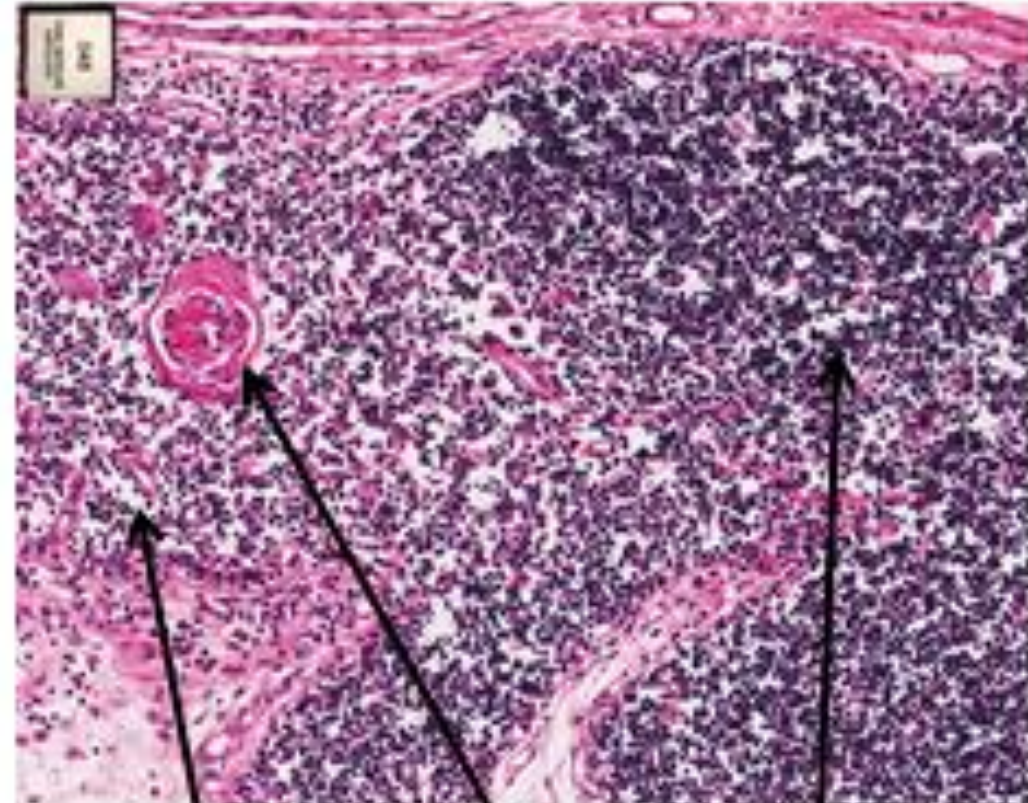
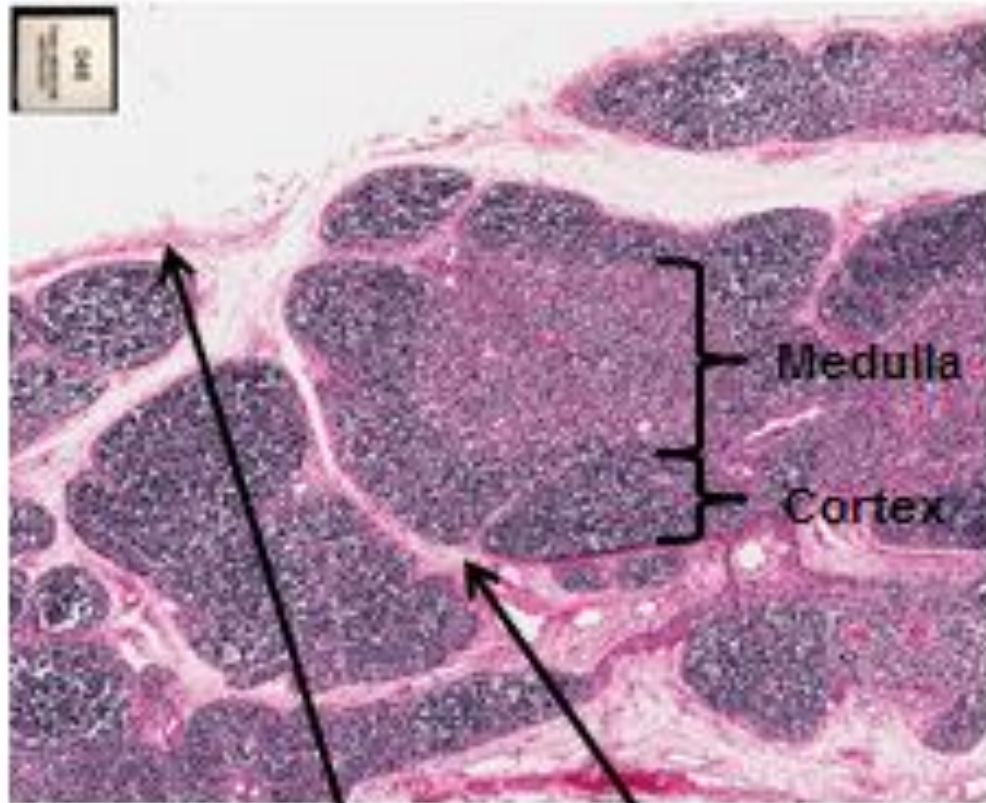
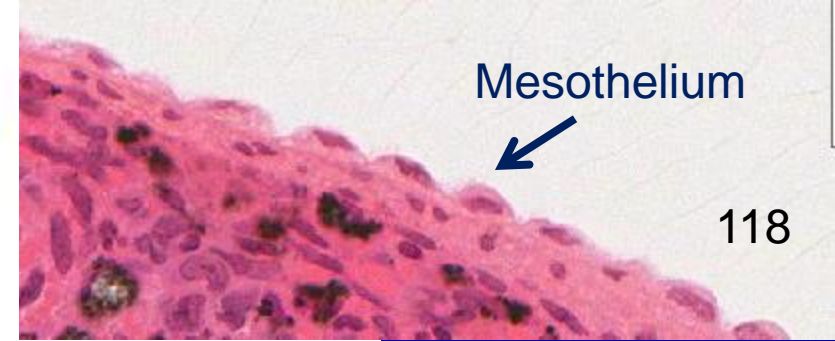
Epithelial reticulum cells

Hassall's  
corpuscles





# Slide 48: Thymus (1 yr old child)



Splenic capsule =  
Dense  
irregular  
connective  
tissue  
covered with  
mesothelium



# Lymph Nodes – Filtration of Lymph

## Basic structure

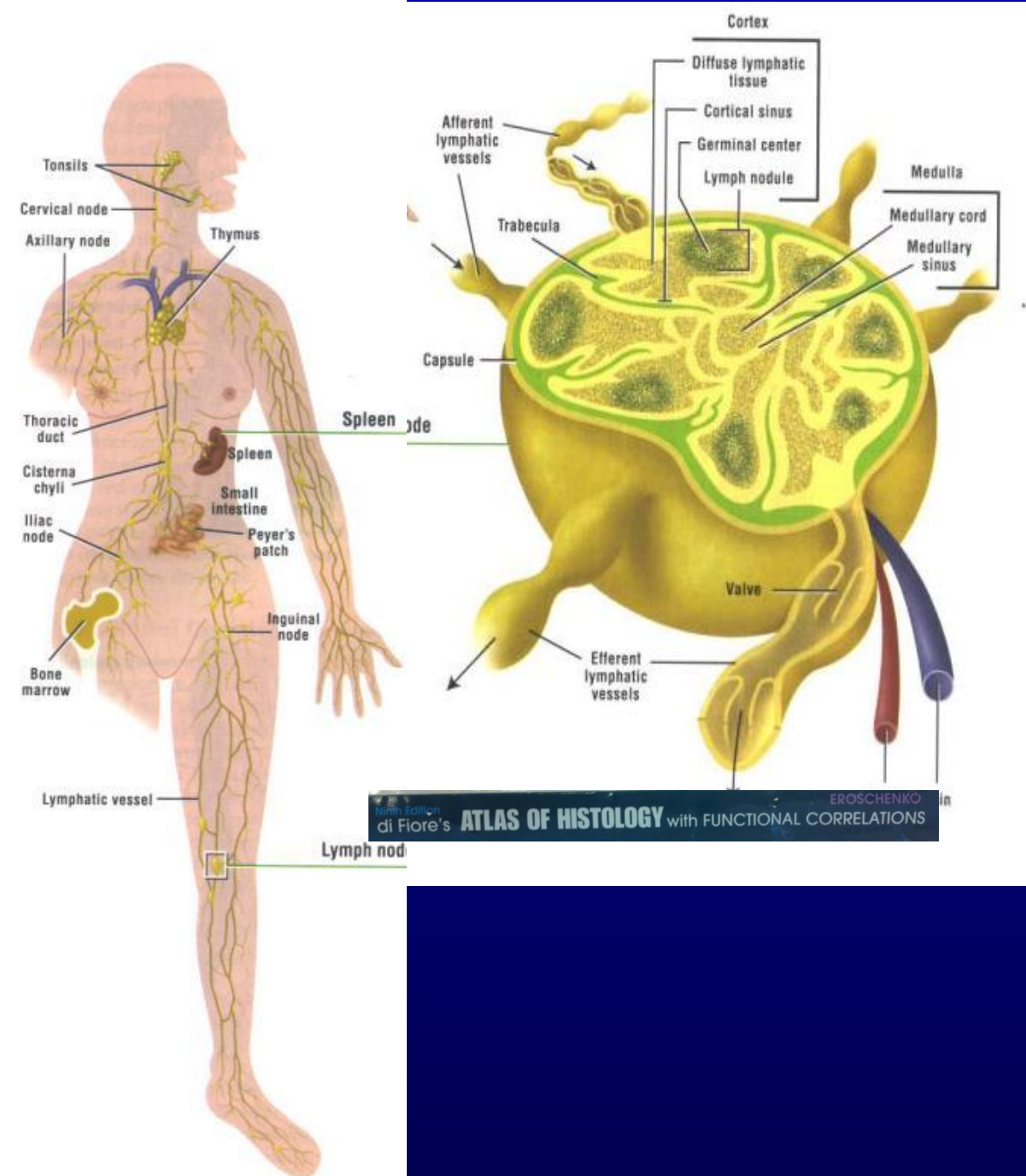
- Lymphatic vessels
- Vasculature
- Reticular framework (**mesoderm**)

## Cortex

- Follicles - B lymphocytes
- Perifollicular - T lymphocytes

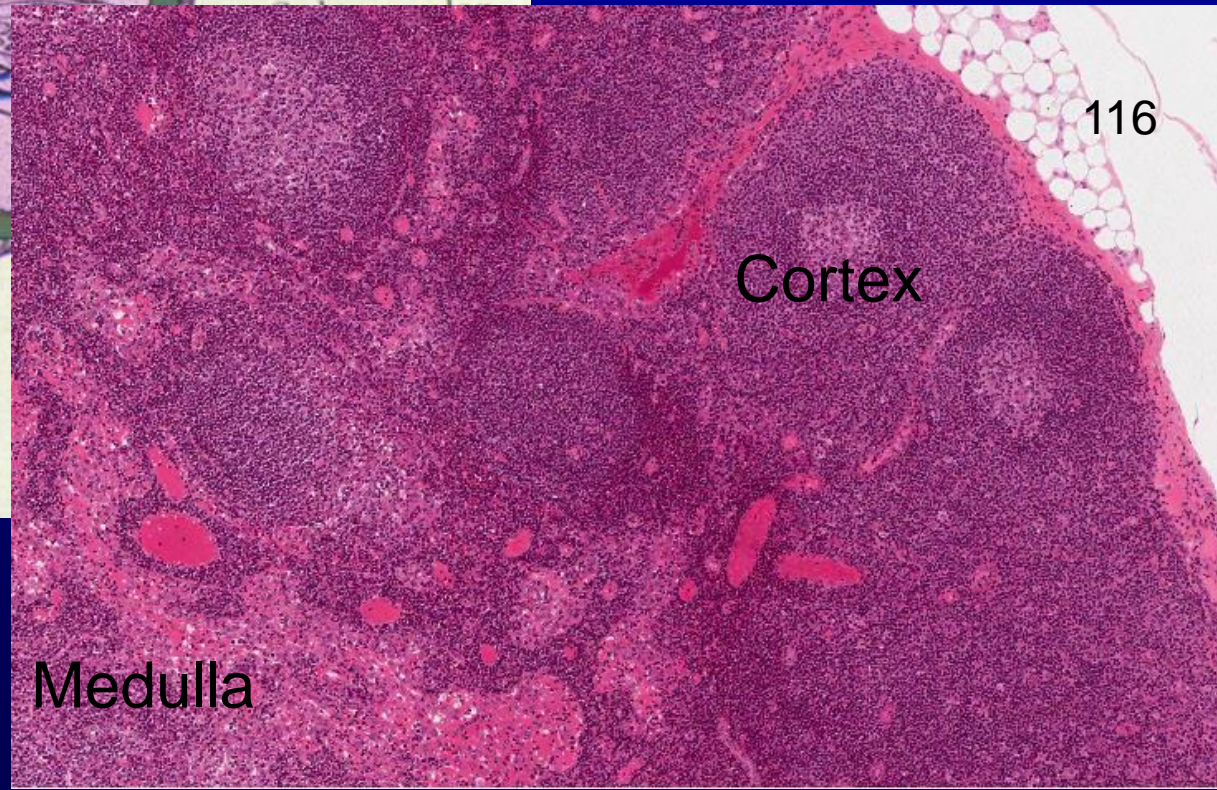
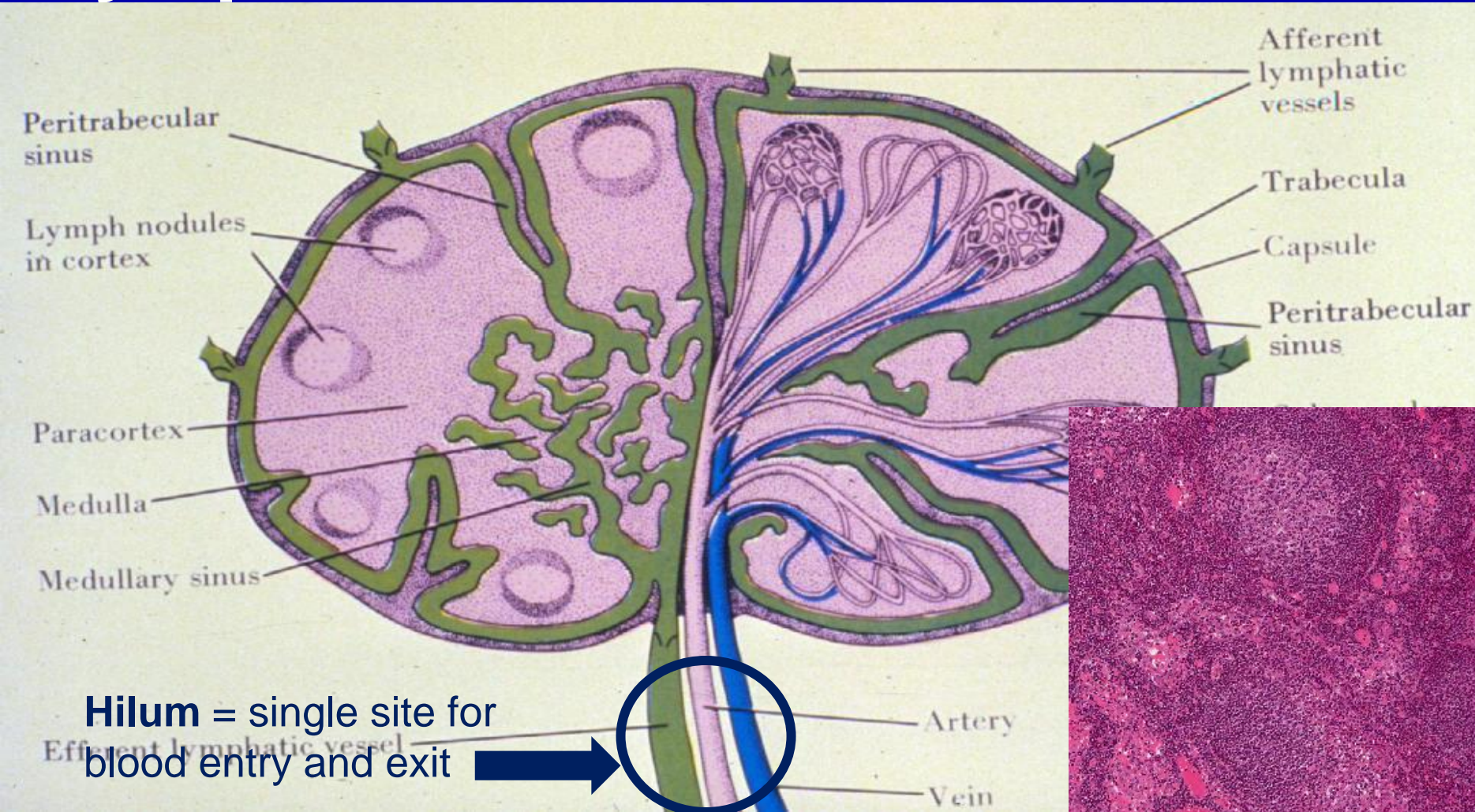
## Medulla

- Cords
- Sinuses



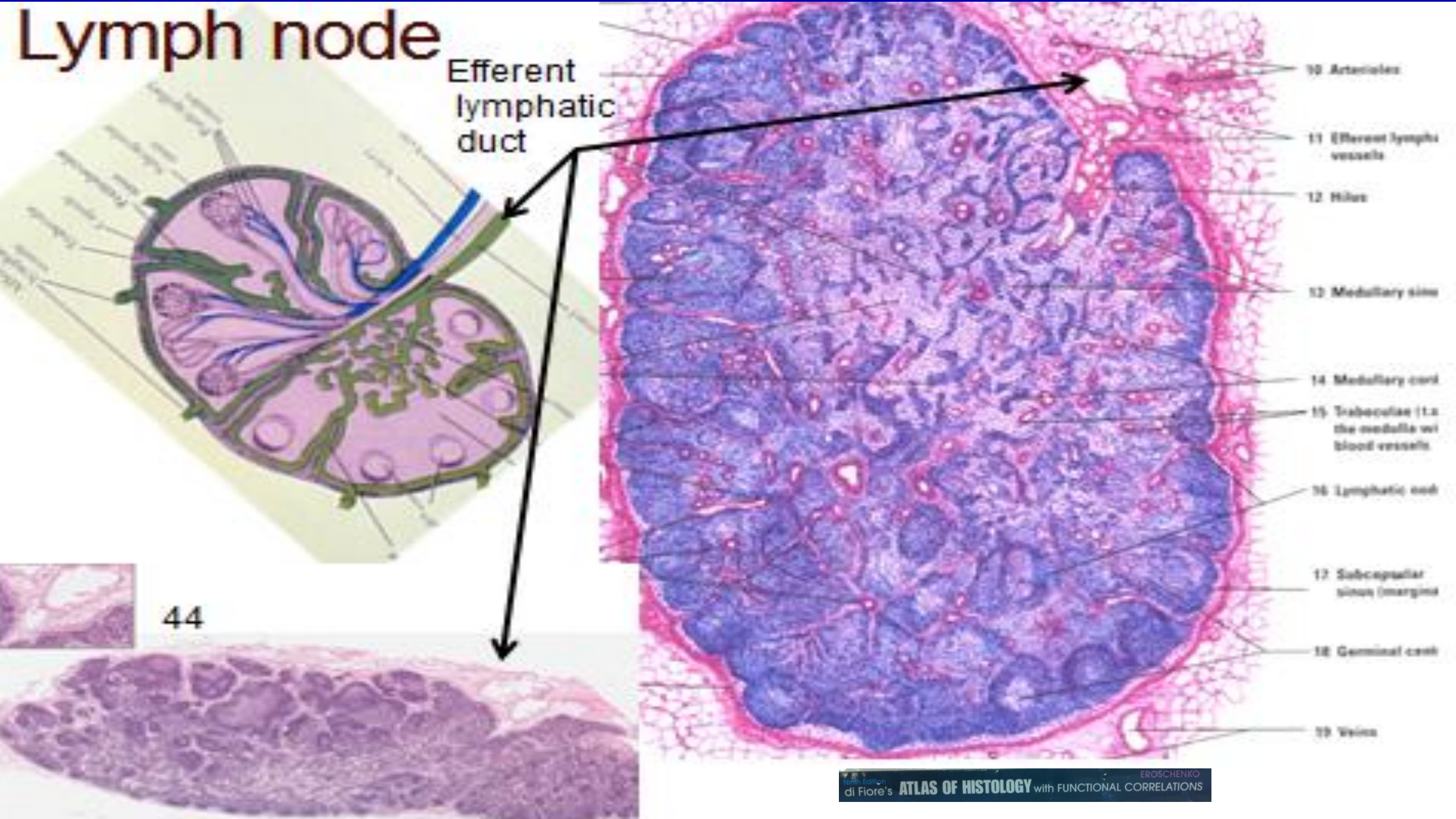


# Lymph Node





# Lymph node

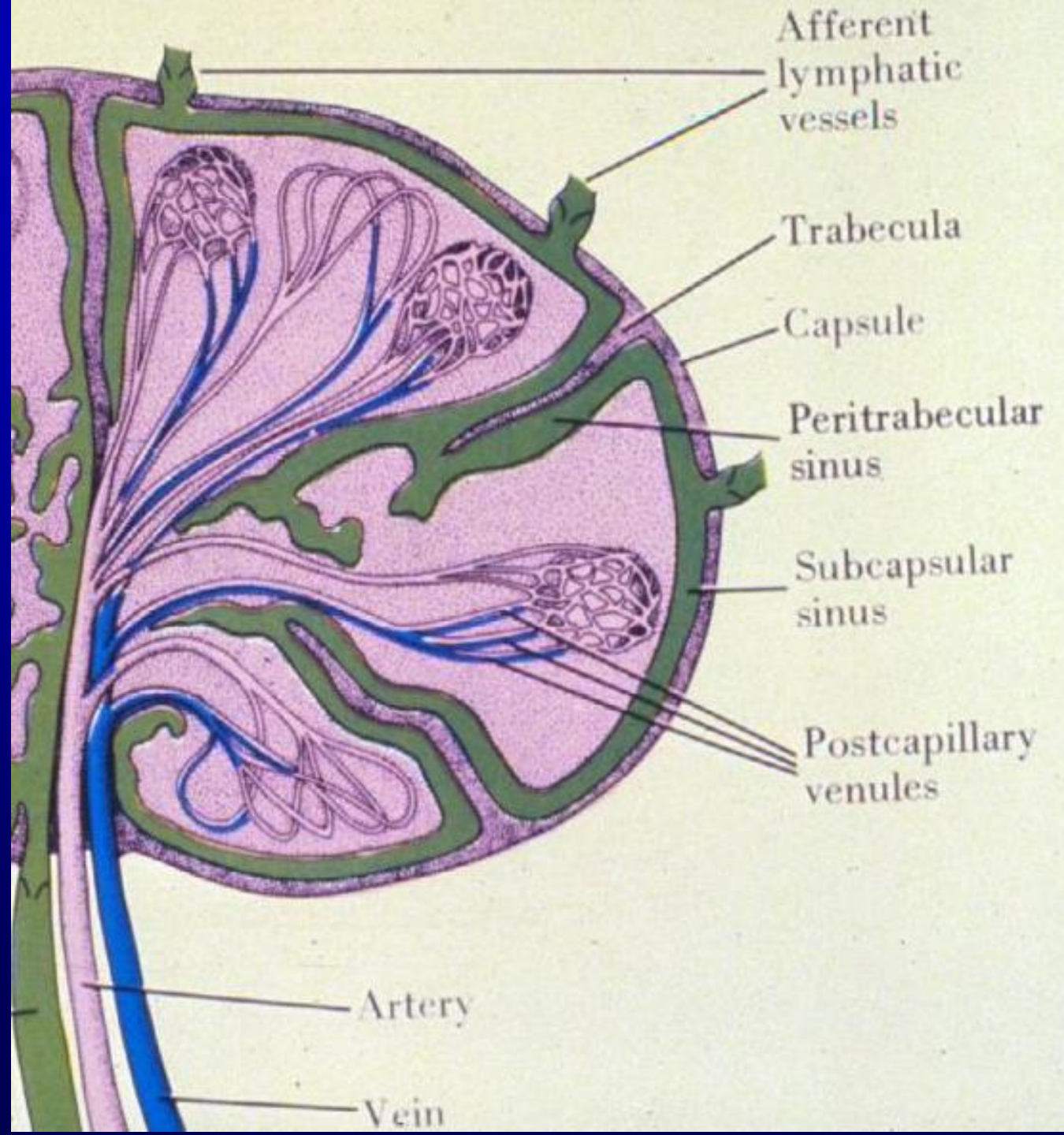




# Lymph Nodes - Filtration of Lymph

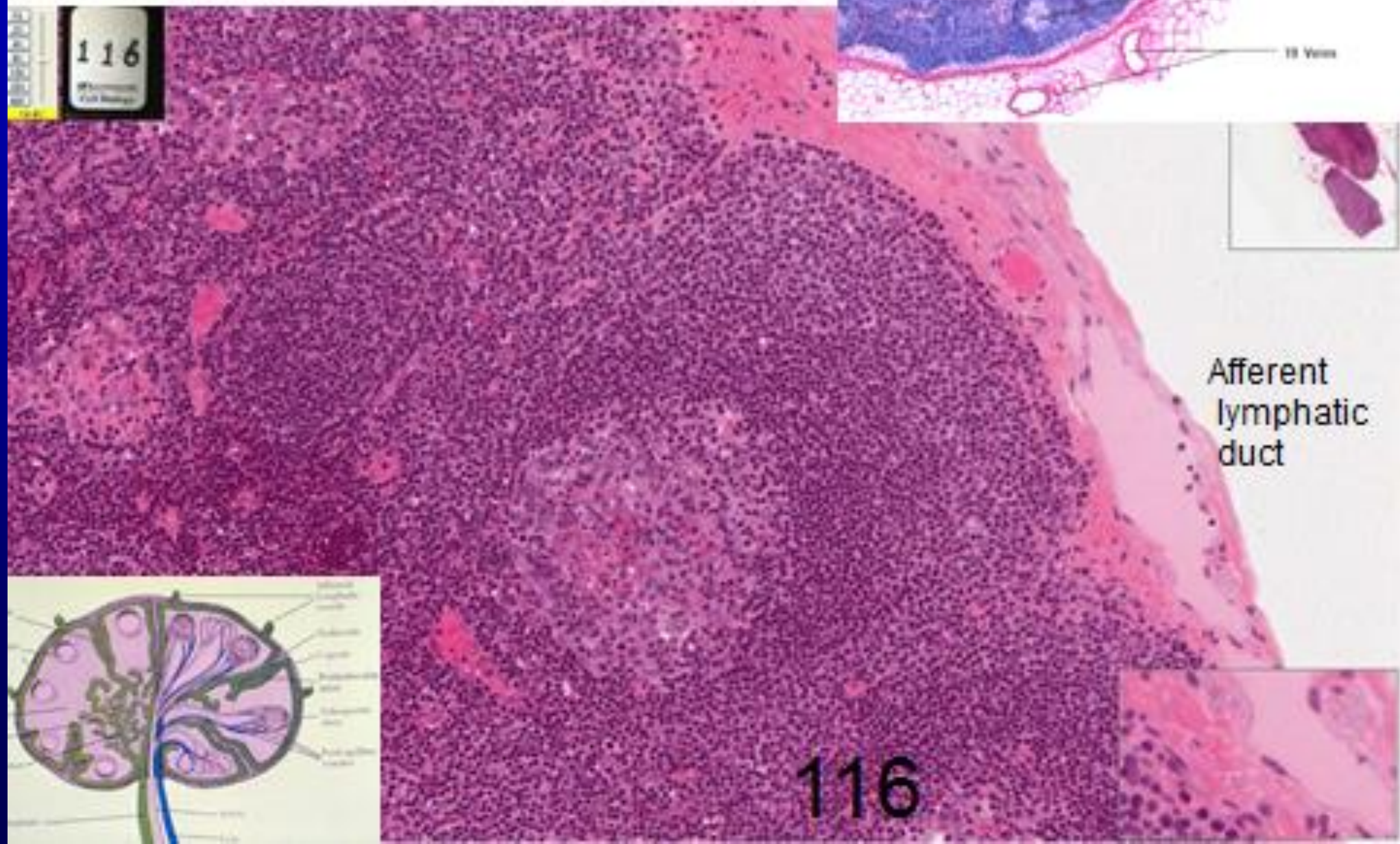
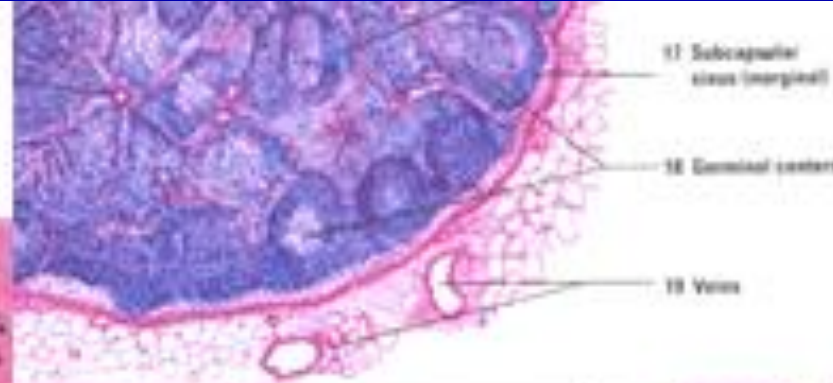
## Basic structure

