Blood

Al-Farabi Kazakh National University Higher School of Medicine

Circulating Blood Cells

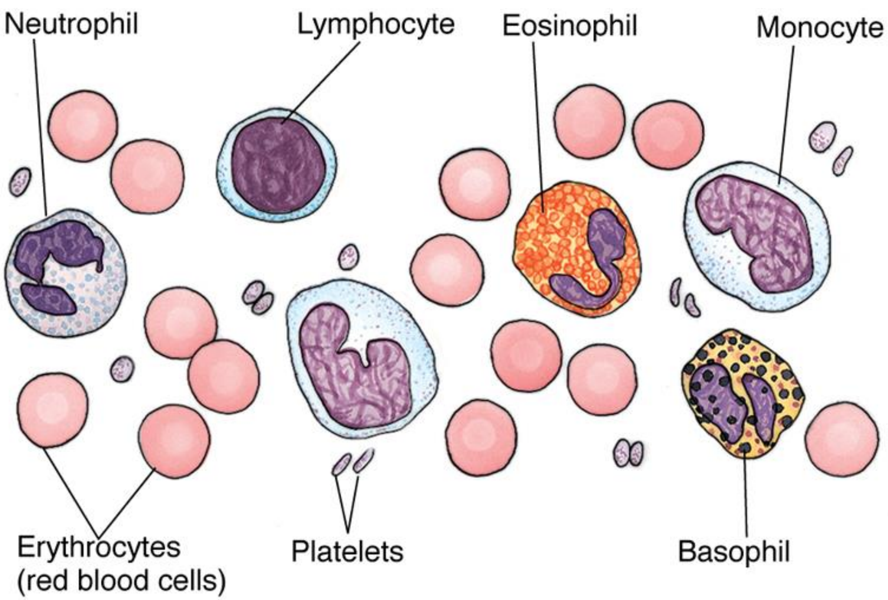


Figure 10–2 Cells and platelets of circulating blood.

The total volume of **blood** of an average adult is about 5 L, and it circulates throughout the body within the confines of the circulatory system. Blood is a specialized connective tissue composed of formed elements and a fluid component (the extracellular matrix) known as **plasma**.

The formed elements are composed of cells and cell fragments, known as platelets. Light microscopic examination of the formed elements is performed using either the Wright or Giemsa stains, and identification of blood cells is based on the colors produced by these stains.

The cells of blood are subdivided into two major components, **red blood cells** (RBC) and **white blood cells** (WBCs, leukocytes).

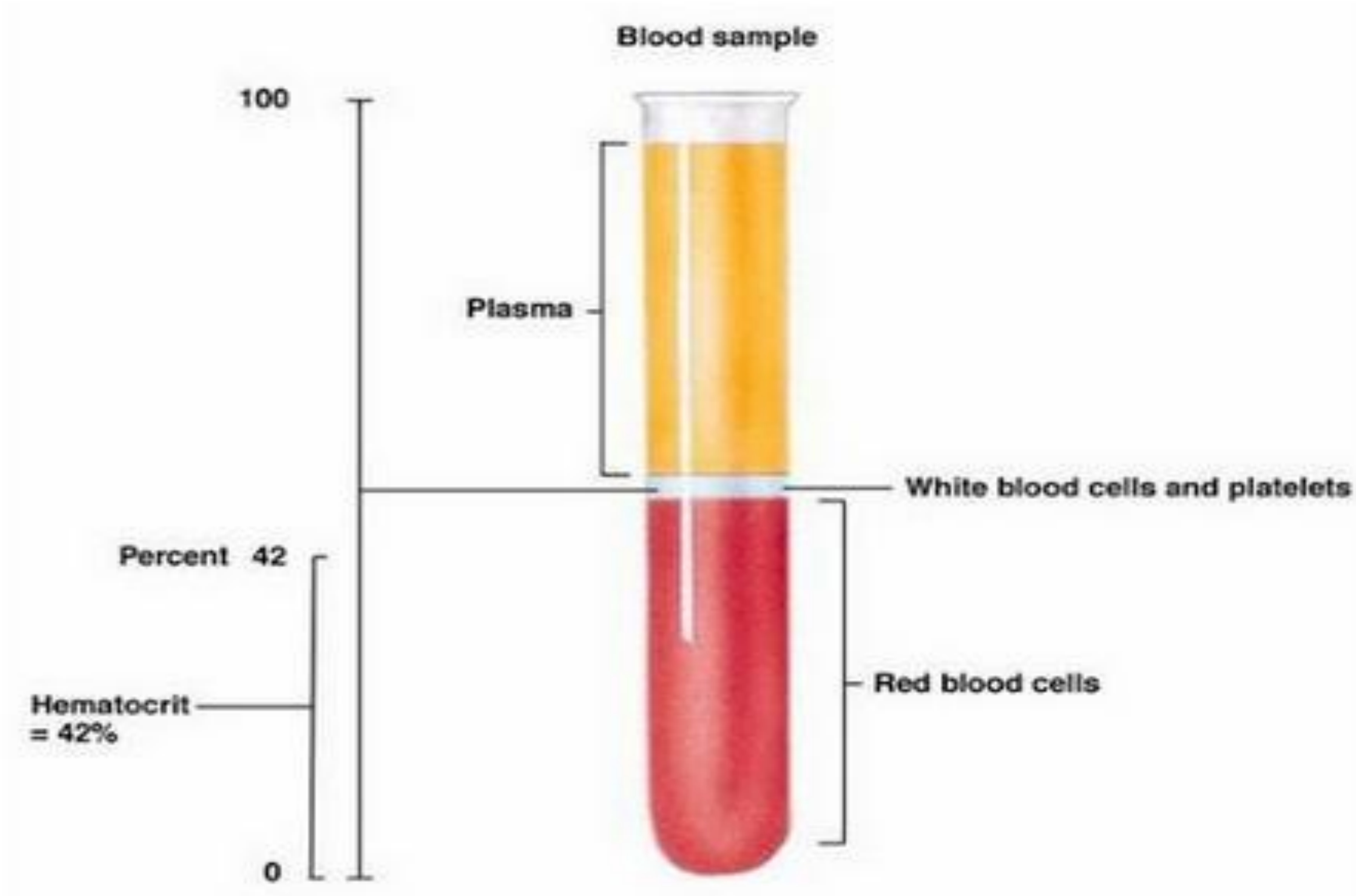
Red blood cells lose their nuclei and organelles during development, therefore mature, circulating RBC are anucleated cells whose cytoplasm is filled with hemoglobin.

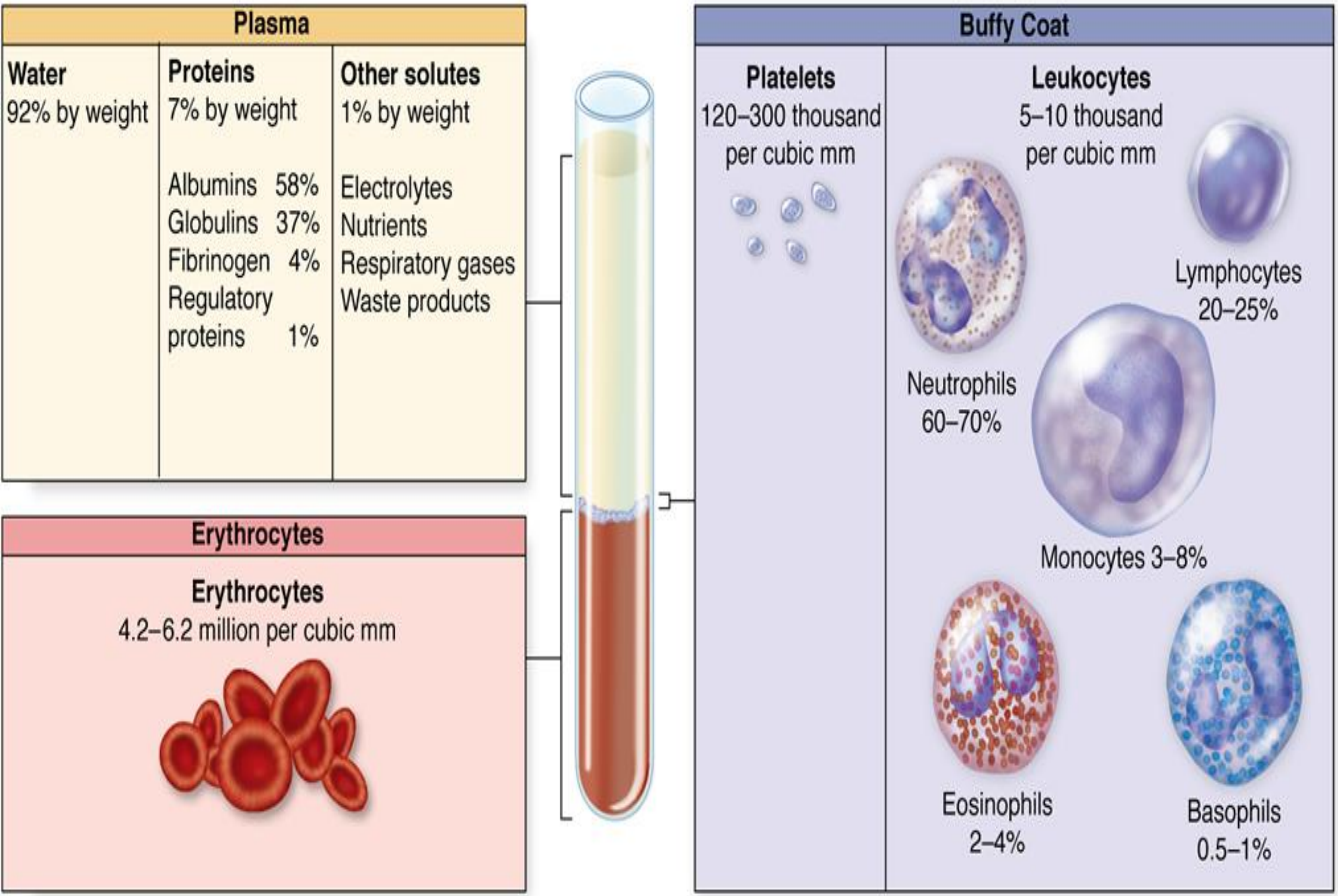
White blood cells are subdivided into two categories, those without specific granules, **agranulocytes** and those housing specific granules, **granulocytes**. **Lymphocytes** and **monocytes** belong to the former and **neutrophils, eosinophils**, and **basophils** belong to the latter category.

Platelets are round to oval cell fragments derived from megakaryocytes.

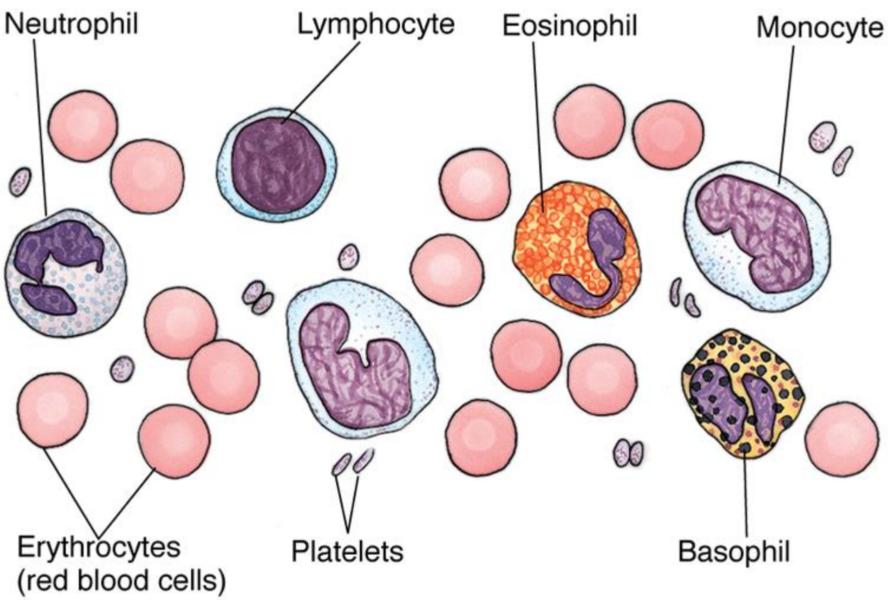
For more information see Formed Elements in Chapter 10 of Gartner and Hiatt: Color Textbook of Histology, 3rd ed. Philadelphia, W.B. Saunders, 2007.

