

# Cells and Tissues of the Immune System

## Aims

- To become familiar with the cells and tissues involved in the immune response

## Learning outcomes

- List all the cells involved in immunity and identify their key characteristics
- Explain how to distinguish between the different cells
- Describe the structure and function of lymphoid tissue

# Lymphatic System

- The lymphatic system consists of lymphatic vessels and the lymphoid organs.
- This system, which is closely associated with the cardiovascular system
- , has three main functions that contribute to homeostasis
- : (1) lymphatic capillaries take up excess tissue fluid and return it to the blood stream;
- (2) lacteals receive lipoproteins<sup>1</sup> at the intestinal villi and transport them to the blood stream and
- (3) the lymphatic system helps defend the
- body against disease.

# The lymphatic system

- **Blood components from capillaries enter tissues making extracellular fluid that provides food & gas exchange**
- **Extracellular fluid drains into vessels called LYMPHATICS VESSELS**
- **Lymphocytes and other leucocytes use this system to migrate around the body**

- Lymph flows one way from a capillary to ever larger
- lymphatic vessels and finally to a lymphatic duct, which enters a sub clavian vein.



# Lymphoid tissues

- Lymphocytes found in blood, but majority are either in discrete clusters or organised in specific tissues
- Components are either primary, secondary or tertiary lymphoid tissues

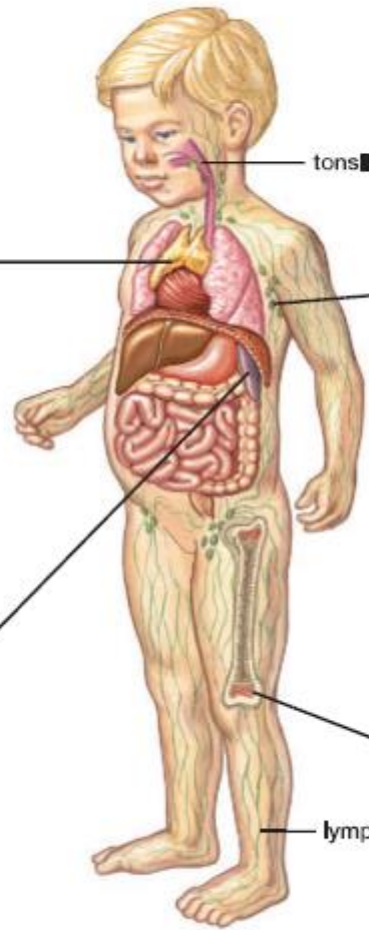
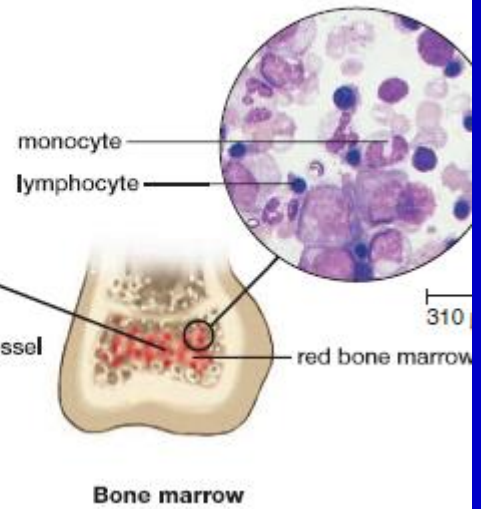
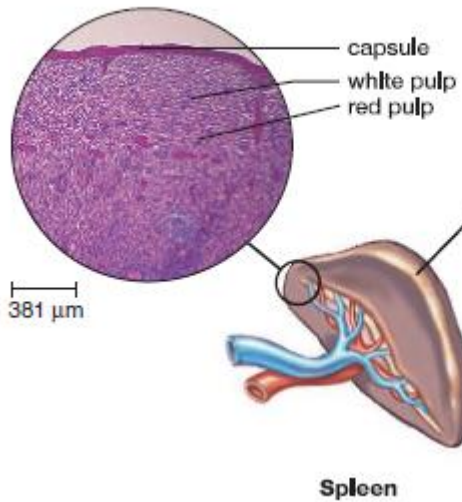
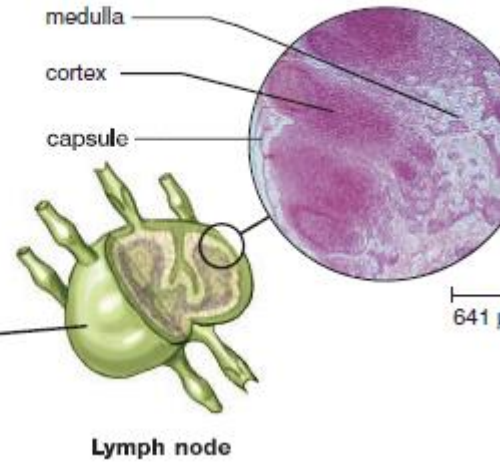
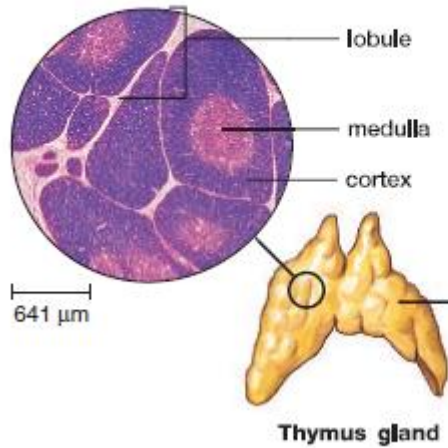
## Primary lymphoid tissues

- Involved in development & differentiation of lymphocytes & include:

‘Bursa equivalent’ tissues: foetal liver & adult bone marrow in man produced blood cell & (B cells) maturation

Thymus gland: (T cells) maturation

Chapter 8 Lymphatic and Immune Systems



# Bone marrow

- foetal liver & adult bone marrow in man.
- They have stem cells which produce blood cells

## **The Red Blood Cells**




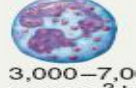



Blood is composed of cells and a fluid containing many inorganic and organic molecules. Red blood cells are very abundant in blood and function in oxygen transport.

**The White Blood Cells** There are several types of white blood cells, and each type has a specific function in defending the body against disease.

Platelets are fragments of larger cells that function in blood clotting

## **Plasma**

Plasma is over 90% water and contains a variety of proteins and other molecules.