- Lymphatic vessels
- Vasculature





# Lymph node





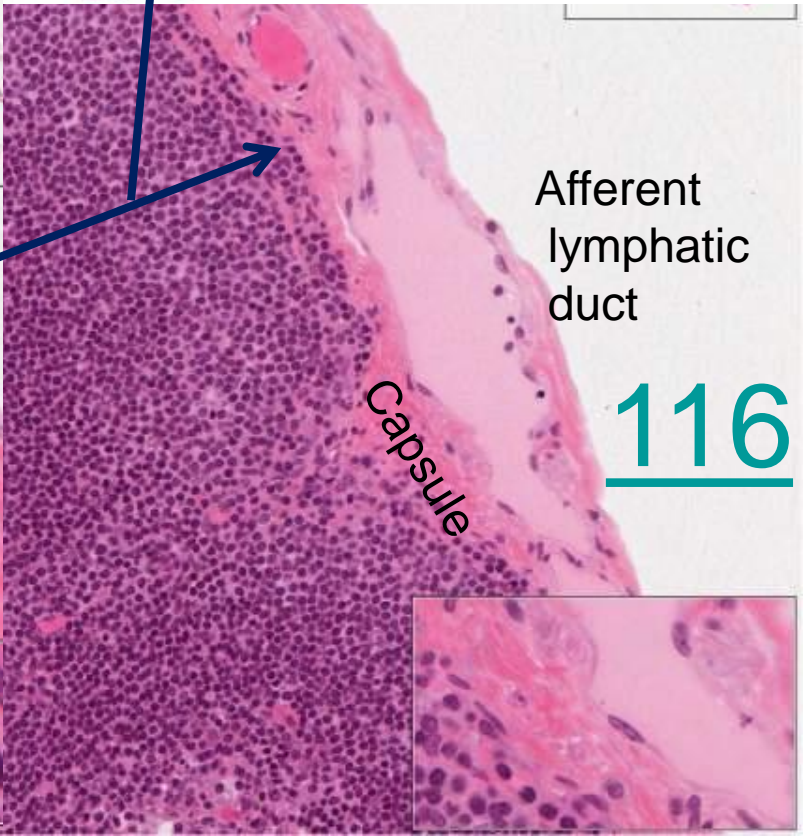
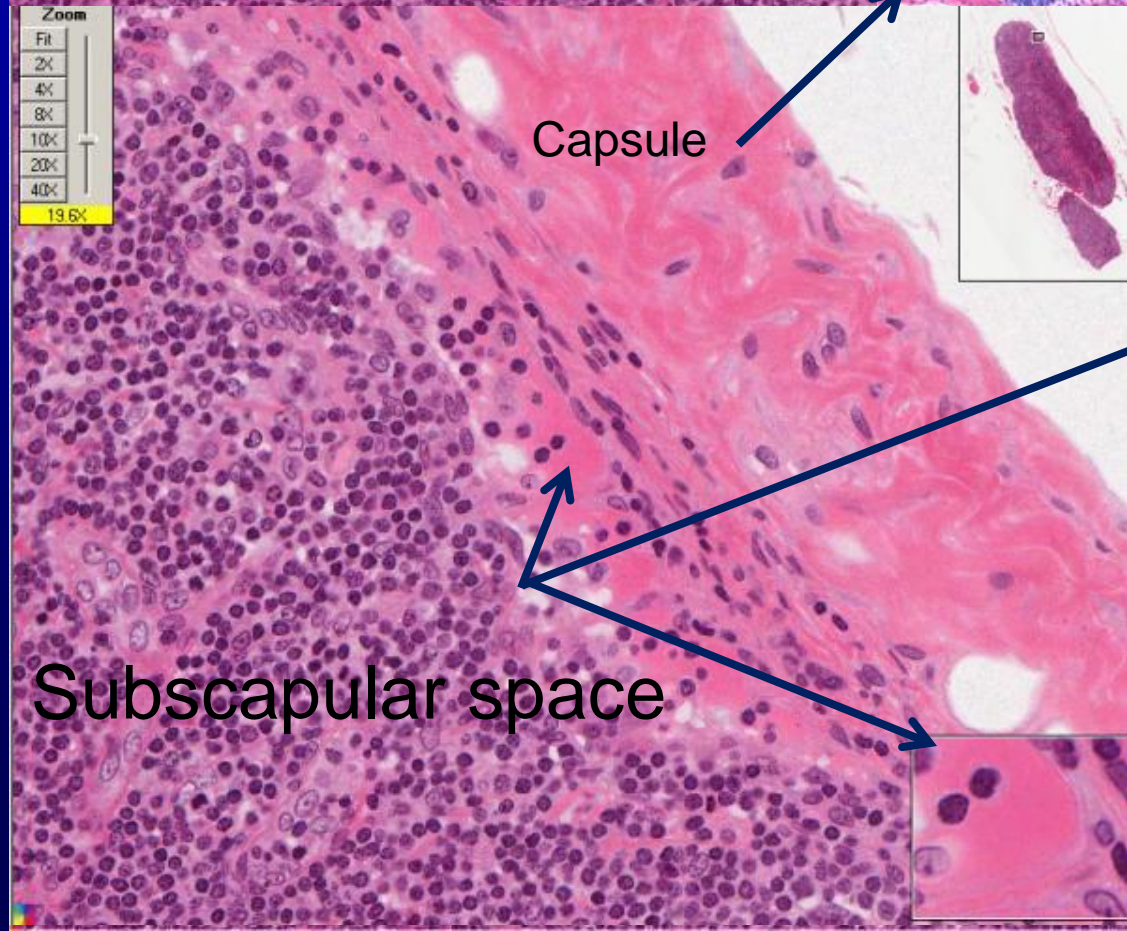
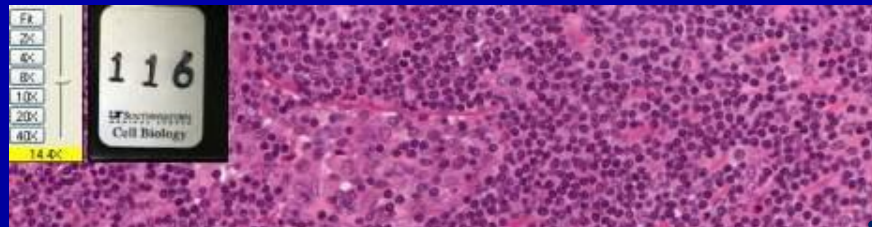
**Efferent lymphatic duct**

**Both afferent and efferent lymphatic vessels characterize lymph nodes.**





# Lymph node

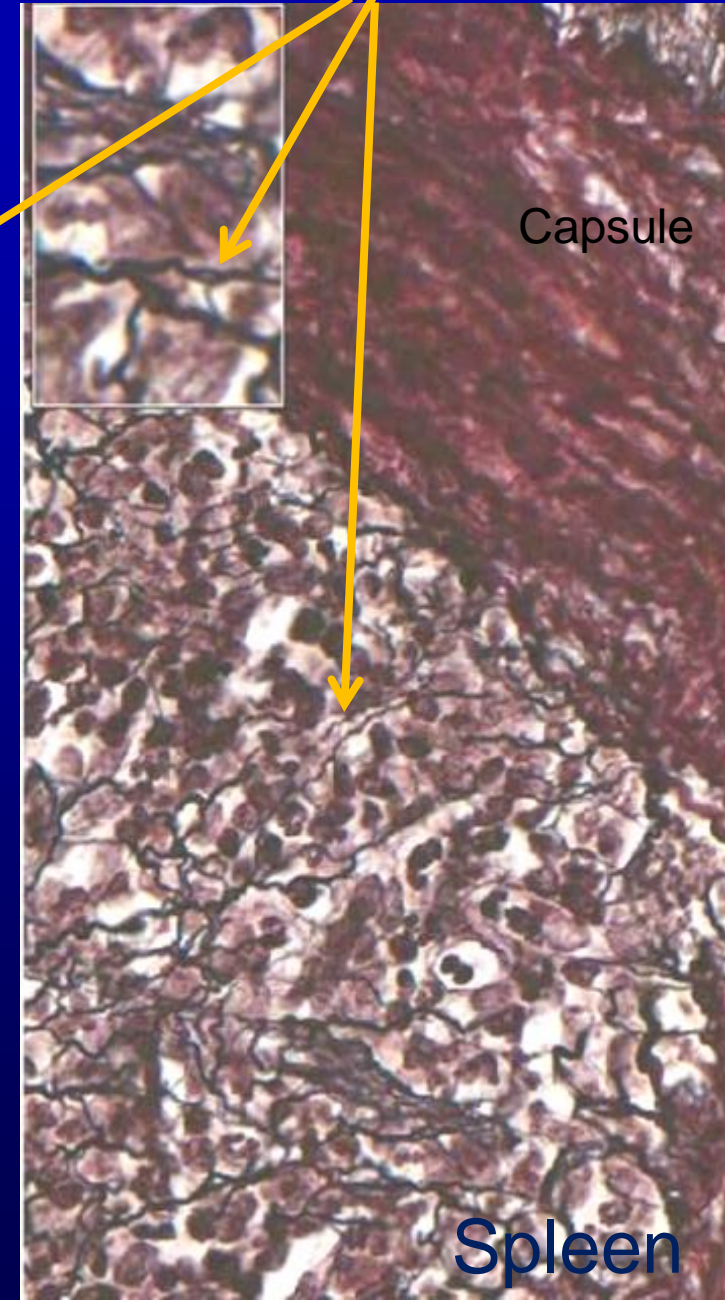
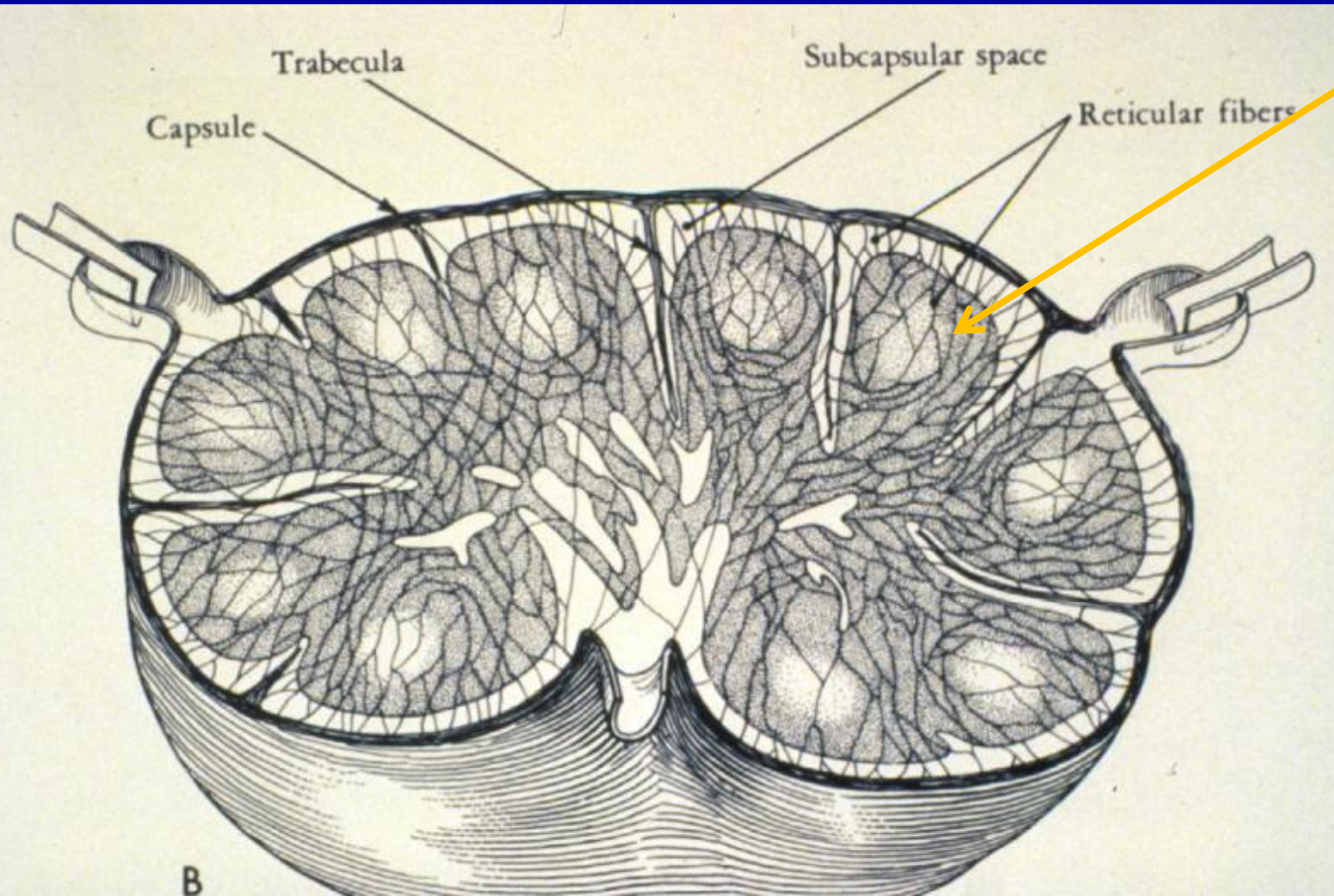




# Lymph Nodes - Filtration of Lymph

Reticular fibers

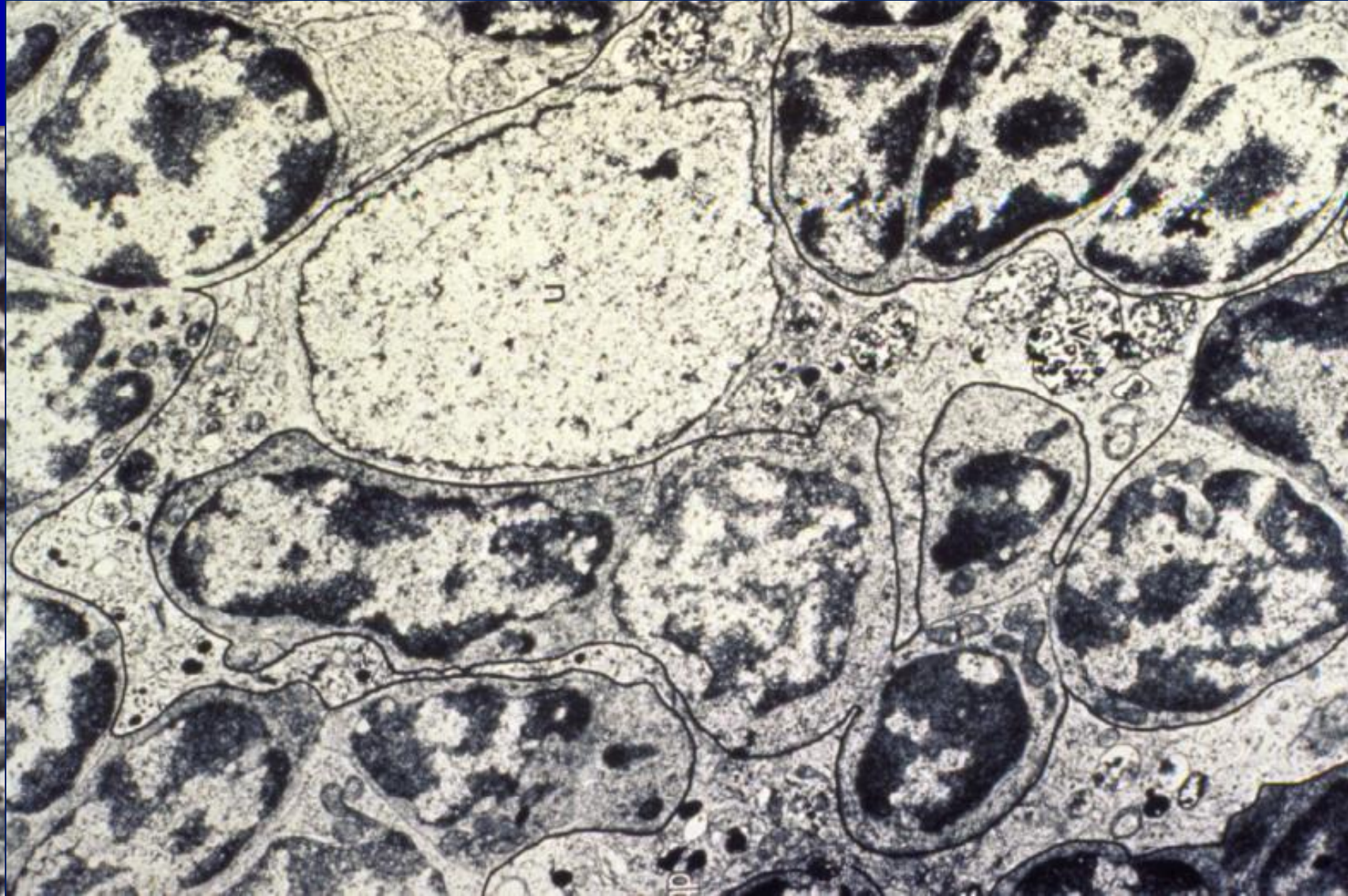
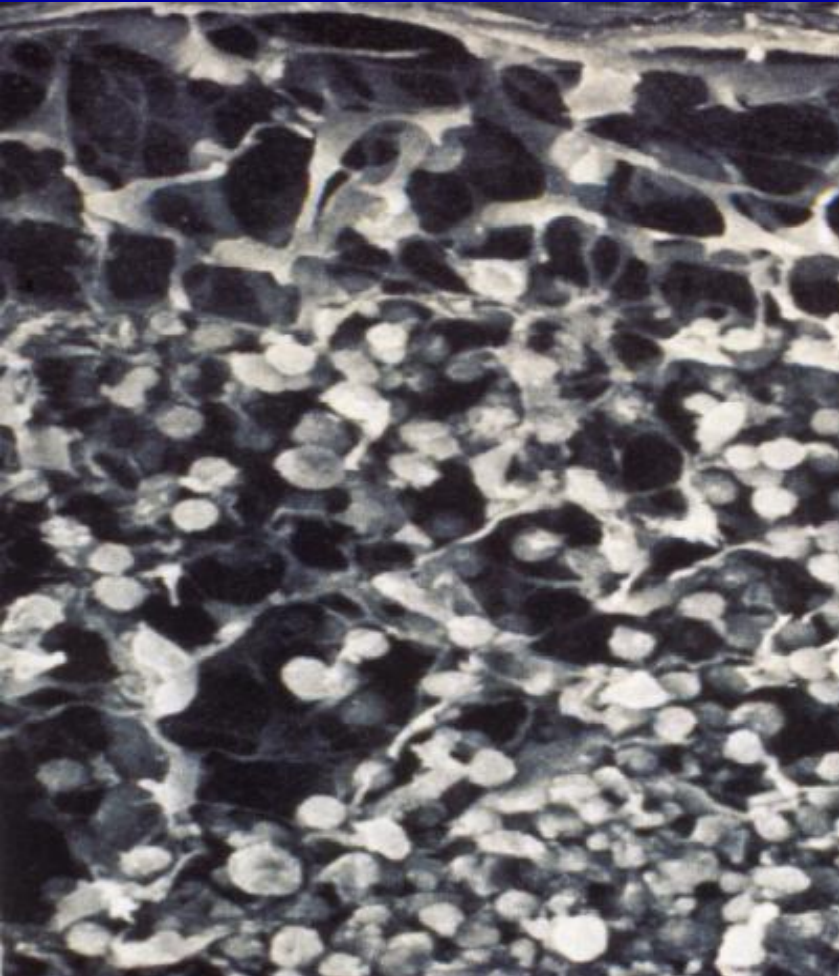
## Basic structure - reticular framework





# Lymph Nodes - Filtration of Lymph

Basic structure - reticular framework

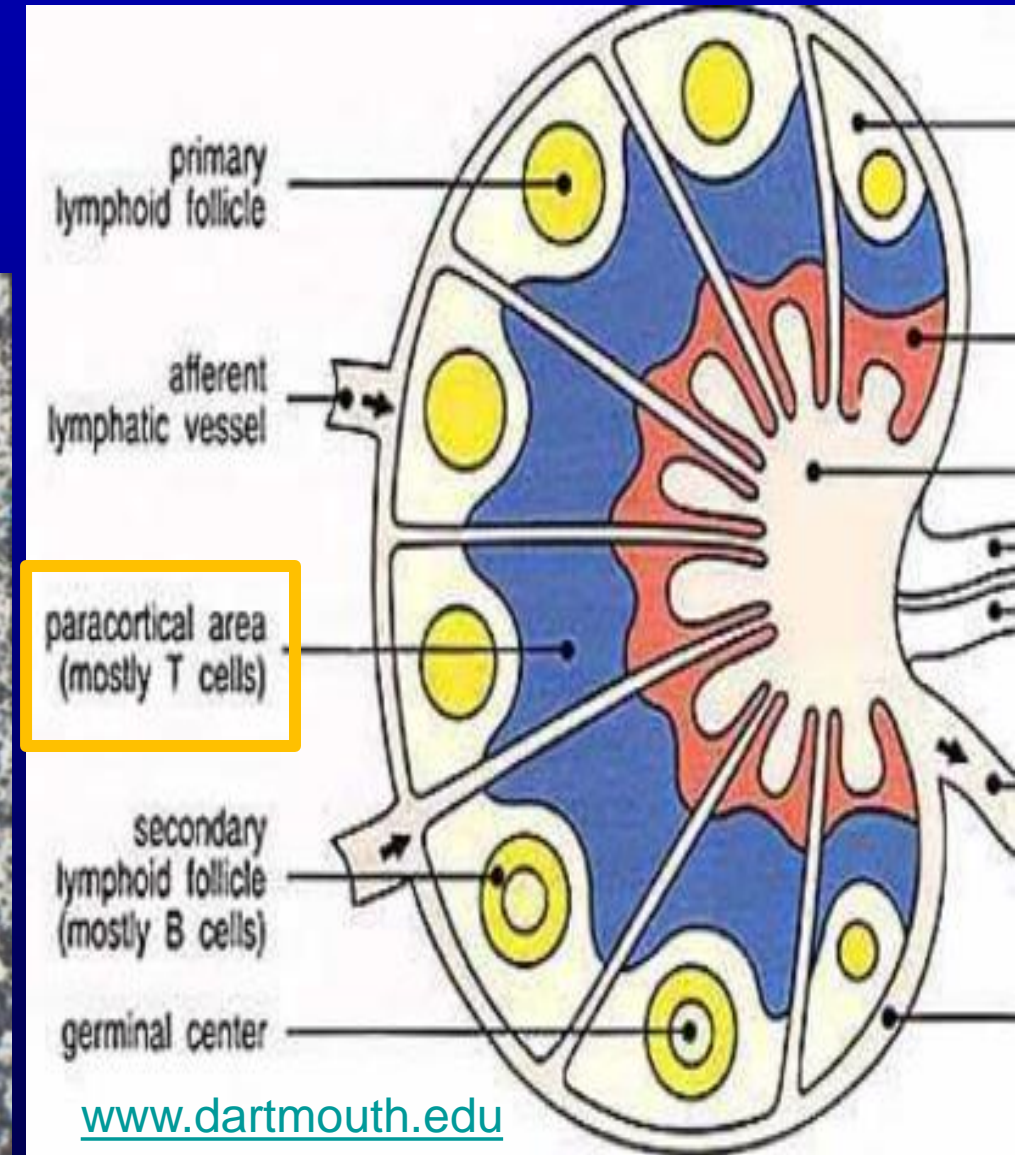
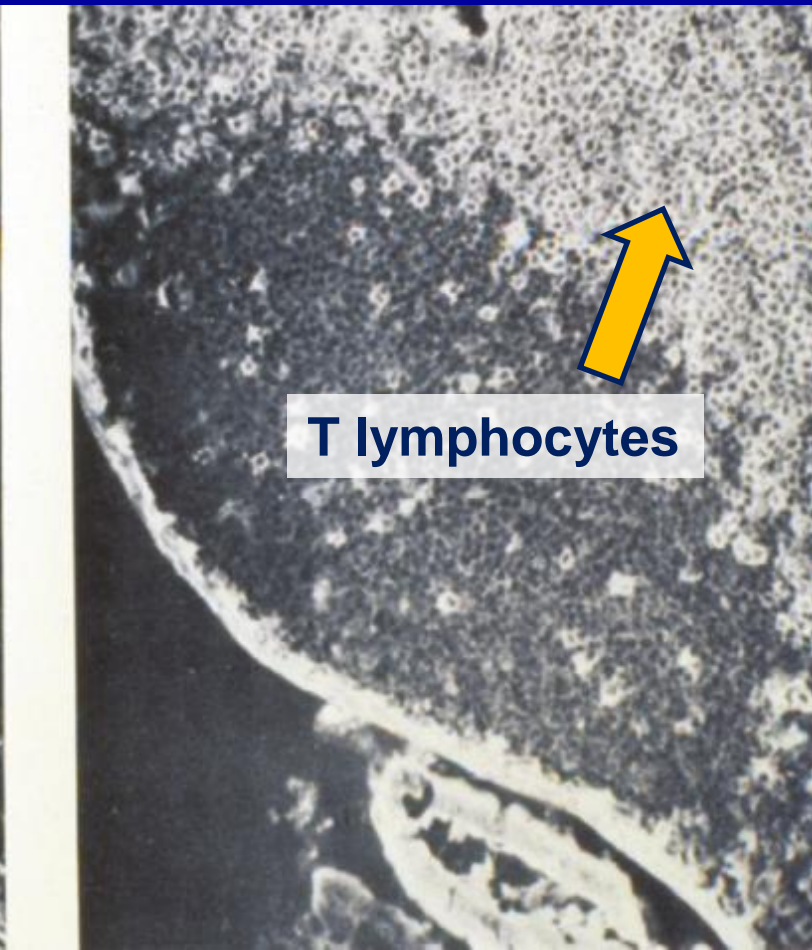
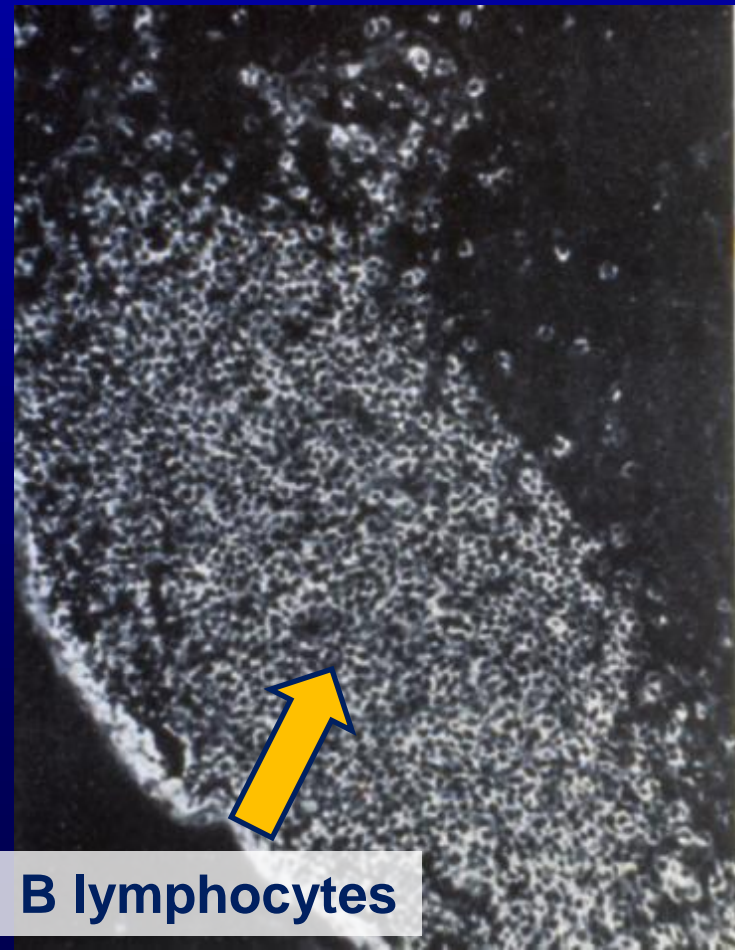




# Lymph Nodes - Filtration of Lymph

## Cortex

- Follicles - B lymphocytes (in lymph nodule)
- Perifollicular - T lymphocytes (in paracortex)