Hematocrit


Blood sample
100
Plasma
White blood cells and platelets
Percent 42
Red blood cells
Hematocrit
= 42%
0


Plasma
Water
92% by weight
Proteins
7% by weight
Albumins 58%
Globulins 37%
Fibrinogen 4%
Regulatory proteins 1%
Other solutes
1% by weight
Electrolytes
Nutrients
Respiratory gases
Waste products
Erythrocytes
Erythrocytes
4.2–6.2 million per cubic mm
Buffy Coat
Platelets
120–300 thousand per cubic mm
Leukocytes
5–10 thousand per cubic mm
Neutrophils 60–70%
Lymphocytes 20–25%
Monocytes 3–8%
Eosinophils 2–4%
Basophils 0.5–1%

Circulating Blood Cells



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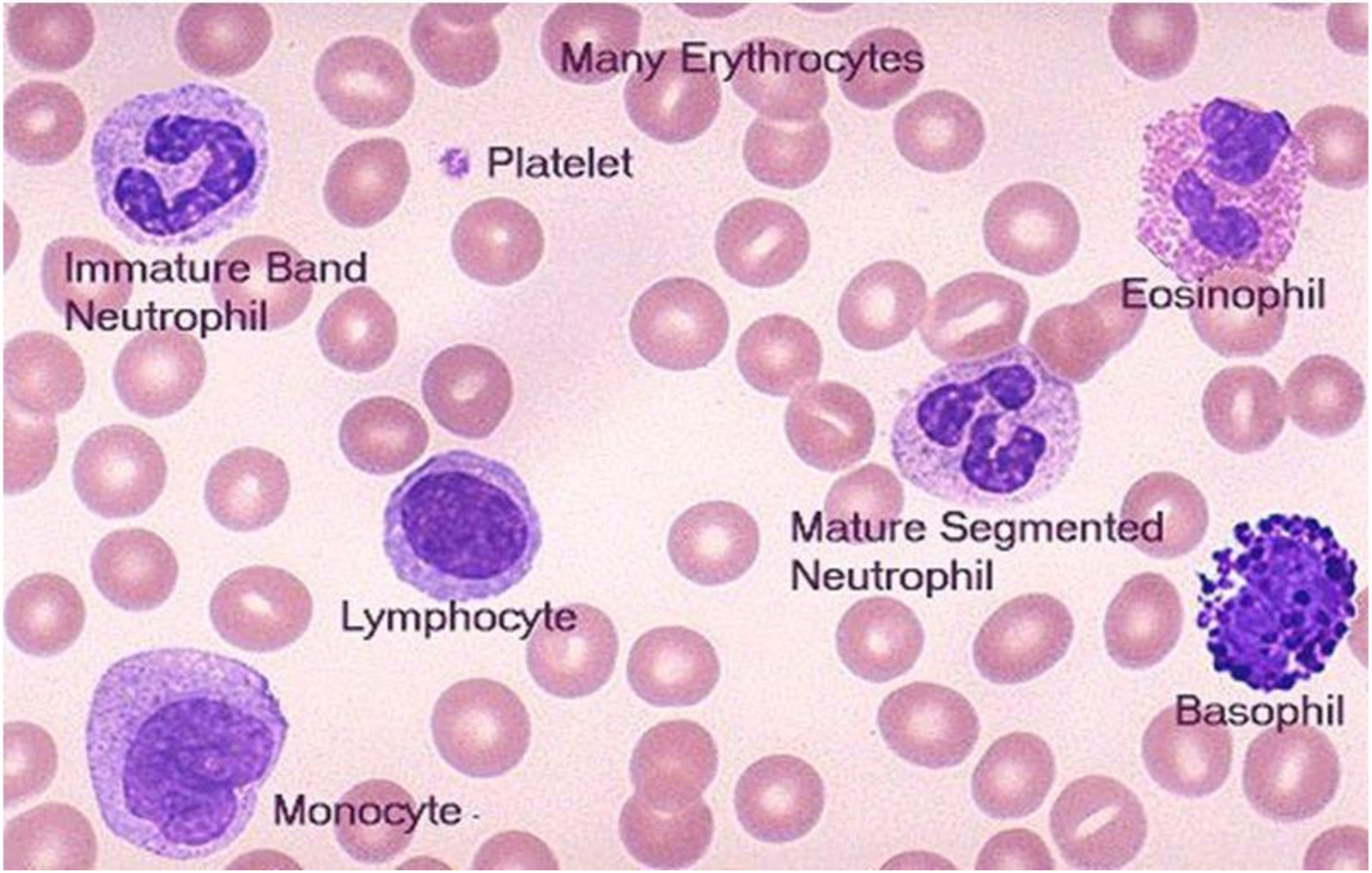
BLOOD HISTOLOGY
RED AND WHITE BLOOD CELLS



Circulating Cells of Blood (cont.)

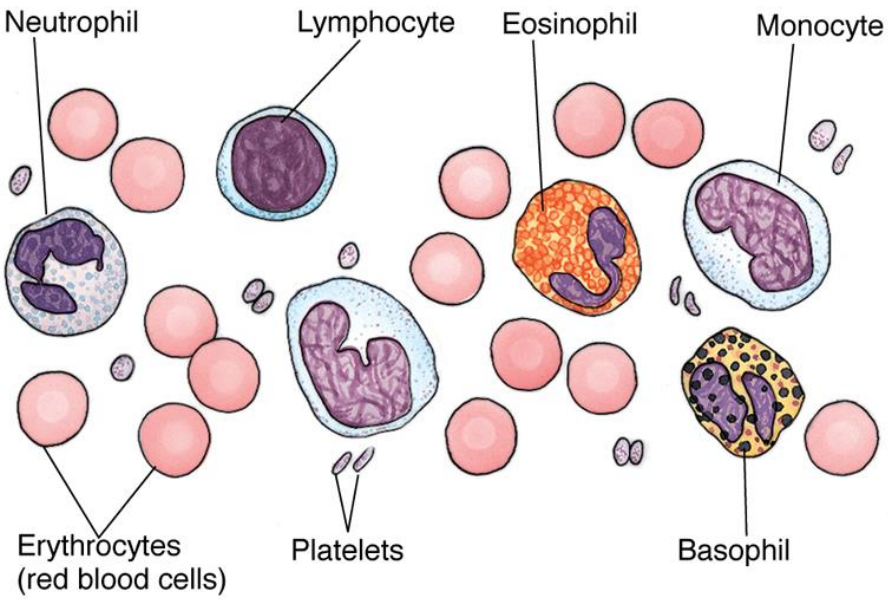


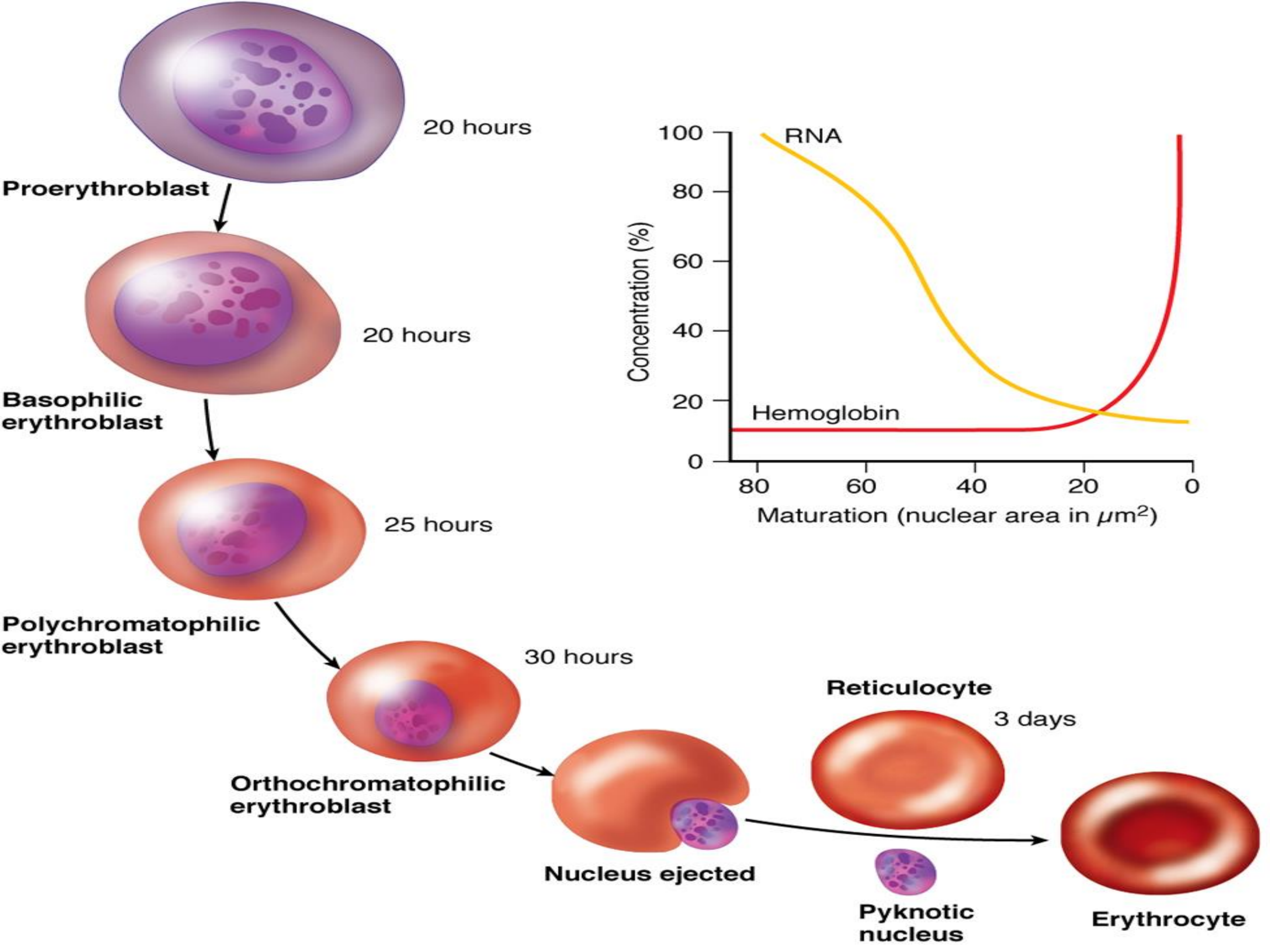
Figure 10–2 Cells and platelets of circulating blood.

Red blood cells are packed with **hemoglobin,** a large tetrameric protein composed of four polypeptide chains, each of which is covalently bound to an iron-containing **heme.** It is hemoglobin that provides the *unstained* cell with its pale yellow color. The globin moiety of hemoglobin releases CO_2, and the iron binds to O_2 in regions of high oxygen concentration, as in the lung. However, in oxygen-poor regions, as in tissues, hemoglobin releases O_2 and binds CO_2. This property of hemoglobin makes it ideal for the conveyance of respiratory gases. Hemoglobin carrying oxygen is known as **oxyhemoglobin,** and hemoglobin carrying carbon dioxide is called **carbaminohemoglobin** (or **carbamylhemoglobin**).

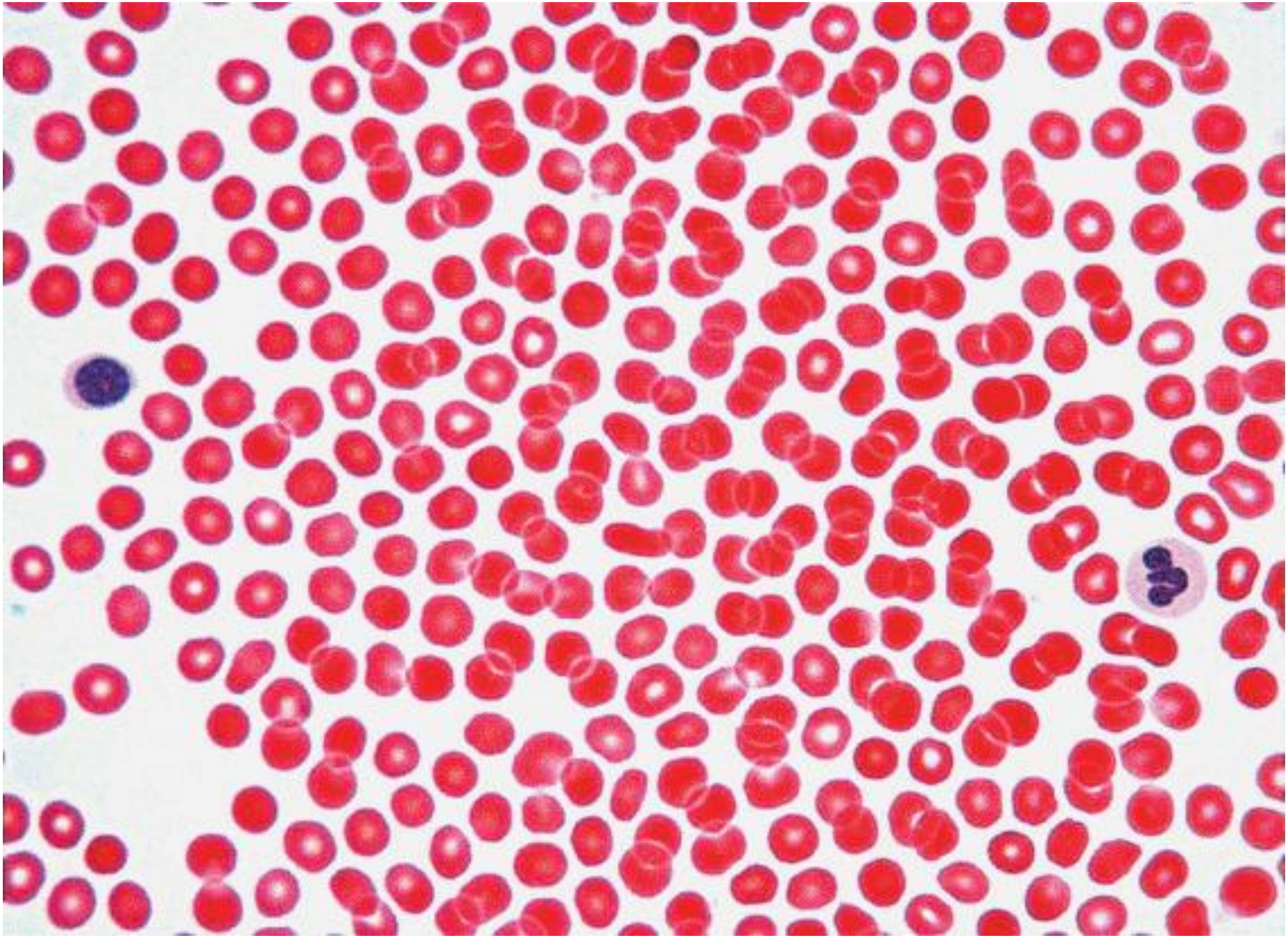
The extracellular surface of the red blood cell plasmalemma has specific inherited carbohydrate chains that act as antigens and determine the blood group of an individual for the purposes of blood transfusion. The most notable of these are the **A** and **B antigens,** which determine the four primary blood groups, **A, B, AB,** and **O** (Table 10–2).