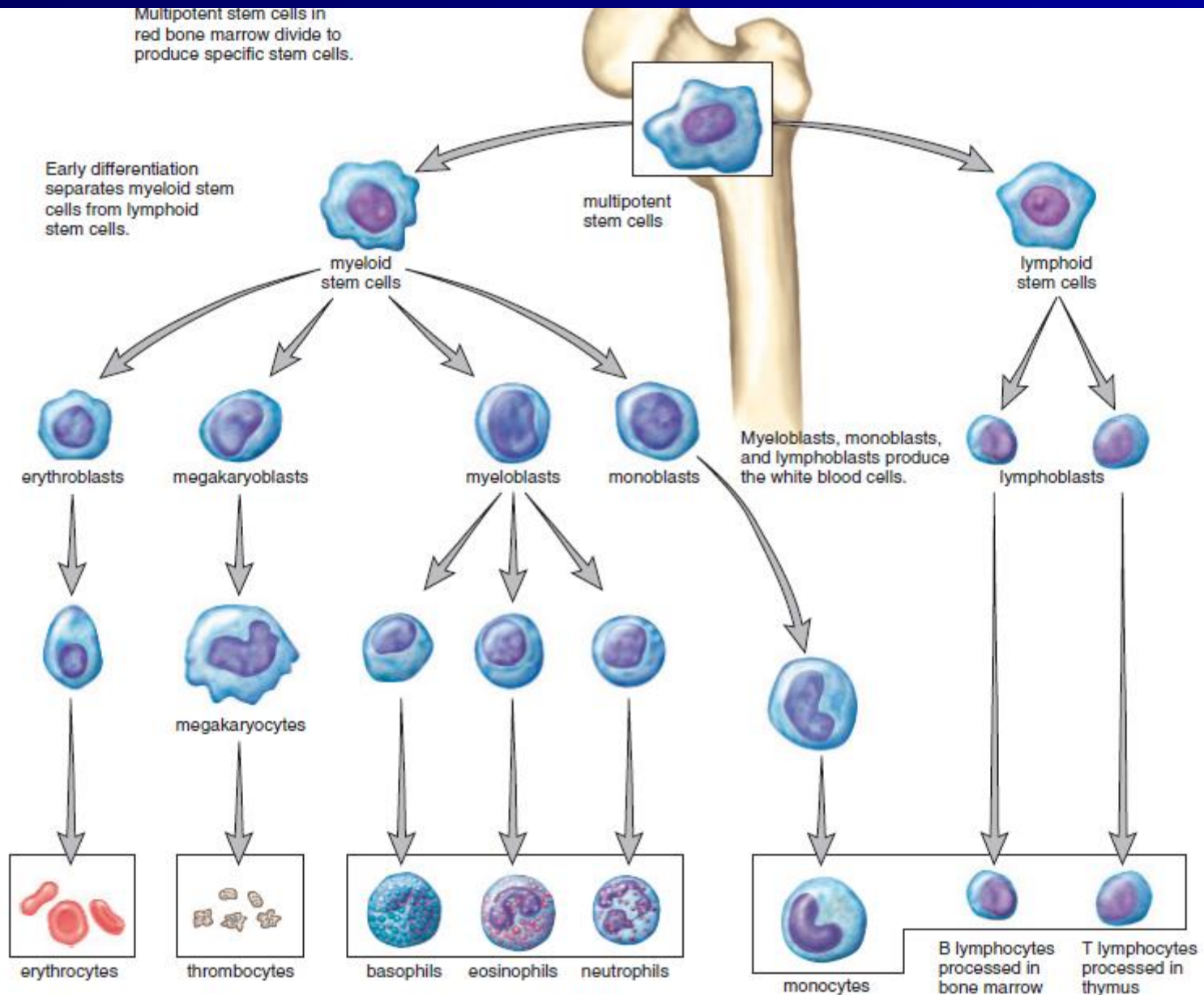
FORMED ELEMENTS	Function and Description	Source	PLASMA	Function	Source
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<b>White Blood Cells</b> (leukocytes) 4,000–11,000 per mm <sup>3</sup> blood  <i>Granular leukocytes</i> <ul style="list-style-type: none"> <li> <b>Basophils</b>              20–50 per mm<sup>3</sup> blood         </li> <li> <b>Eosinophils</b>              100–400 per mm<sup>3</sup> blood         </li> <li> <b>Neutrophils</b>              3,000–7,000 per mm<sup>3</sup> blood         </li> </ul> <i>Agranular leukocytes</i> <ul style="list-style-type: none"> <li> <b>Lymphocytes</b>              1,500–3,000 per mm<sup>3</sup> blood         </li> <li> <b>Monocytes</b>              100–700 per mm<sup>3</sup> blood         </li> </ul>	Fight infection  10–12 μm in diameter Spherical cells with lobed nuclei; large, irregularly shaped, deep-blue granules in cytoplasm; release histamine which promotes blood flow to injured tissues  10–14 μm in diameter Spherical cells with bilobed nuclei; coarse, deep-red, uniformly sized granules in cytoplasm; phagocytize antigen-antibody complexes and allergens  10–14 μm in diameter Spherical cells with multilobed nuclei; fine, pink granules in cytoplasm; phagocytize pathogens  5–17 μm in diameter (average 9–10 μm) Spherical cells with large round nuclei; responsible for specific immunity  10–24 μm in diameter Large spherical cells with kidney-shaped, round, or lobed nuclei; become macrophages which phagocytize pathogens and cellular debris	Red bone marrow	Salts (less than 1% of plasma)  Gases Oxygen Carbon dioxide  Nutrients Lipids Glucose Amino acids  Nitrogenous wastes Urea Uric acid  Other Hormones, vitamins, etc.	Maintain blood osmotic pressure and pH; aid metabolism  Cellular respiration End product of metabolism  Food for cells  Excretion by kidneys  Aid metabolism	Absorbed from intestine  Lungs Tissues  Absorbed from intestine  Liver  Varied
<ul style="list-style-type: none"> <li> <b>Platelets</b> (thrombocytes)              150,000–300,000 per mm<sup>3</sup> blood         </li> </ul>	Aid clotting  2–4 μm in diameter Disk-shaped cell fragments with no nuclei; purple granules in cytoplasm	Red bone marrow	Plasma 55%  Formed elements 45%		



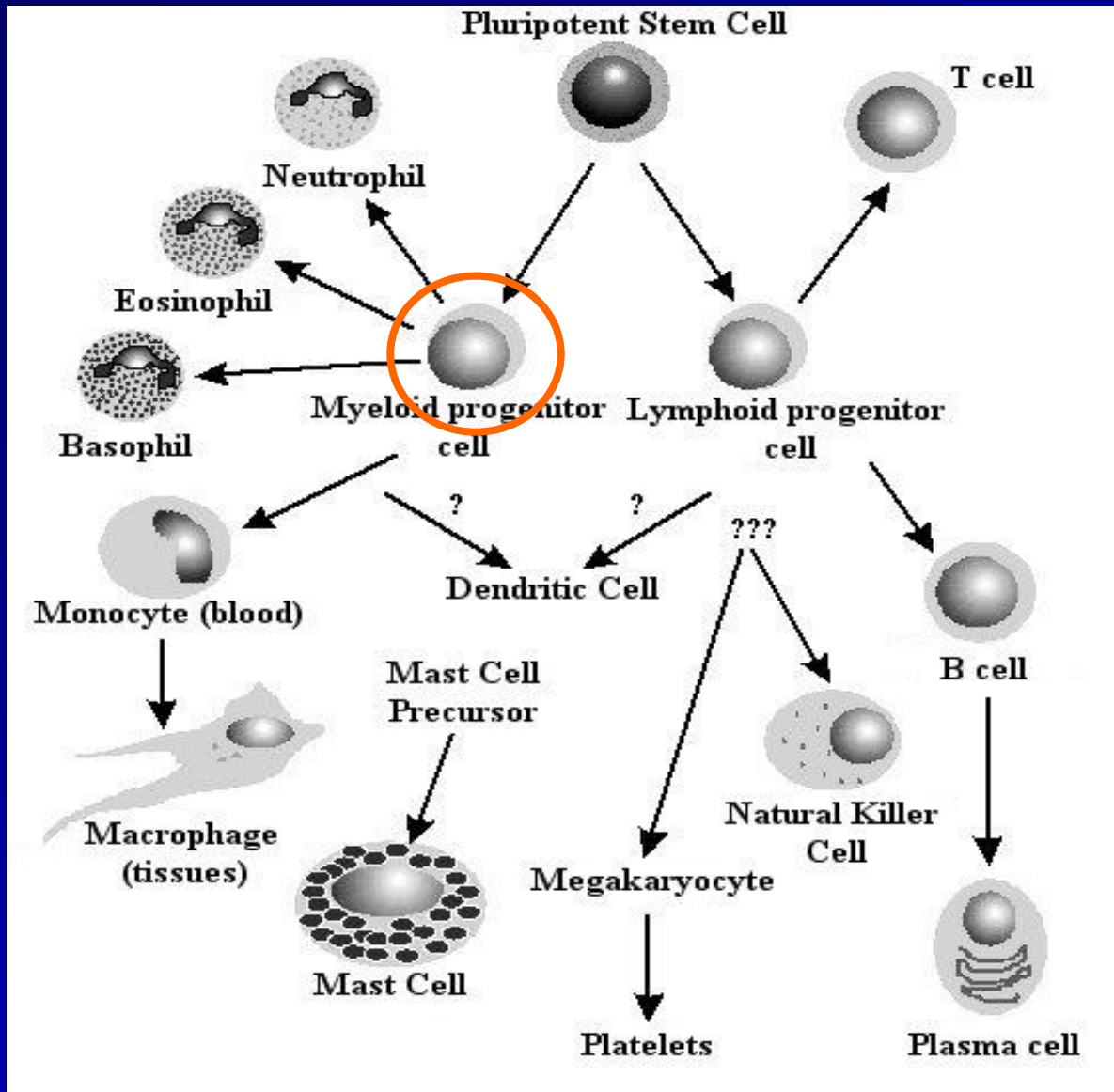
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Multipotent stem cells in red bone marrow divide to produce specific stem cells.