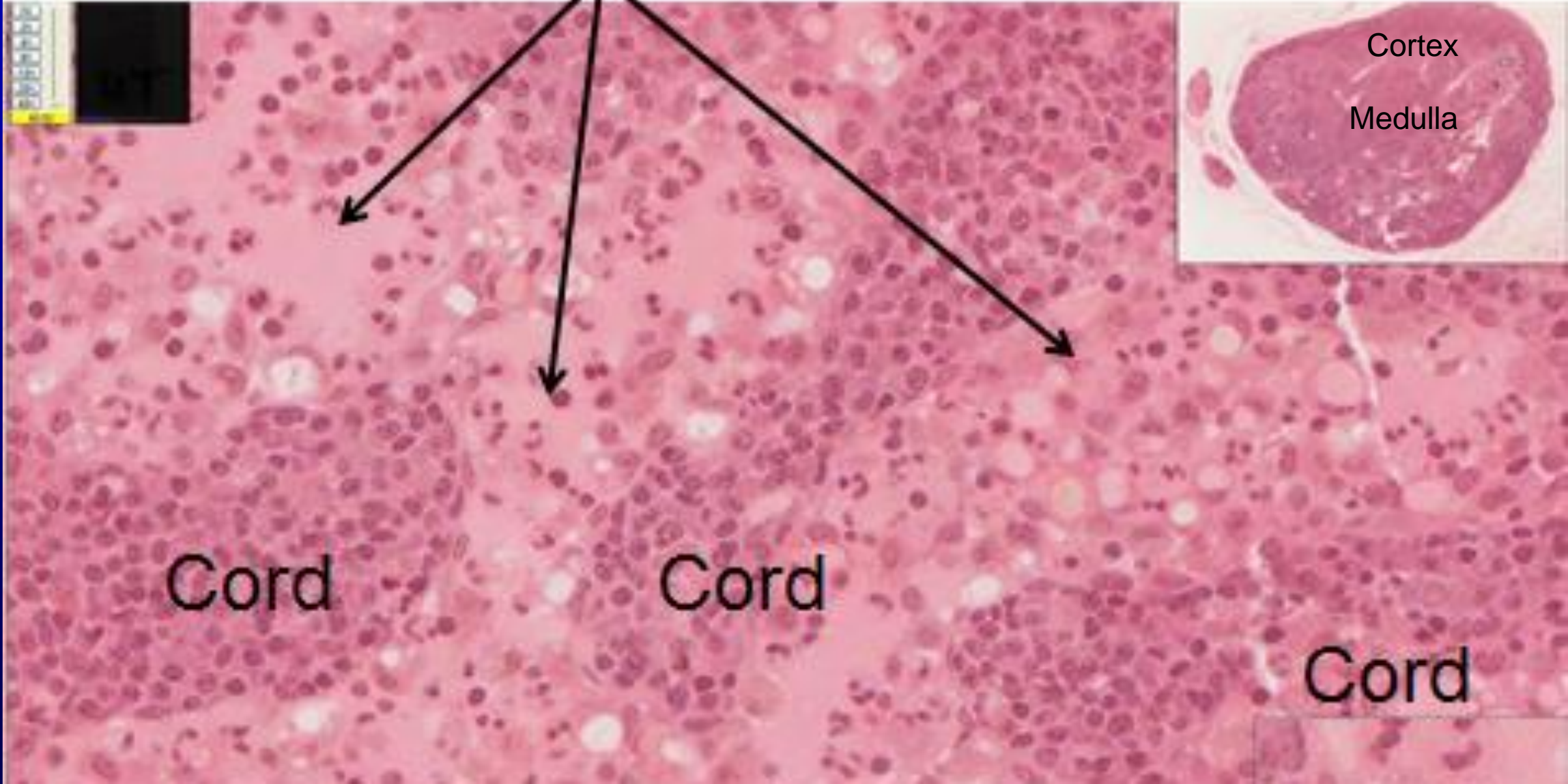




19754

# Lymph sinus in lymph node

Medulla



Cortex

Medulla

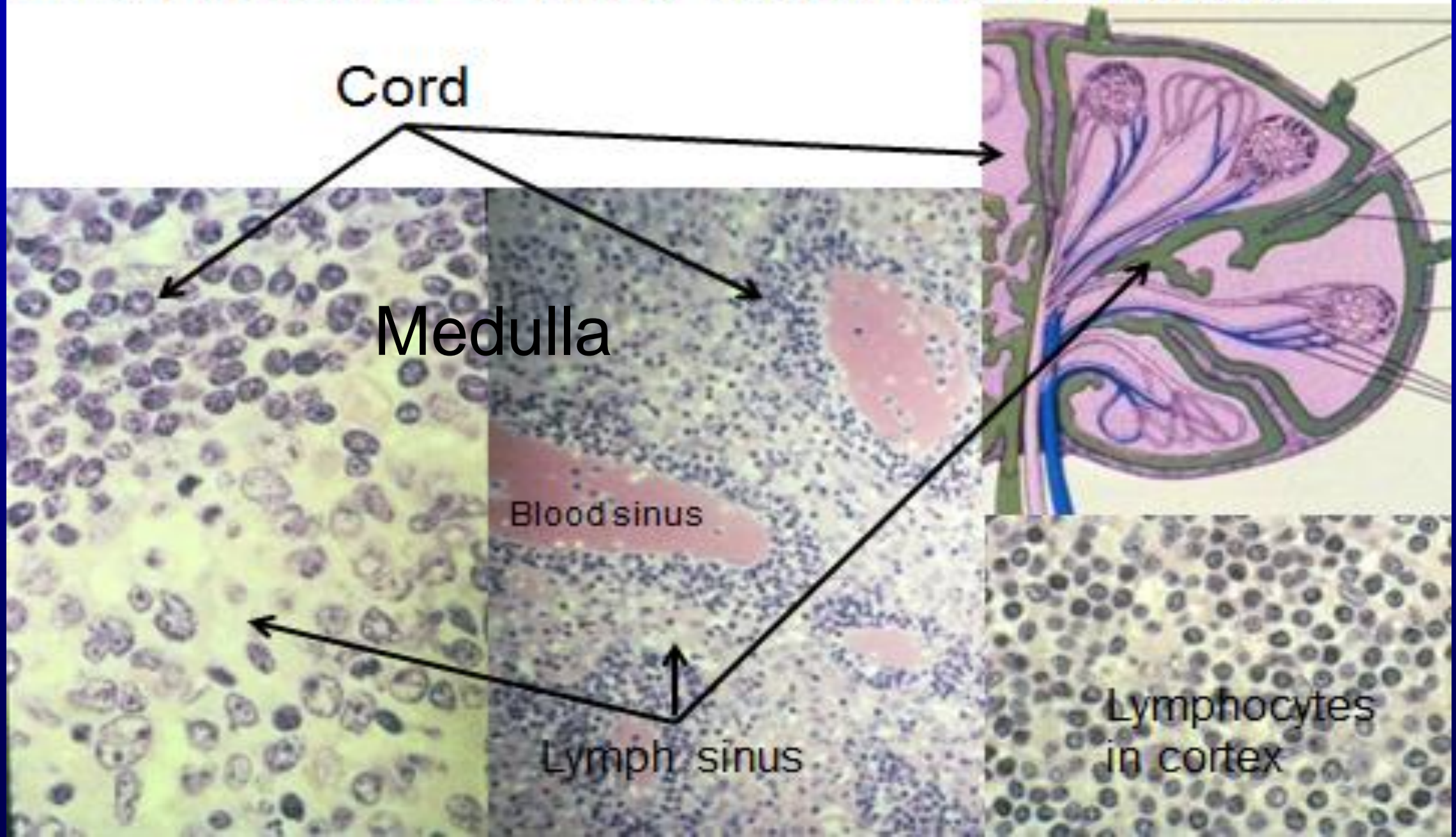
Cord

Cord

Cord



# LYMPH NODES AND LYMPHOID TISSUE





# Lymph Nodes and Lymphoid Tissue

Lymph flow

Lymphopoiesis

Lymphocyte circulation

- High endothelial venules
  - Receptors for T&B cells only
- One-way traffic

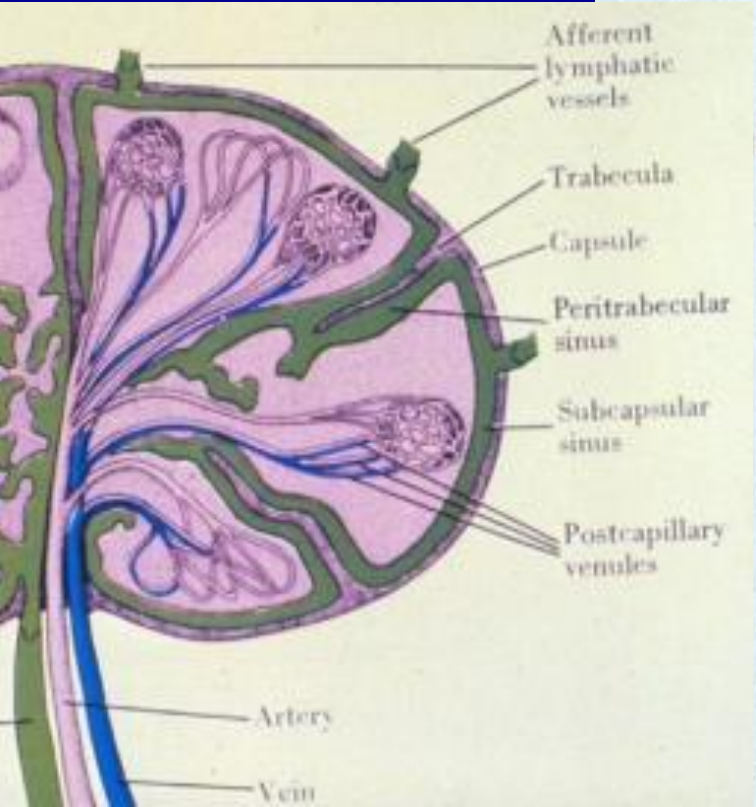
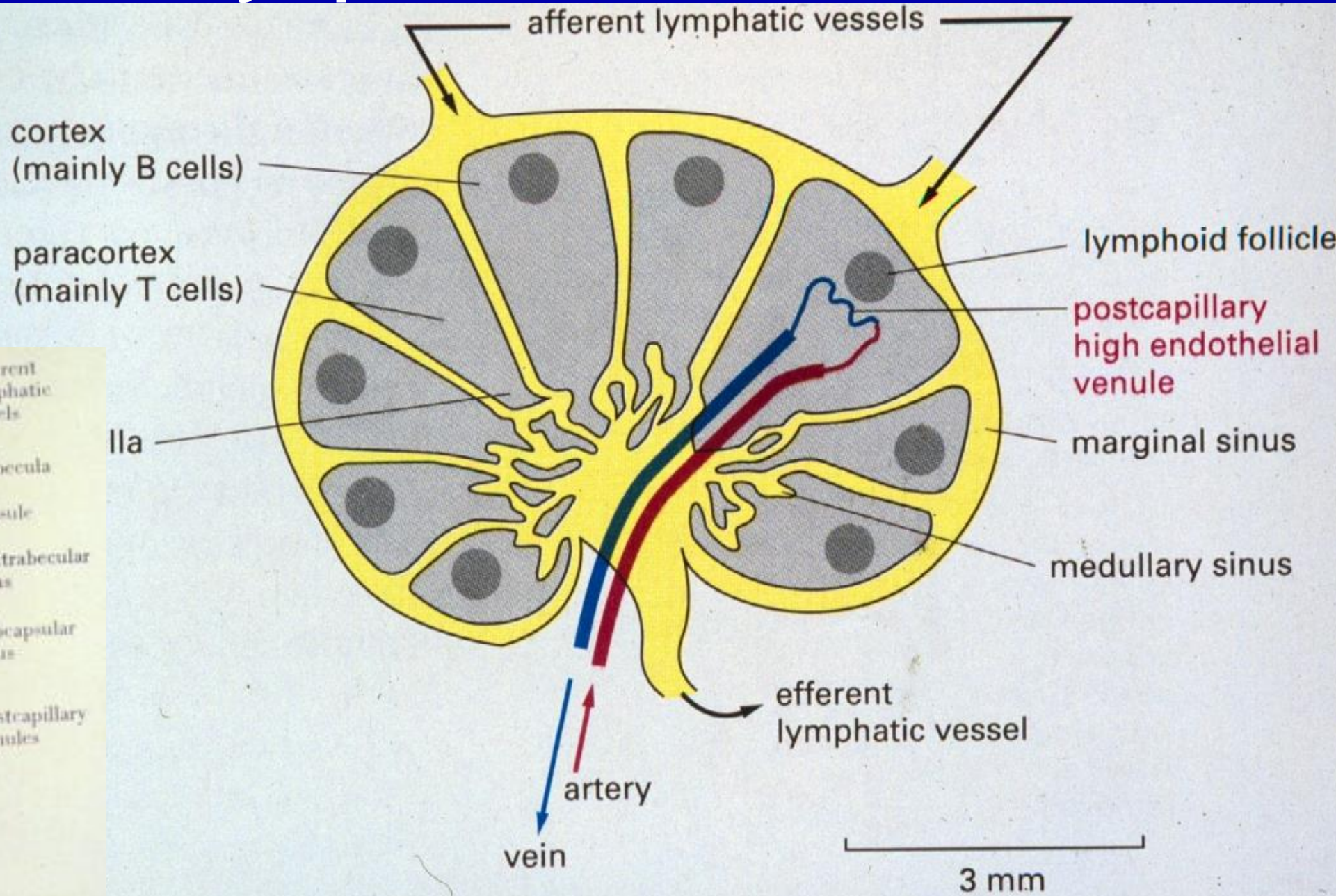
Gut-associated lymphoid tissue

- Tonsils
- Peyer's patches



# Lymph Nodes and Lymphoid Tissue

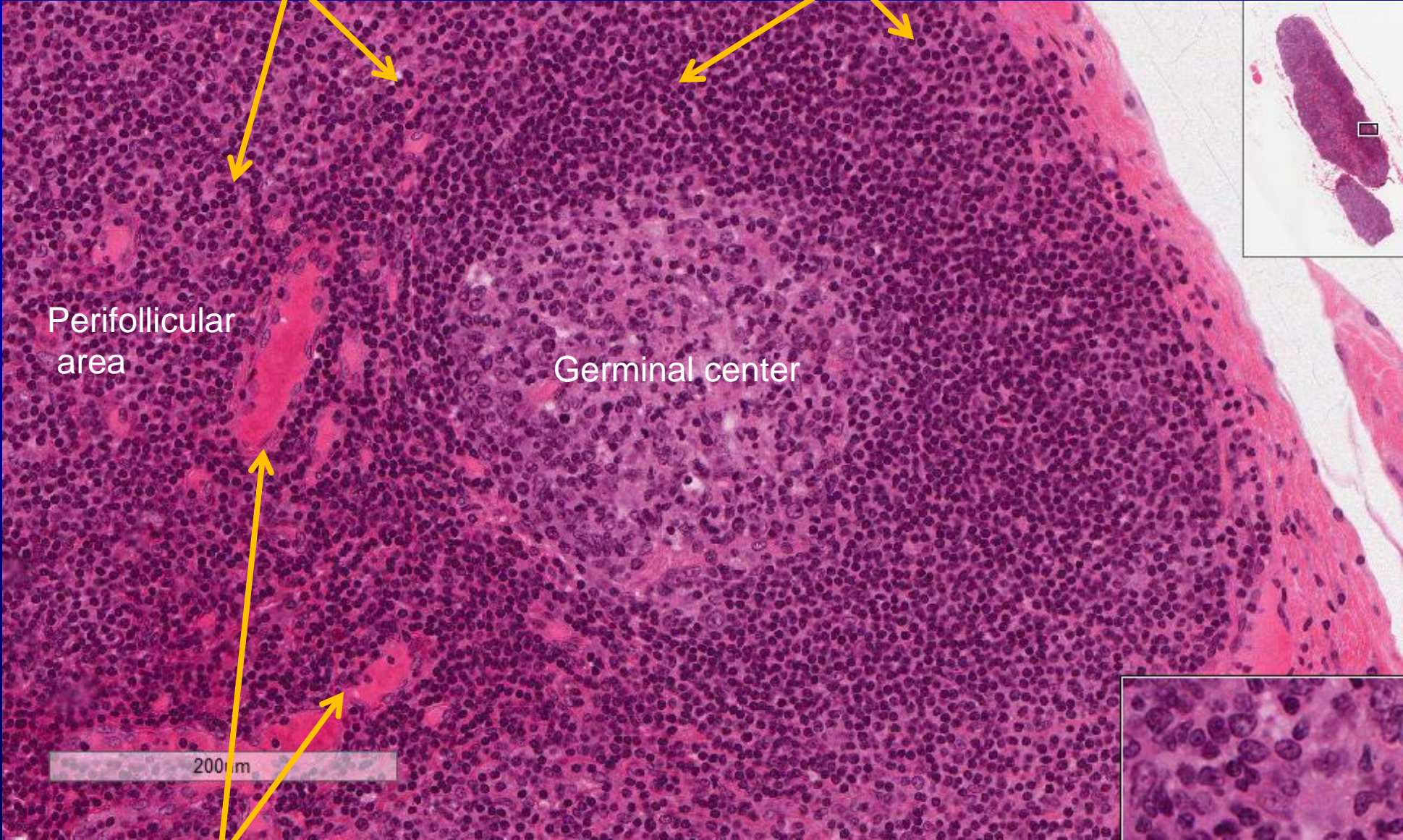
## Lymph flow





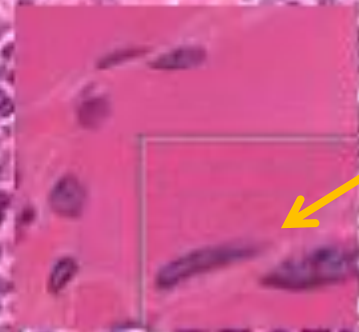
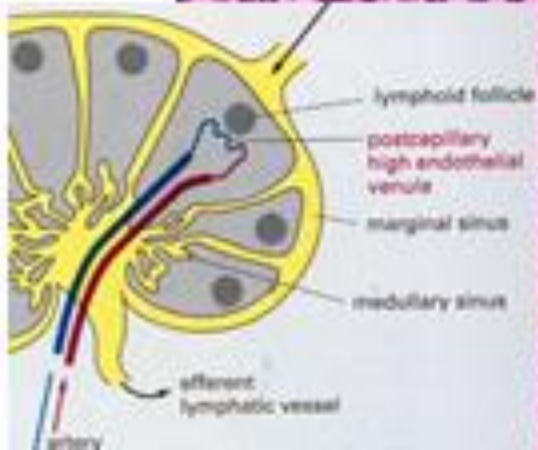
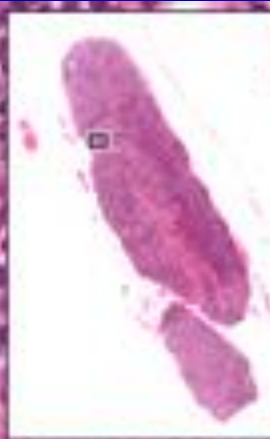
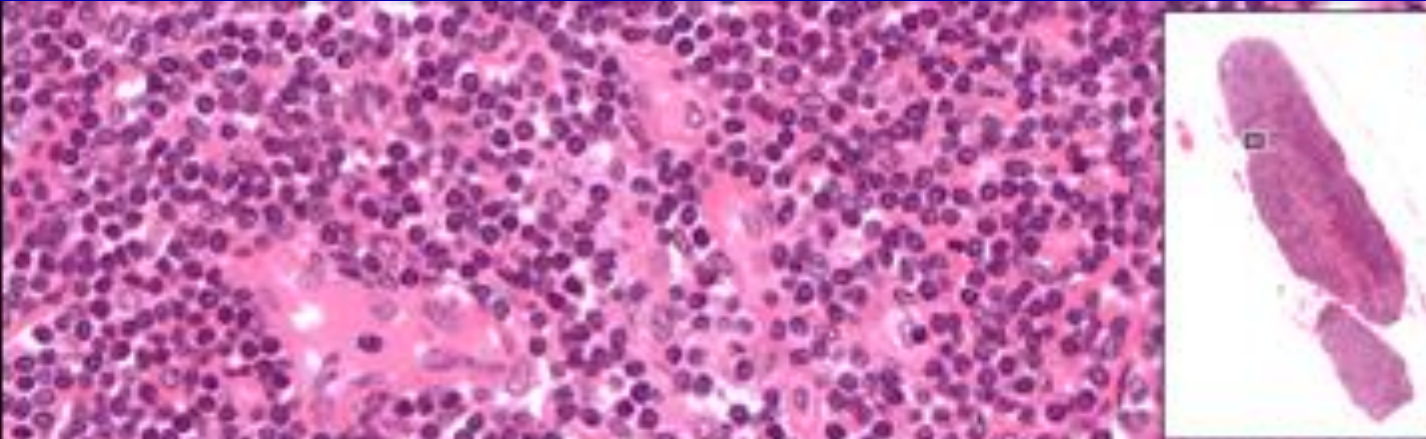
Predominantly T lymphocytes

Predominantly B lymphocytes, around germinal center



High endothelial venules = sites where blood-borne lymphocytes enter the node.





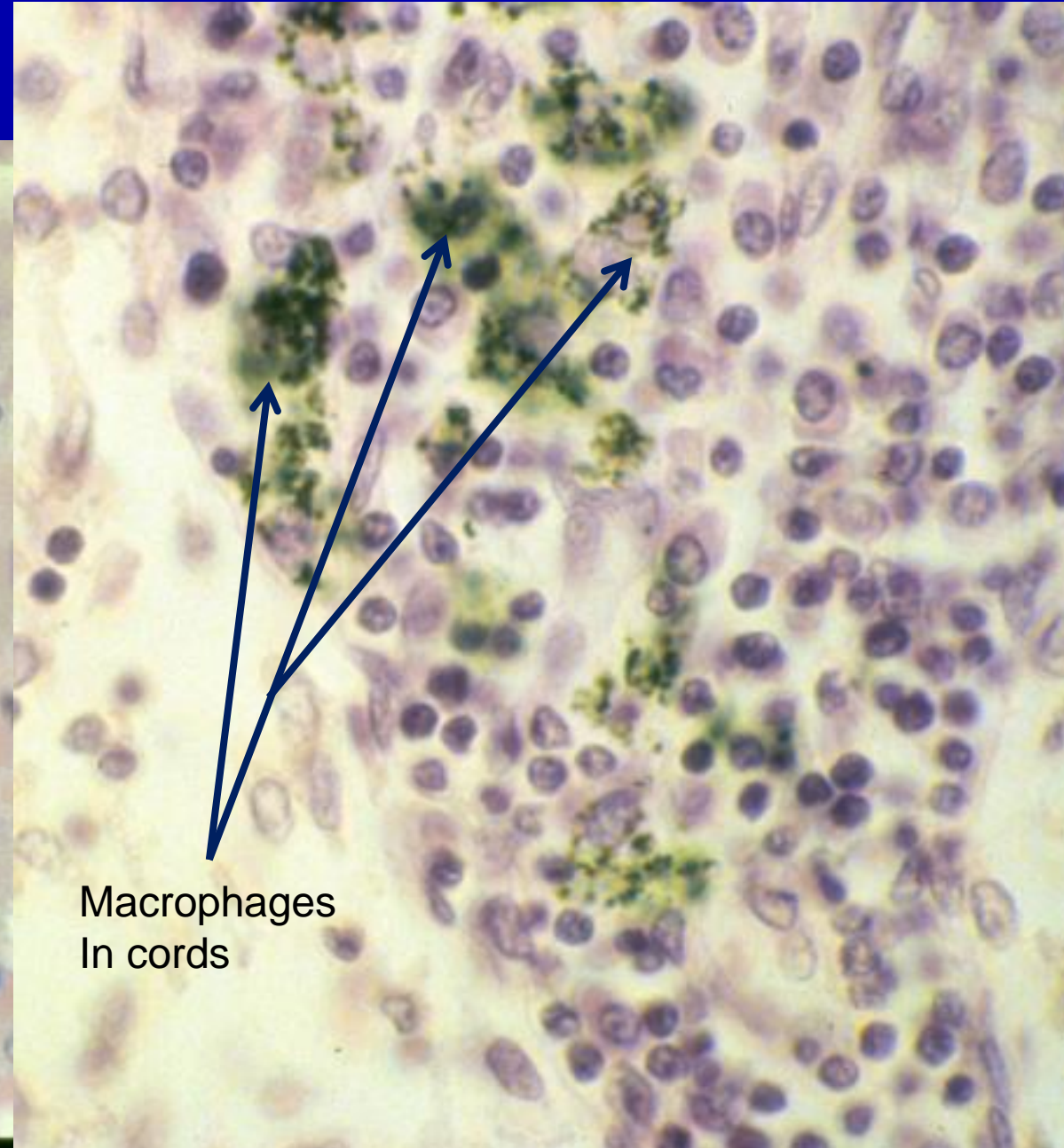
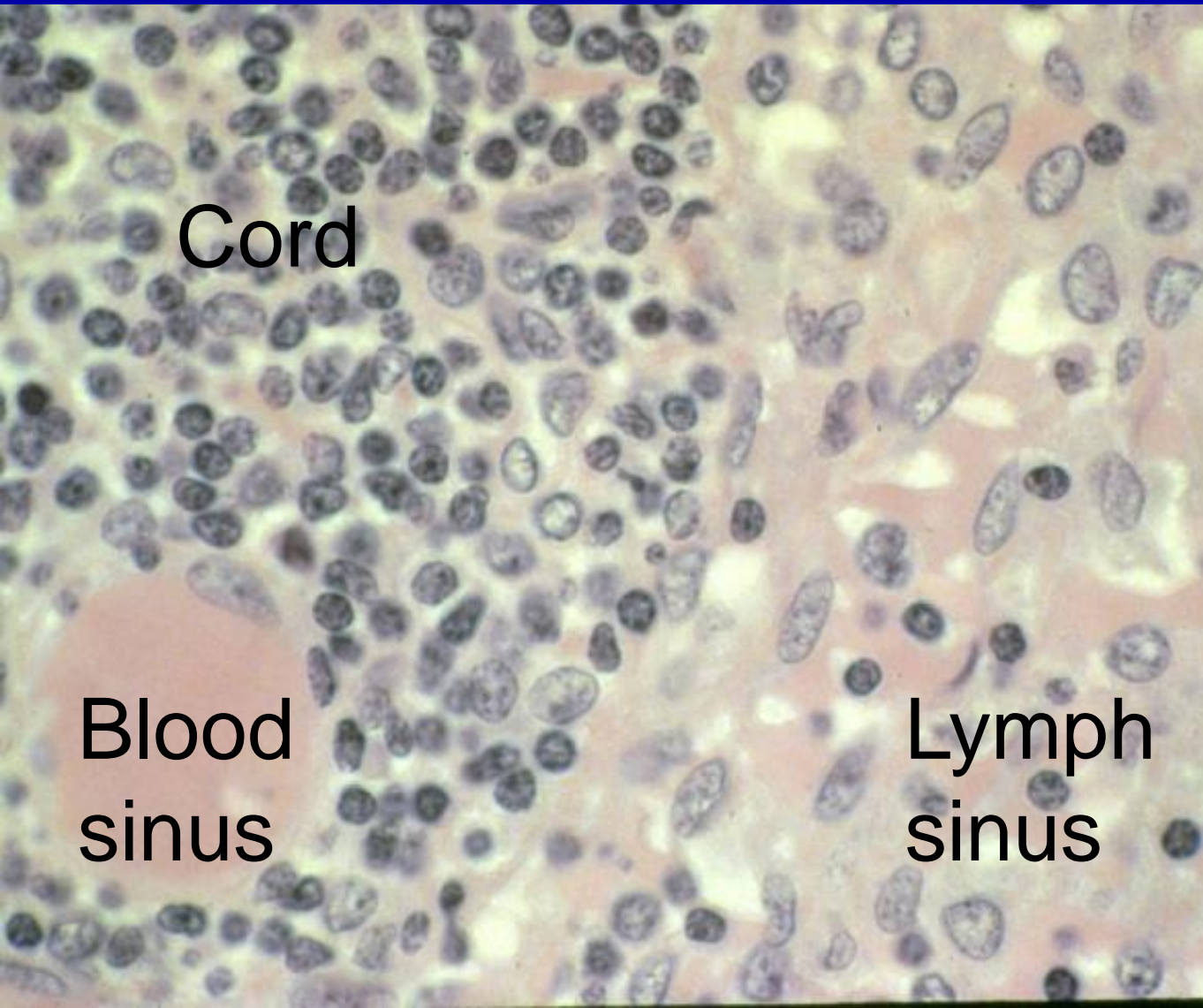
Typical venule endothelium

High endothelial venules endothelium



# Lymph Node medulla

## Lymphopoiesis

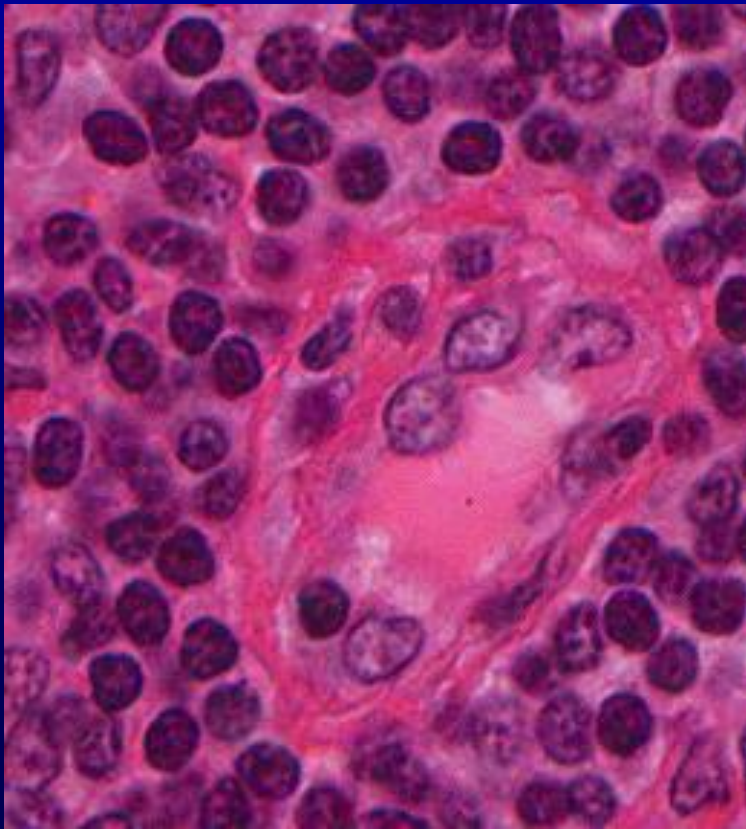
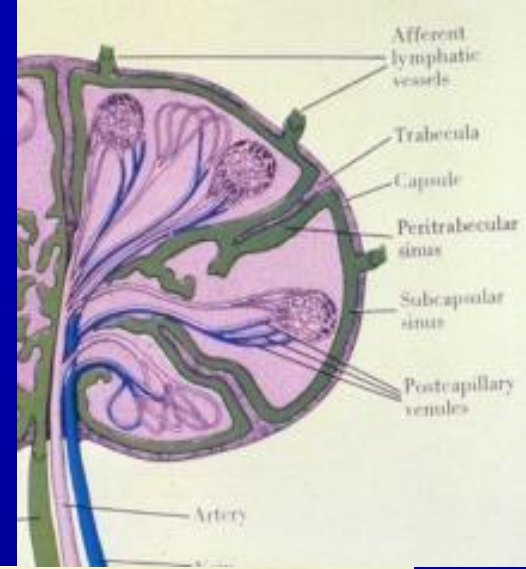




# Lymph Nodes and Lymphoid Tissue

## Lymphocyte circulation

- High endothelial venules  
Receptors for T&B cells only
- One-way traffic





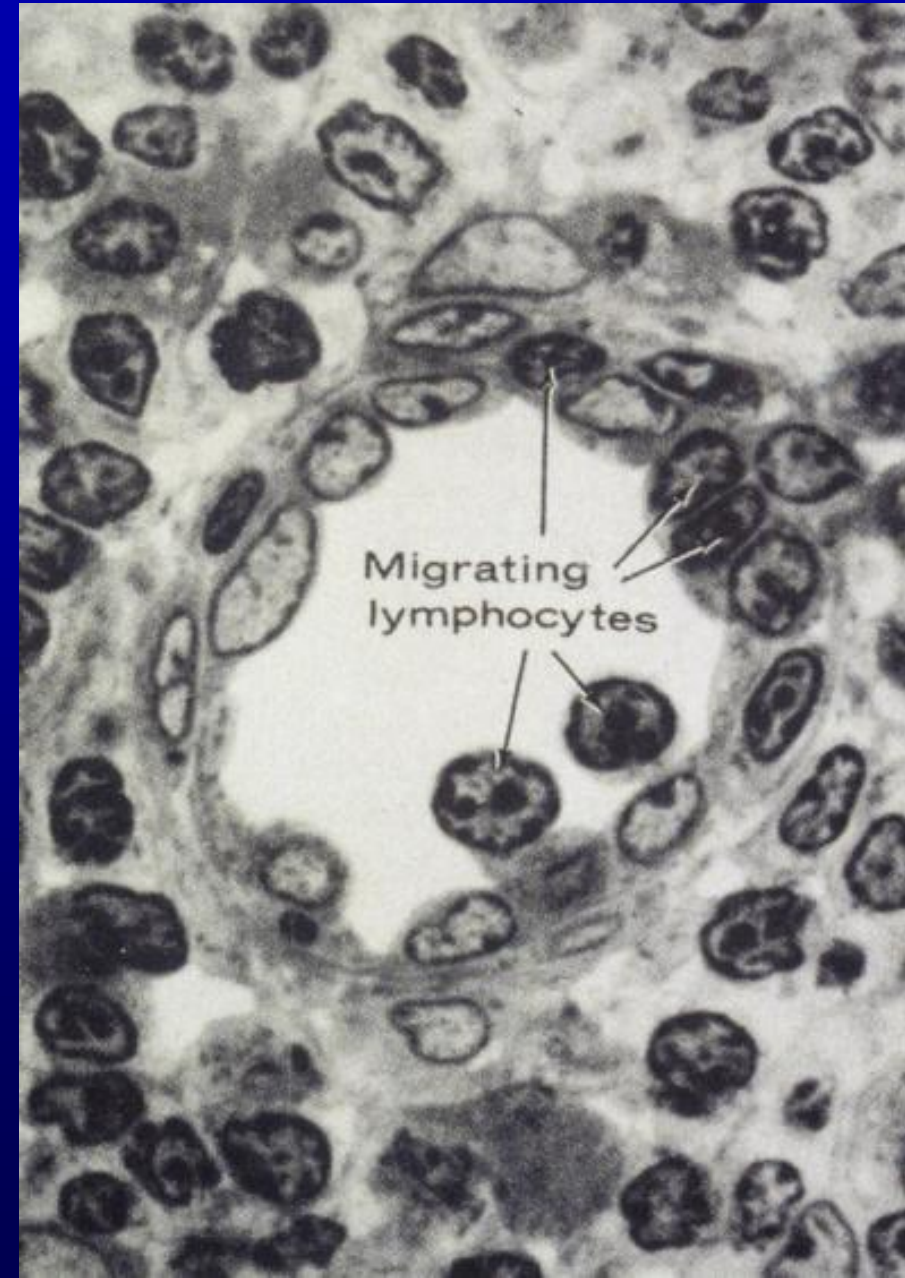
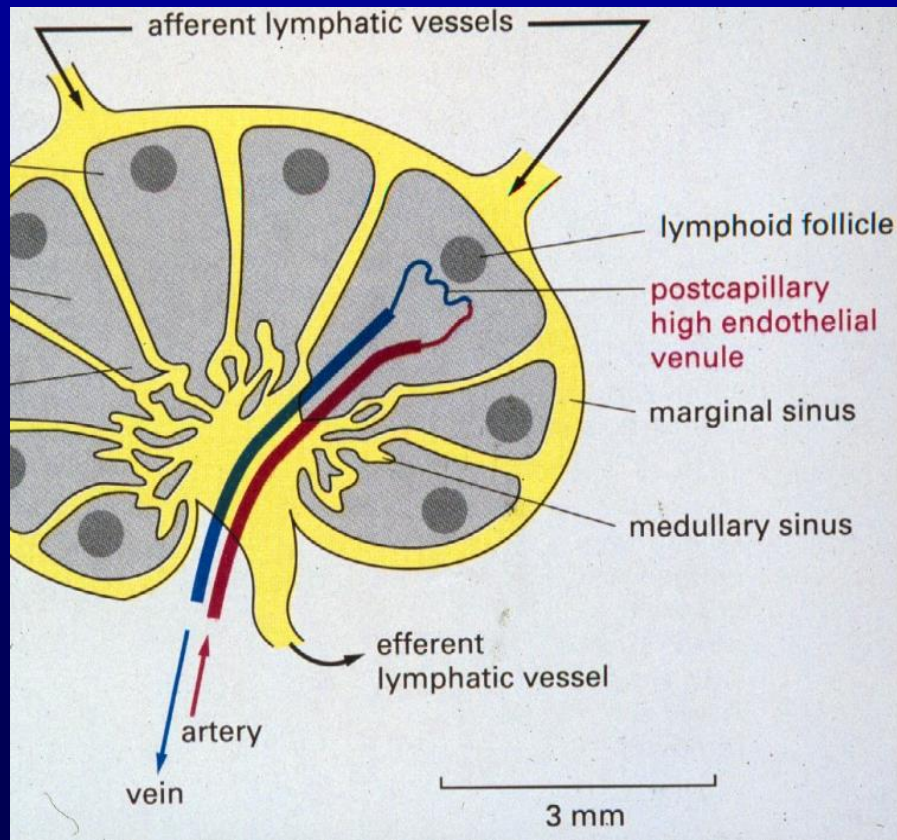
# Lymph Nodes and Lymphoid Tissue