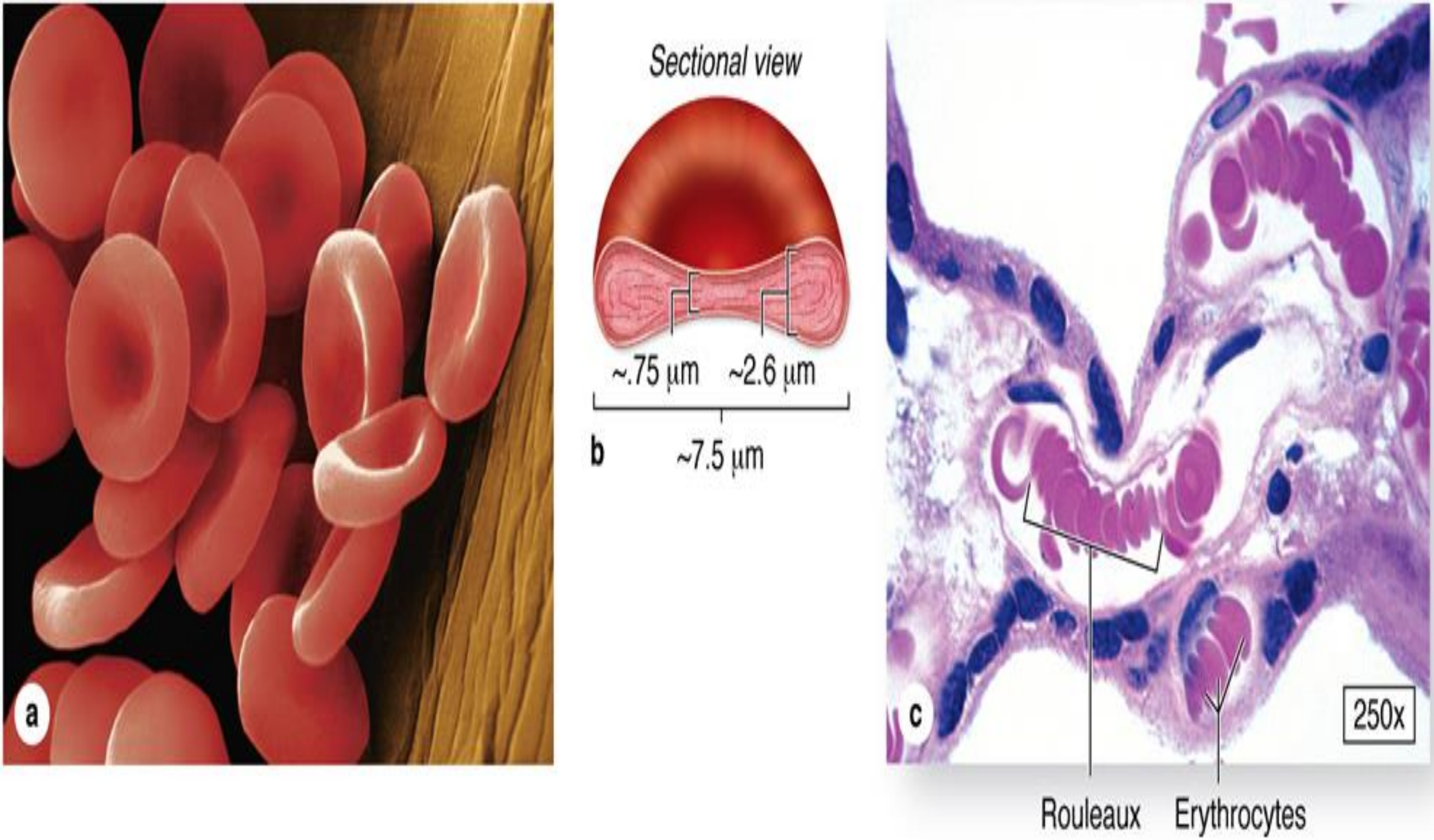
Another important blood group, the **Rh** group, is so named because it was first identified in rhesus monkeys. Three of the Rh antigens (C, D, and E) are so common in the human population that the erythrocytes of 85% of Americans have one of these antigens on their surface, and these individuals are thus said to be **Rh$^+$.**

For more information see Erythrocytes in Chapter 10 of Gartner and Hiatt: Color Textbook of Histology, 3rd ed. Philadelphia, W.B. Saunders, 2007.



Proerythroblast
20 hours
Basophilic erythroblast
20 hours
Polychromatophilic erythroblast
25 hours
Orthochromatophilic erythroblast
30 hours
Nucleus ejected
Reticulocyte
3 days
Pyknotic nucleus
Erythrocyte
RNA
Hemoglobin
Concentration (%)
100
80
60
40
20
0
Maturation (nuclear area in μm^2)




a
Sectional view
~.75 μm
~2.6 μm
b
~7.5 μm
c
250x
Rouleaux
Erythrocytes

НОРМОЦИТЫ 75 %, d=7,5 МКМ

МАКРОЦИТЫ 12,5 %, d= 8 мкм

(анизоцитоз)

МИКРОЦИТЫ 12,5%,

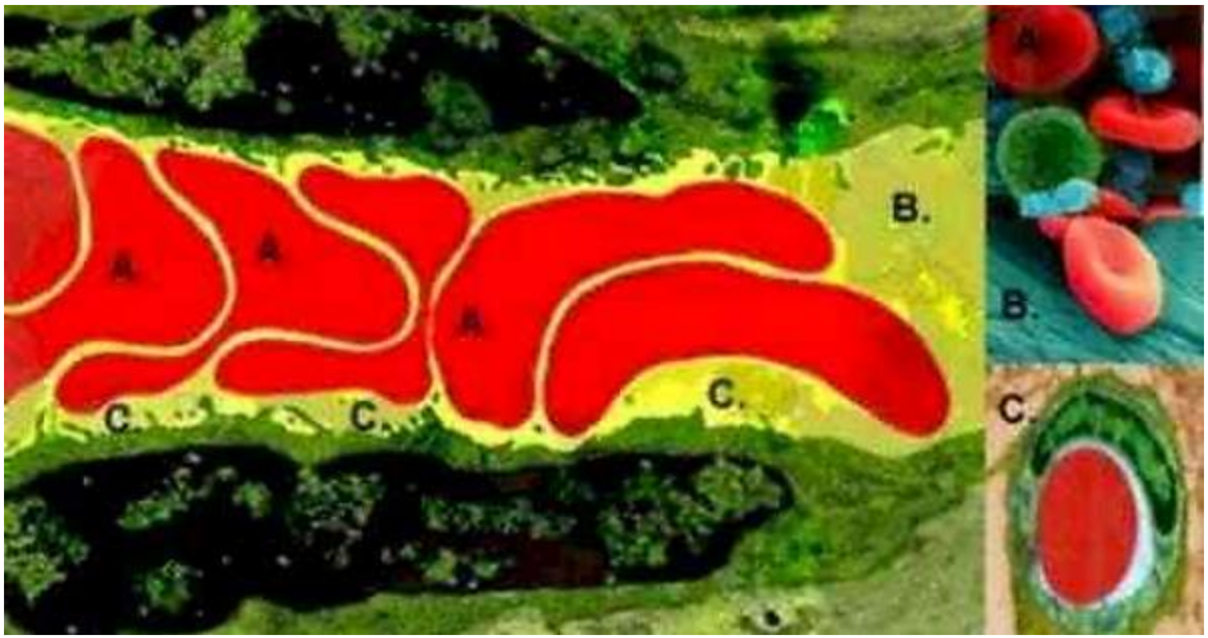
d = 6 мкм

(анизоцитоз)

муж
3,9 – 5,5 X10^{12}/Л.

жен
3,7 – 4,9 X 10^{12} /Л.

Red blood cells look weird when they're squeezing through capillaries.



How Blood Cells Change Shape

Millions of times during their four-month lifespan, human red blood cells must squeeze through tiny capillaries to deliver their payload of oxygen and pick up waste carbon dioxide-functions essential to life.

How Blood Cells Change Shape

Red blood cells have a diameter of about eight microns, or millionths of a meter. As they flow through the body, they often encounter blood vessels, such as those in the brain, with a diameter of only about two microns. Each time the cells reach such a vessel, they must stretch into a bullet-like shape to squeeze through and then return to their original disc shape upon exiting the vessel.

How Blood Cells Change Shape

Do red blood cells change shape?

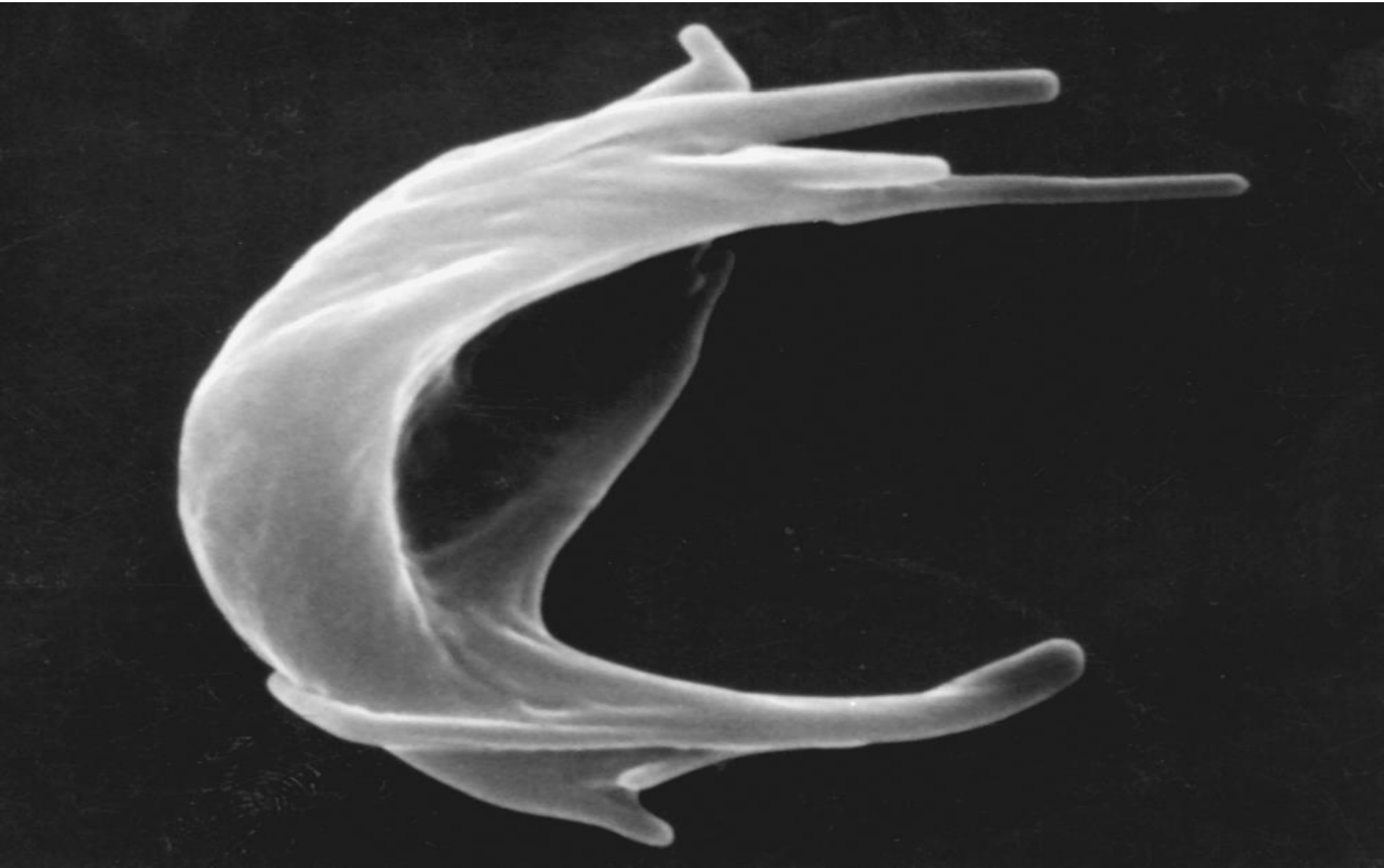
Human red blood cells rushing through the body to carry oxygen and carbon dioxide to and from the organs are forced to squeeze through smaller and smaller blood vessels. ... To change shape, the cells rearrange protein components of their internal scaffolding, called the cytoskeleton

Red Blood Cells In A Capillary Vessel is a photograph by David M Phillips which was uploaded on June 30th, 2014.

This image shows a healthy red blood cell (left) and a sickle cell (right).

SCIEPRO / Getty Images

sickle cell anemia



Platelets

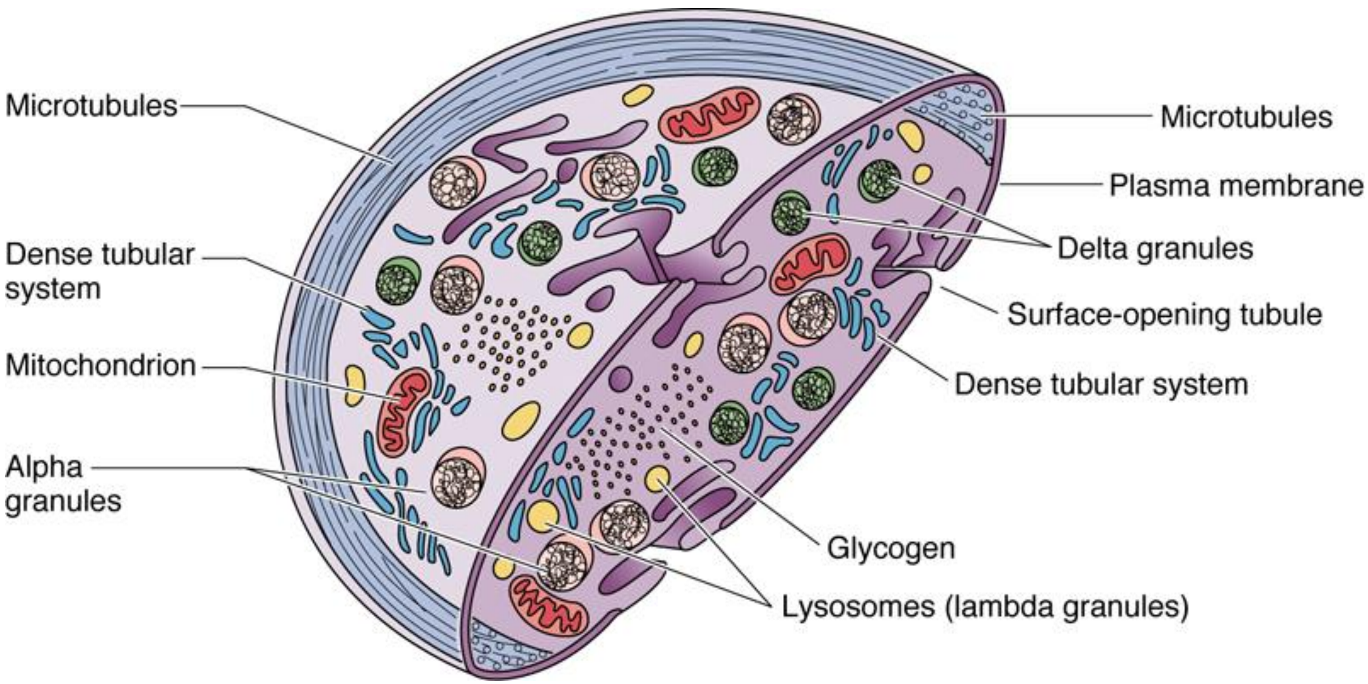
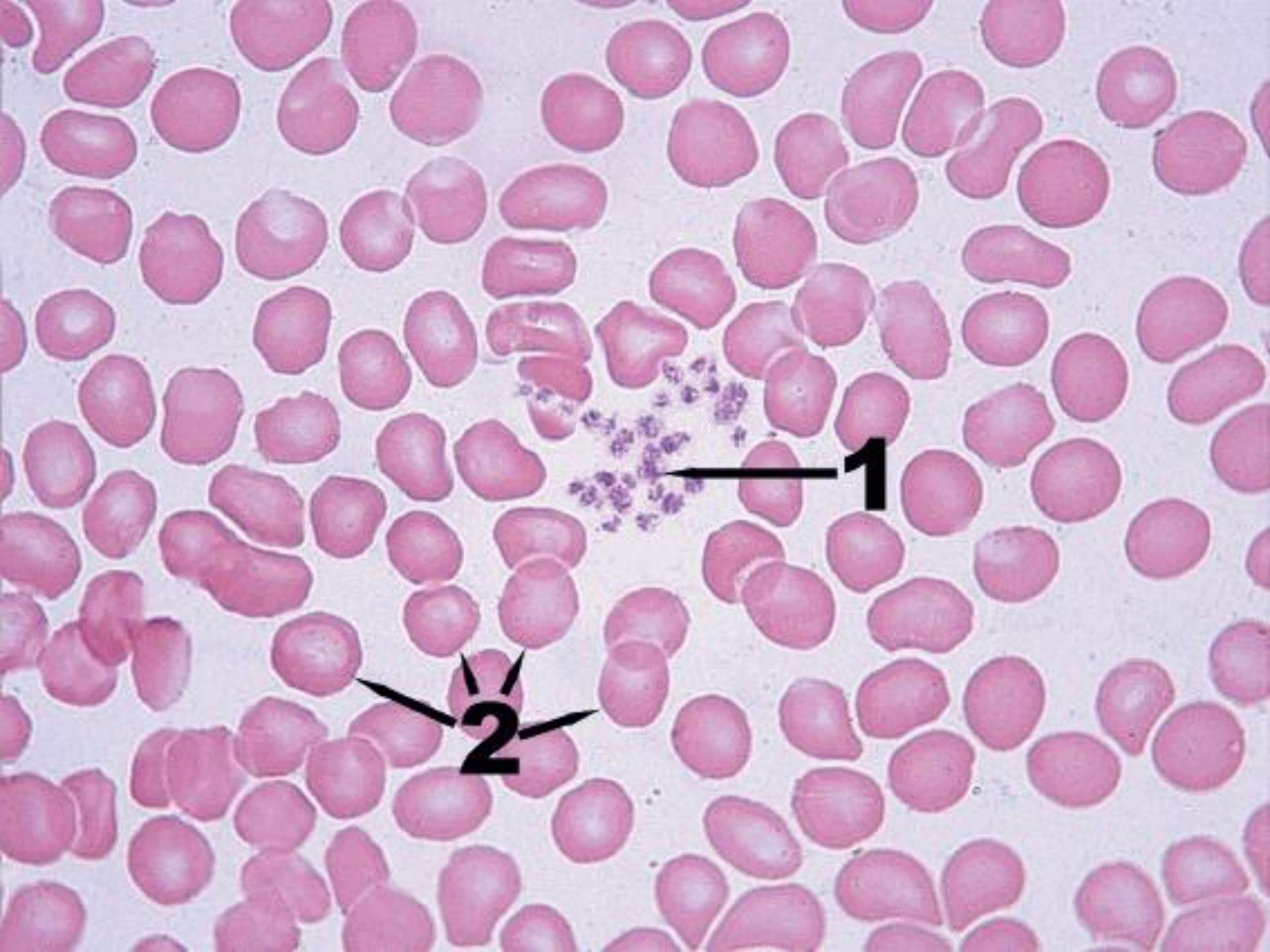