# Cells involved in immunity



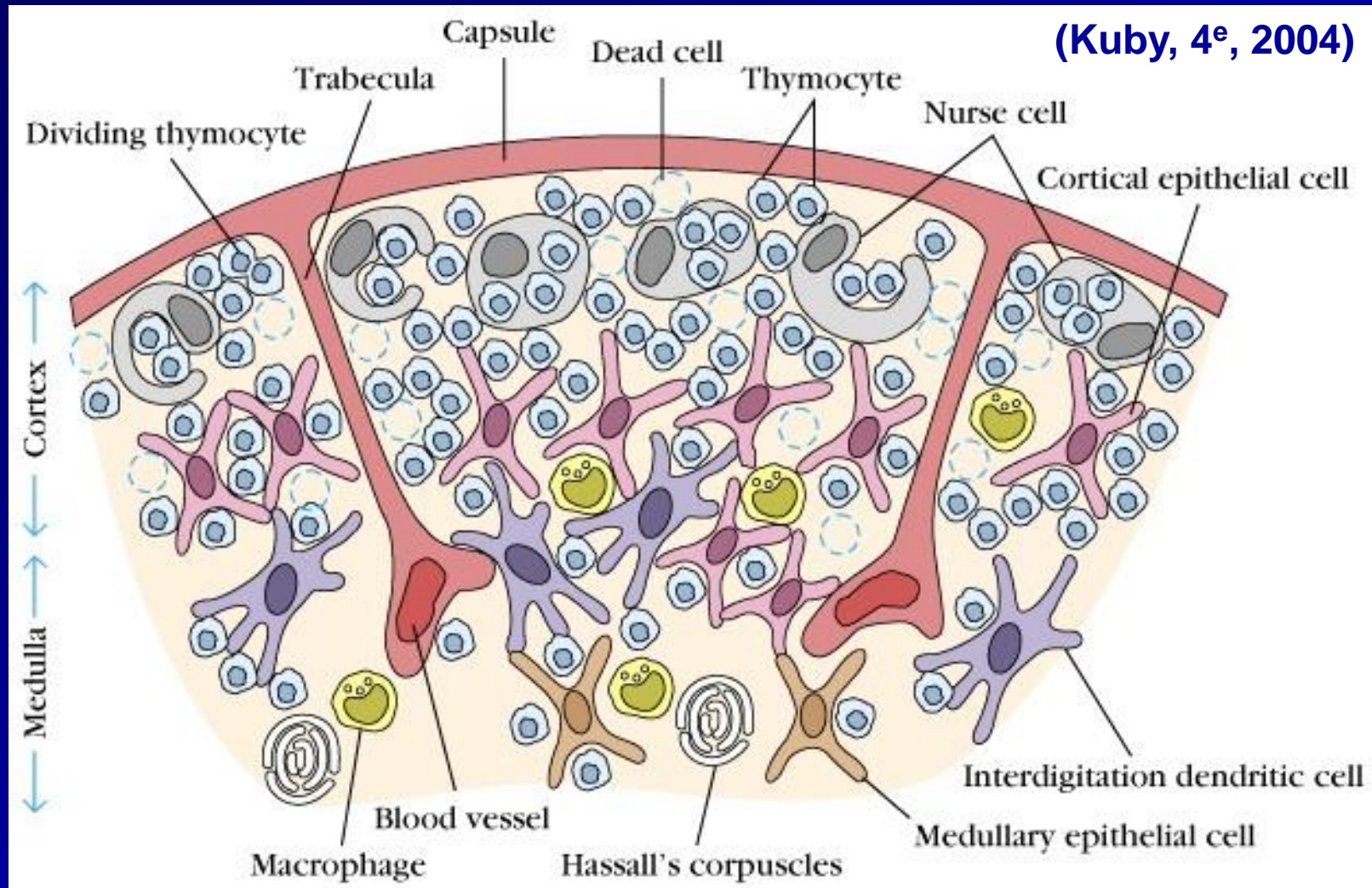
# The Thymus

- First organ to received from bone marrow & provides environment for T cell **maturation** and **education**
- 2 lobes divided into lobules by trabeculae (or connective tissue walls)
- Each lobe has outer CORTEX & inner MEDULLA
- Thymocytes are surrounded by **EPITHELIAL cells**
- In cortex, THYMIC NURSE cells affect thymocyte development
- In medulla & corticomedullary junction where most blood vessels are found there is a special type of dendritic cell: **interdigitating** cells
- Cells pass from cortex to medulla while differentiating into T cells:  
Enter expressing **neither CD4 or CD8**), pass through expressing either CD4 (helper) **or CD8** (cytotoxic)



# THE THYMUS

(Kuby, 4<sup>e</sup>, 2004)



# Secondary Lymphoid Tissues

1-Lymph nodes

2-The Spleen

3-Mucosa-associated lymphoid tissue  
Payer's patches

**Secondary lymphoid tissues function**

- Allow accumulation of Antigen
- Present Antigen to both naïve & memory lymphocytes