Lymphocyte circulation

High endothelial venules

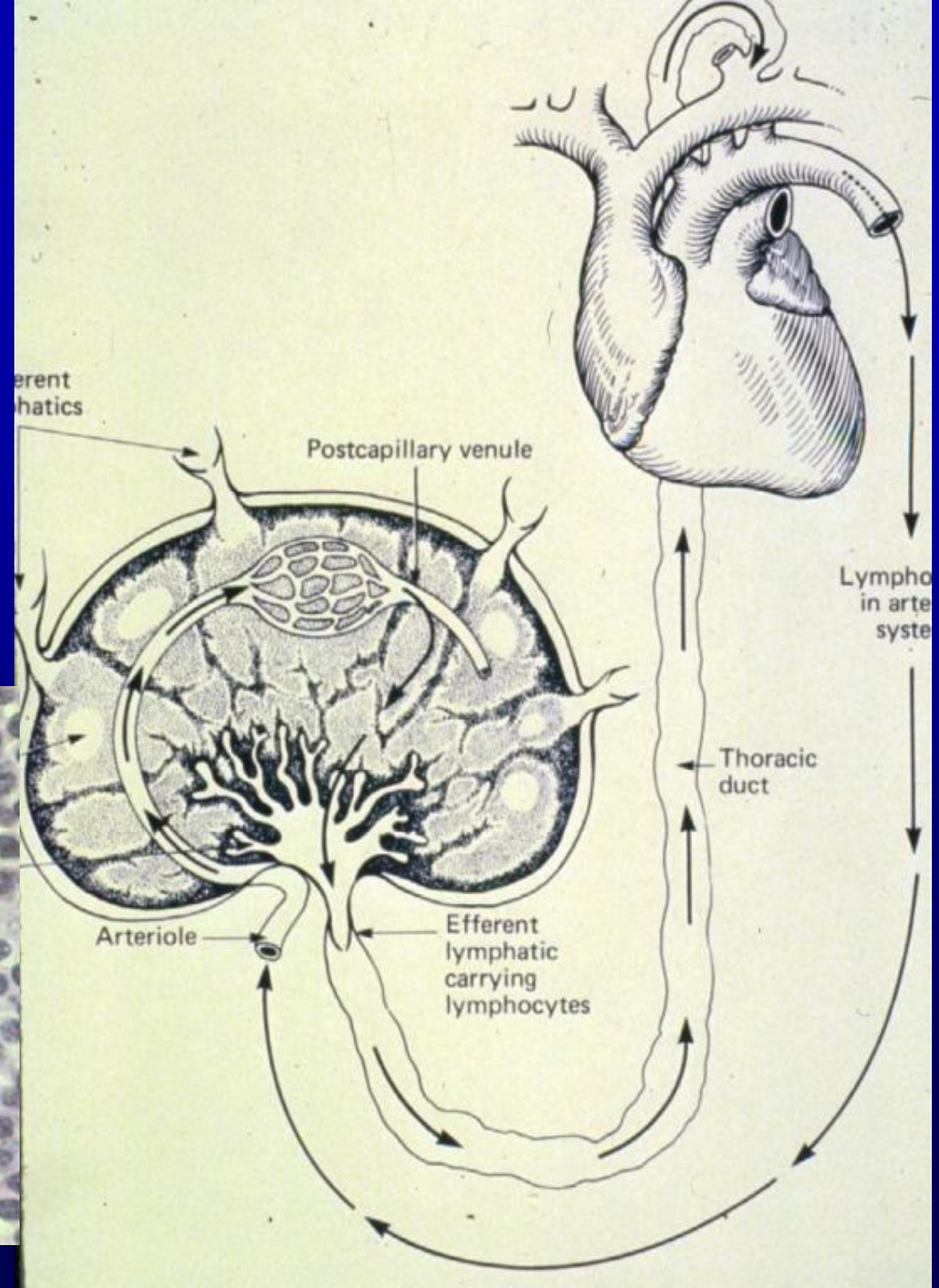
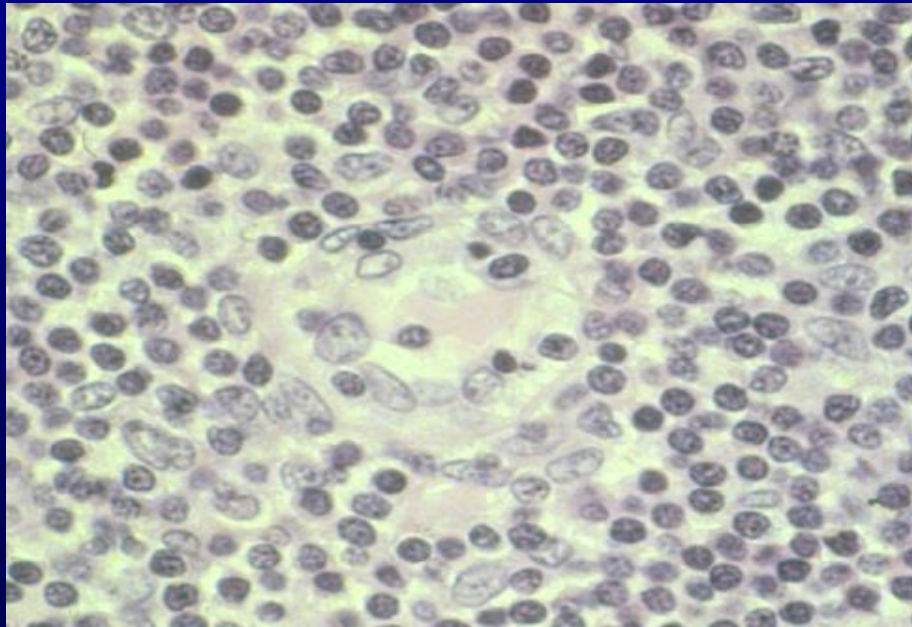
Receptors for T&B cells only

One-way traffic



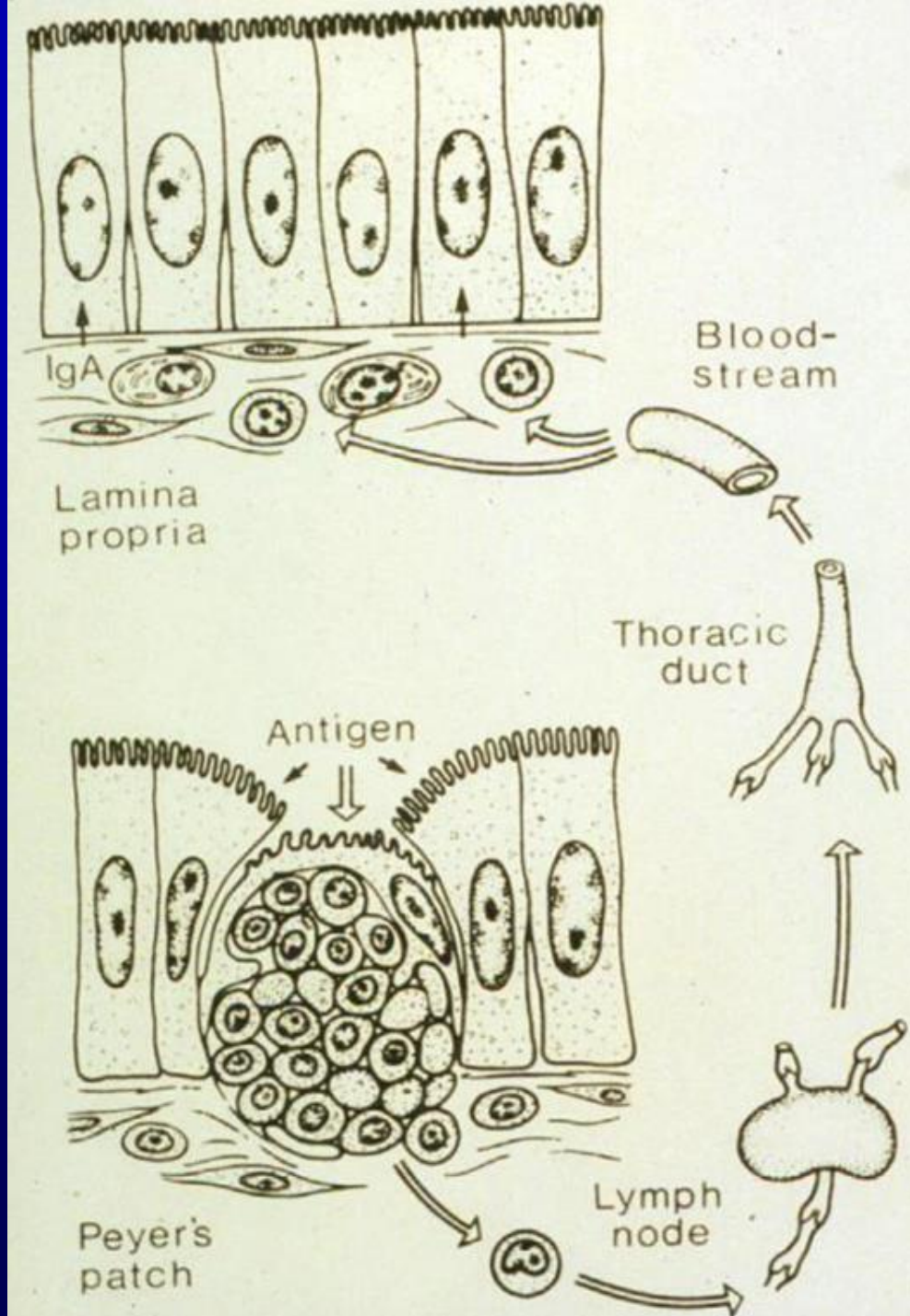


# Recycling of Lymphocytes Through Lymph Nodes



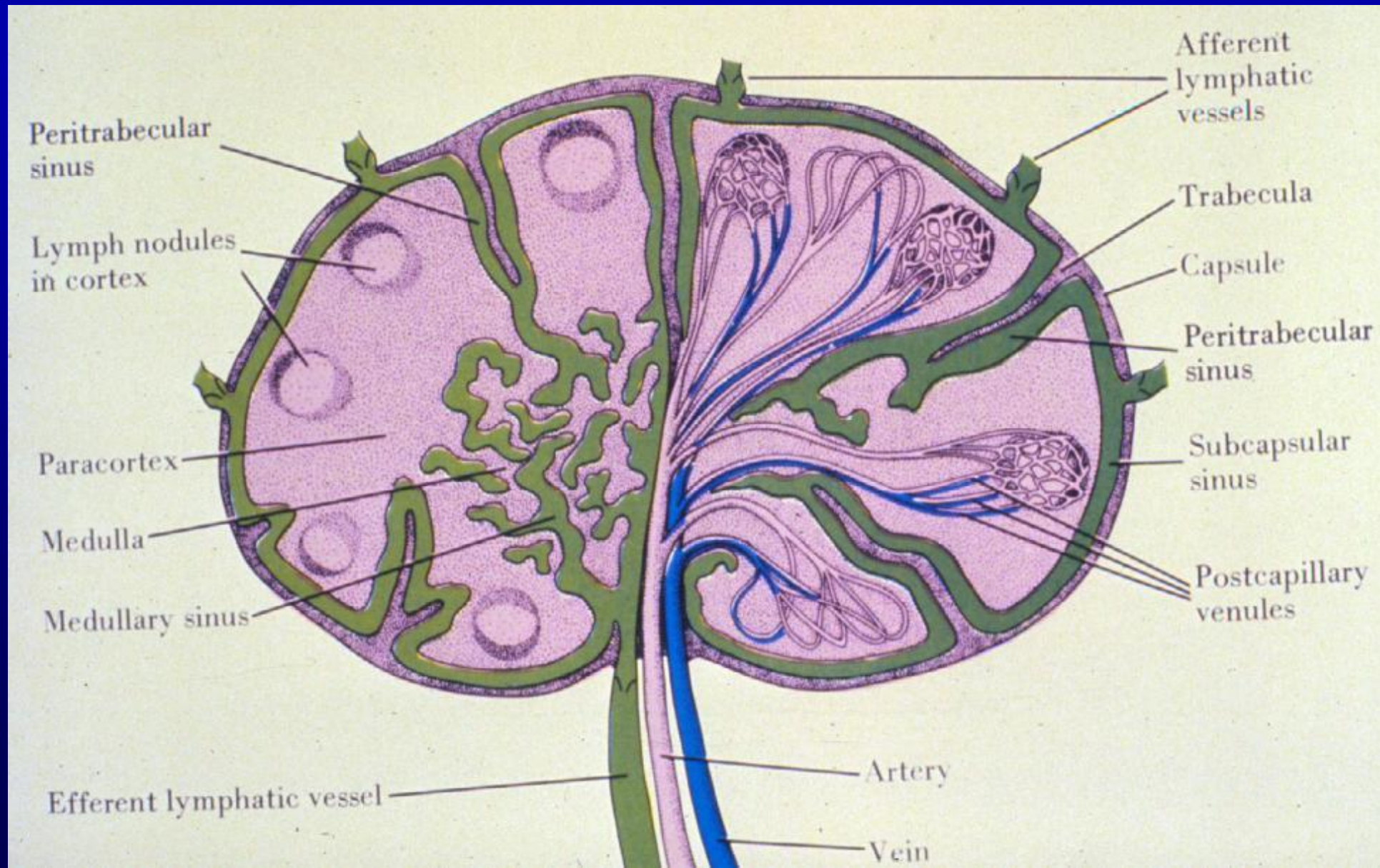


**Lymph Nodes –  
filtration  
of lymph to allow  
potentially active  
lymphocytes to  
see/respond to its  
antigen if present in  
the lymph**





# Lymph Node - Summary

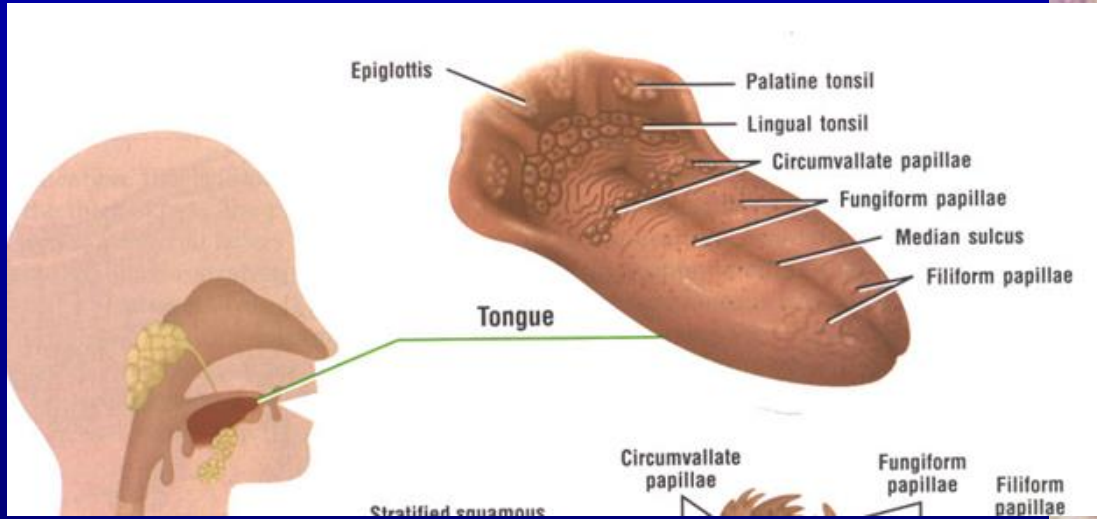




# Lymphoid Tissue

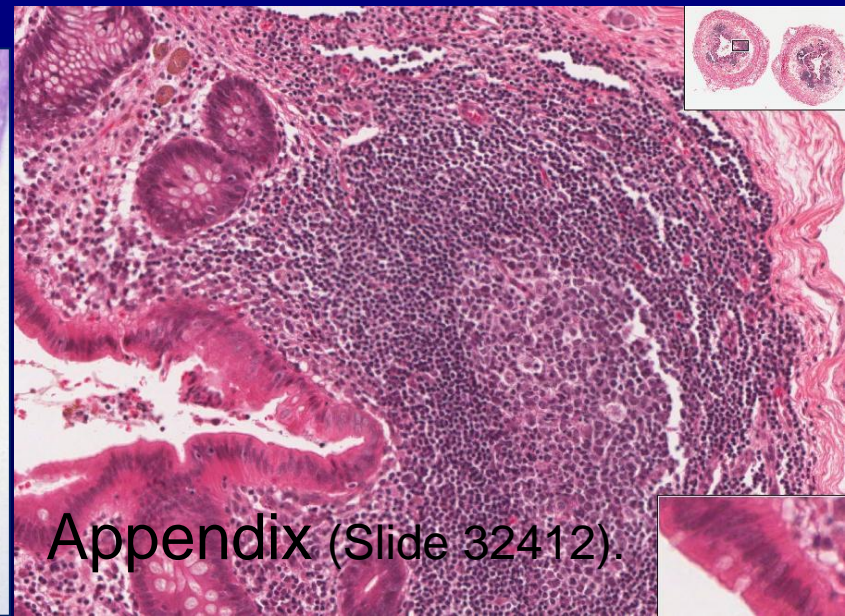
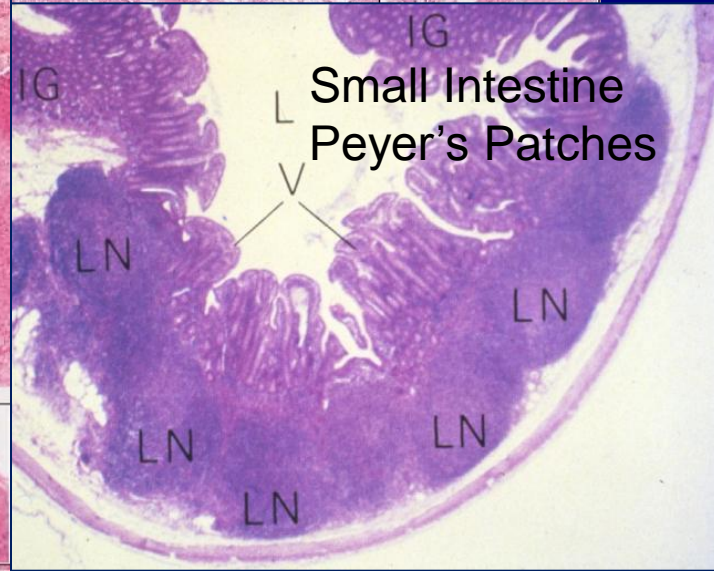
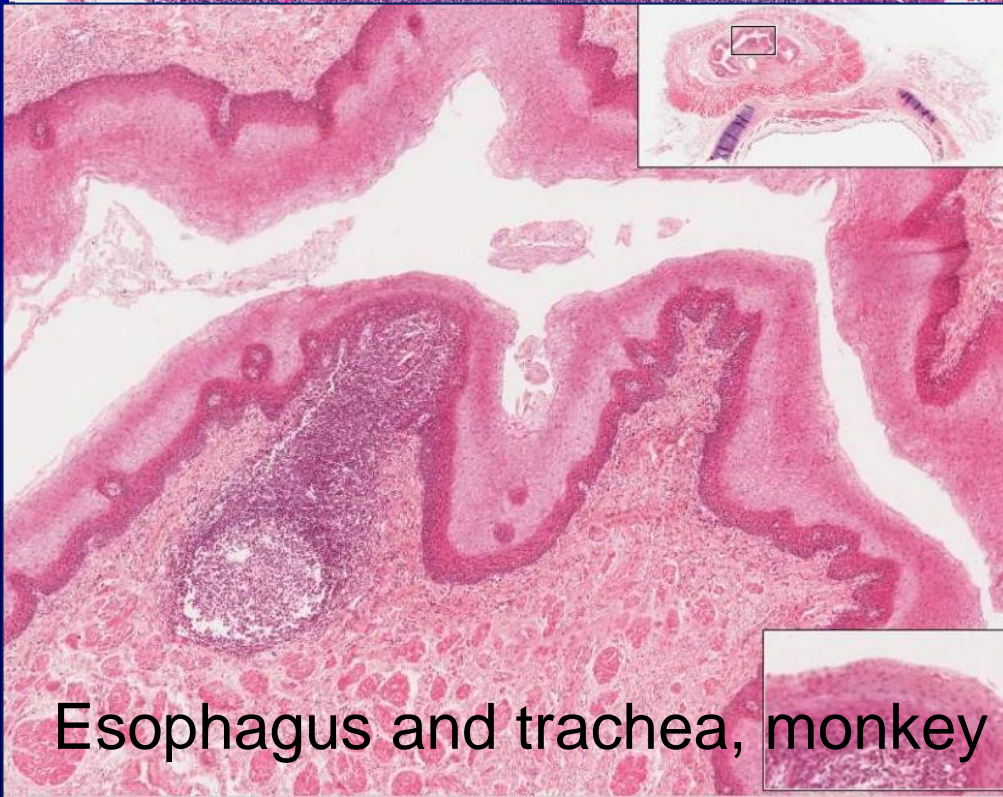
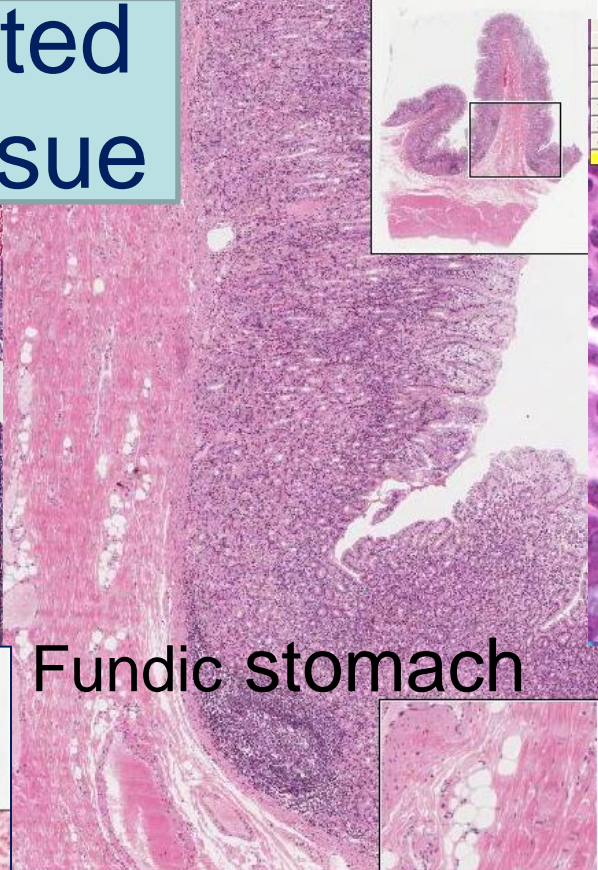
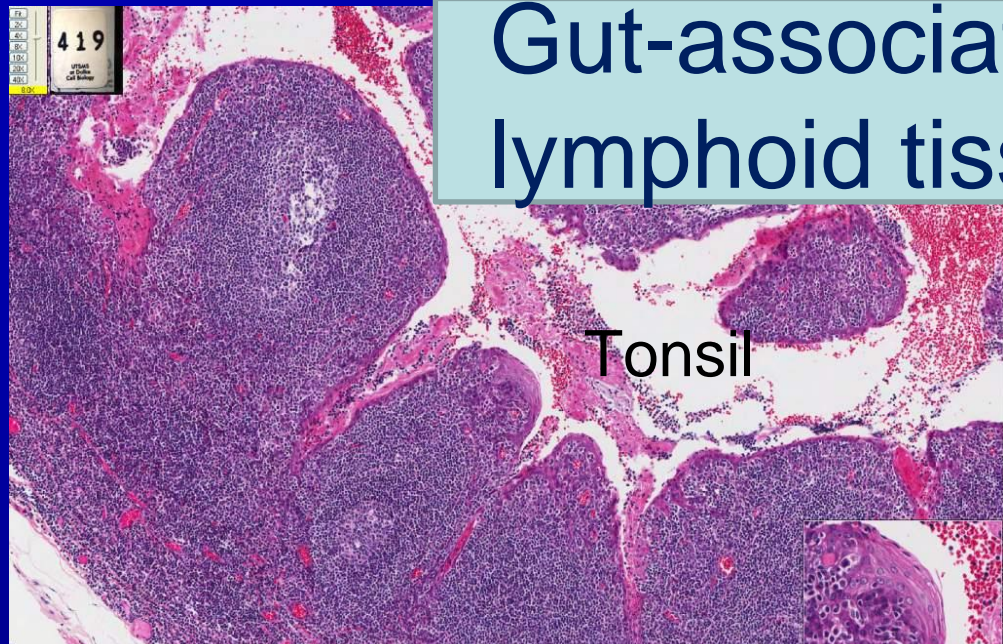
## Gut-associated lymphoid tissue

### – Tonsils





# Gut-associated lymphoid tissue

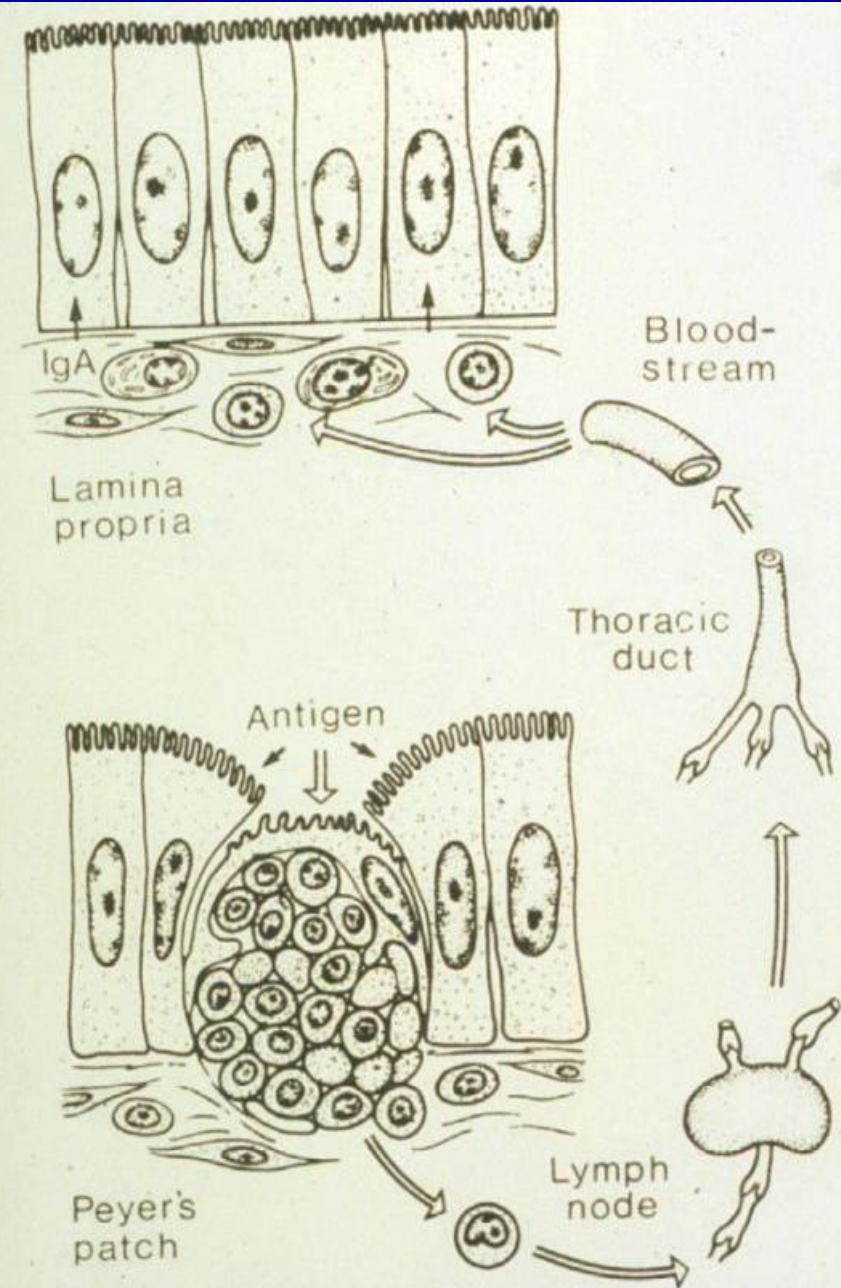




# Peyer's Patches

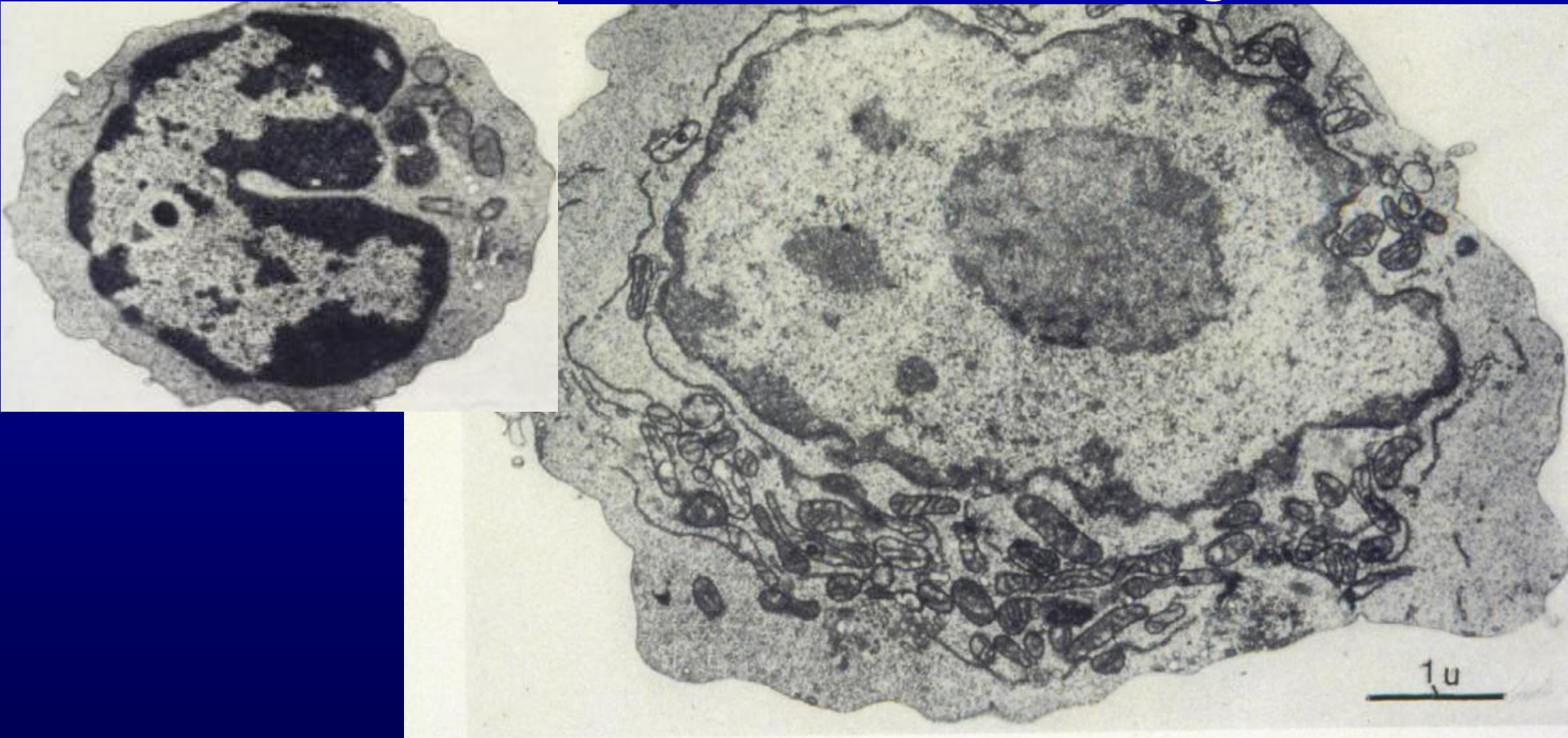


**Figure 26-14.** Surface view of a group of lymphoid follicles in the intestinal mucosa. Villi are lacking over the dome of the follicles. (Scanning micrograph from Komuro, T. and Y. Hashimota. 1990. *Cell Tissue Res.* 239:183.)