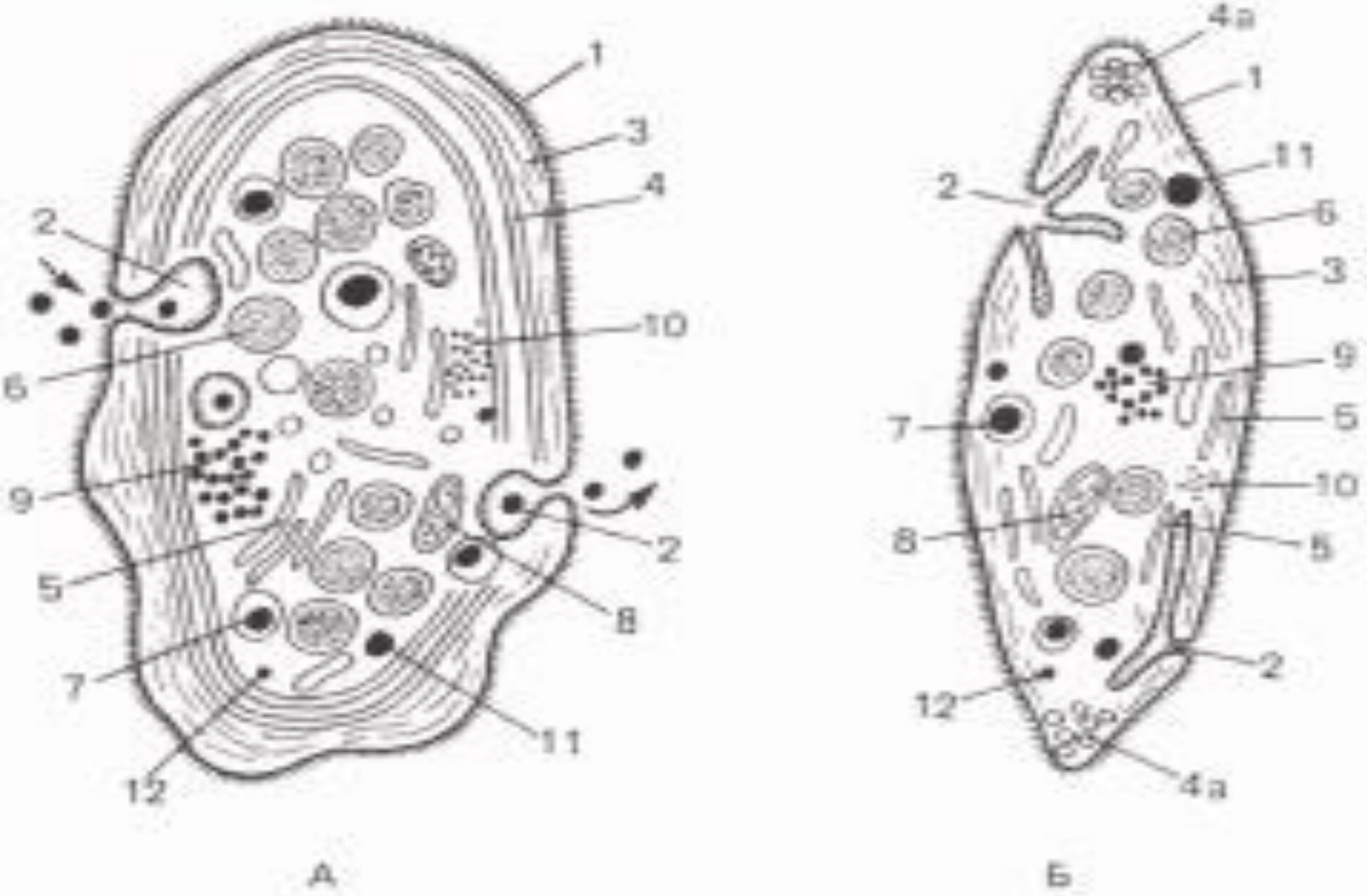
Figure 10–10 Platelet ultrastructure. Note that the periphery of the platelet is occupied by actin filaments that encircle the platelet and maintain the discoid morphology of this structure.

Platelets are about 2 to 4 μm in diameter in blood smears. In light micrographs, they display a peripheral clear region, the **hyalomere,** and a central darker region, the **granulomere.** The platelet plasmalemma has numerous receptor molecules as well as a relatively thick glycocalyx. There are between 250,000 and 400,000 platelets per mm_3 of blood, each with a life span of less than 14 days.

If the endothelial lining of a blood vessel is disrupted and platelets come in contact with the subendothelial collagen, they become **activated,** release the contents of their granules, adhere to the damaged region of the vessel wall **(platelet adhesion),** and adhere to each other **(platelet aggregation).** Interactions of tissue factors, plasma-borne factors, and platelet-derived factors form a blood clot.

For more information see Platelets in Chapter 10 of Gartner and Hiatt: Color Textbook of Histology, 3rd ed. Philadelphia, W.B. Saunders, 2007.


1
2



Тромбоциттің ультрамикроскопиялық құрылысы. (қан пластинкасы).
А- горизонтальды кесінді; Б- көлденең кесінді.

1-гликокаликсы бар плазмолеммасы; 2- плазмолемма инвагинациямен байланысқан түтікшелердің ашық жүйесі; 3- актин филаменттері; 4- микротүтікшелердің көлденең кесіндісі; 5- тығыз тубулин жүйесі; 6- α-түйіршіктері; 7- β-түйіршіктері; 8- митохондриялар; 9- гликоген түйіршіктері; 10- ферритин түйіршіктері; 11- лизосомалар; 12- пероксисомалар (Н.А.Юрина бойынша).

Circulating Cells of Blood (cont.)

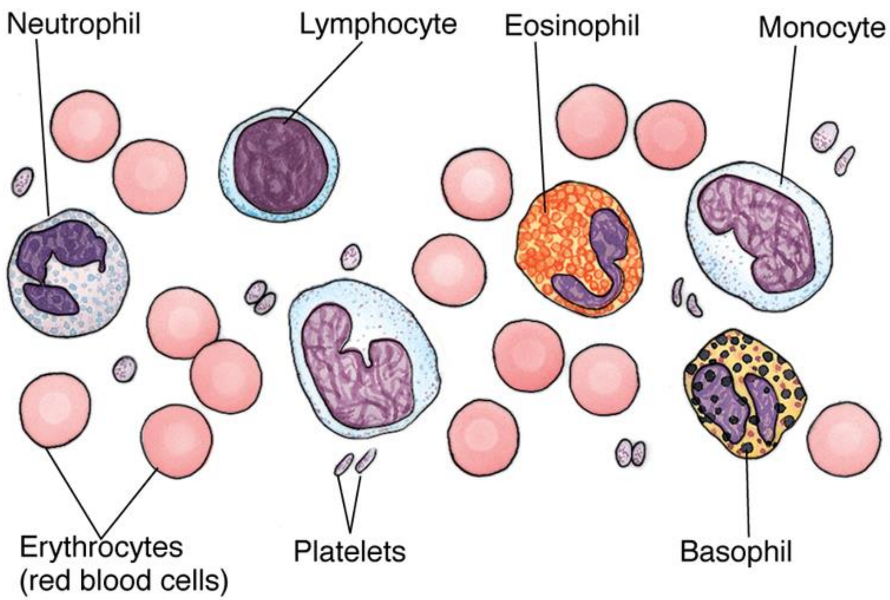


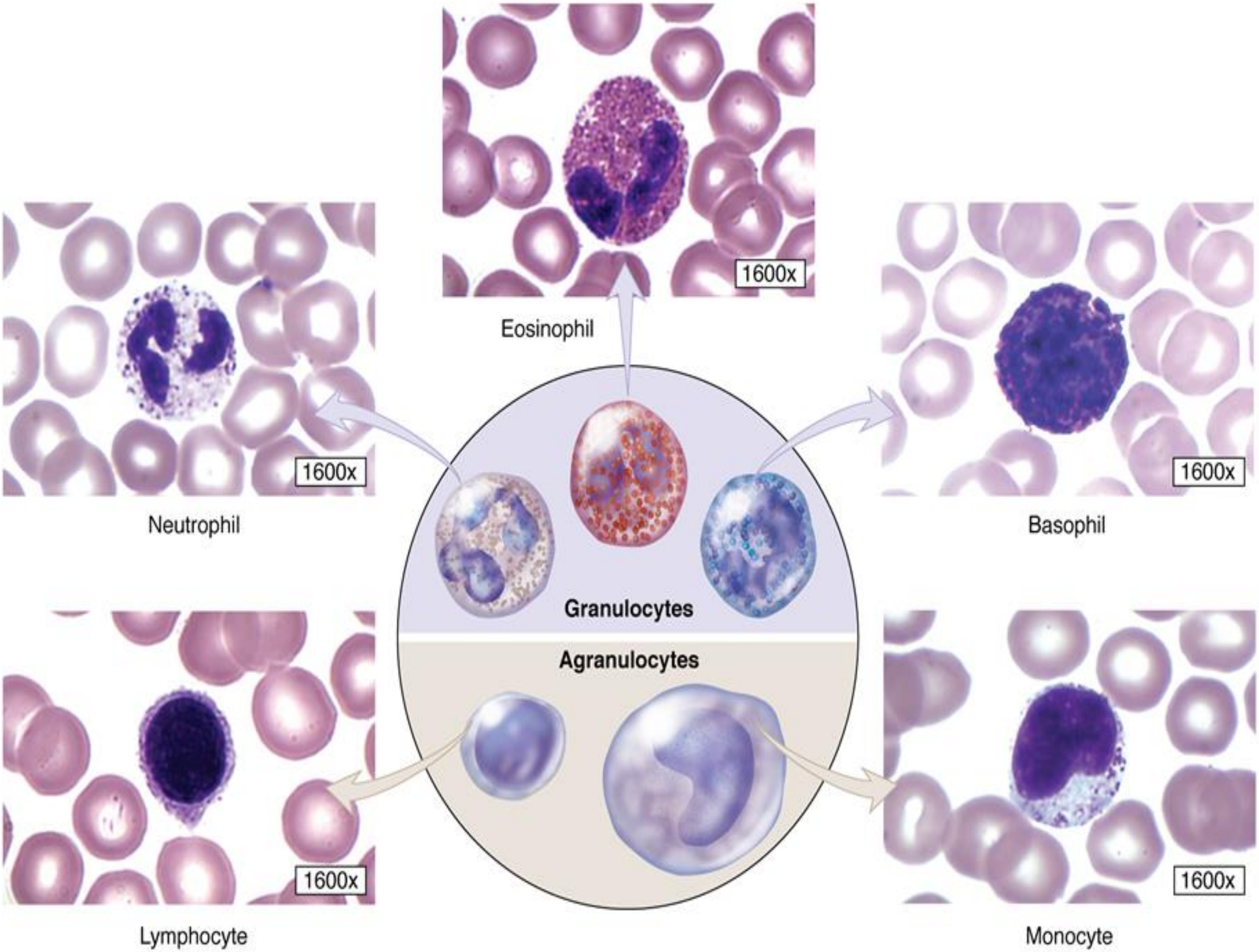
Figure 10–2 Cells and platelets of circulating blood.