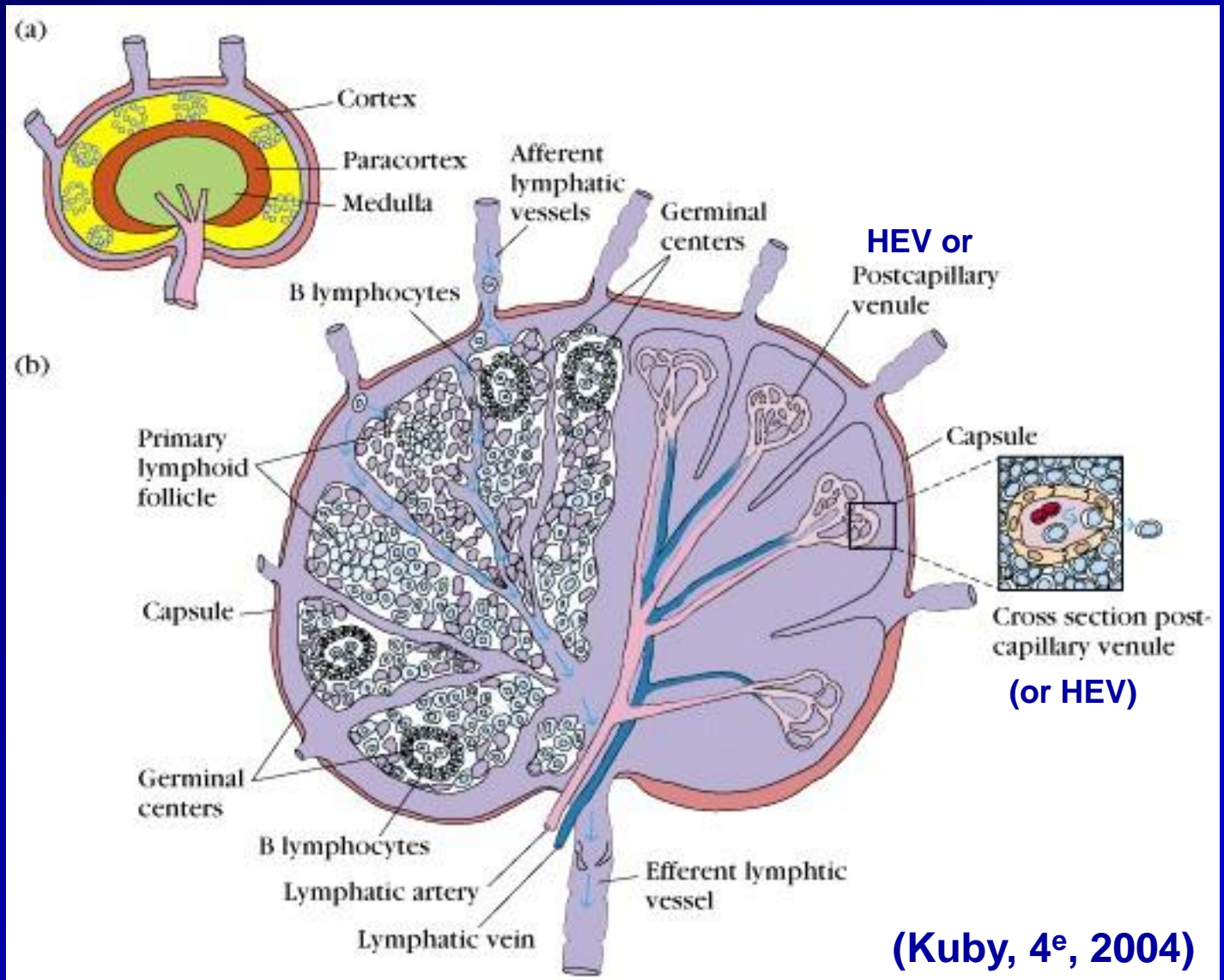
# Secondary Lymphoid Tissues

## Lymph nodes

- Small, bean-shaped, tissue aggregates at junction of major lymph vessels, 1-25mm diameter, becoming much larger in infection
- Surrounded by a capsule & supported by a reticulum, 3 main areas: cortex, para cortical area, and medulla
- The Lymph carries Ag from tissues to lymph nodes allowing cells of the immune system to get **together** with antigen to start specific immune responses
- Cells flow to medulla & drain into efferent lymphatic at the hilus
- Blood lymphocytes enter lymph nodes at High Endothelial Veinules (HEV) & return via thoracic duct



# Lymph Node



# Lymph nodes

- T cells collect in paracortical areas, B cells in outer cortex
- Paracortical region contains large lymphocytes & activated cells –**BLAST cells**
- Medulla contains **plasma cells** secreting Ab
- B cells form dense aggregates –**FOLLICLES**
- Primary follicles are via dense & uniform centre contains larger cells associated with **macrophages** –  
**GERMINAL CENTRE**
- After Ag exposure, lymph node shows increased turnover of lymphocytes

# The Spleen

- lymphoid organ with other non-immunological functions
- Capsule with fibrous partitions (SEPTAE)
- Lymphocytes enter and leave mainly via blood stream
- 2 types of tissue: RED & WHITE PULP
- Red pulp: filters damaged or aged red cells

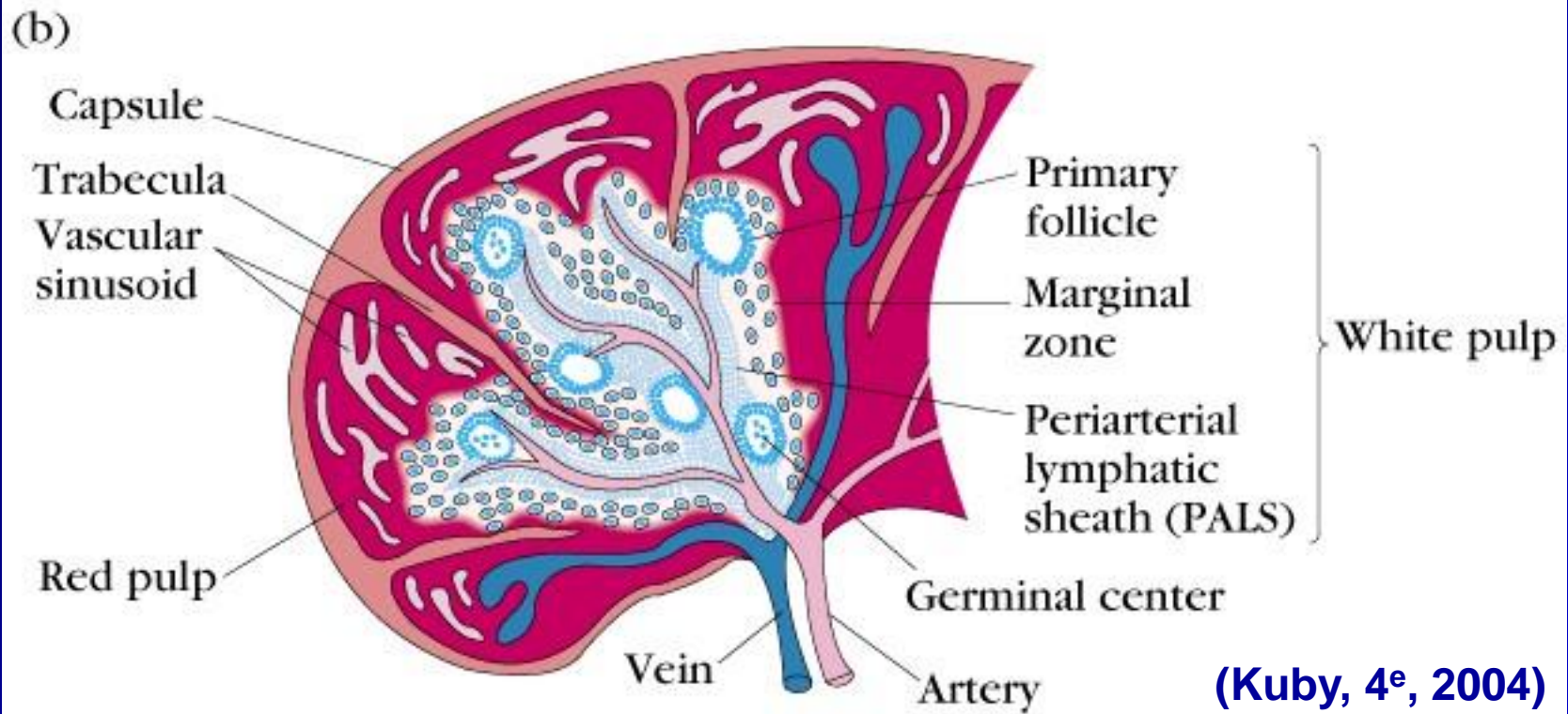
# The Spleen

## White pulp:

- cells & tissues surrounding major arterial branches & associated clusters of lymphocytes –
- the lymphatic follicles or( nodules ) :the Follicles similar to those in lymph nodes.
- 
- B-dependent area consists of lymphoid follicles
- T-dependent area consists of the peri arterial lymphatic sheath (PALS)