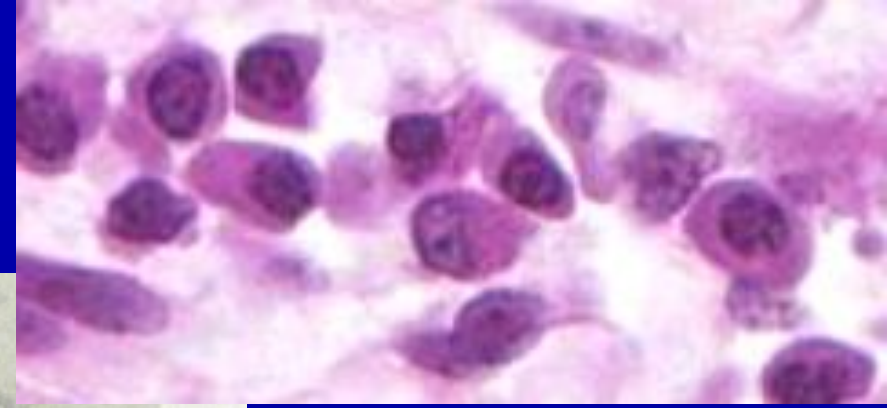


# Activated Lymphocyte that has seen its antigen

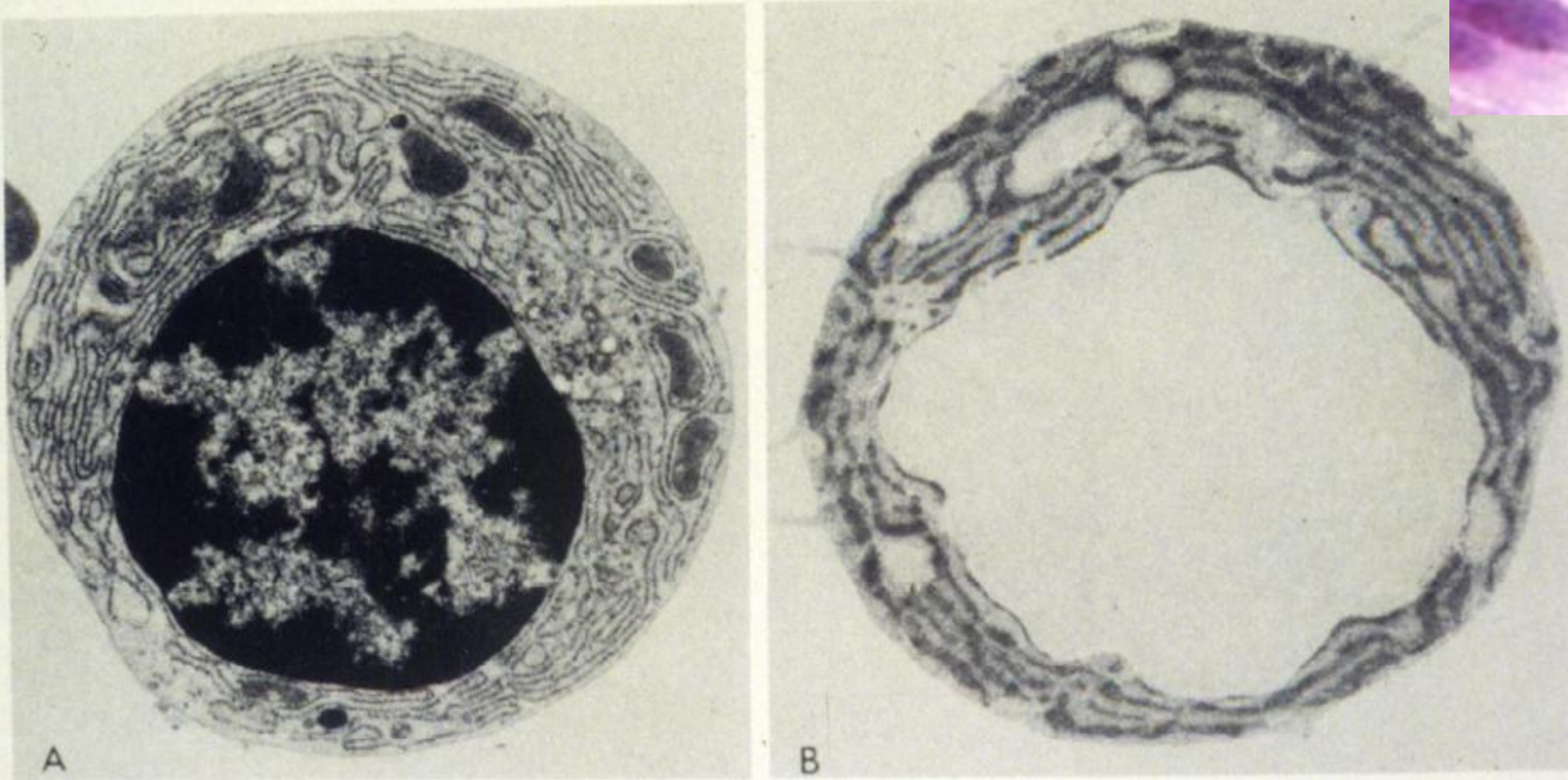


**Figure 13-4.** Electron micrograph of a lymphoblast showing the large nucleolus, numerous mitochondria, and a few profiles of endoplasmic reticulum.





## Plasma cells

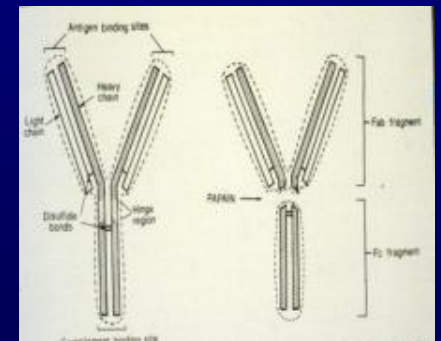


**Figure 13-7.** (A) Electron micrograph of a plasma cell from the rat spleen. The cytoplasm displays a highly developed rough endoplasmic reticulum. (B) Plasma cell from the spleen of a rabbit, which was injected with horseradish peroxidase, used as an antigen. (B) The spleen cells were subsequently exposed to the peroxidase antigen and stained by the histochemical reaction for demonstrating peroxidase activity. The dense reaction product is seen in the cisternae of endoplasmic reticulum, indicating the presence of anti-peroxidase antibody. (Micrograph courtesy of E.D. Leduc and S. Avrameas.)



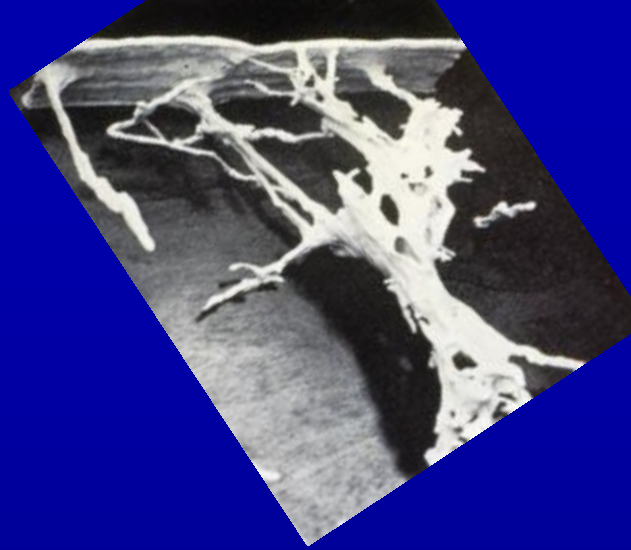
# Roles and Specific Actions of Antibodies in Immunity

- Complement - mediated lysis
- Opsonization - promote phagocytosis
- Toxin neutralization
- Prevention of microbial binding to mucosal surface
- Virus neutralization - interferes with cell penetration
- Degranulation of mast cells





# Spleen



**Overall structure**

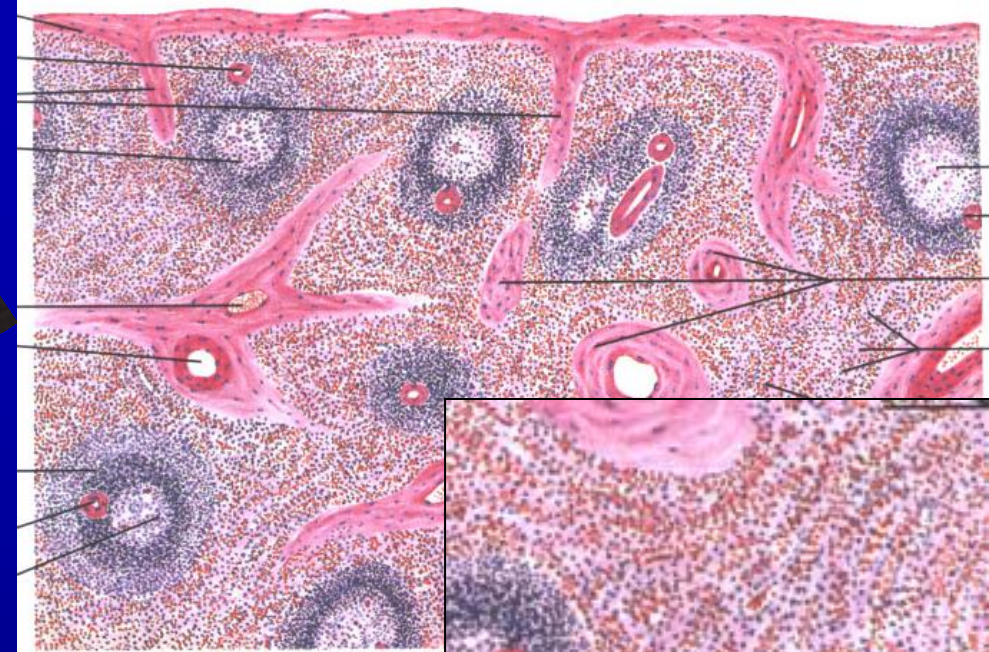
**Vascular arrangement**

**White pulp**

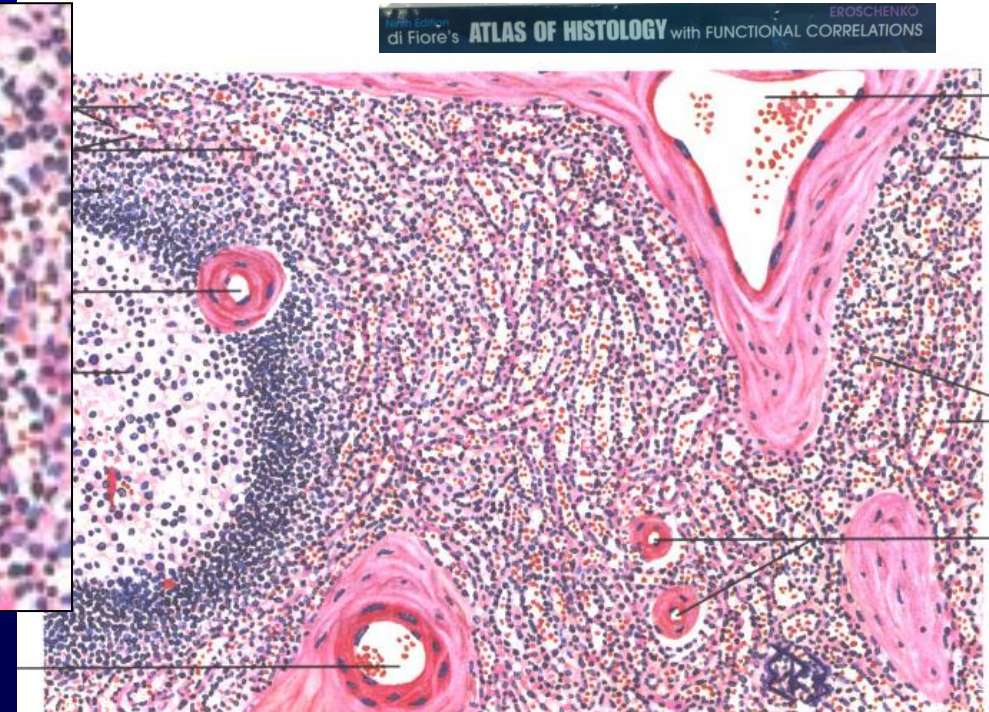
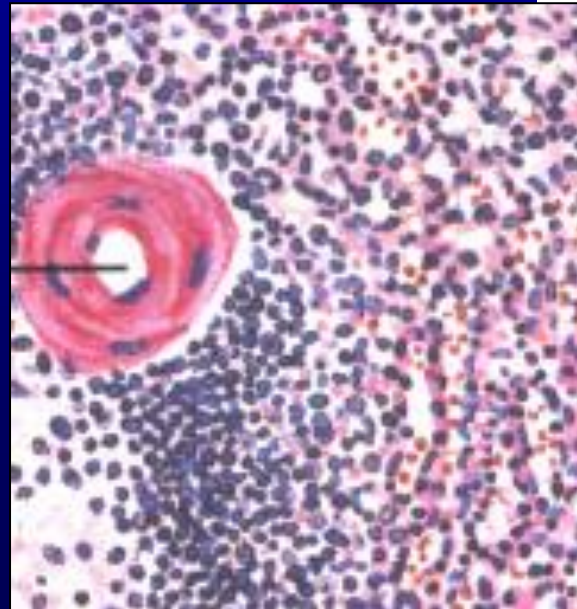
- Central artery
- Periarteriolar lymphatic sheath
- Follicles - B lymphocytes

**Red pulp**

- Venous sinuses
- Pulp cords (Billroth's strands/Cords of Billroth)
- Marginal zone



g. 8-8 Spleen (panoramic view)

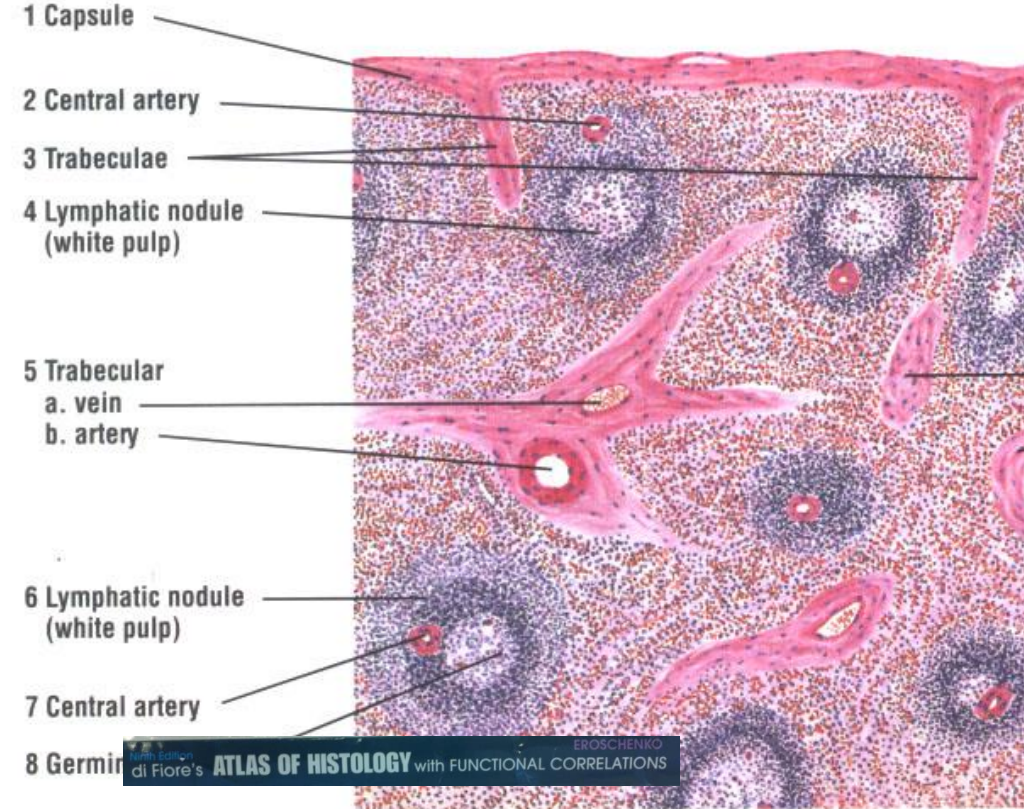
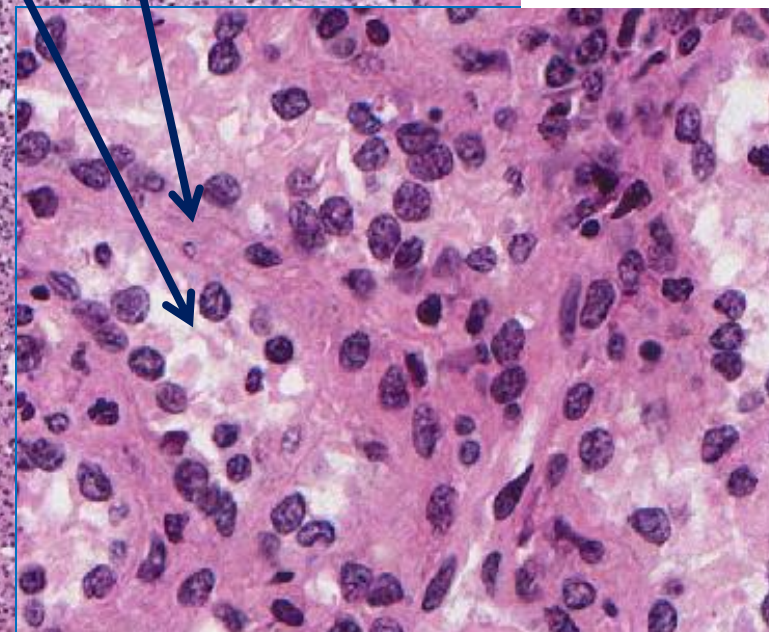
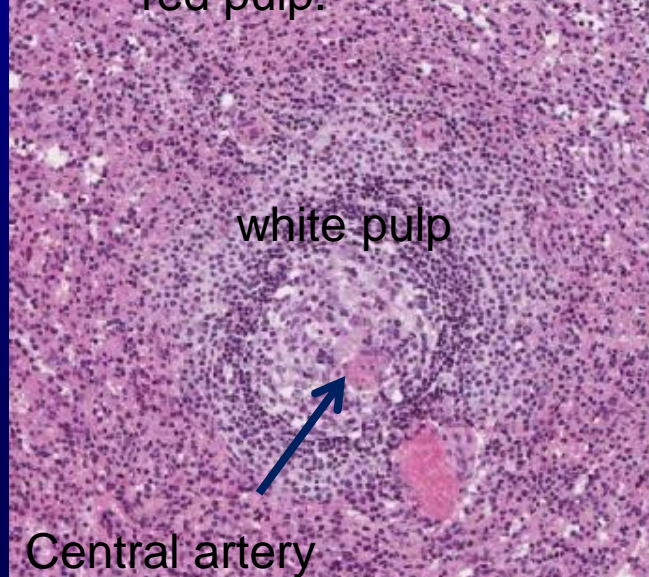
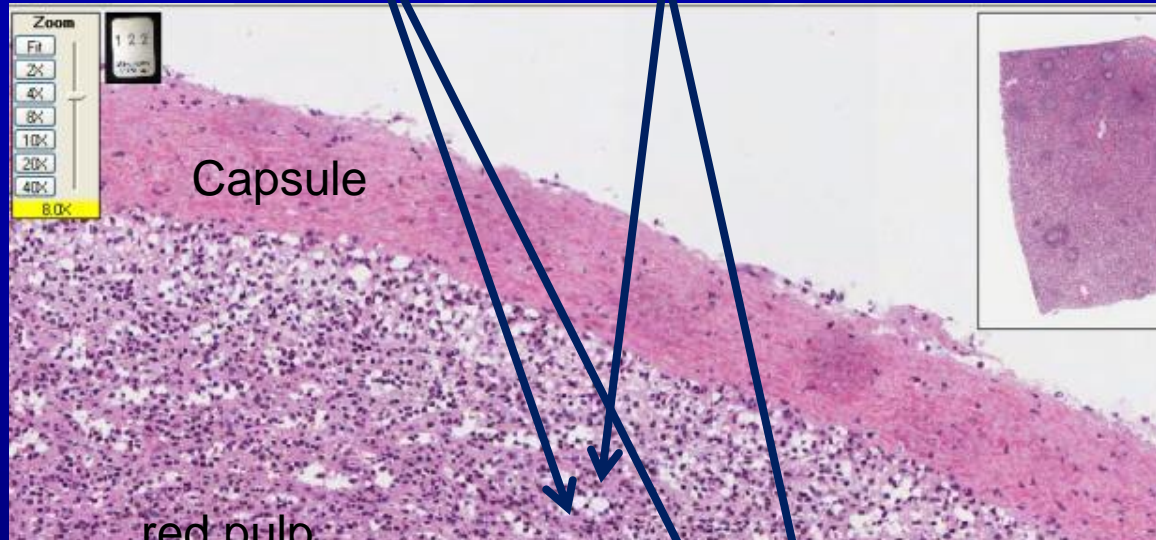


di Fiore's **ATLAS OF HISTOLOGY** with FUNCTIONAL CORRELATIONS EROSCHENKO



# Spleen

Venous sinuses and Billroth's strands



Primary function of the spleen is filtration of blood.

Spleen has no afferent lymphatics so it can not filter the lymph



# Spleen

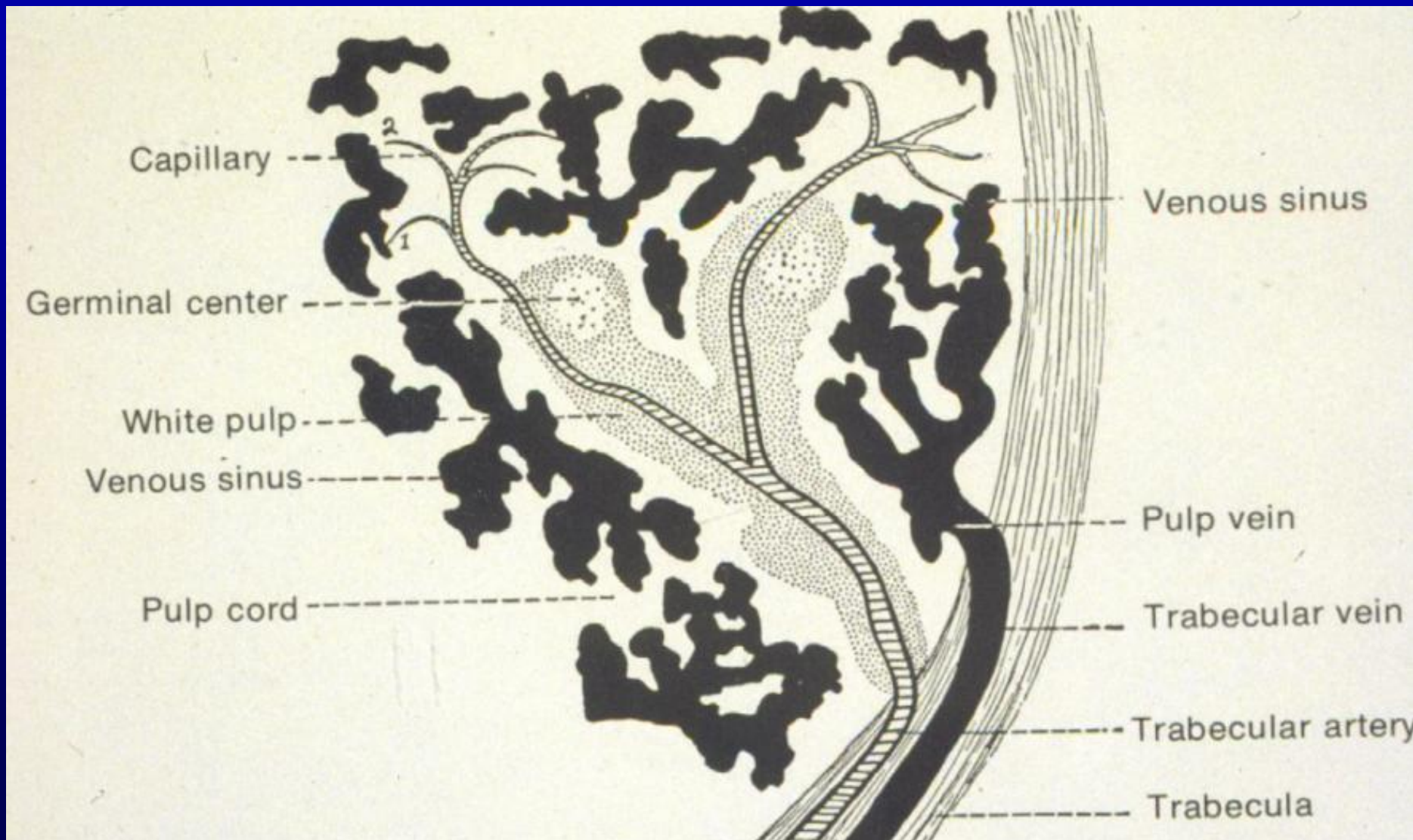
## Blood flow

- Filtration
- Removal of old red blood cells

Two circulation options in spleen

Closed circulation is typical of that in other organs

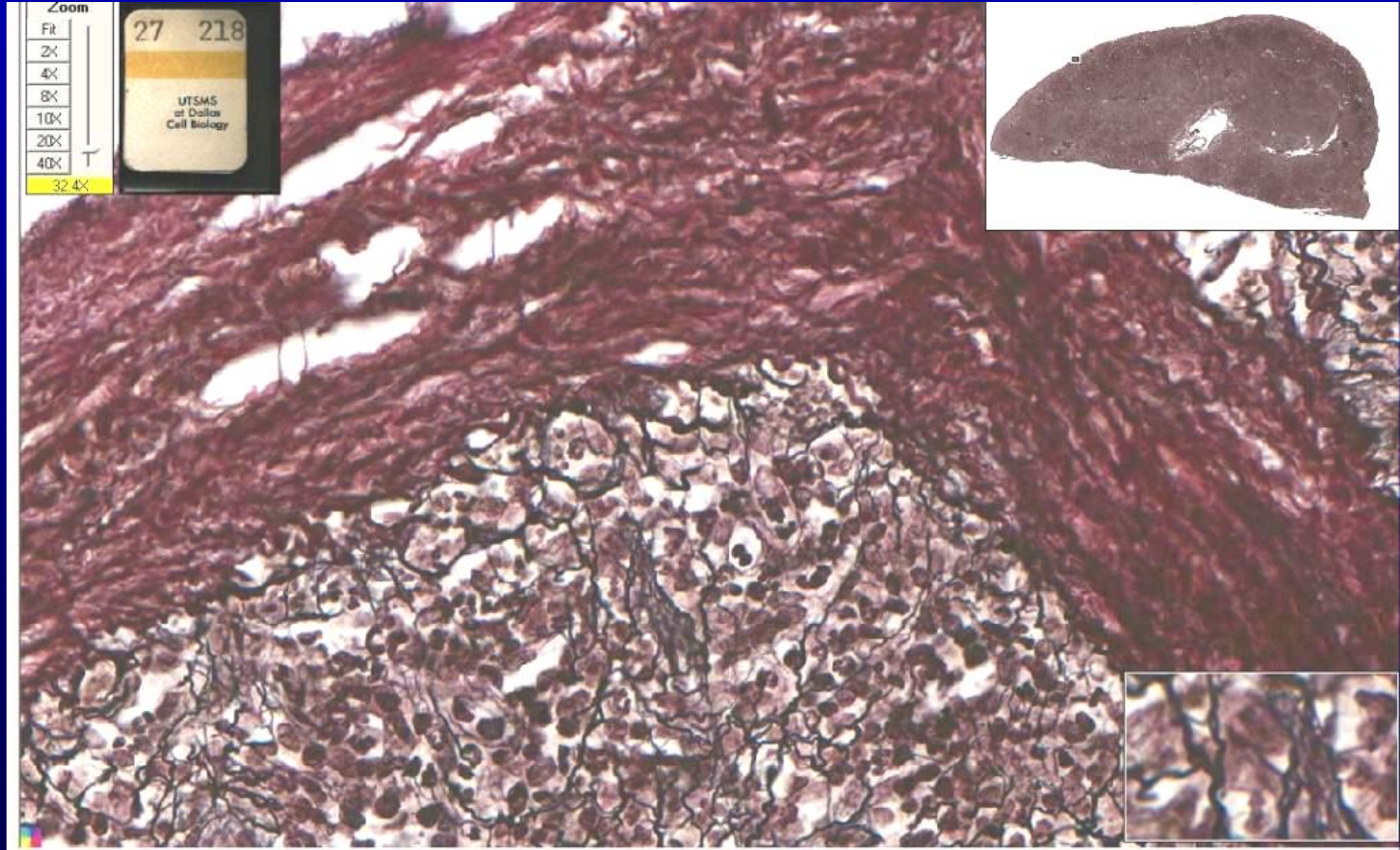
Open circulation that is unique to the spleen