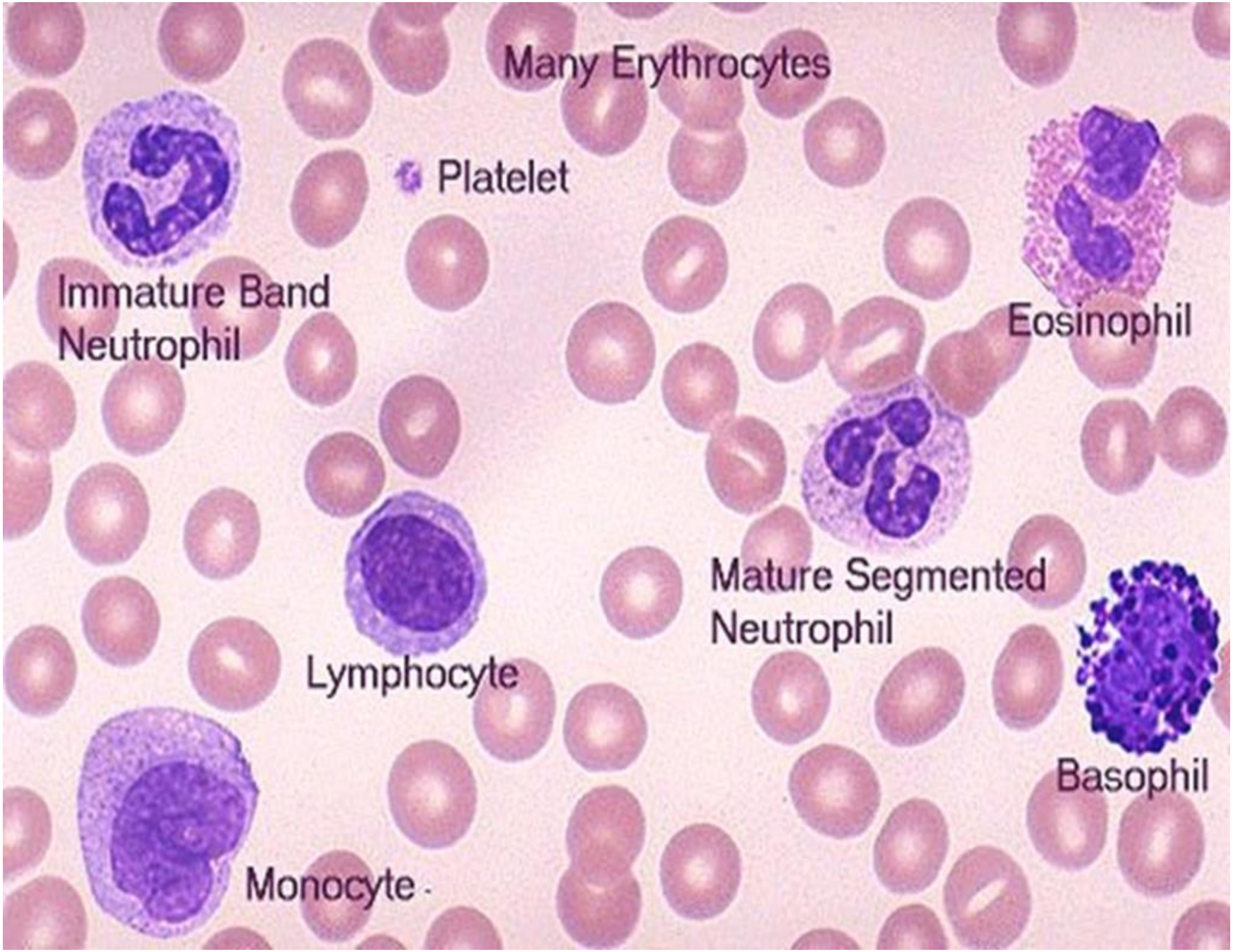
Neutrophils are the most numerous of the white blood cells, constituting 60% to 70% of the total leukocyte population. The lobes of their multilobed nucleus are connected to each other by slender chromatin threads. In females, the nucleus presents a characteristic small appendage, the "drumstick," which contains the condensed, inactive second X chromosome. but is not always evident in every cell. Neutrophils are among the first cells to appear in acute bacterial infections. They possess very small specific granules.

Eosinophils constitute less than 4% of the total white blood cell population. They are round cells containing large, salmon pink colored specific granules. They have a sausage-shaped, bilobed nucleus in which the two lobes are connected by a thin chromatin strand and nuclear envelope. Eosinophils function in parasitic infections and phagocytosing antigen-antibody complexes.

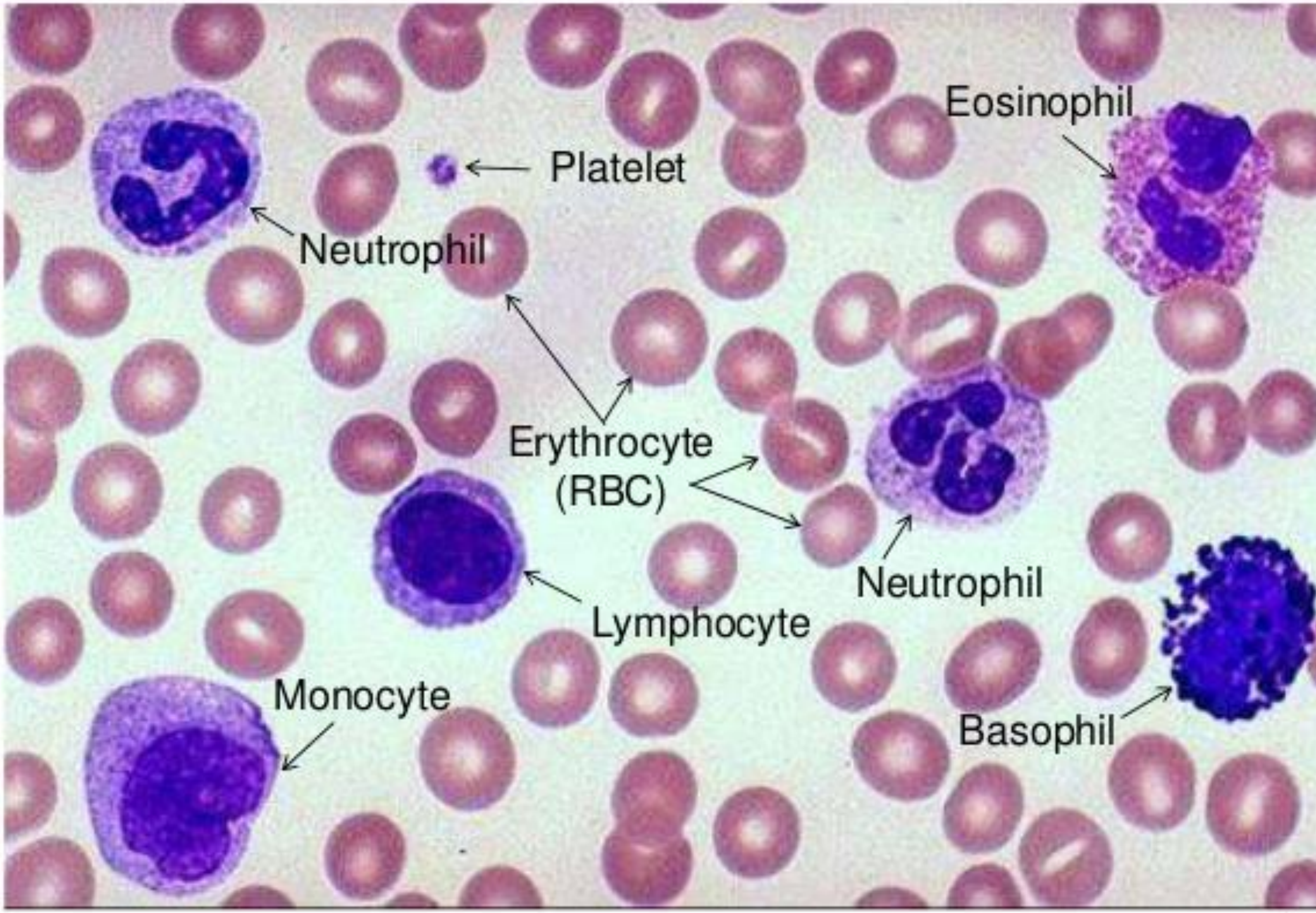
Basophils constitute less than 1% of the total leukocyte population. They are round cells and have an **S**-shaped nucleus, which is commonly masked by the large darkblue to black specific granules present in the cytoplasm. Basophils have several surface receptors on their plasmalemma, including **immunoglobulin E (IgE) receptors.** Their function is very similar to those of mast cells.

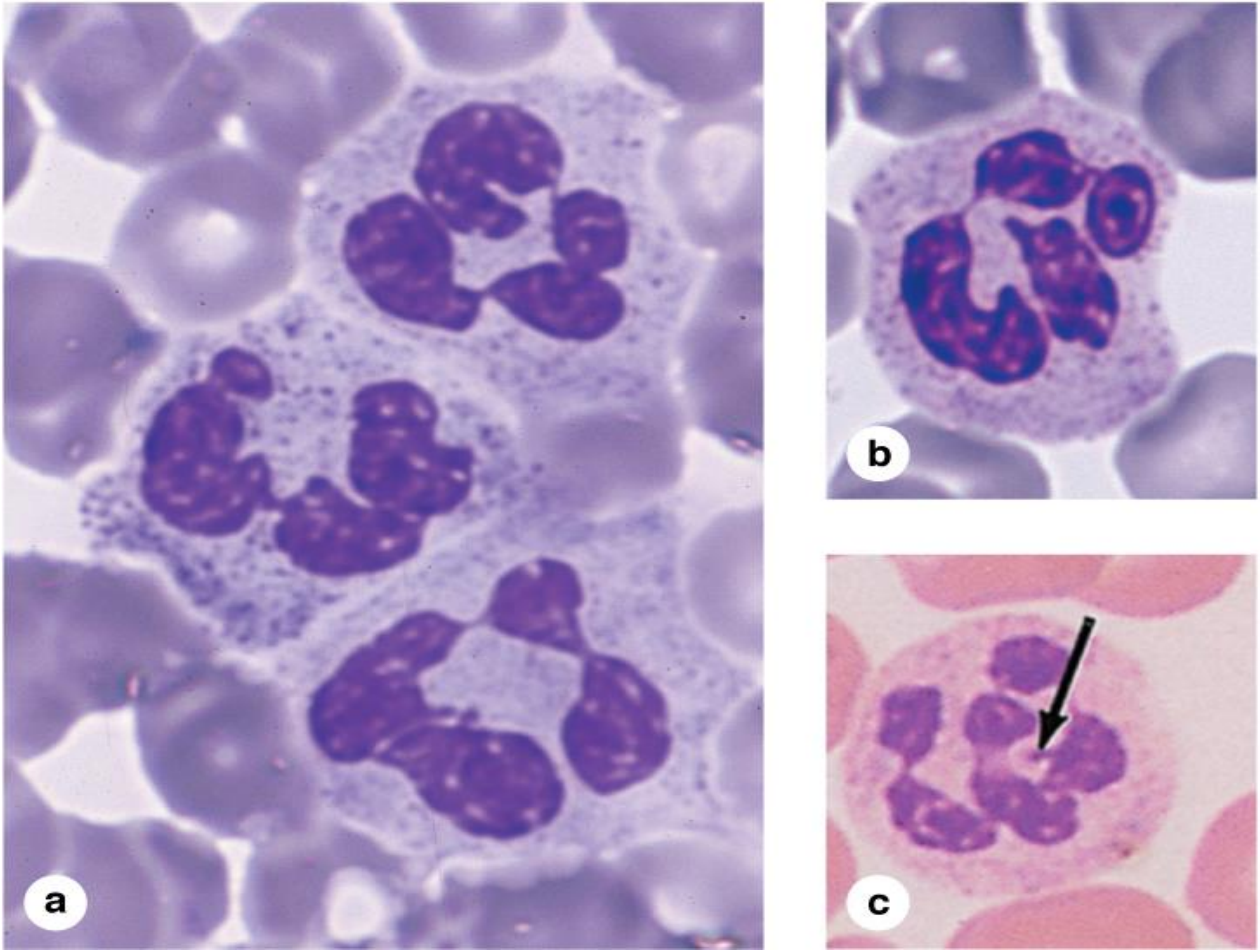
For more information see Neutrophils, Eosinophils, Basophils in Chapter 10 of Gartner and Hiatt: Color Textbook of Histology, 3rd ed. Philadelphia, W.B. Saunders, 2007.