**Immunological role:** as for lymph nodes with germinal centres developing during immune responses

# The Spleen





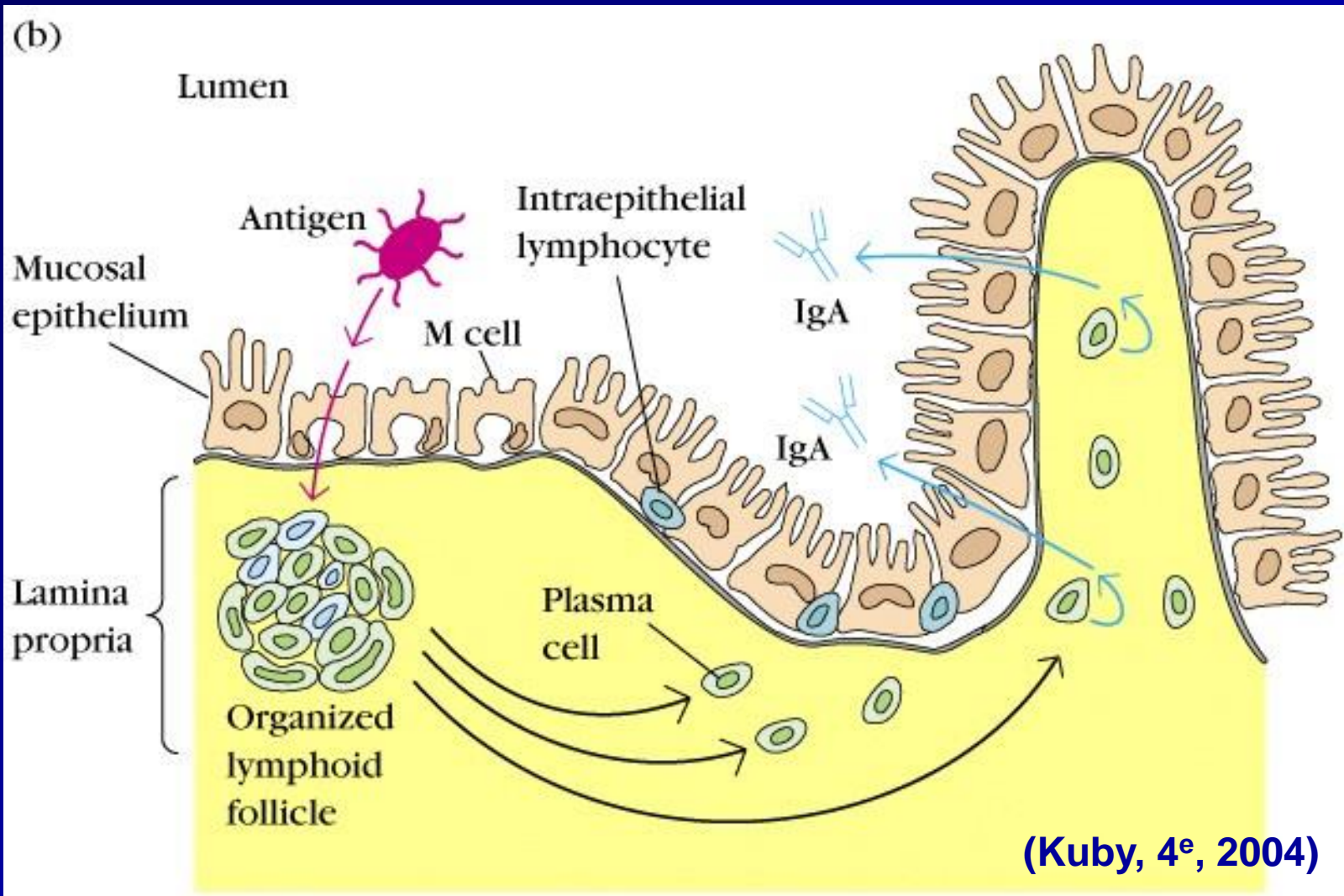
# Mucosa-associated lymphoid tissue

- Diffusely distributed lymphoid tissues in lining (mucosae) of gastrointestinal, respiratory & urinogenital tracts
- Gut-associated lymphoid tissue (GALT) and bronchus
- GALT made up of **Peyer's patches** and isolated follicles in colonic sub mucosa
- Lymphocytes also found in **lamina propria**, intestinal epithelium & in lumen of intestine

# Payer's patches

- Aggregates of lymphocytes; B cells form central follicle surrounded by T cells & macrophages
- Have efferent lymphatics that drain into mesenteric lymph nodes, but **no afferent** lymphatics
- Covered by specialised lymphoepithelium consisting of cells known as **M cells**
- Ag in gut enters via M cells that selectively take up particles & deliver them to lymphoid follicles also by specialised dendritic cells which 'reach' into the gut lumen!

# GALT



# Peyer's patches





**THANK YOU**  
**Will MEET IN NEW LECTURE**

# The Blood

## **The Red Blood Cells**




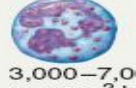



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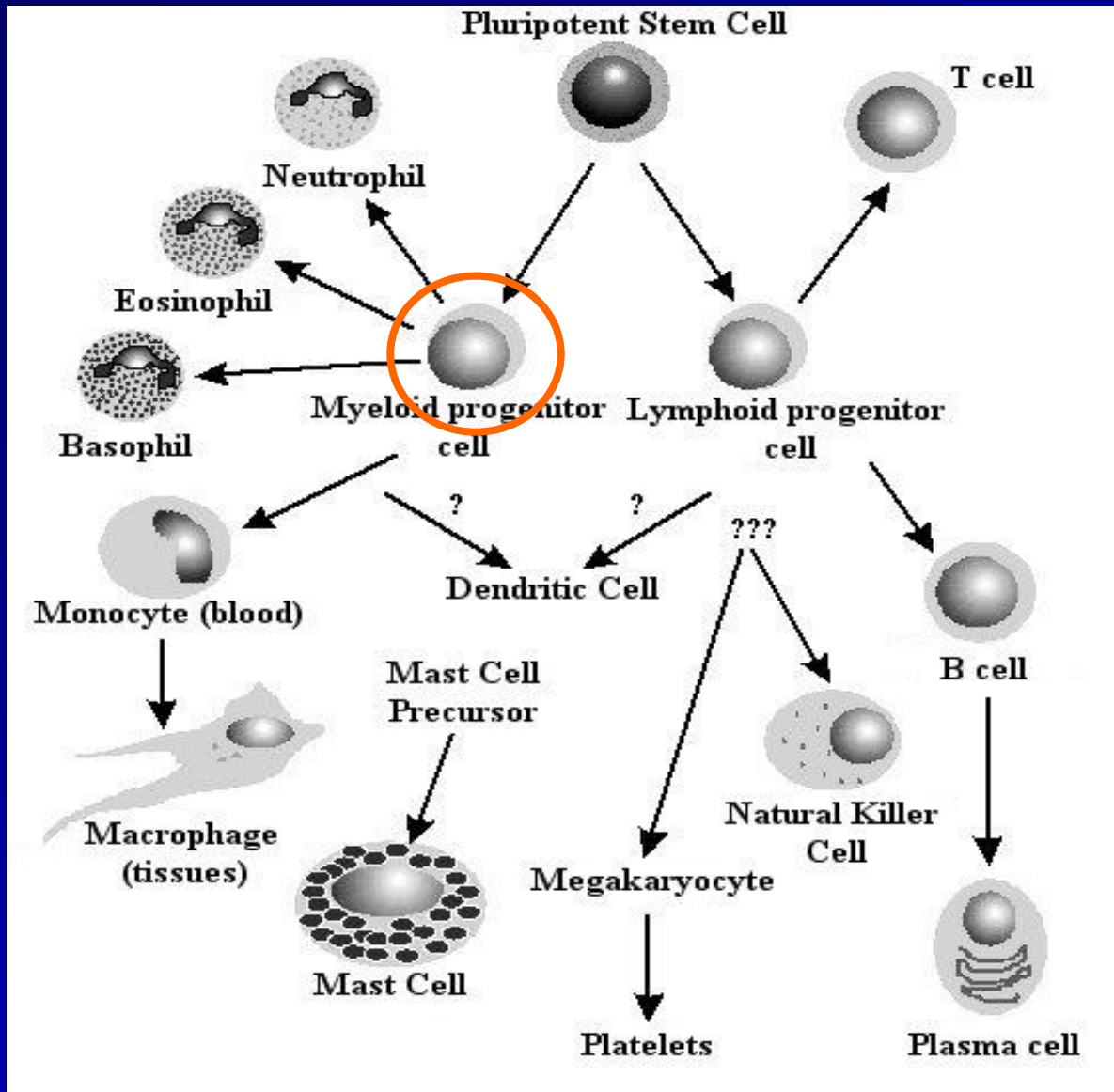
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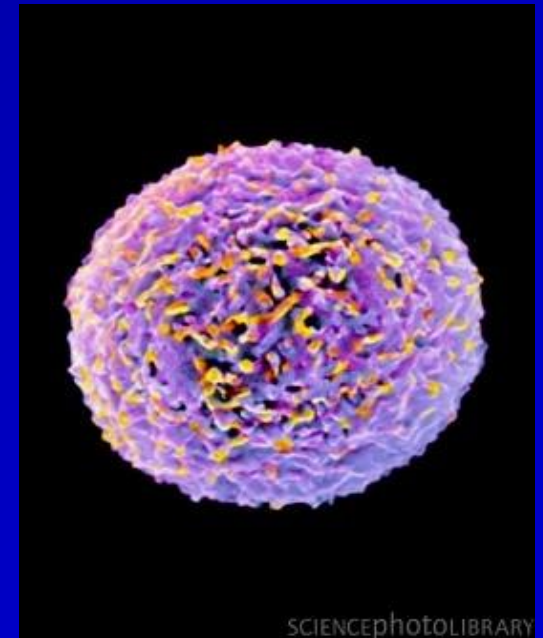
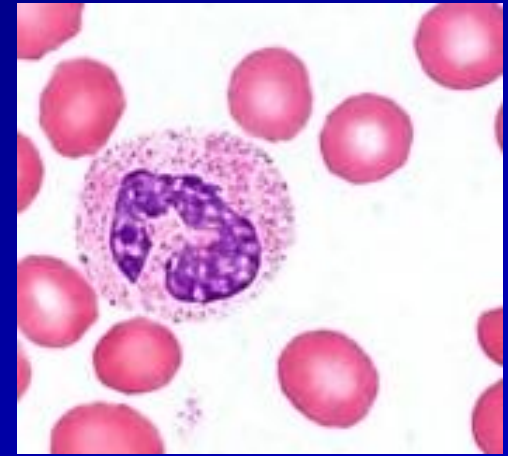
- List all the cells involved in immunity and identify their key characteristics
- Explain how to distinguish between the different cells
- Describe the structure and function of lymphoid tissue