218

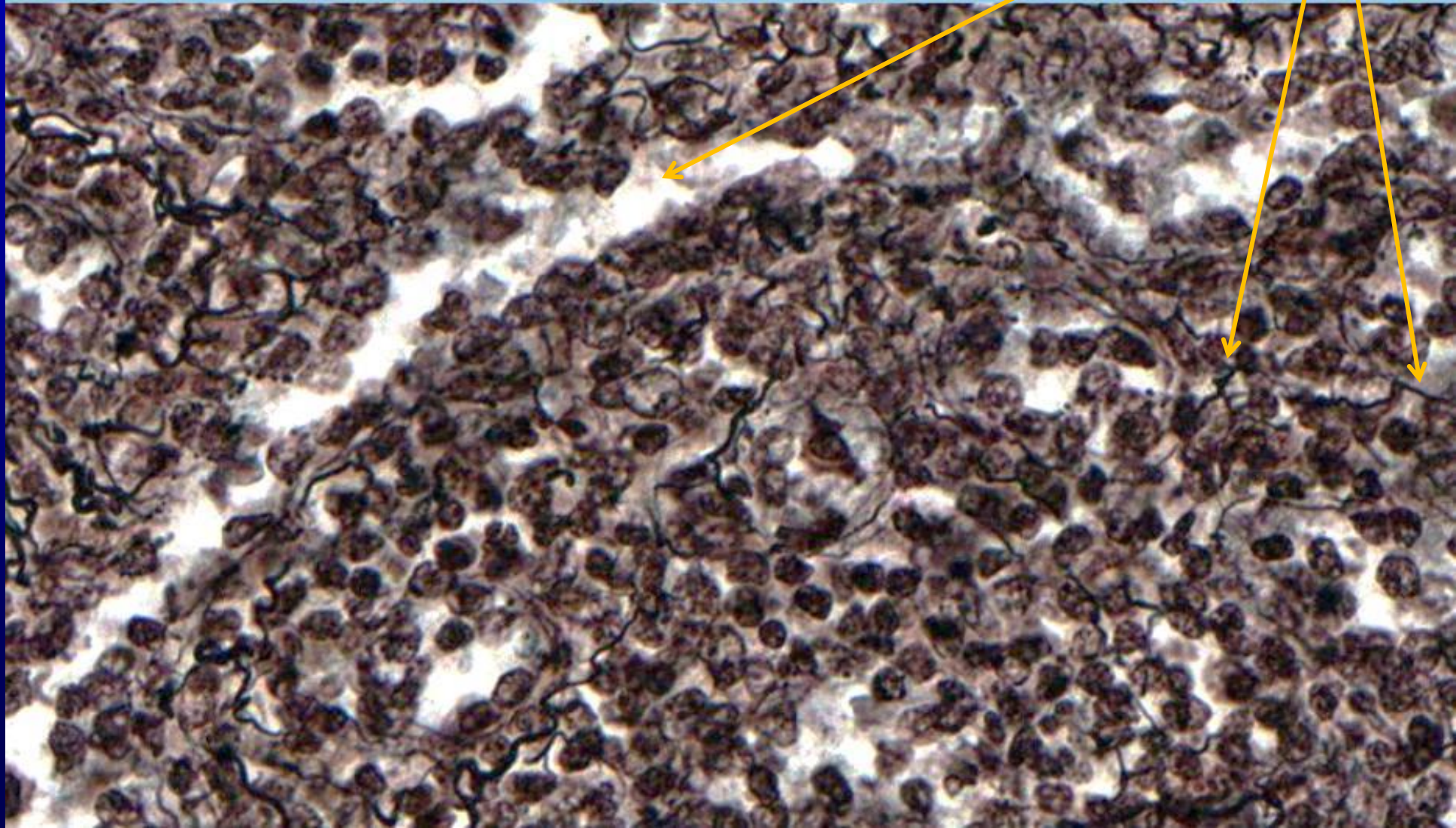
# Spleen (reticulum stain)- capsule and reticulum fibers





218

Spleen (reticulum stain)- reticulum fibers in strands between venous (blood) sinus





# Spleen

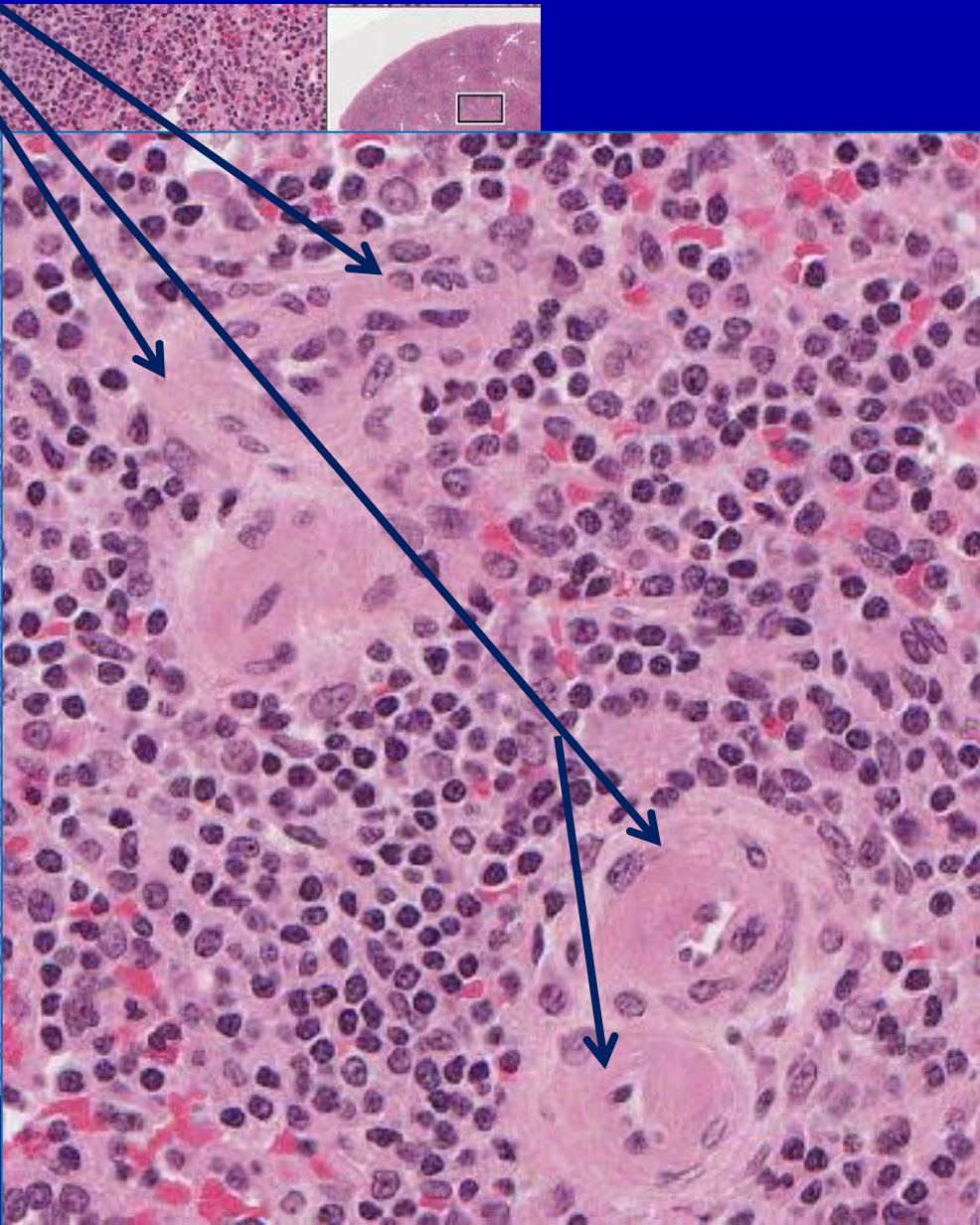
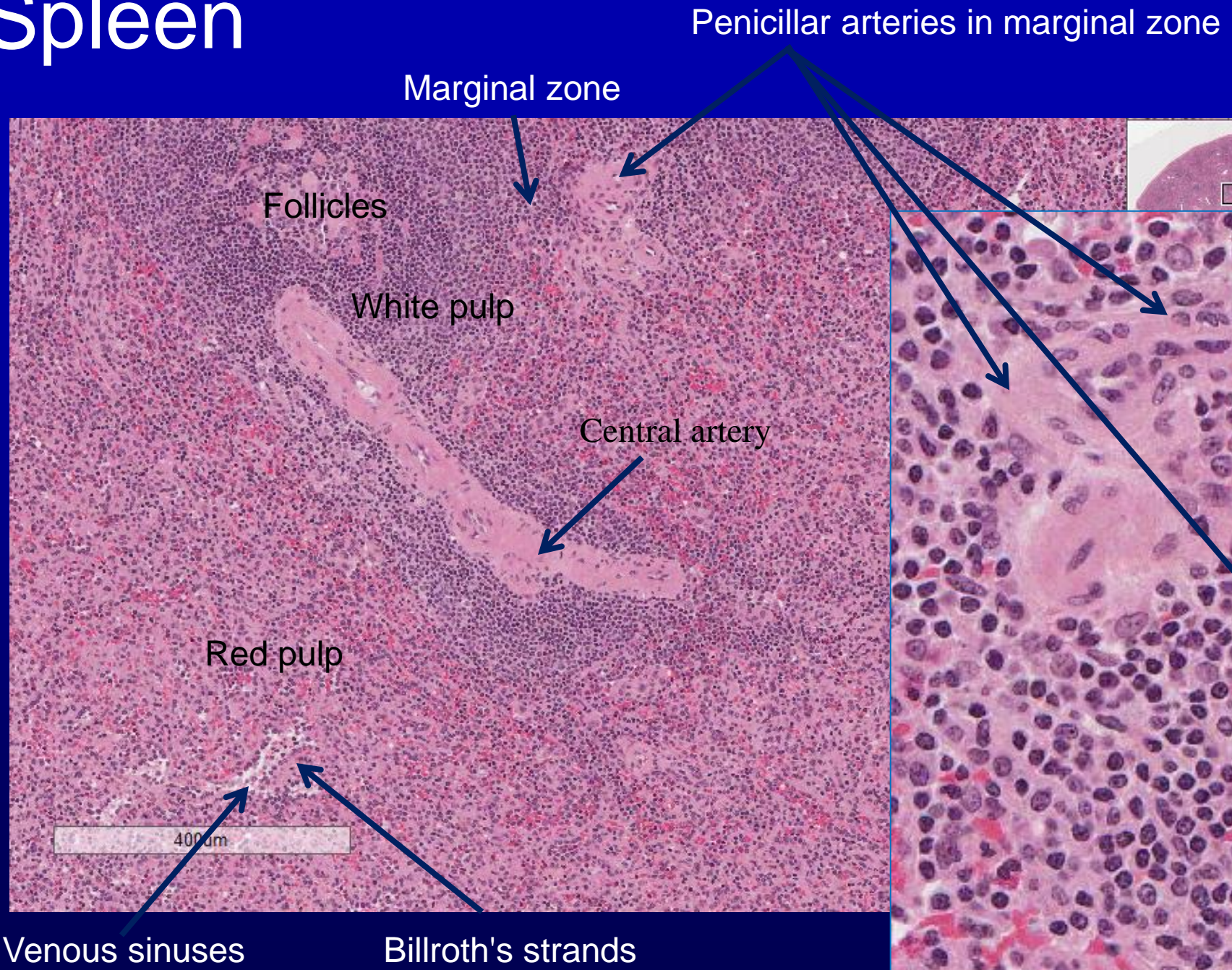
Red Pulp

White  
Pulp





# 117 Spleen



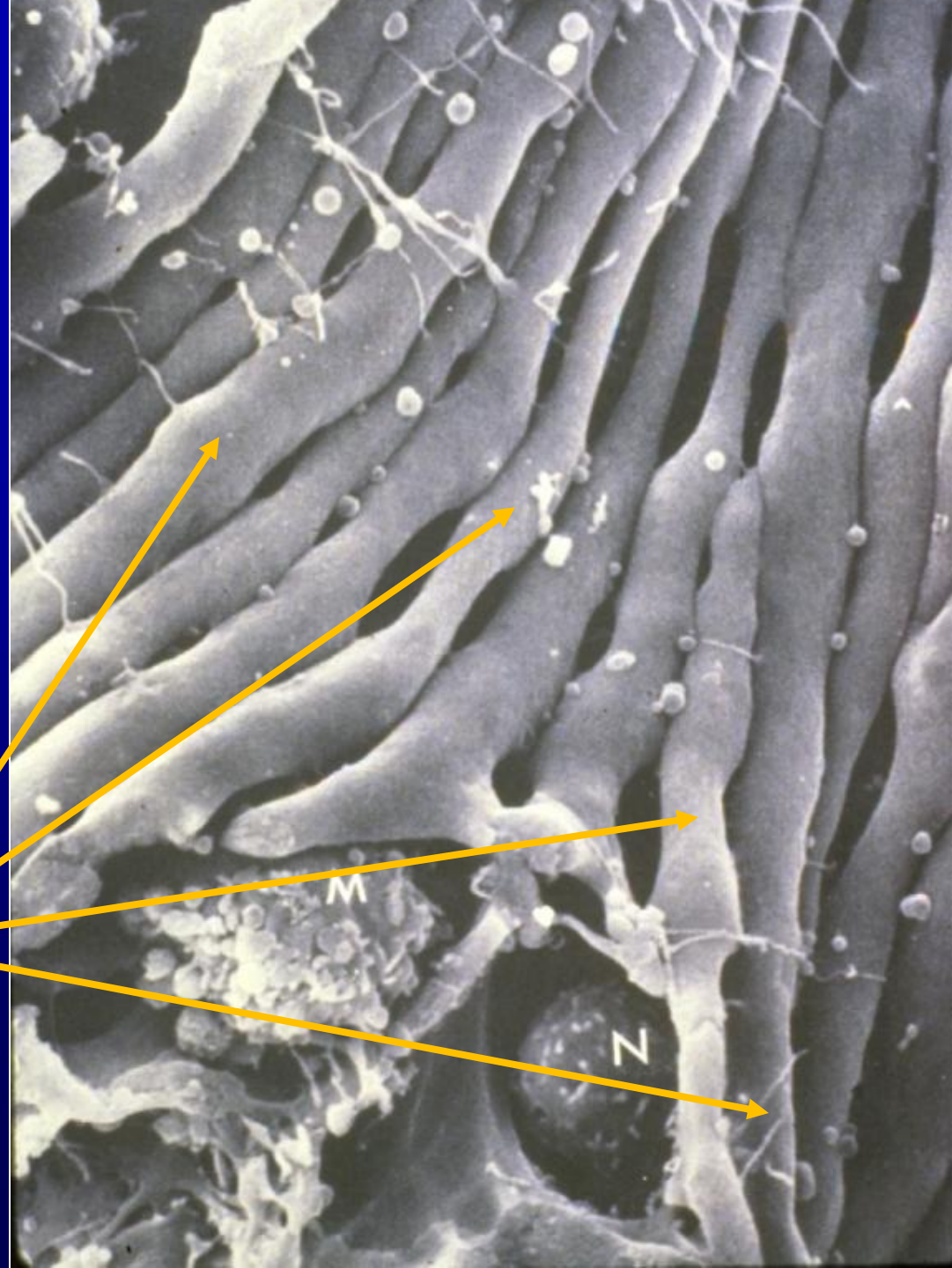


# Spleen

## Blood flow

- Filtration
- Removal of old red blood cells

**Littoral cells:** picket-fence type endothelial cells of vascular sinus

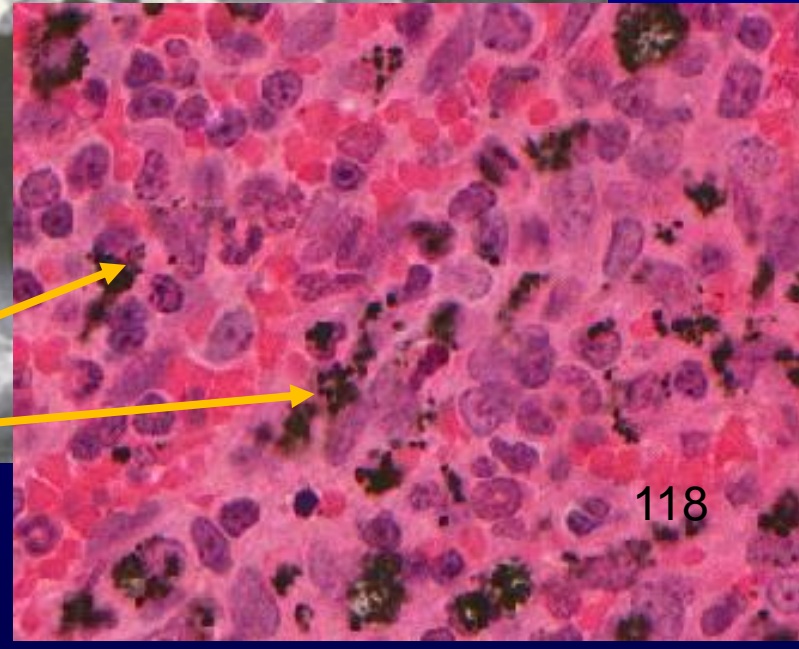
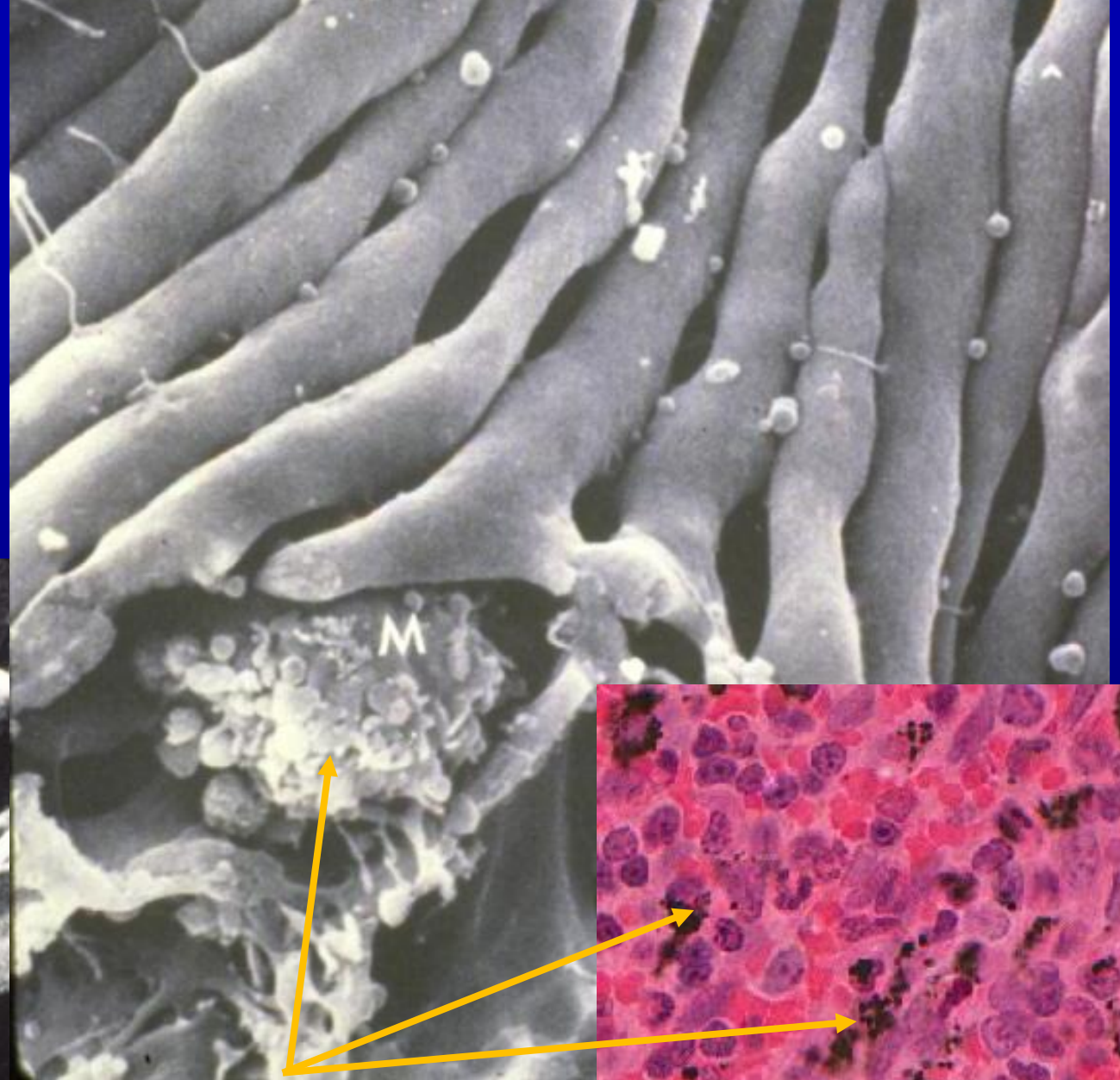




# Spleen

## Blood flow

- Filtration
- Removal of old red blood cells



Macrophages in the splenic cords

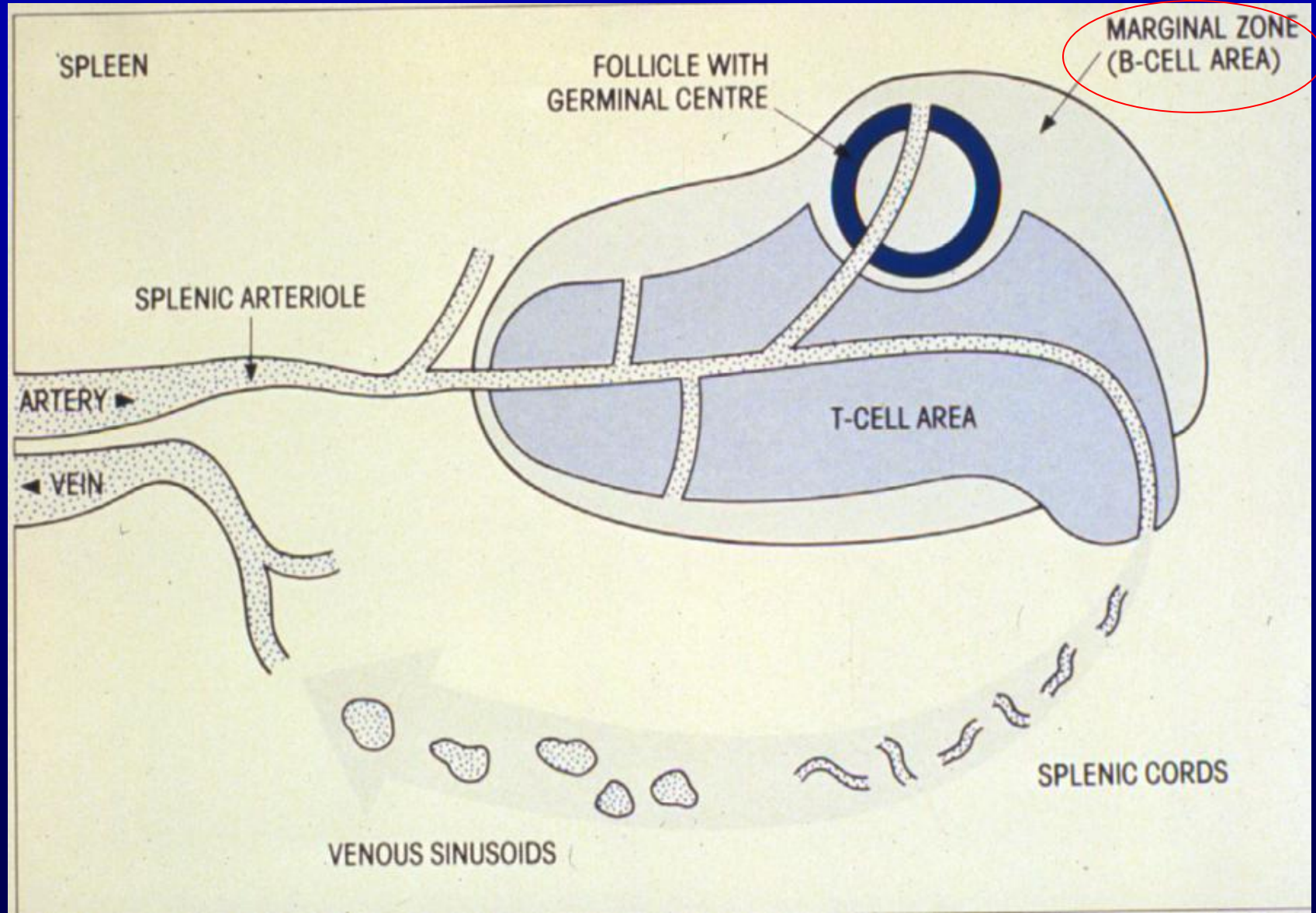






# Spleen

## White pulp

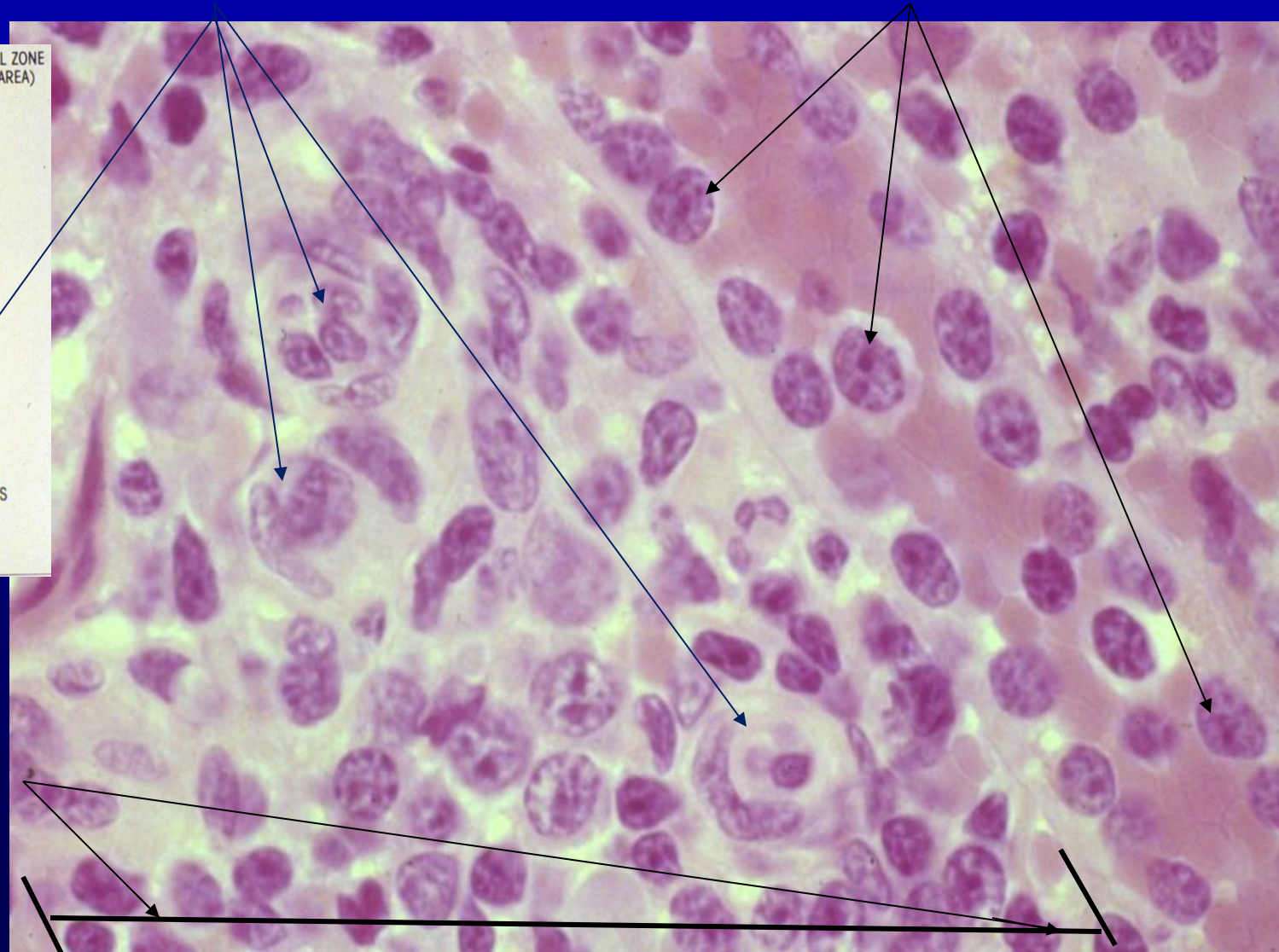
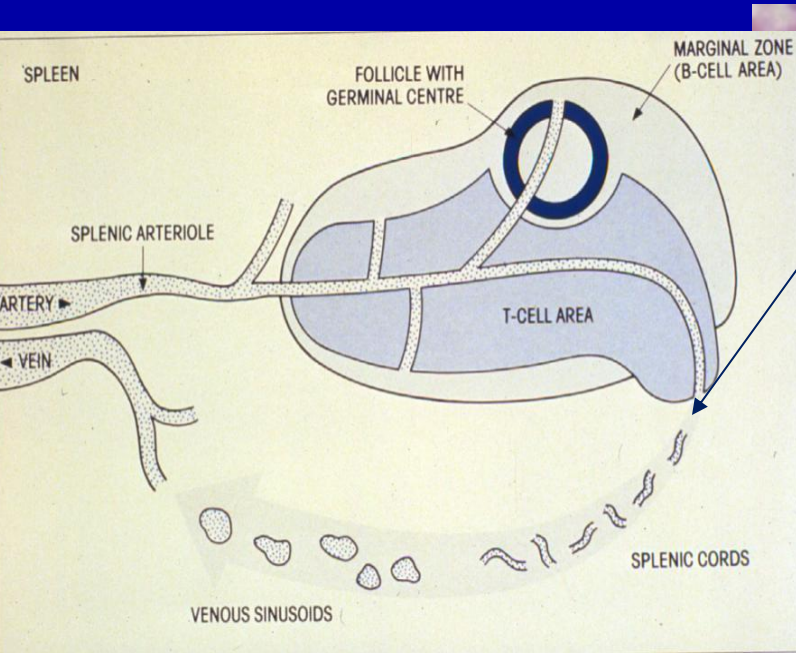