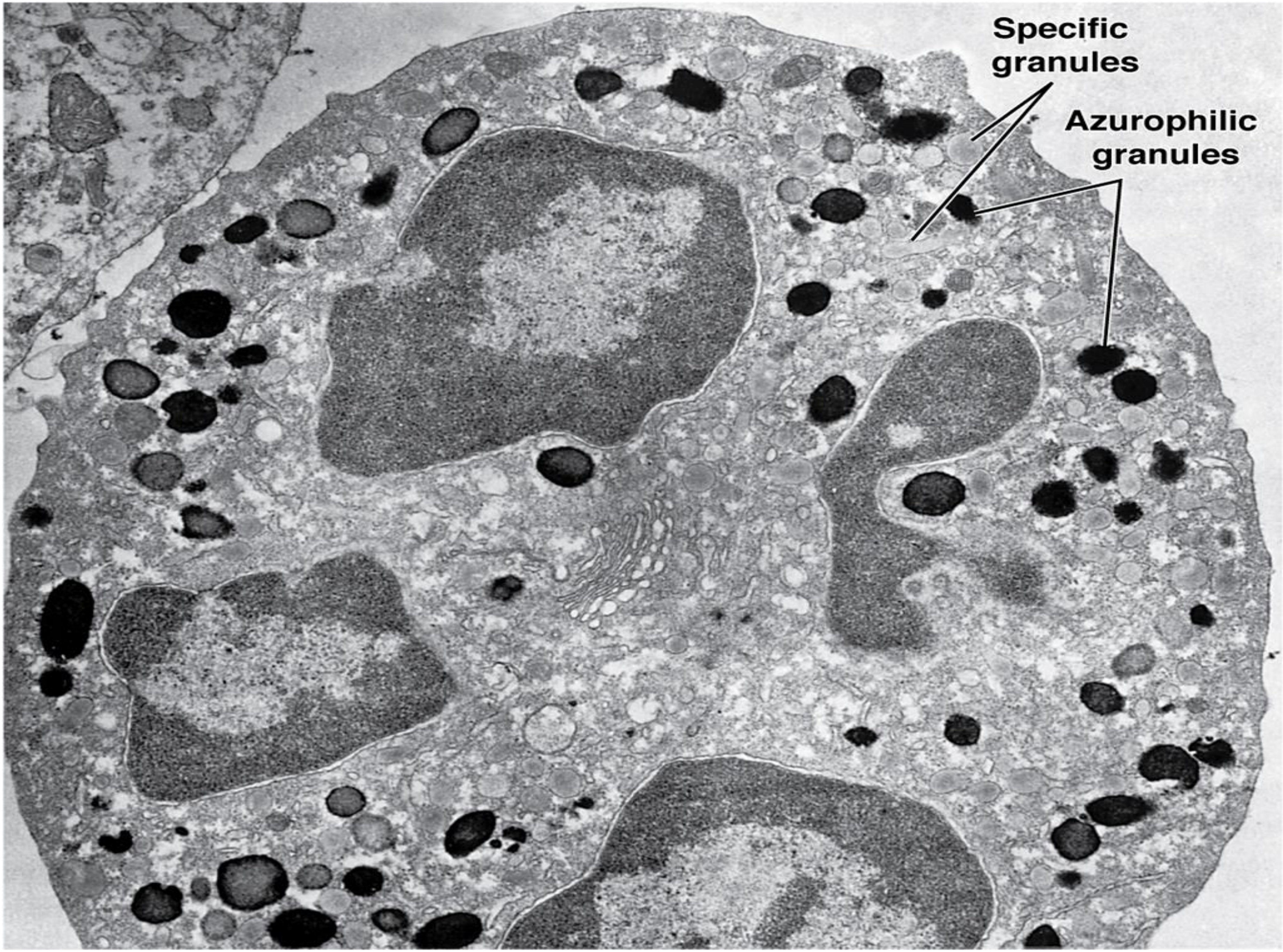

Eosinophil
1600x
Neutrophil
1600x
Basophil
1600x
Granulocytes
Agranulocytes
Lymphocyte
1600x
Monocyte
1600x

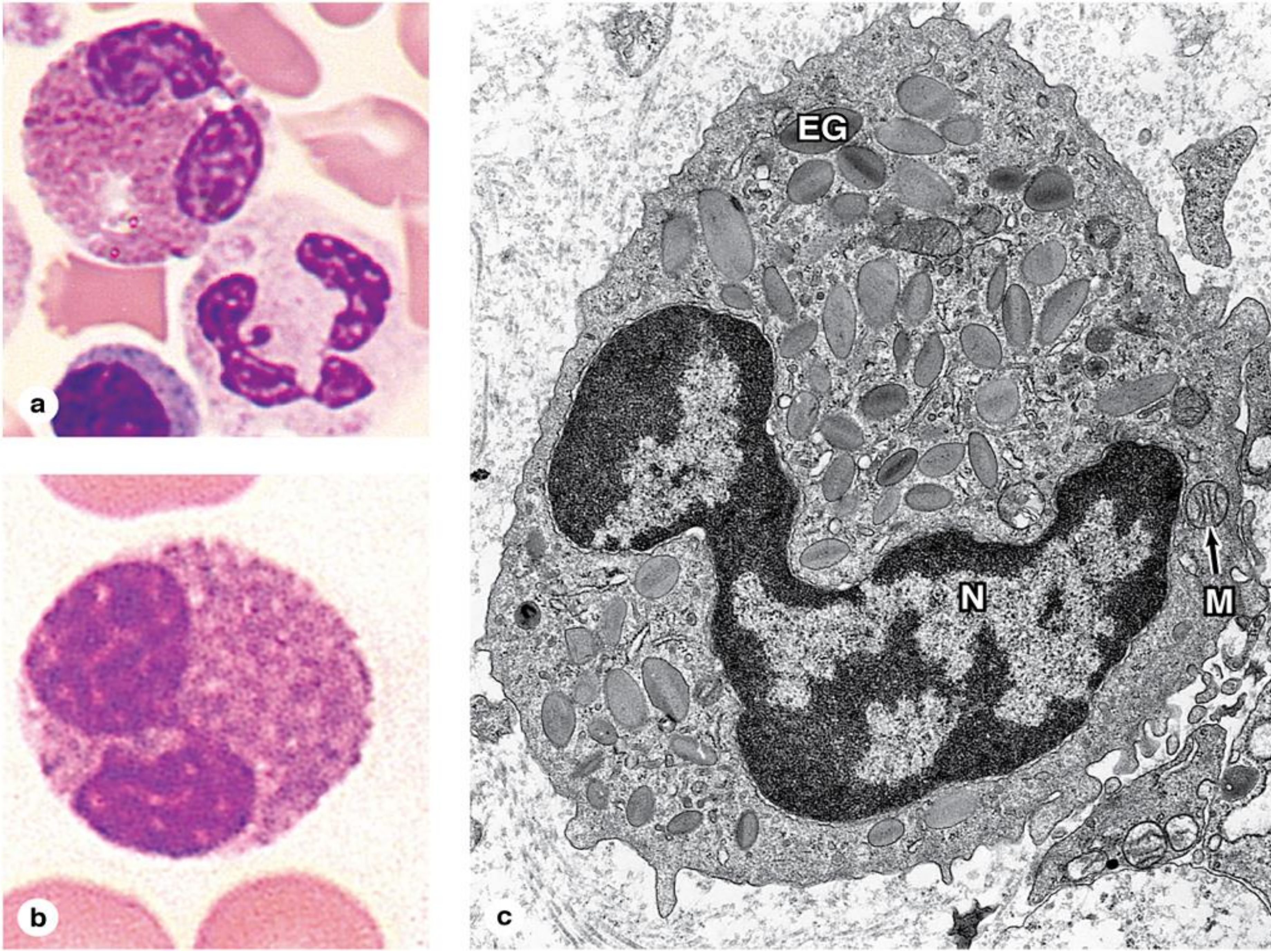

Many Erythrocytes
Platelet
Immature Band
Neutrophil
Eosinophil
Mature Segmented
Neutrophil
Lymphocyte
Basophil
Monocyte

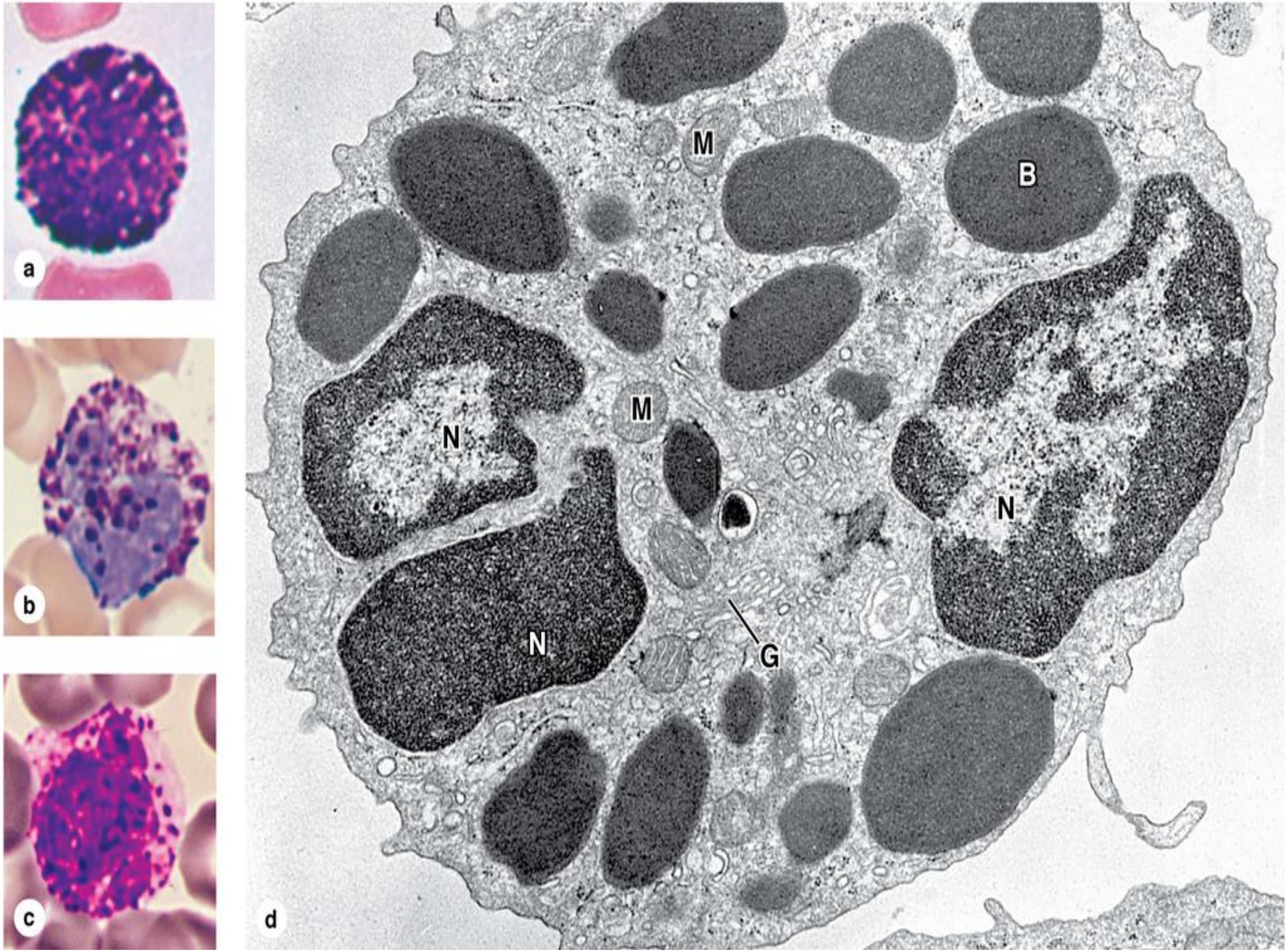
Blood: Histology

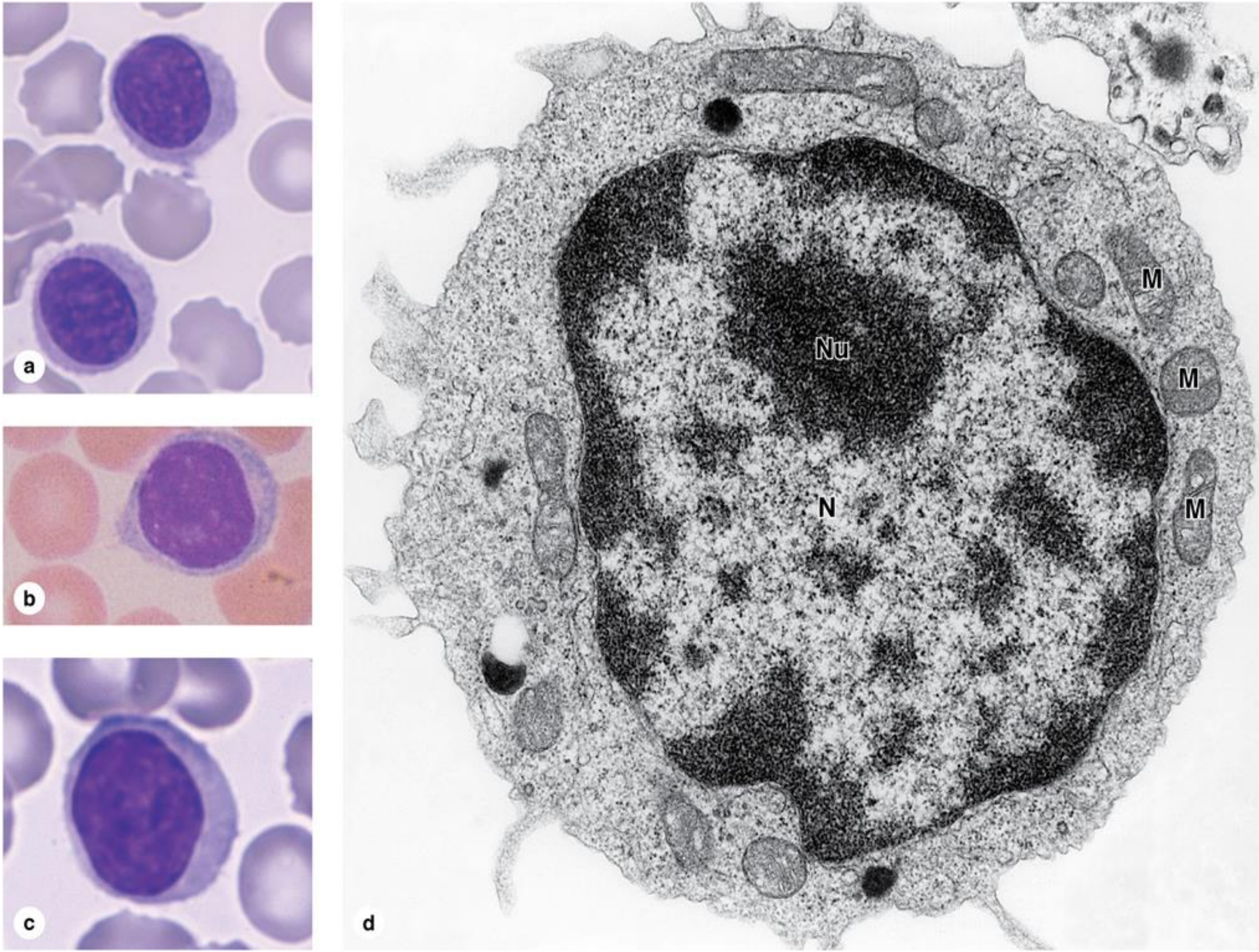



a
b
c


Specific granules
Azurophilic granules


a
b
EG
N
M
c


a
b
c
d
M
M
B
N
N
N
G


a
b
c
d
Nu
N
M
M
M

Circulating Cells of Blood (cont.)