# Cells involved in immunity



# Neutrophils

- Large cells (10-20 microns); only live about 2-3 days
- 90% of granulocytes are neutrophils
- Neutral staining cytoplasmic granules containing enzymes e.g. lysozyme
- Phagocytic, kill bacteria by microbicidal mechanisms
- Most important cell in non-viral infections

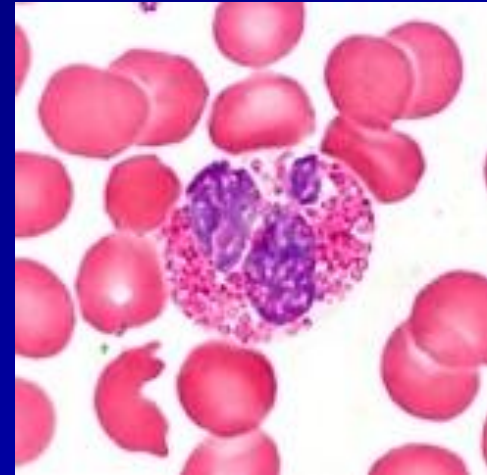


# Myeloid progenitor cell

- Gives rise to polymorphonuclear leukocytes and monocytes
- Polymorphs include neutrophils, eosinophils and basophils also called granulocytes (60-70% white blood cells)
- Monocytes are blood borne; in tissues they become macrophages (MΦ)

# Eosinophils

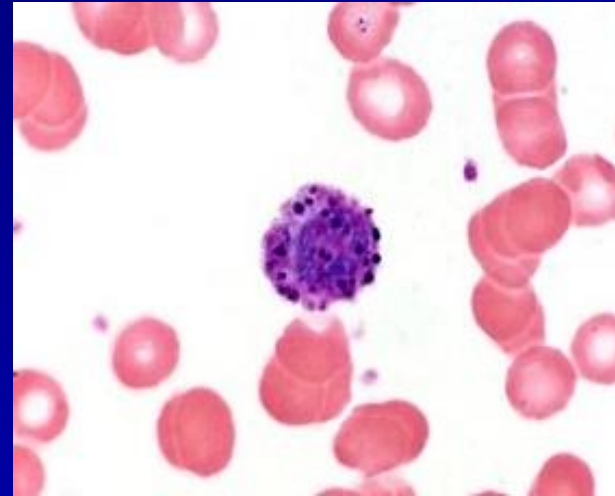
- Contain prominent granules, which stain red with eosin
- Granules contain a crystalline core cytotoxic for parasites; EOSINOPHIL BASIC PROTEIN
- Important in immunity to helminth infections
- Phagocytic, though this is not a major function





# Basophils

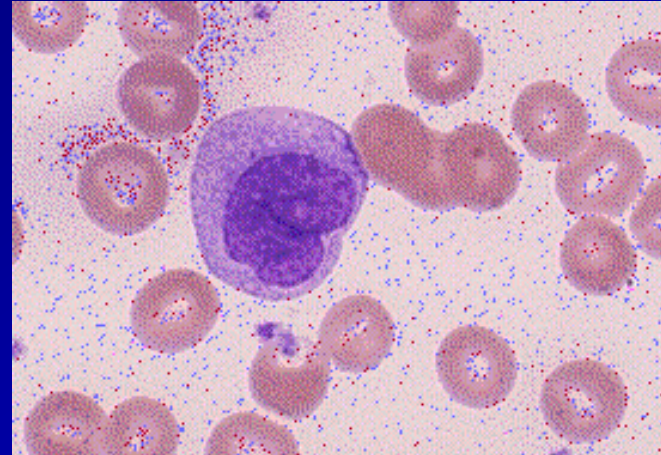
- $<0.2\%$  white blood cells, only go into tissues during inflammation
- When stimulated, release substances that promote inflammation
- Important in allergy
- Not thought to phagocytose



# Monocytes and macrophages

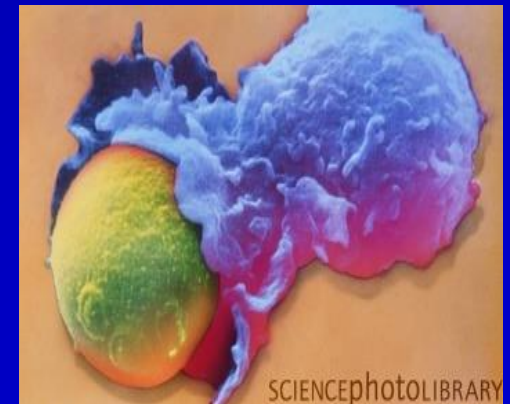
## Monocytes

- in blood 1-2 days
- Mononuclear leukocytes
- Phagocytic



## Macrophages

- MCs in tissues = macrophages (M $\Phi$ )
- Up to 10x larger than MCs
- can live months or years
- Characteristics of macrophages depend on tissue e.g. Kupffer cells in liver, microglia of brain
- Phagocytic (like neutrophils and eosinophils), adherent