# Spleen

Penicillar arteries

Littoral cells: picket-fence type endothelial cells of vascular sinus



Billroth's strand or splenic strand



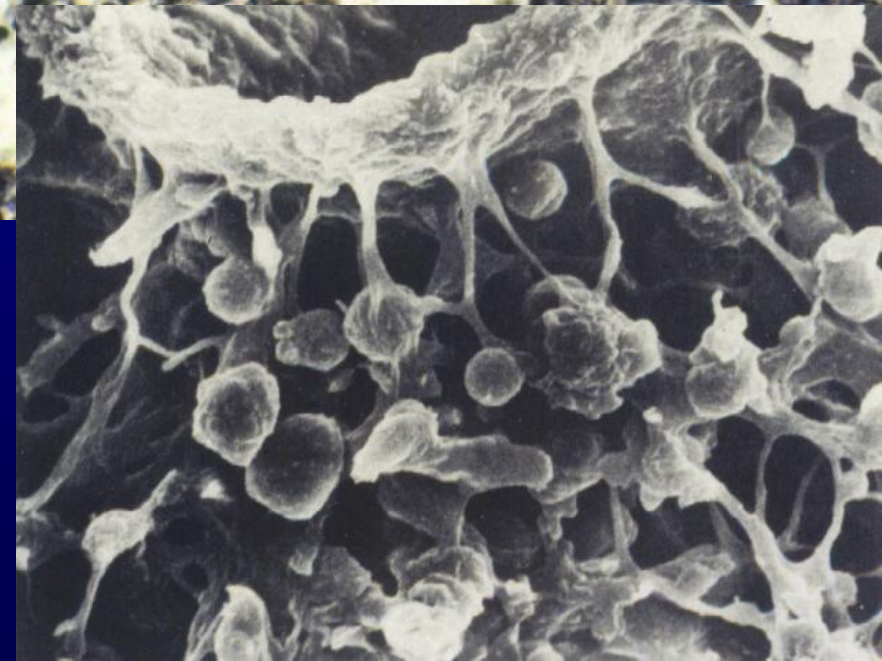
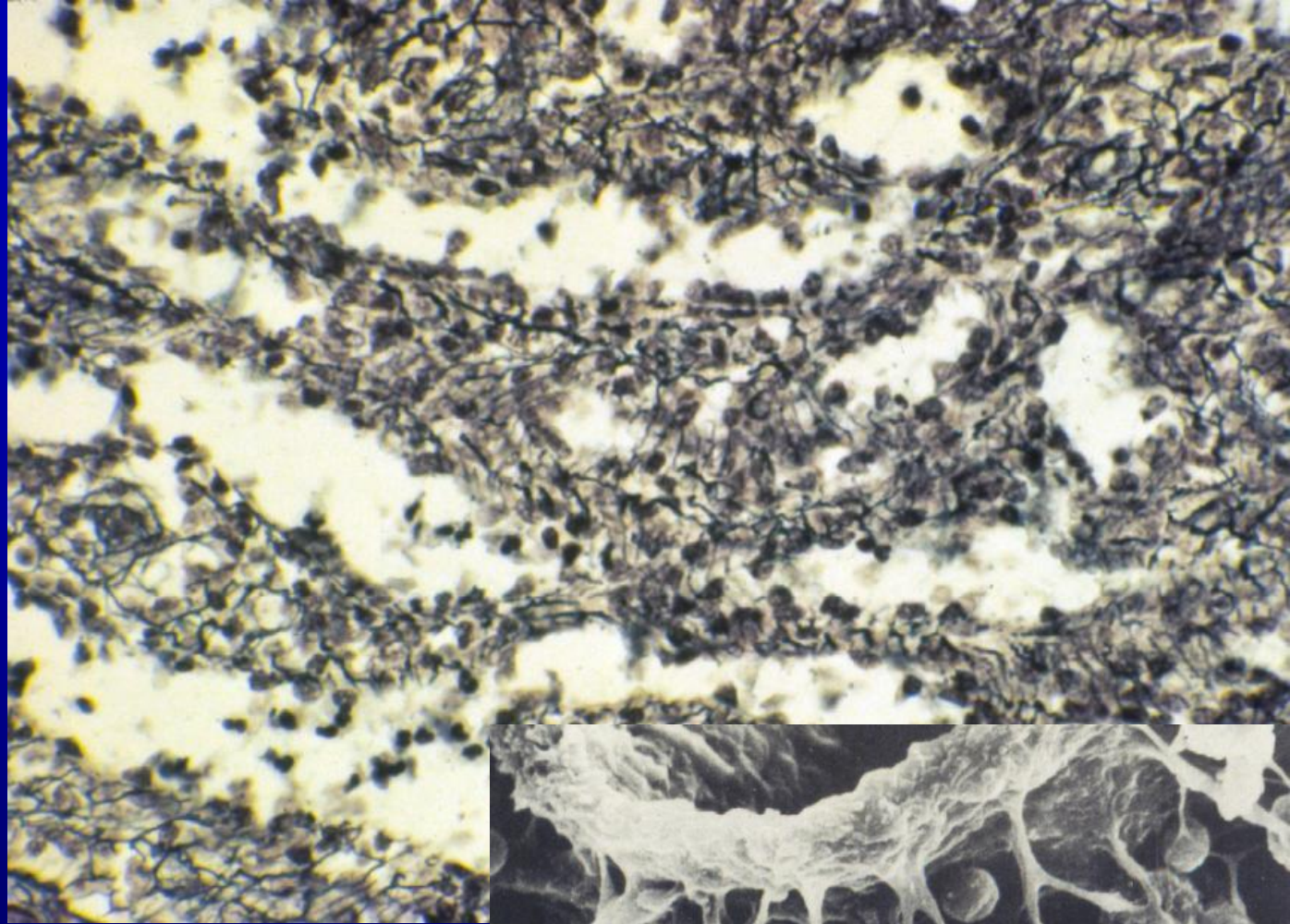
# Spleen

## Reticular fiber framework

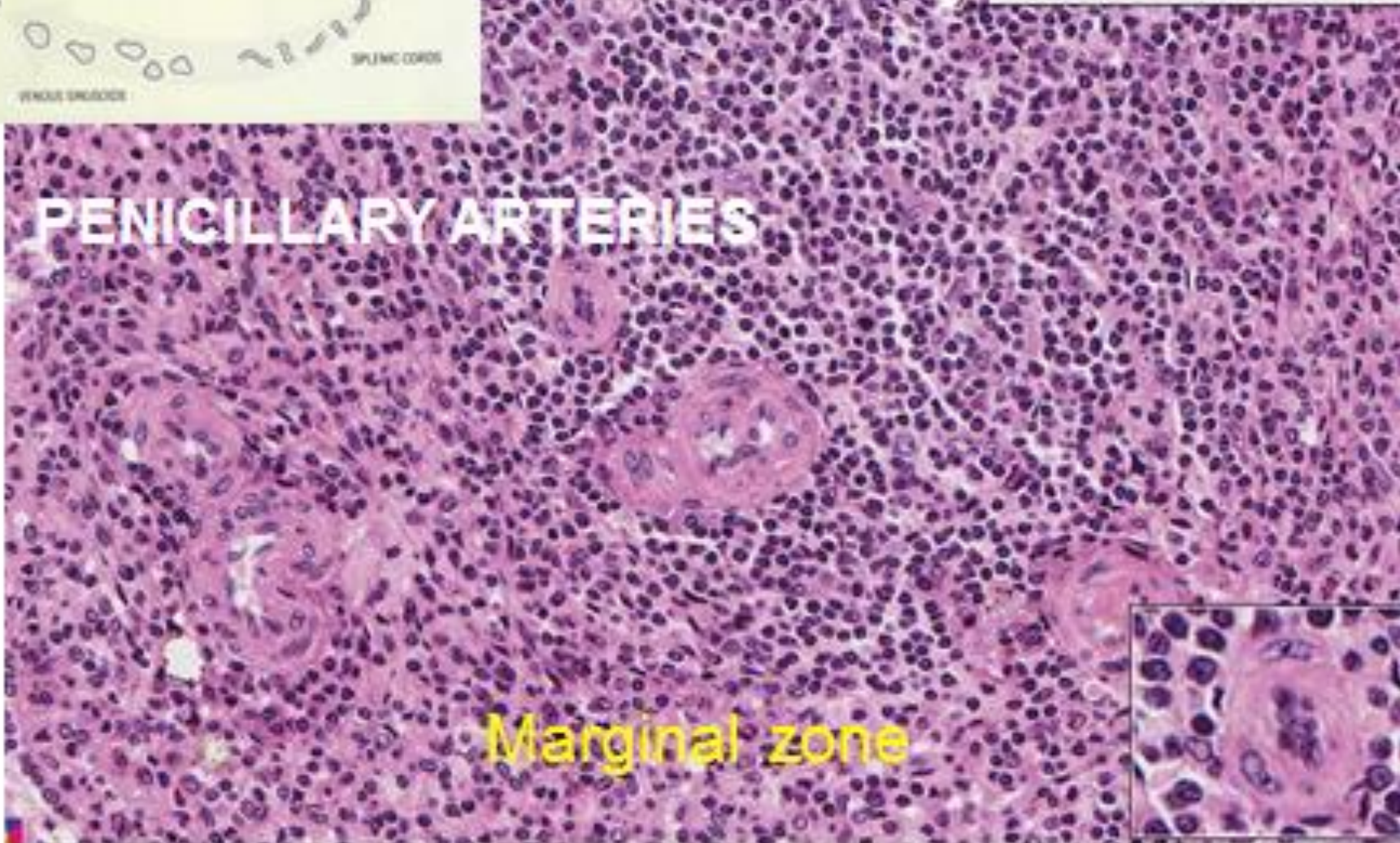
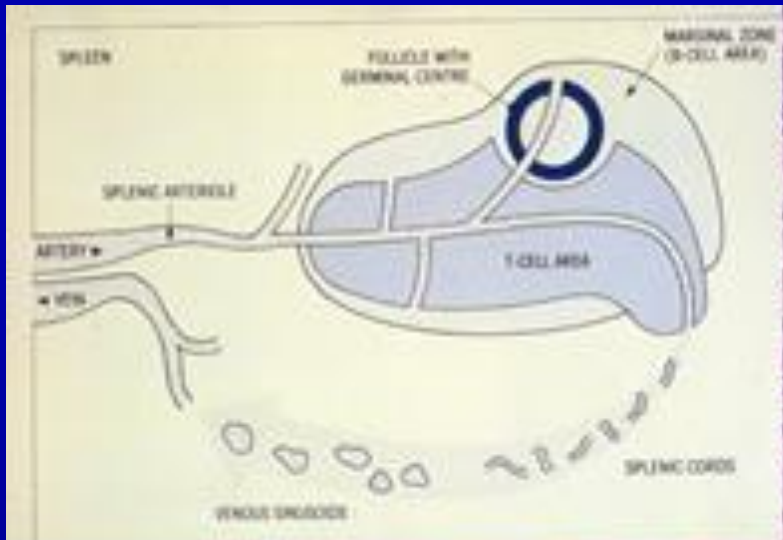
- Reticulum cell - mesoderm

## Blood flow

- Penicillar arteries
- Extravascular sojourn of blood cells
  - Filtration
  - Removal of old red blood cells
  - Pitting of reticulocytes







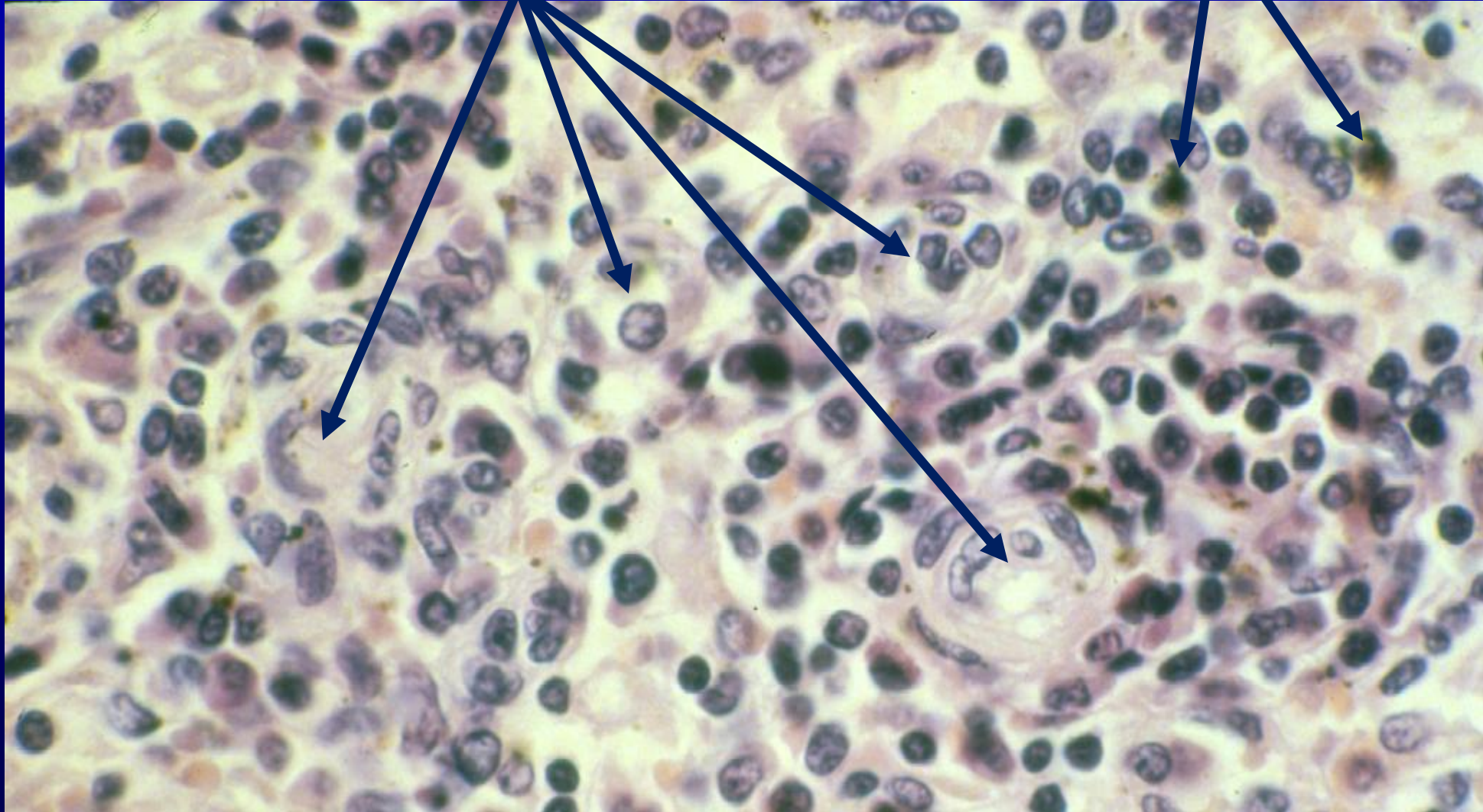


# Spleen

**Blood flow**

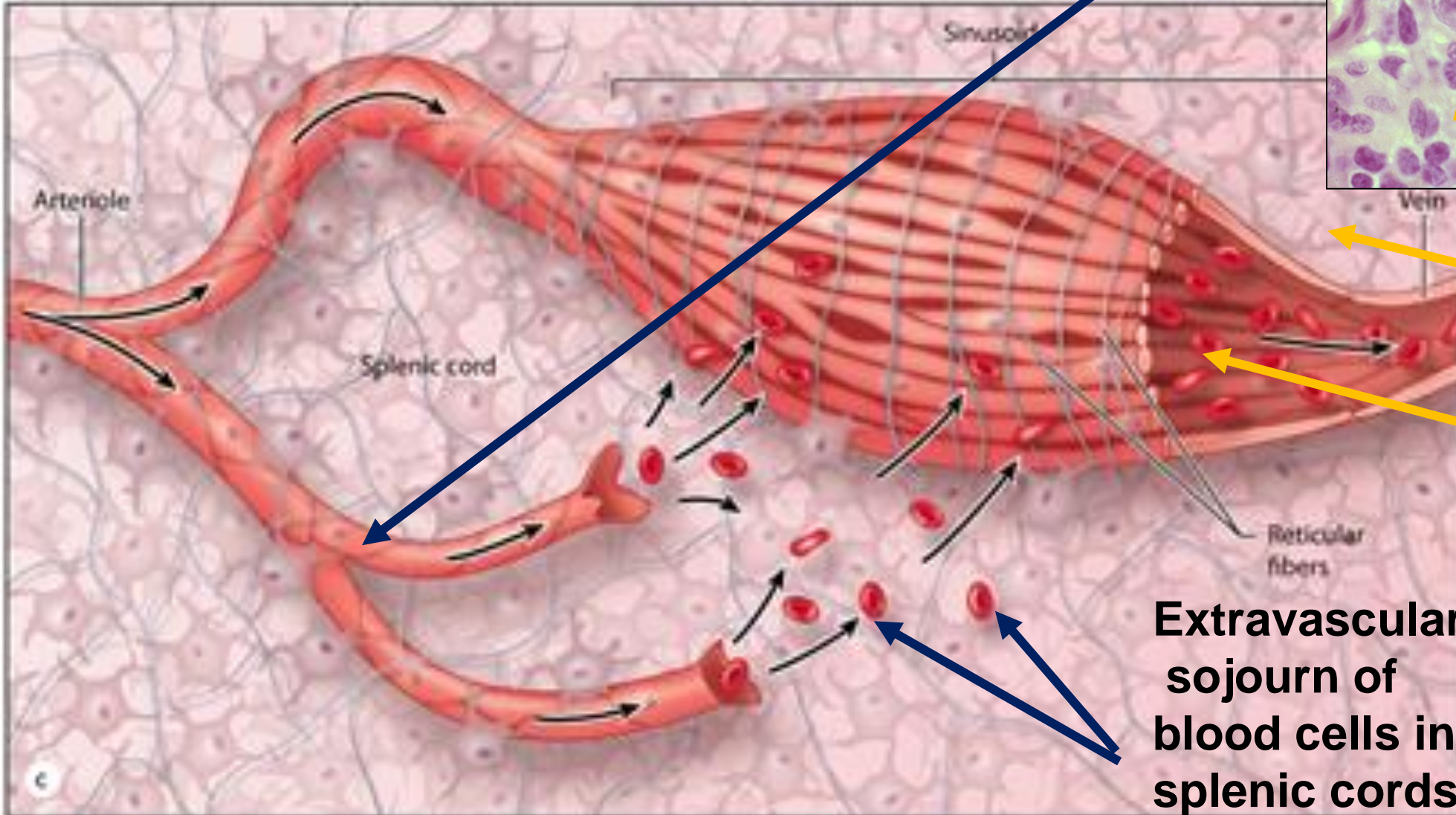
– Penicillar arteries

**Macrophages**

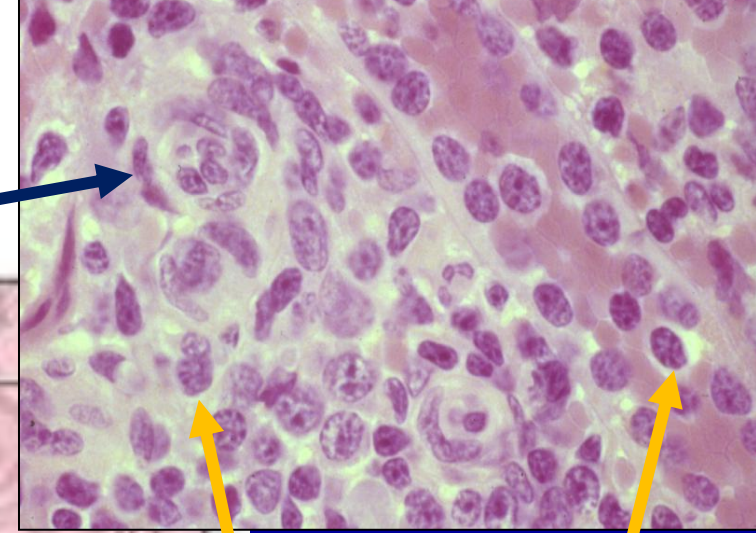




# Blood flow in spleen



Penicillar arteries



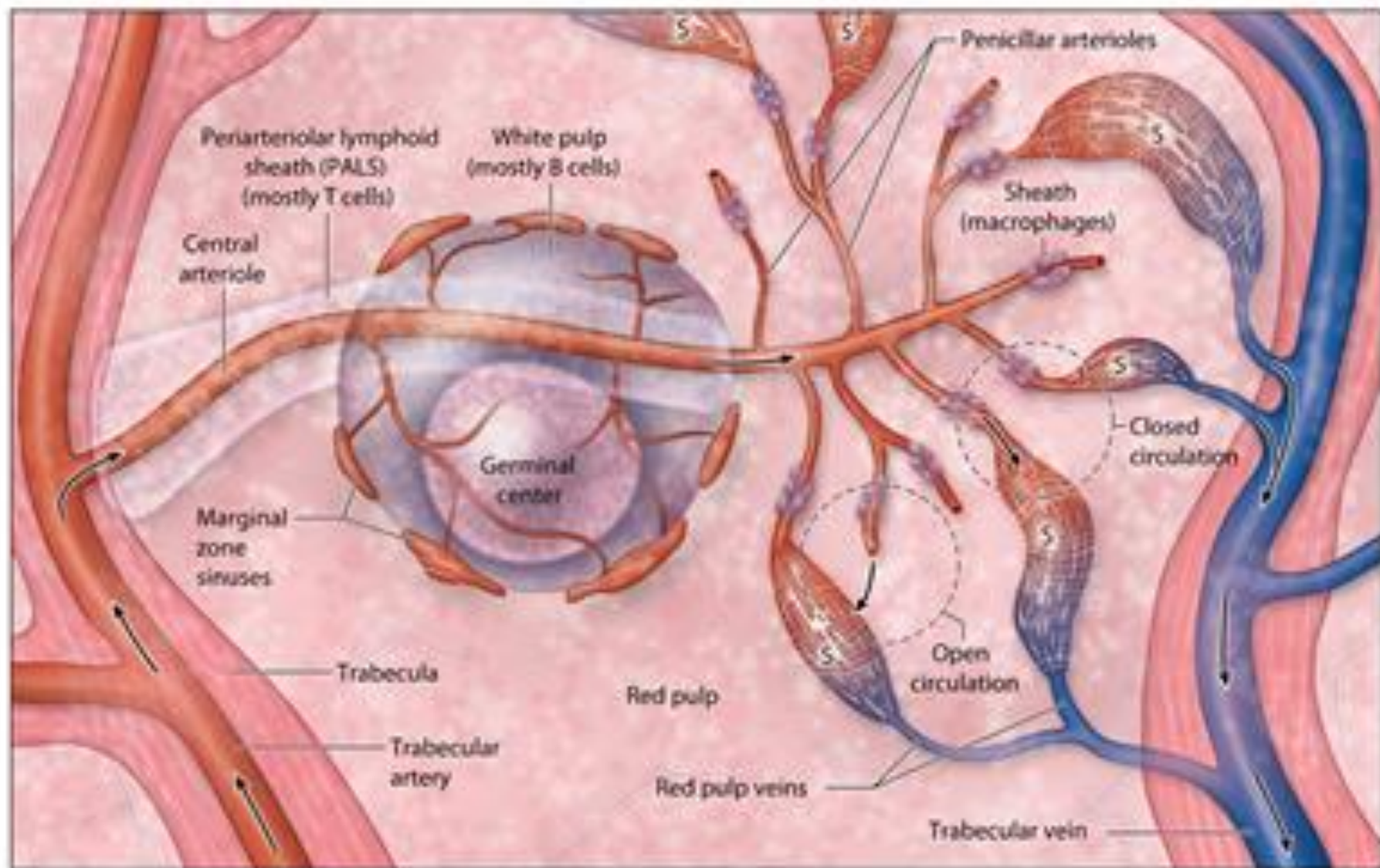
Splenic Cord

Sinusoid

Extravascular sojourn of blood cells in splenic cords

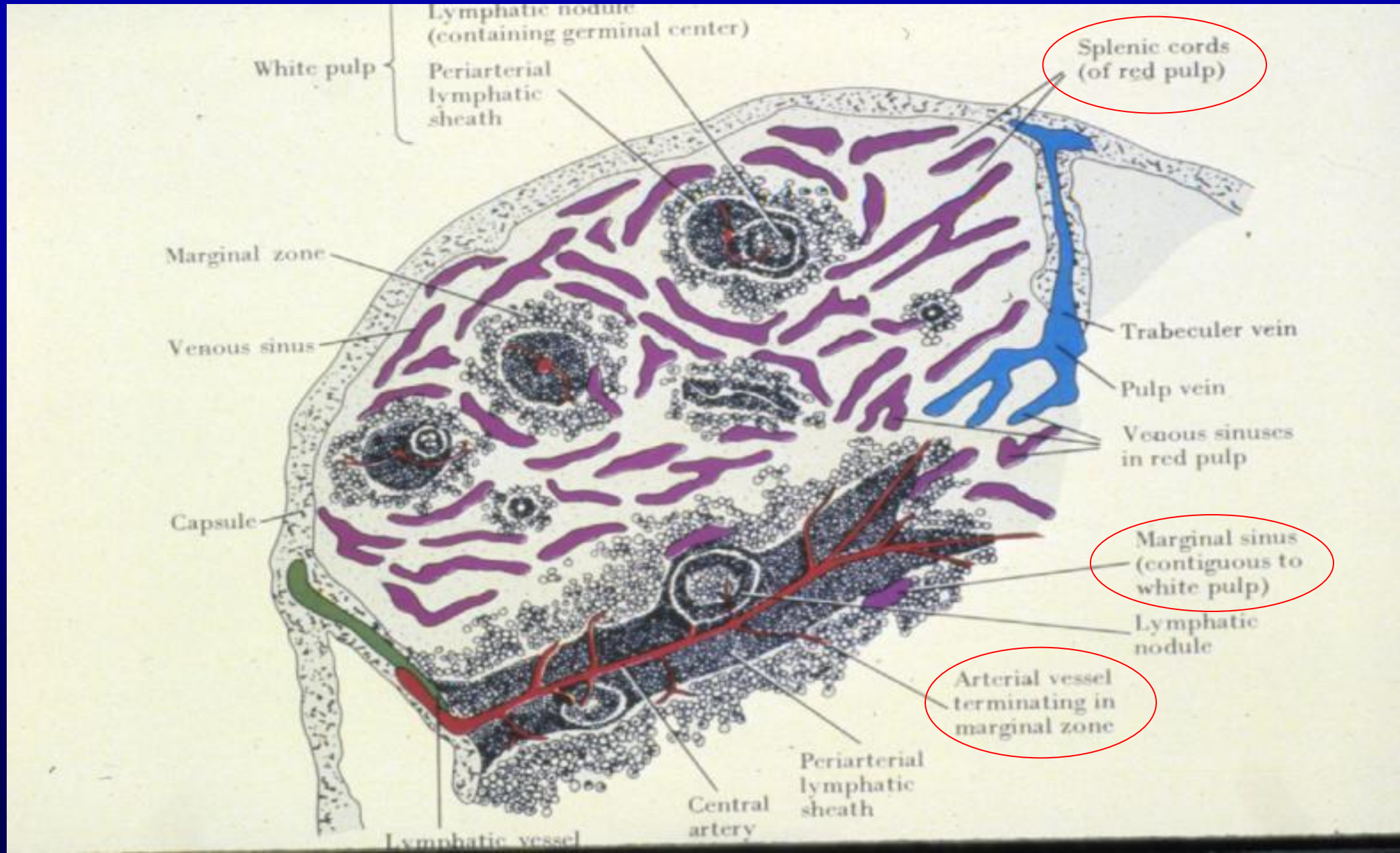


# Blood flow in spleen





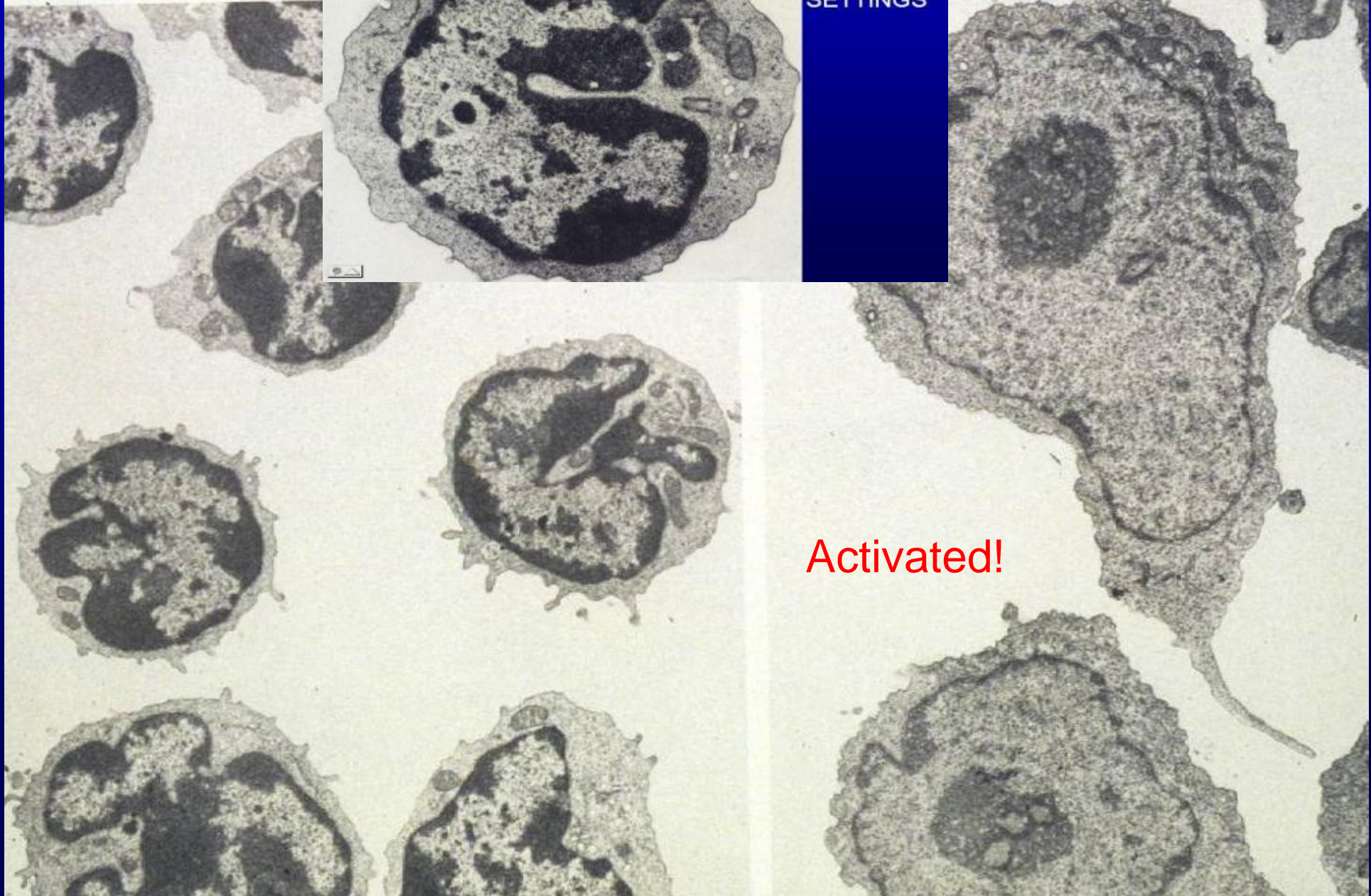
# Spleen





# MAIN PLAYER, THE LYMPHOCYTE

IN  
DIFFERENT  
SETTINGS



Activated!