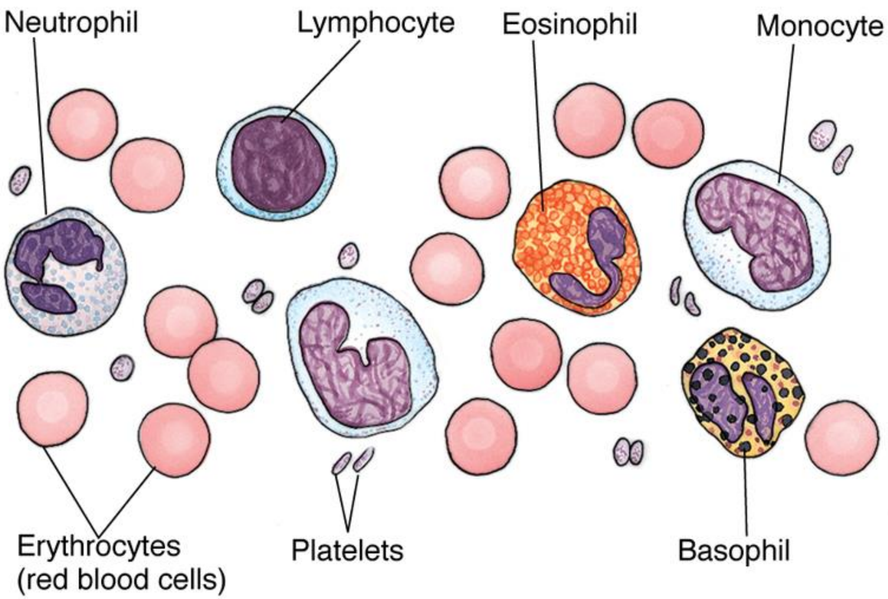
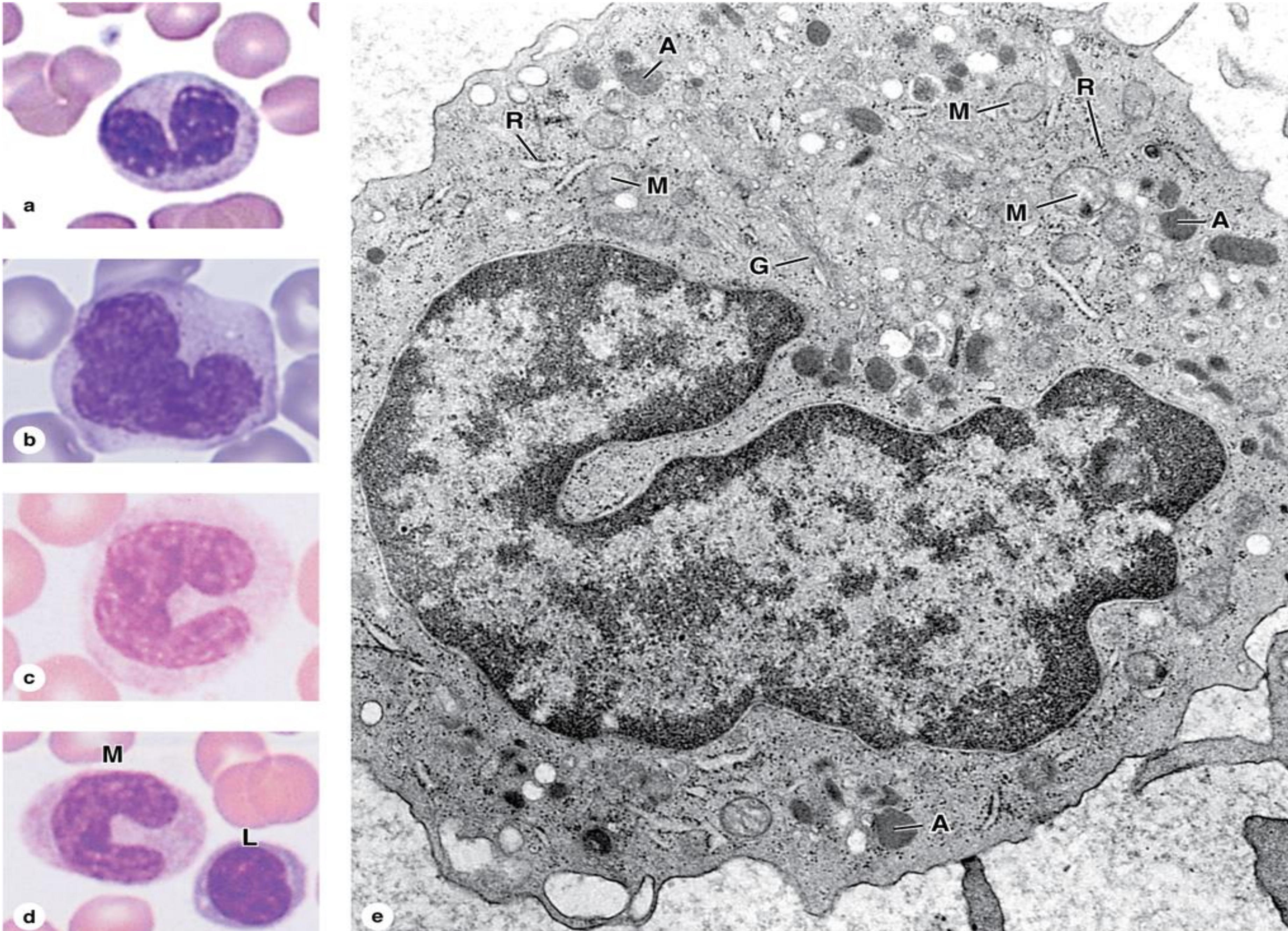


Figure 10–2 Cells and platelets of circulating blood.

Monocytes are the largest of the circulating blood cells and constitute 3% to 8% of the leukocyte population. They have a large, acentric, kidney-shaped nucleus whose lobe-like extensions seem to overlap one another. The chromatin network is coarse but not overly dense, their cytoplasm is bluish gray and has numerous azurophilic granules, (lysosomes) and occasional vacuole-like spaces, but no specific granules. Macrophages are avid phagocytes, and as members of the **mononuclear phagocyte system** they phagocytose and destroy dead and defunct cells as well as antigens and foreign particulate matter (such as bacteria). They also have a major role in the immune response

Lymphocytes constitute 20% to 25% of the total circulating leukocyte population. They are round cells, somewhat larger than RBCs, and have a slightly indented, dense, round nucleus that occupies most of the cell. The peripherally situated cytoplasm stains a light blue and contains a few azurophilic but no specific granules. Lymphocytes can be subdivided into three functional categories, namely **B cells, T cells,** and **null cells.** Although morphologically they are indistinguishable from each other, they may be recognized by the differences in their surface markers. They function in the immune response.

For more information see Monocytes and Lymphocytes in Chapter 10 of Gartner and Hiatt: Color Textbook of Histology, 3rd ed. Philadelphia, W.B. Saunders, 2007.


a
b
c
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L
d
A
R
M
R
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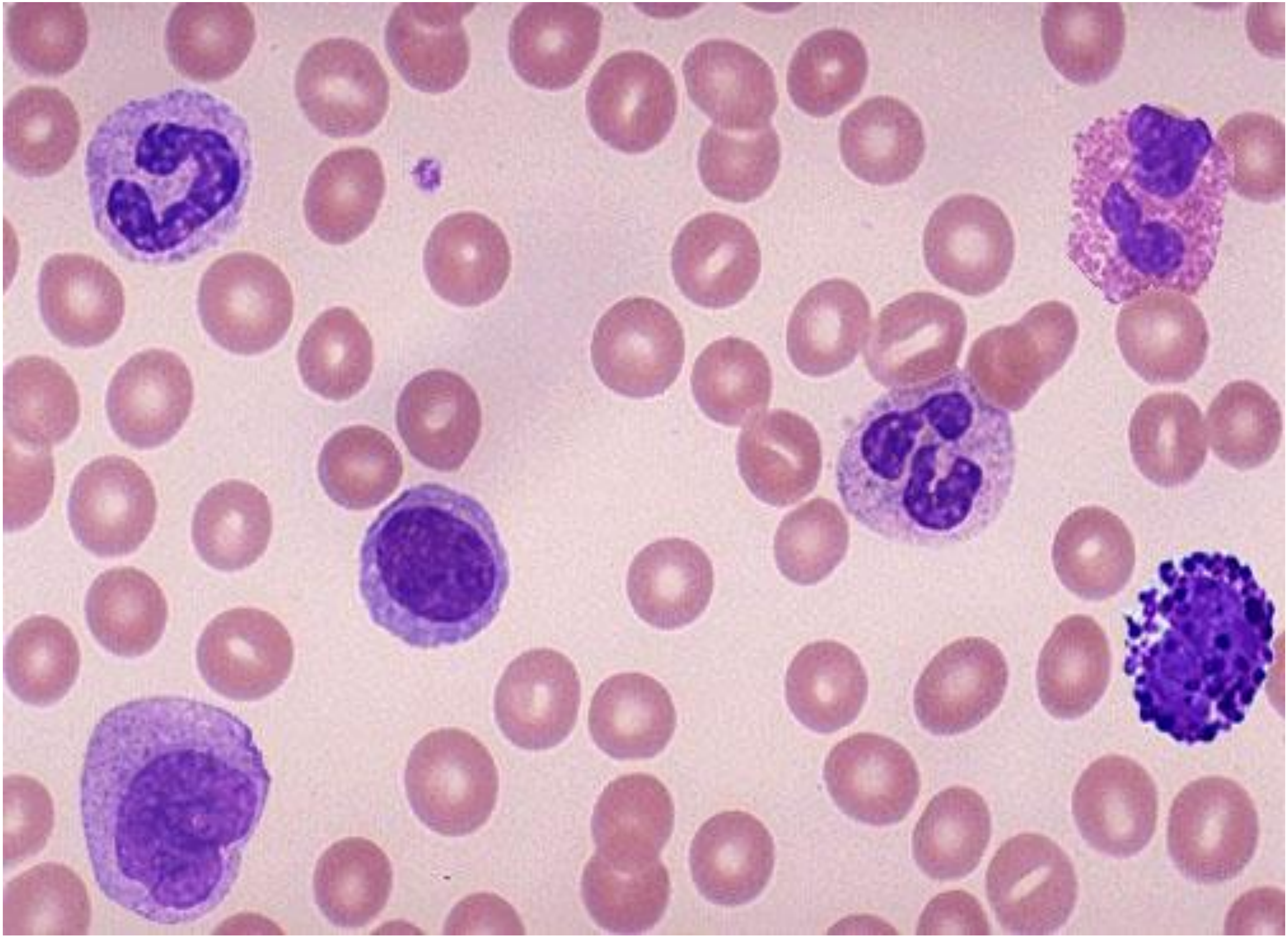
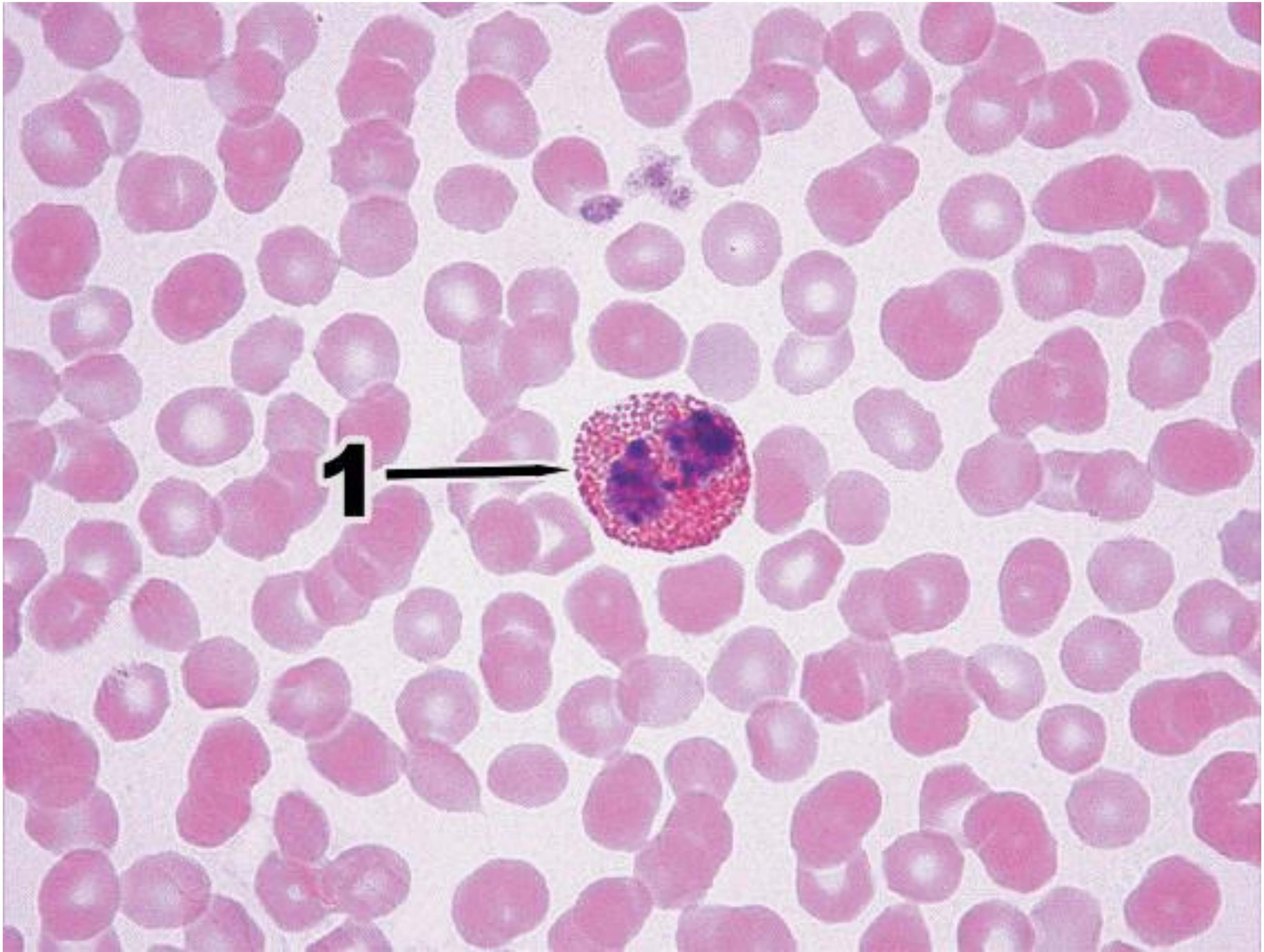
M
A
G
A
e