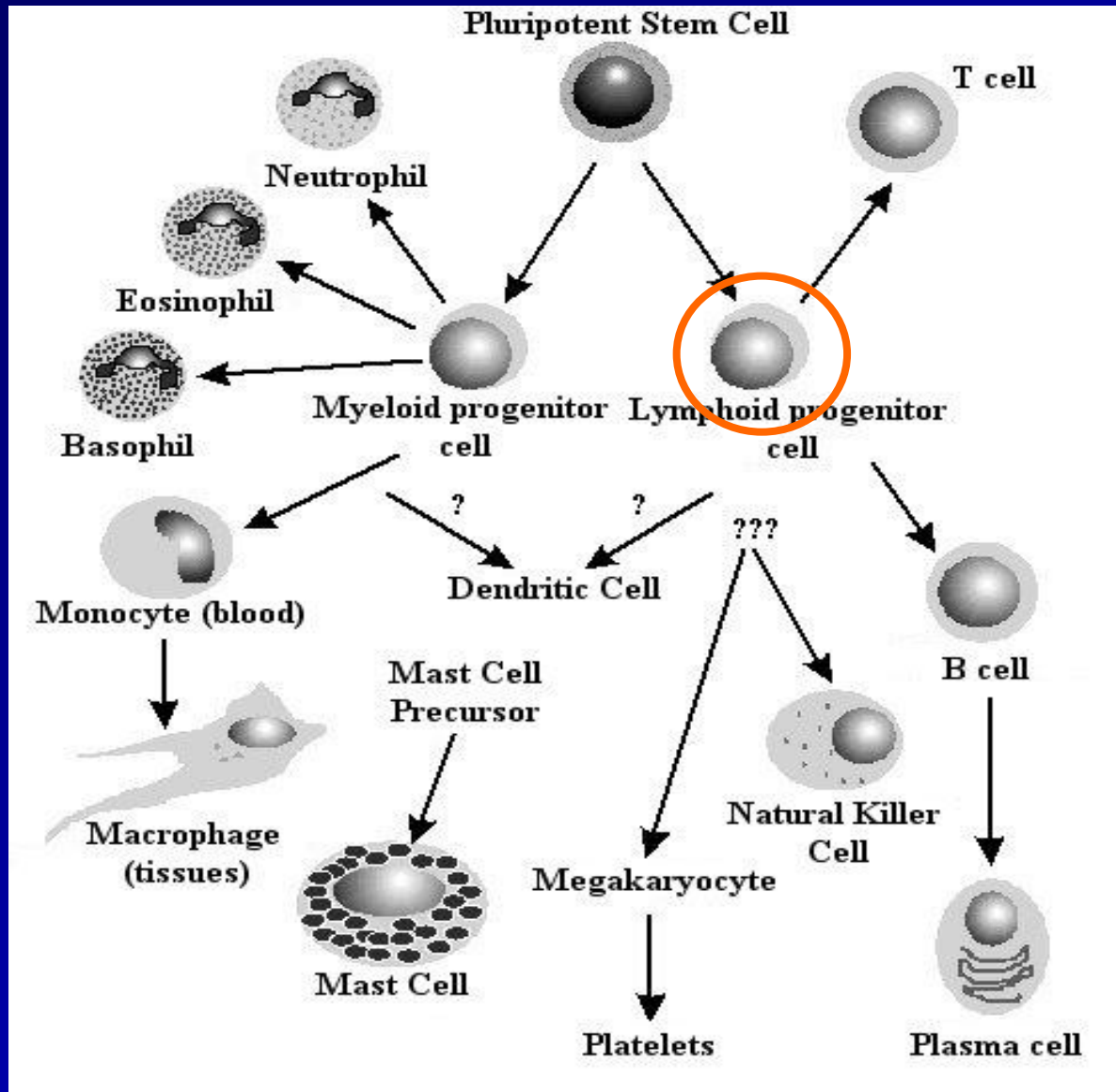


# Monocytes and macrophages

- **MCs and MΦs have a variety of microbicidal mechanisms including enzymes**
- **MCs and MΦs have secrete a huge array of growth factors, chemicals and activation factors**
- **Can be identified by certain molecules on the surface (CD14 & CD15 on MCs)**
- **Good at engulfing ‘foreign’ material and ‘showing ‘ it to other cells of the immune system**

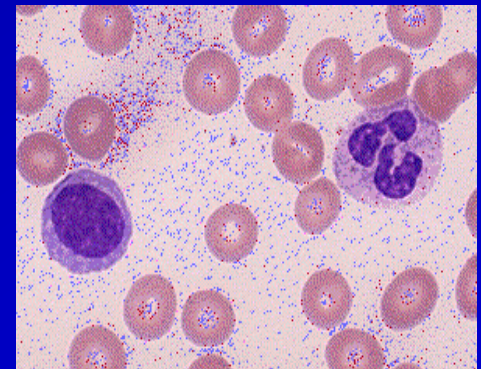
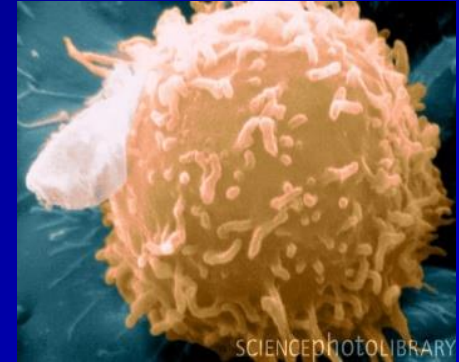


# Cells involved in immunity



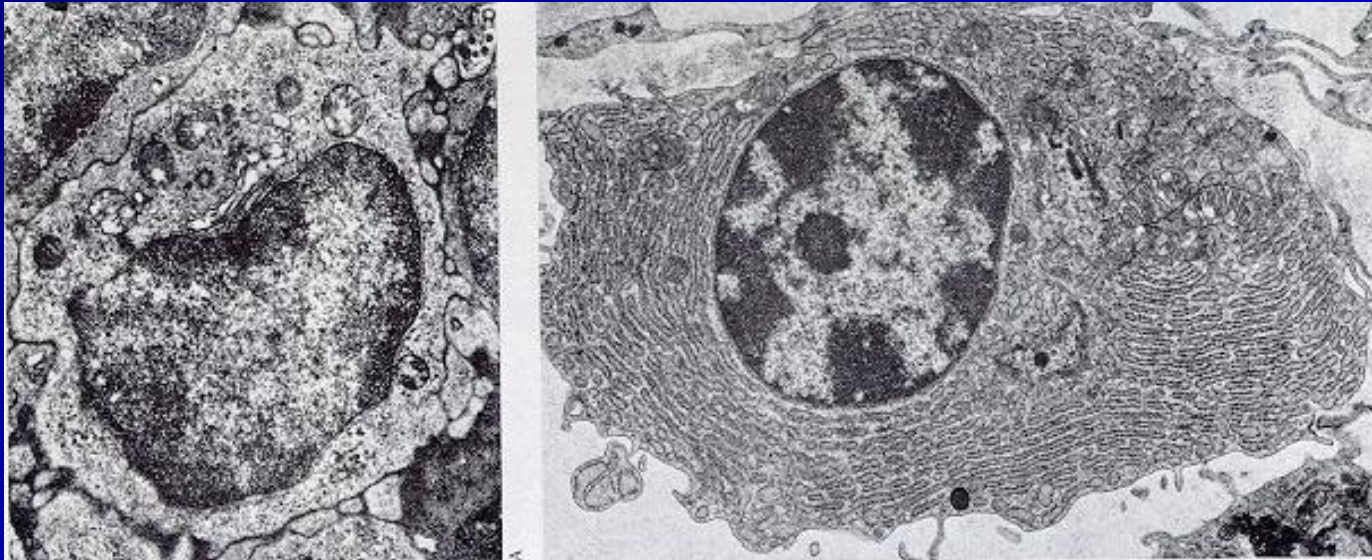
# Lymphoid progenitor cell

- Gives rise to Lymphocytes
- 20-30% peripheral blood white cells
- 6-10um in diameter with large nucleus, small halo of cytoplasm
- Upon stimulation by Ag become EFFECTOR CELLS or MEMORY CELLS
- 2 main types: T cells and B cells (T-lymphocytes and B-lymphocytes)
- Early developmental stage, cells pass to Thymus – become T cells or stay in Bone marrow – become B cells



# B Lymphocytes (B cells)

- Have immunoglobulin/antibody anchored in cell membrane (mlg) to form the B cell antigen receptor (BCR)
- When activated differentiate into Plasma cells and secrete antibody or memory cells