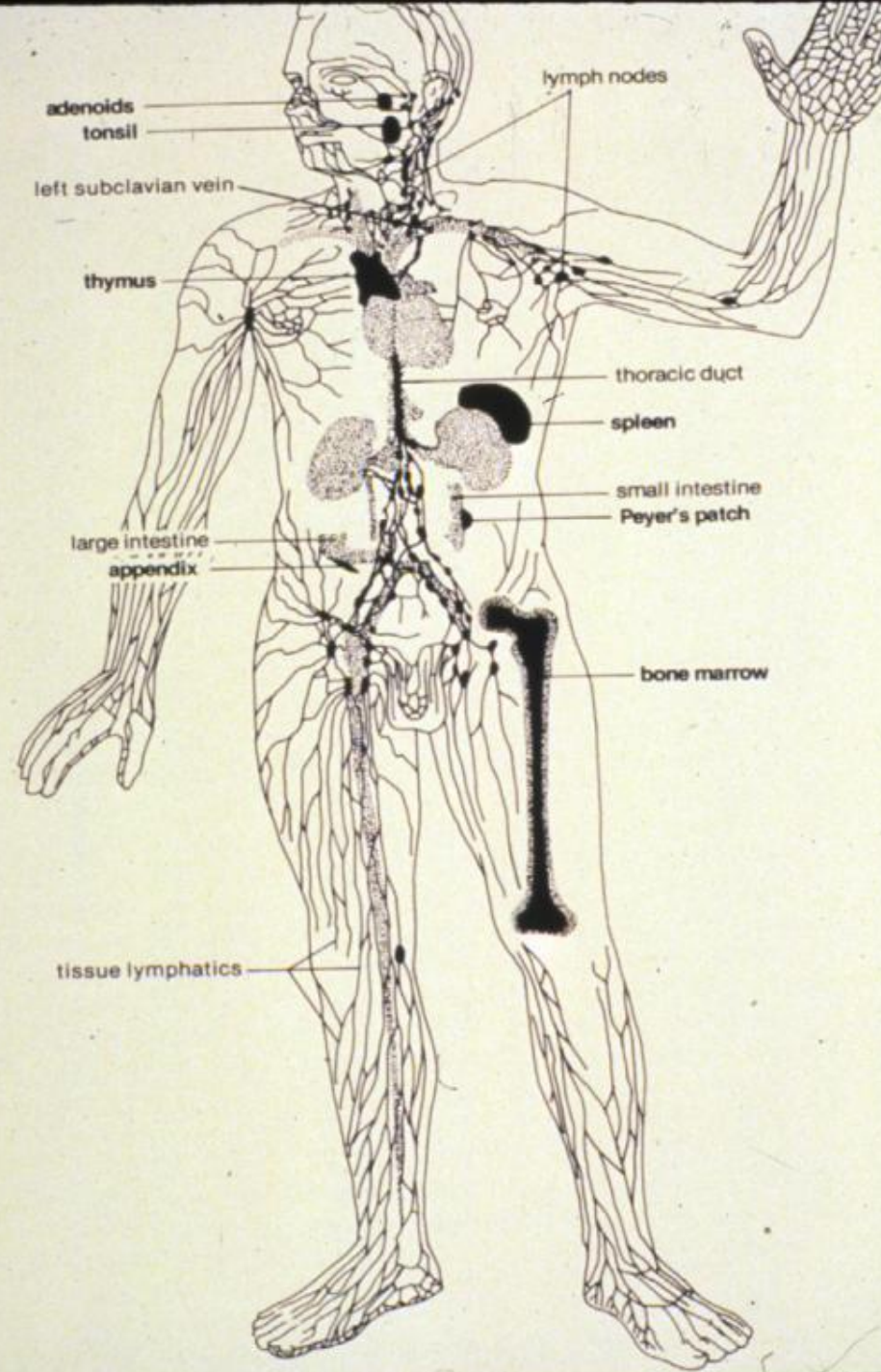
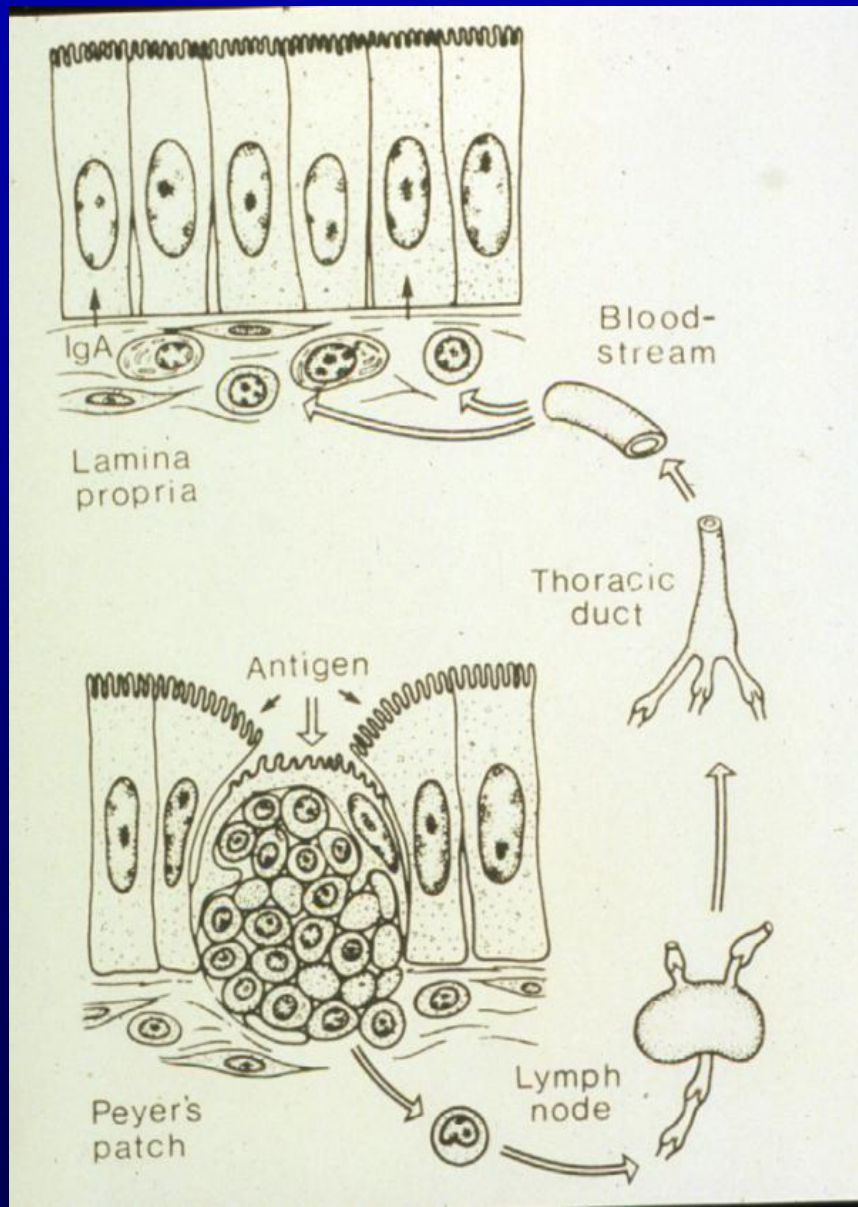


# Natural Killer Cells

- [Http://www.Youtube.Com/watch?V=hnp1eaylhos&feature=fvwp&nr=1](http://www.Youtube.Com/watch?V=hnp1eaylhos&feature=fvwp&nr=1)



# Summary





# Three Key Steps of Combating Infections



reak the cycle of transmission



ill the infectious agent



ncrease host resistance

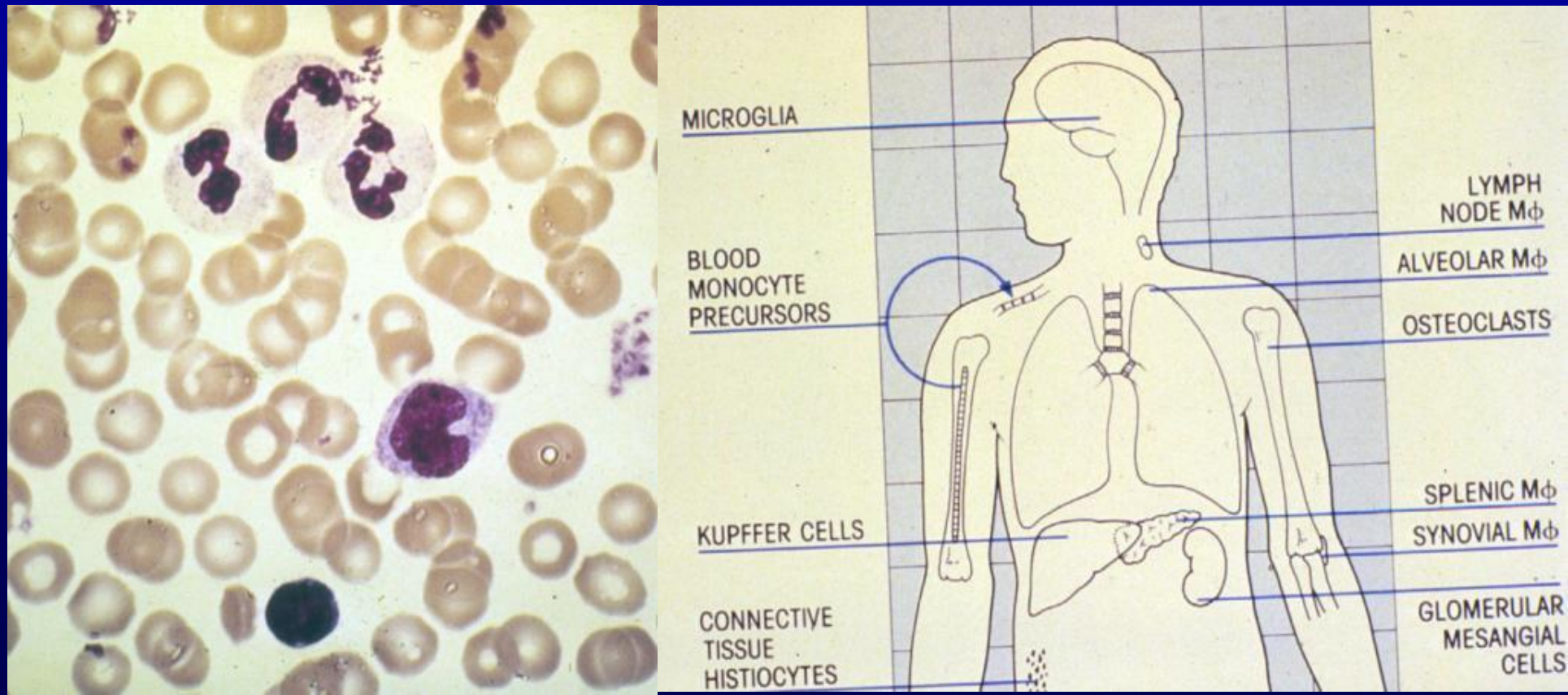
e.g., increase immunity  
of host





# Lines of Defense

- Second line: Phagocytes at work
  - Neutrophils to **K**ill the infectious agent
  - Monocytes - macrophage







# Increase host resistance through **Immunity**

## **Characteristics of Immunity**

- **Acquired** - requires exposure to antigens
- **Specificity** - response is unique to exposure
- **Memory** - remembers previous exposure

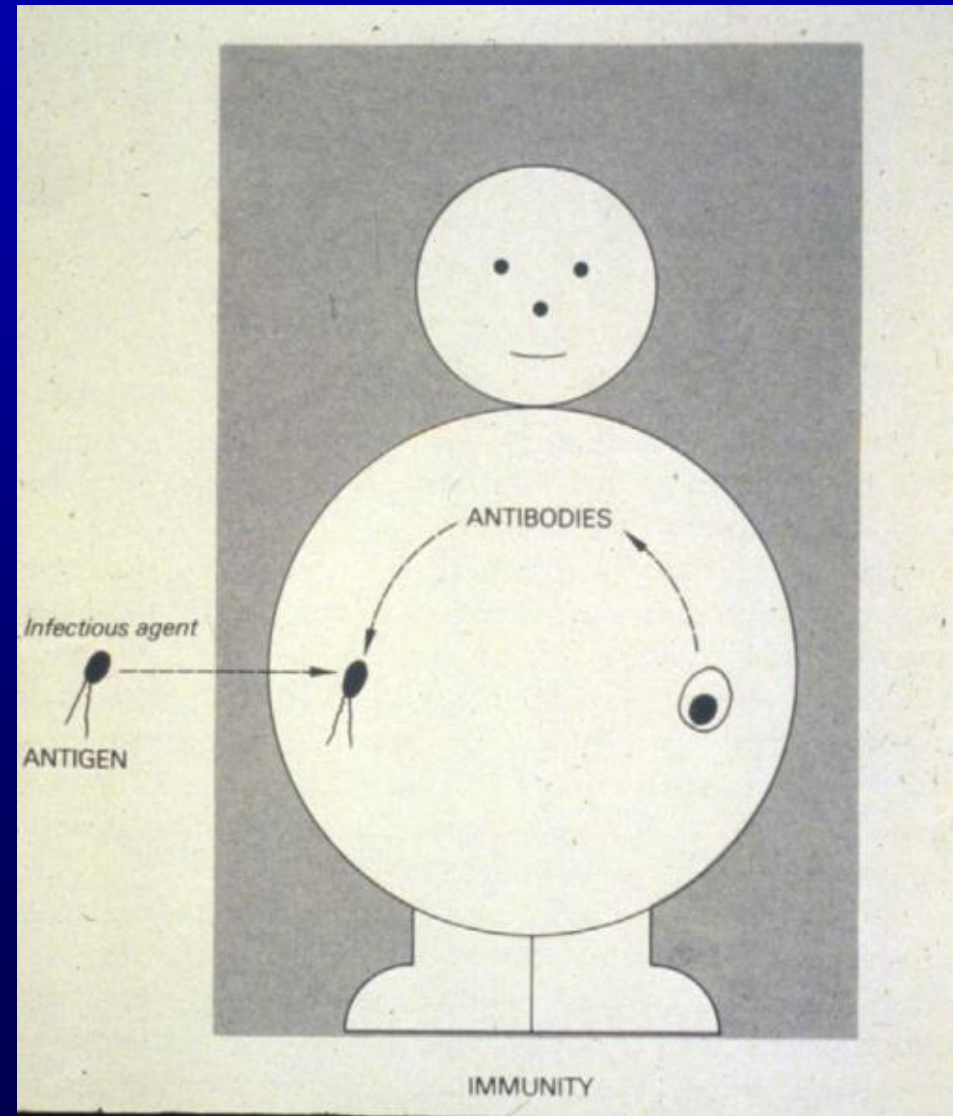


# Characteristics of Immunity

- **Acquired -**
  - **Must be developed**

- **Specificity -**

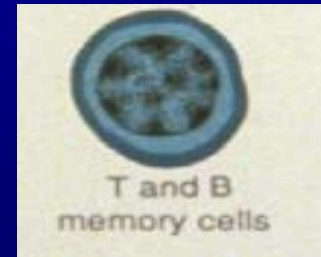
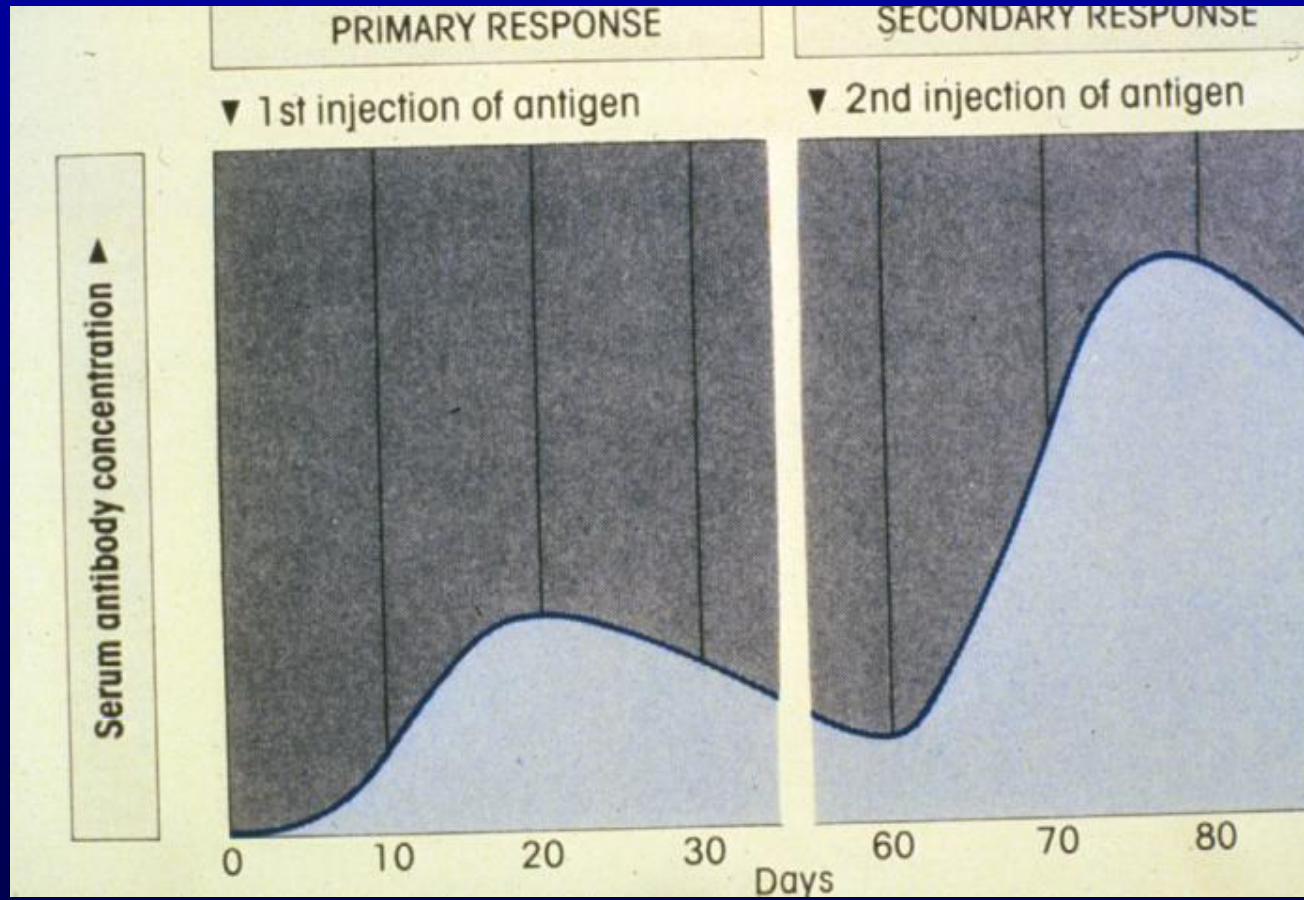
**Antibodies made are specific to specific molecules on the antigen of exposure**





# Characteristics of Immunity

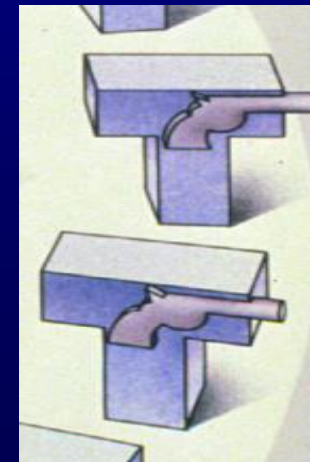
- **Memory: quick second response**
  - Long lived cells





# Types of Immune Response

- **Antibody: mediated**
  - Glycoproteins recognize and bind to antigens
  
- **Cell: mediated**
  - Specifically active cells recognize cell - bind antigens





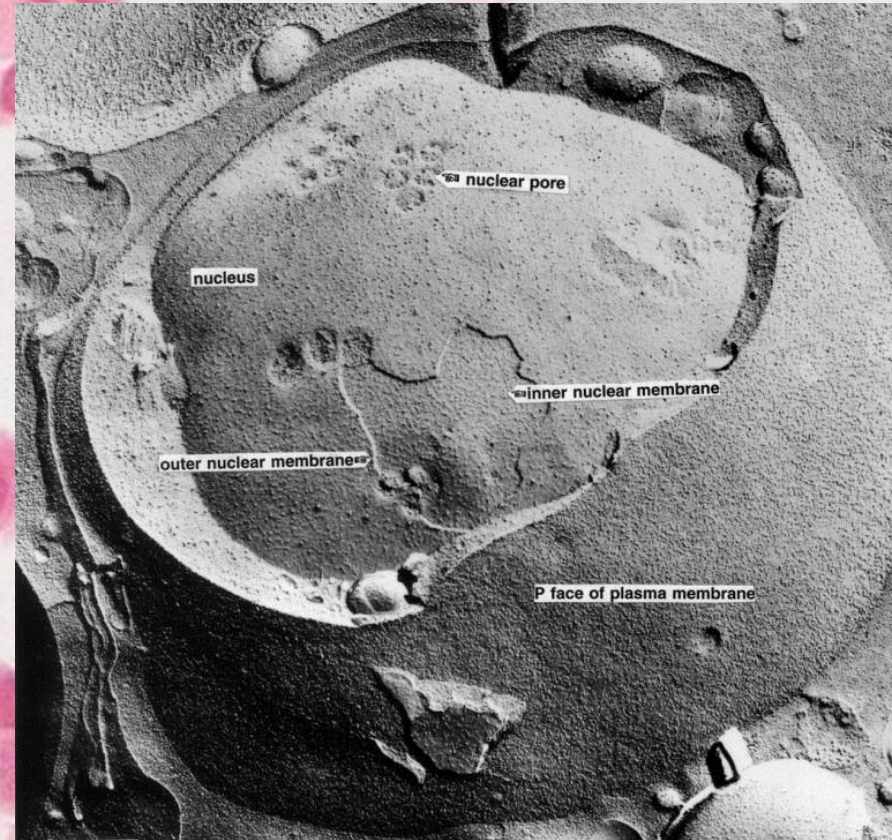
19761

# Bone marrow



Lymphocyte is a main player  
of immune response

Blood  
in vessel





# Summary: Life Cycle of Lymphocytes

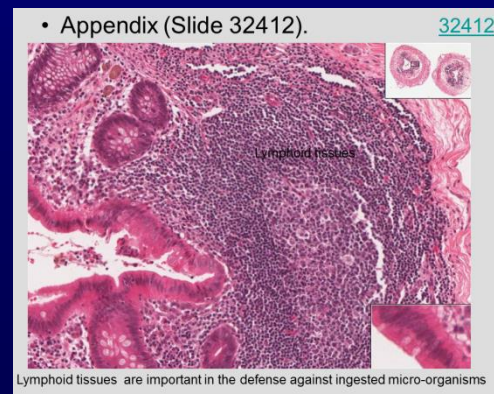
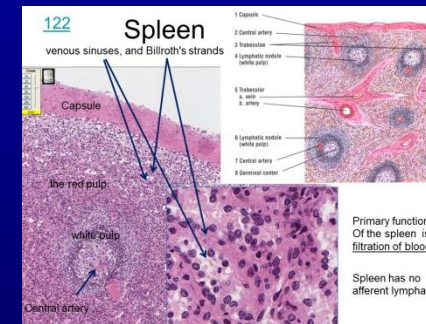
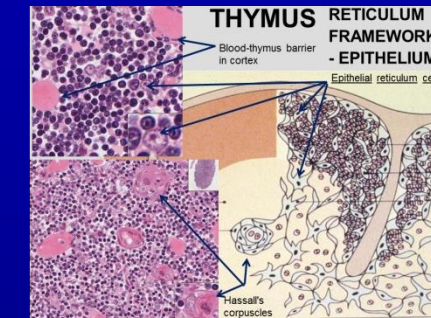
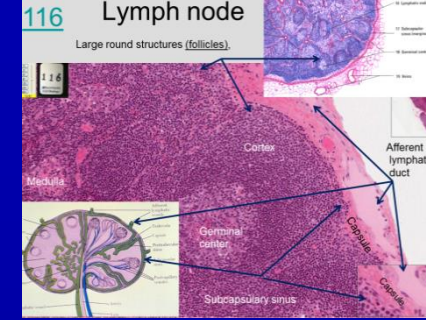
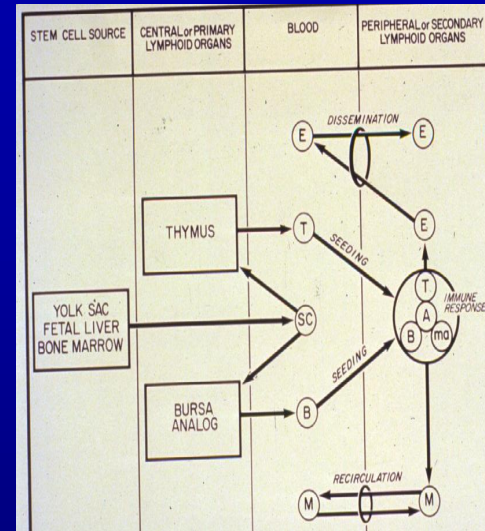
Fetal organs  
Bone marrow

Primary lymphoid organs  
(**Antigen independent** development)

- Thymus – T lymphocytes
- Bone marrow - B lymphocytes

Secondary lymphoid organs  
(**Antigen dependent** development)

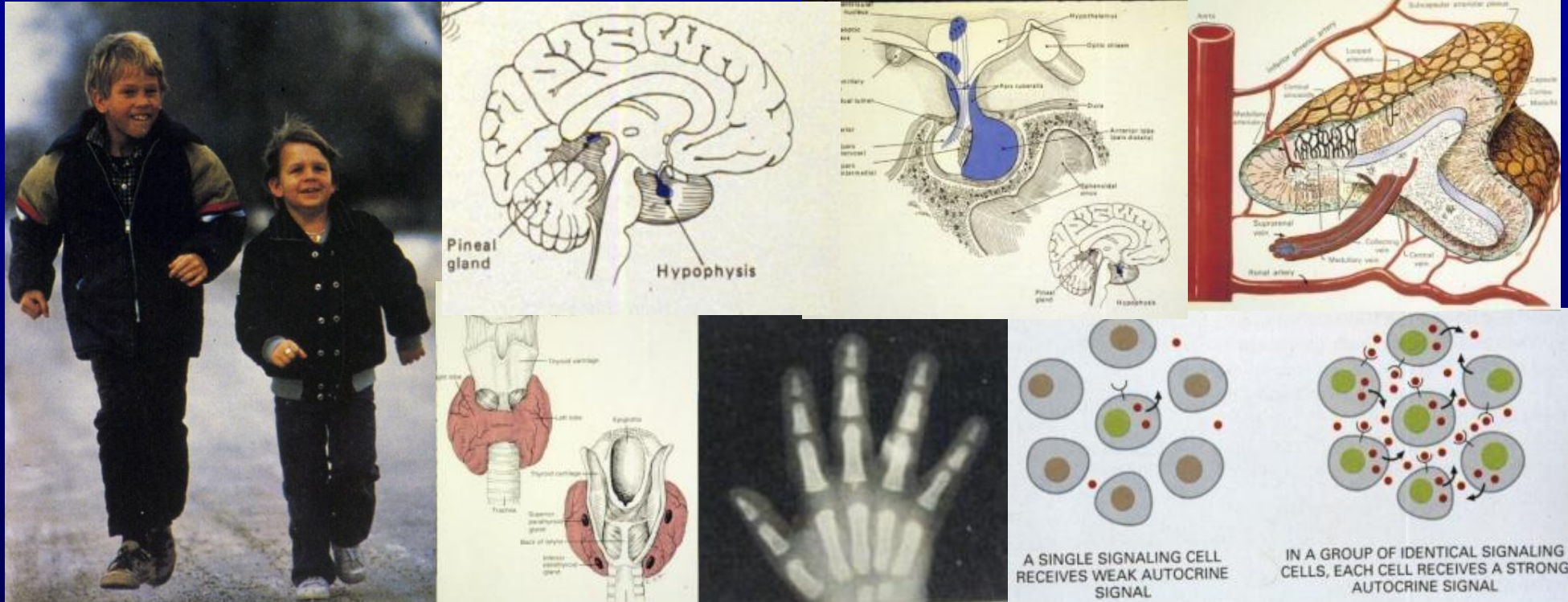
- Lymph nodes
- Lymphoid nodules
- Spleen





Next time

# Endocrine System









# Mammals

## Mammal Mothers Have Milk

What's so great about milk? It's rich in nutrients, full of antibodies, and easy to digest. On top of that, it's portable and convenient. Nursing mammal mothers have food available for their babies on demand.



## Mammals Have Special Earbones

Over millions of years of evolution, two bones in the jaws of our reptile-like ancestors moved to the ear and became part of a sound-amplifying system found only in mammals. You share these earbones with all mammals past and present.

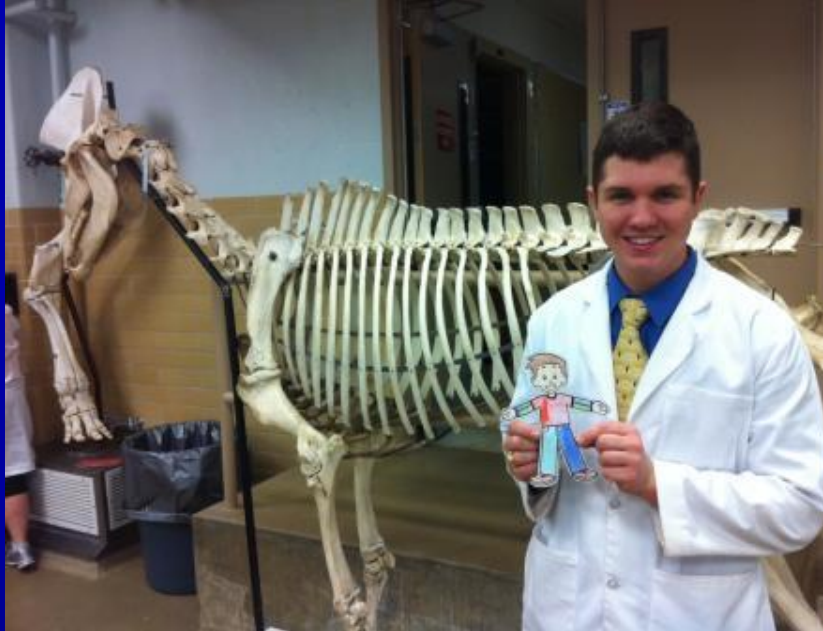


## Mammals Have Hair

Hair has many different uses. It keeps mammals warm and dry, hides them, even helps them feel their way around. Hair can send a warning or serve as a weapon. How many kinds of hair do you see on the mammals in this case?







**Flat Stanley**











Marie H. Reed  
Community Learning Center



A GREAT PLACE TO LEARN  
PANTHERS  
SUCCESS FOR EVERY CHILD









## Many illustrations in these VIBS Histology YouTube videos were modified from the following books and sources: Many thanks to original sources!

- Bruce Alberts, et al. 1983. Molecular Biology of the Cell. Garland Publishing, Inc., New York, NY.
- Bruce Alberts, et al. 1994. Molecular Biology of the Cell. Garland Publishing, Inc., New York, NY.
- William J. Banks, 1981. Applied Veterinary Histology. Williams and Wilkins, Los Angeles, CA.
- Hans Elias, et al. 1978. Histology and Human Microanatomy. John Wiley and Sons, New York, NY.
- Don W. Fawcett. 1986. Bloom and Fawcett. A textbook of histology. W. B. Saunders Company, Philadelphia, PA.
- Don W. Fawcett. 1994. Bloom and Fawcett. A textbook of histology. Chapman and Hall, New York, NY.
- Arthur W. Ham and David H. Cormack. 1979. Histology. J. S. Lippincott Company, Philadelphia, PA.
- Luis C. Junqueira, et al. 1983. Basic Histology. Lange Medical Publications, Los Altos, CA.
- L. Carlos Junqueira, et al. 1995. Basic Histology. Appleton and Lange, Norwalk, CT.
- L.L. Langley, et al. 1974. Dynamic Anatomy and Physiology. McGraw-Hill Book Company, New York, NY.
- W.W. Tuttle and Byron A. Schottelius. 1969. Textbook of Physiology. The C. V. Mosby Company, St. Louis, MO.
- Leon Weiss. 1977. Histology Cell and Tissue Biology. Elsevier Biomedical, New York, NY.
- Leon Weiss and Roy O. Greep. 1977. Histology. McGraw-Hill Book Company, New York, NY.
- Nature (<http://www.nature.com>), Vol. 414:88,2001.
- A.L. Mescher 2013 Junqueira's Basis Histology text and atlas, 13<sup>th</sup> ed. McGraw
- Internet images and videos on biological presentations