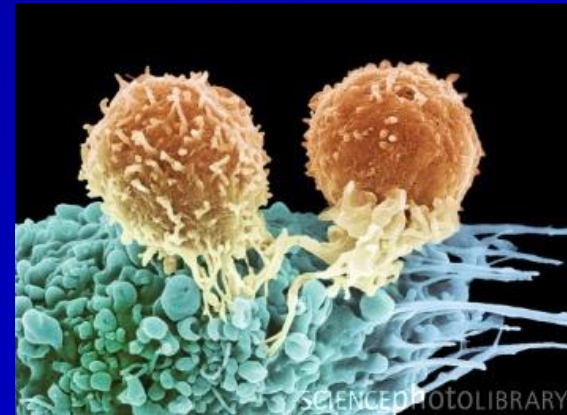


# T lymphocytes

- Have T cell Receptor (TCR) on surface to 'recognise/bind' to foreign material (antigen)
- All T cells express the marker CD3 but there are 2 main sub-groups:

## **Cytotoxic T cells** (express CD8 and CD3)

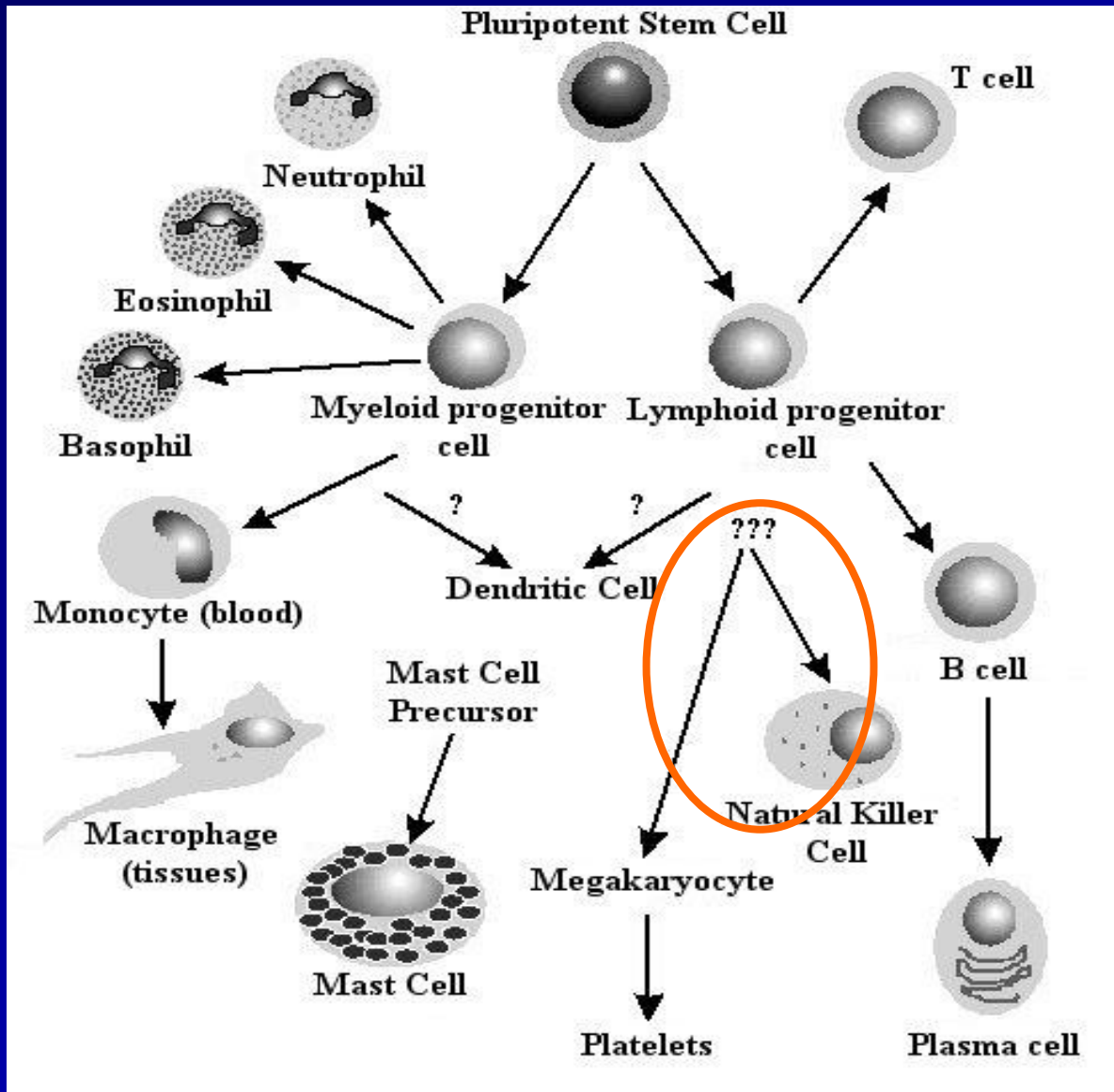
- activated to kill infected targets or to become memory cells



## **Helper T cells** (express CD4 and CD3)

- activated to secrete cytokines or to become memory cells

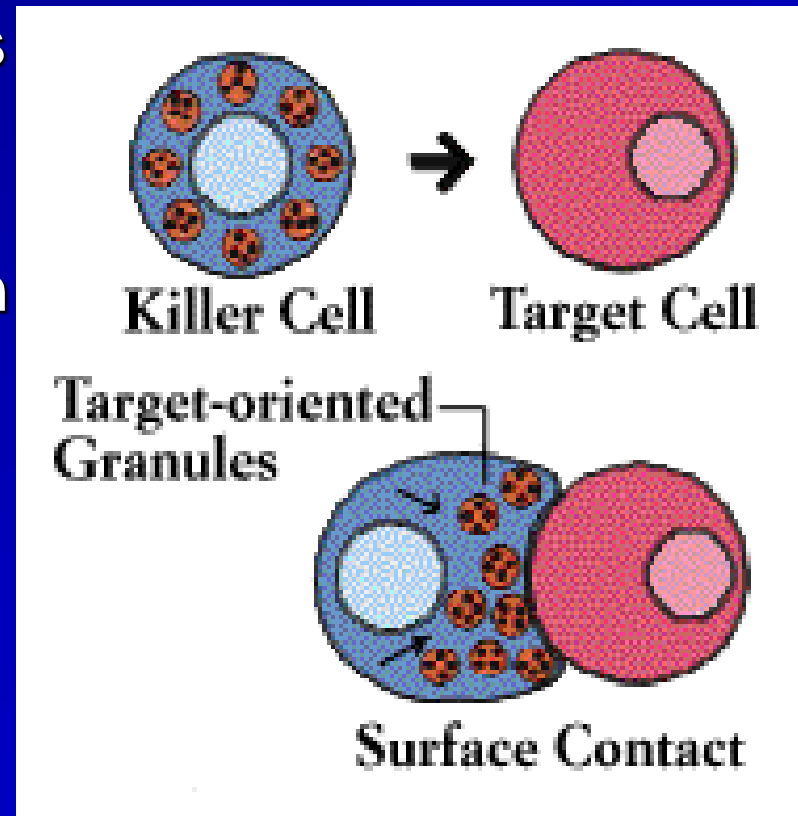
# Cells involved in immunity





# Natural Killer cells (Large granular lymphocytes)

- 4% white blood cells
- Collection of cells playing roles between innate & specific immunity
- Lymphocyte-like but larger with granular cytoplasm
- Kill certain tumour & virally infected cells
- Target cell destruction is caused by cytotoxic molecules called granzymes & perforins



# Megakaryocytes & platelets

- Mature megakaryocytes are polyploid
- Megakaryocytes give rise to platelets by cytoplasmic fragmentation of cell
- Platelets are contractile, adhere to other cells & surfaces & play important roles in blood coagulation

**THANK YOU**  
**Will MEET IN NEW LECTURE**