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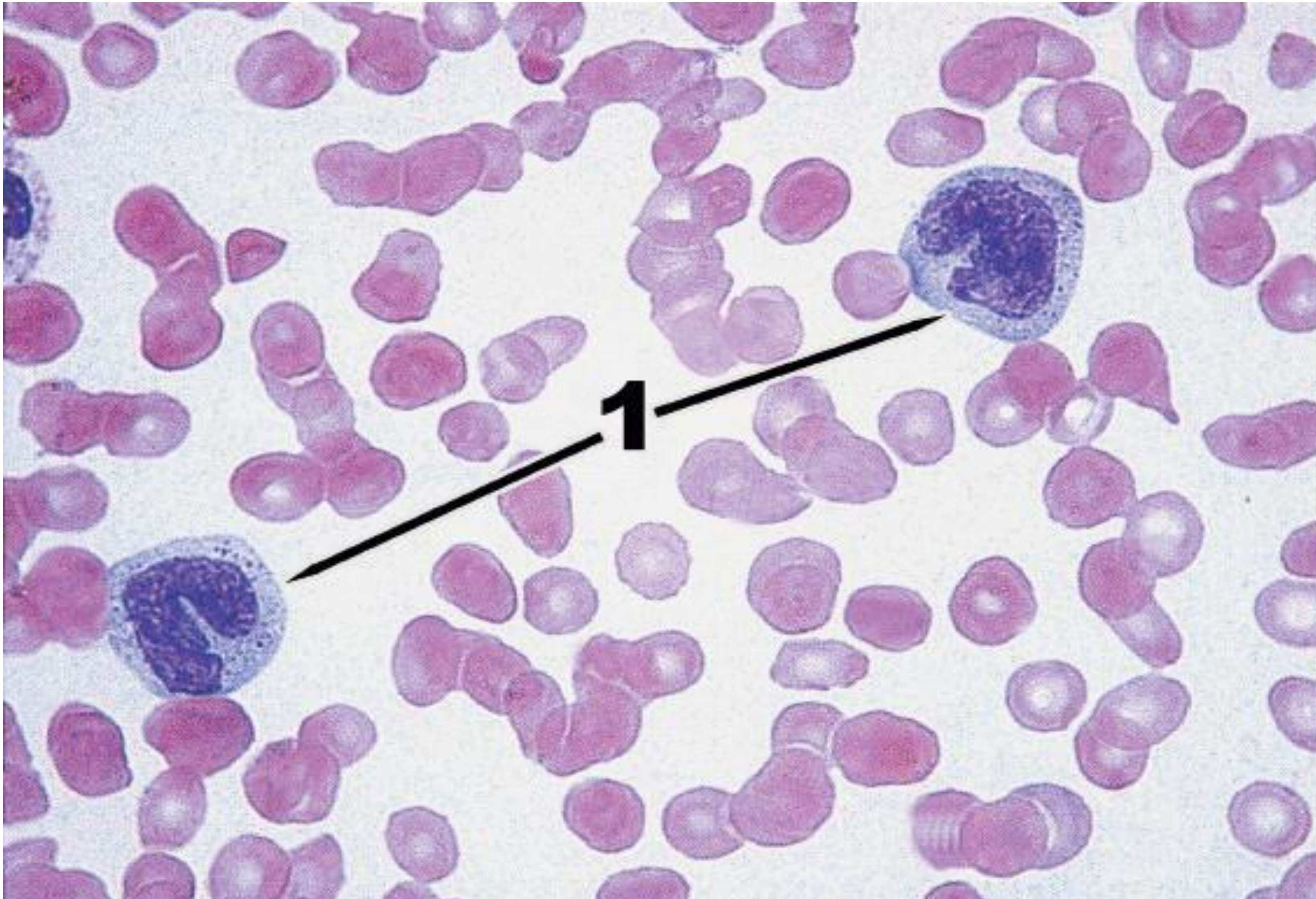
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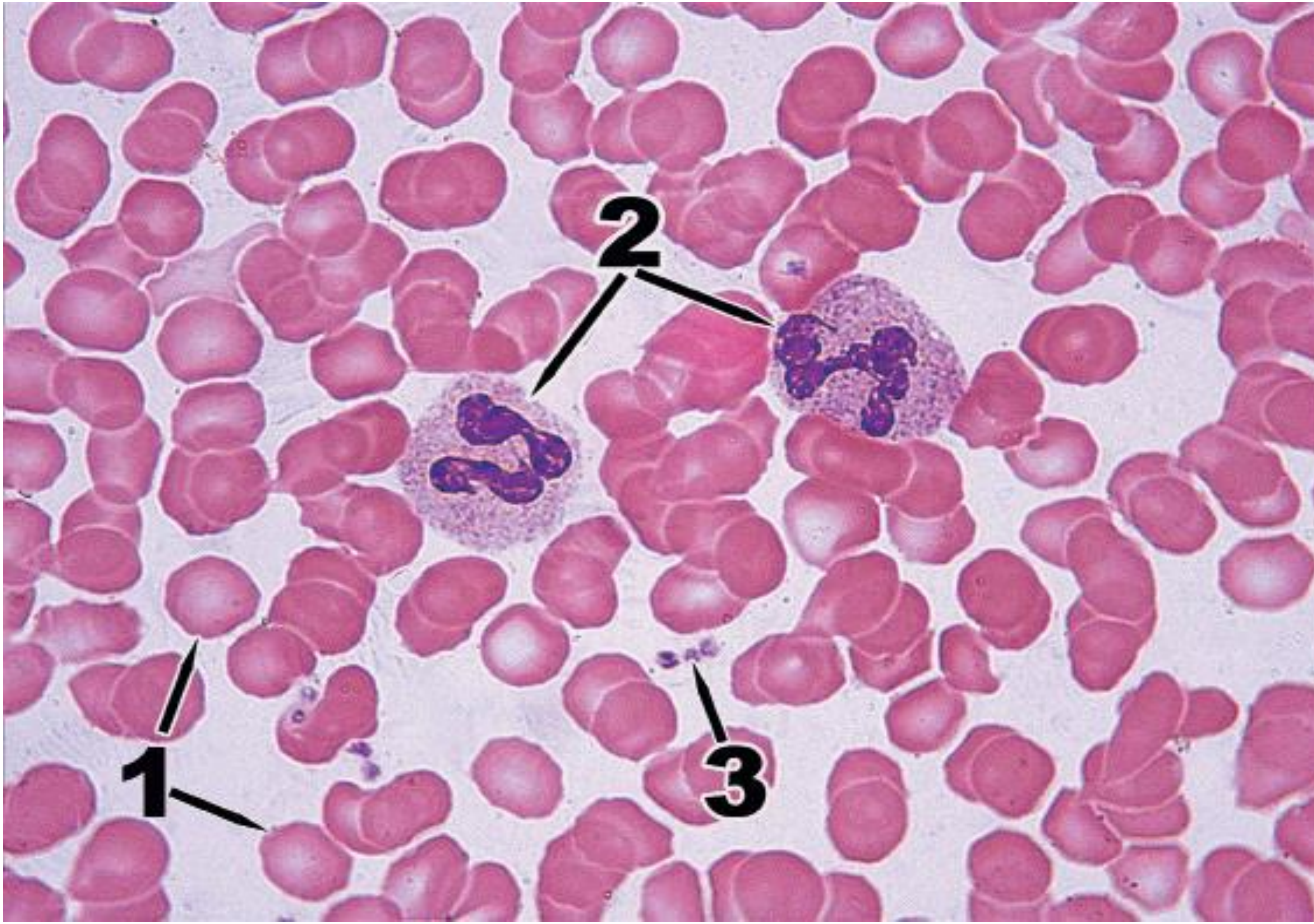
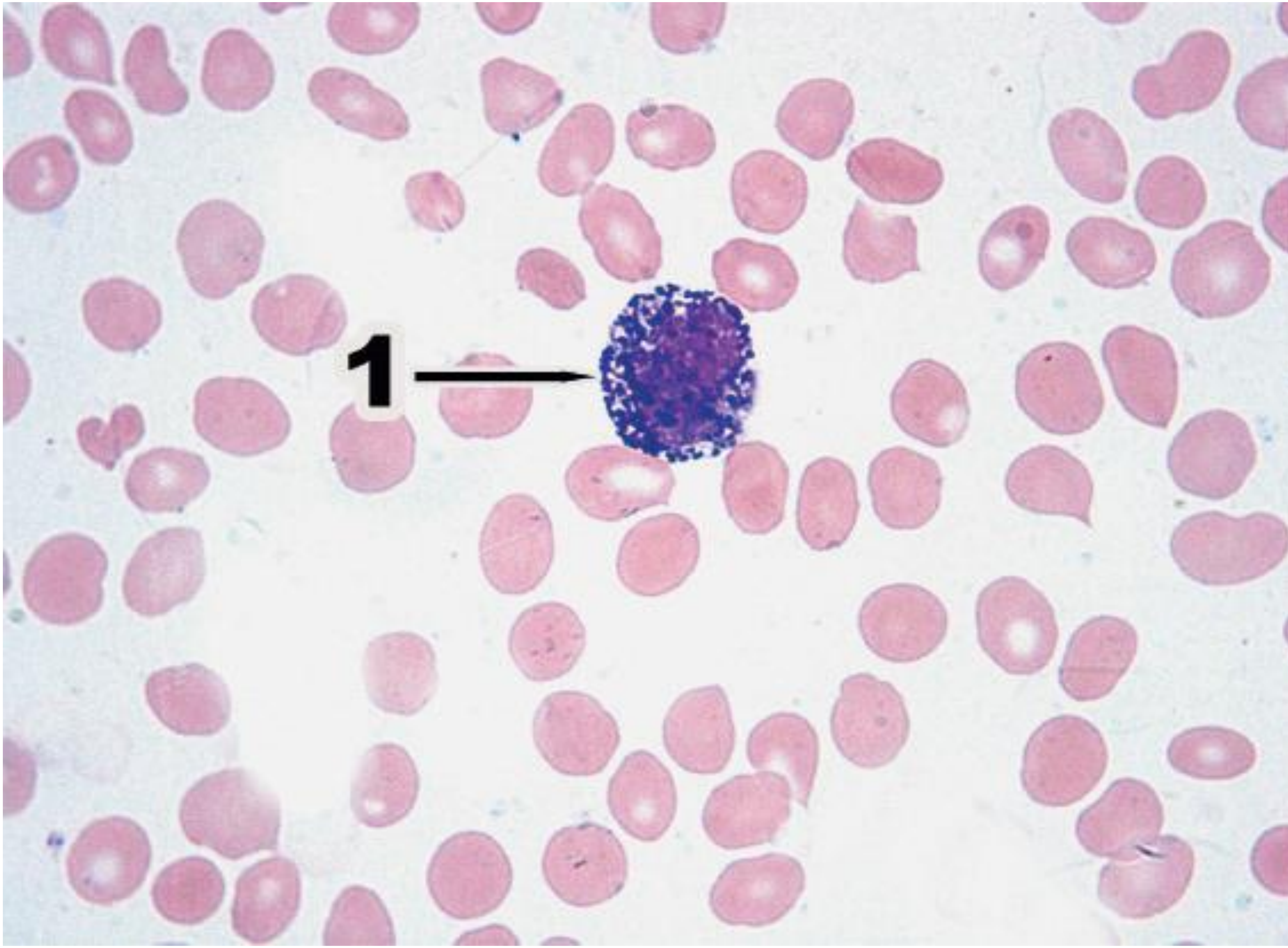

2
1
3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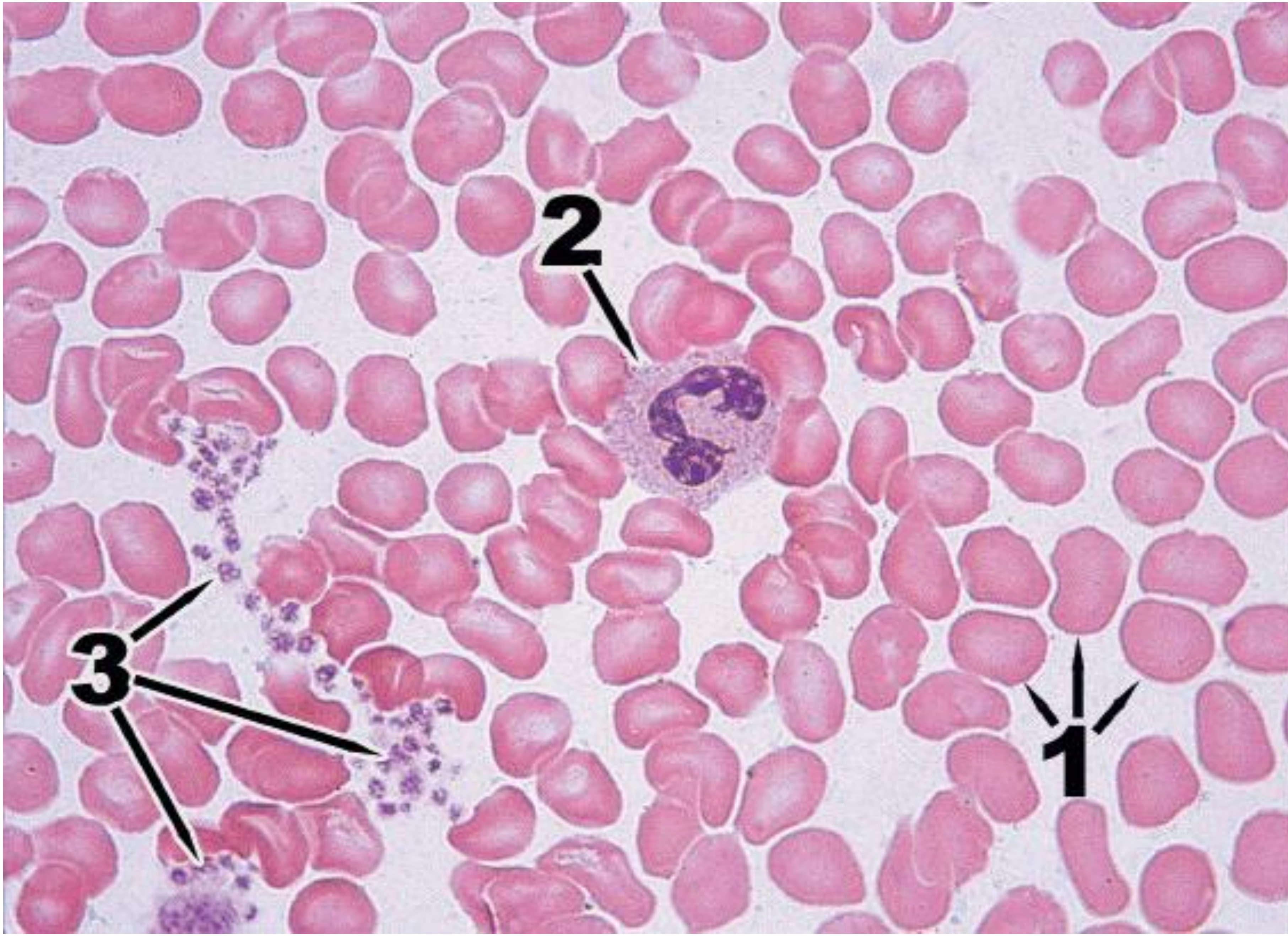
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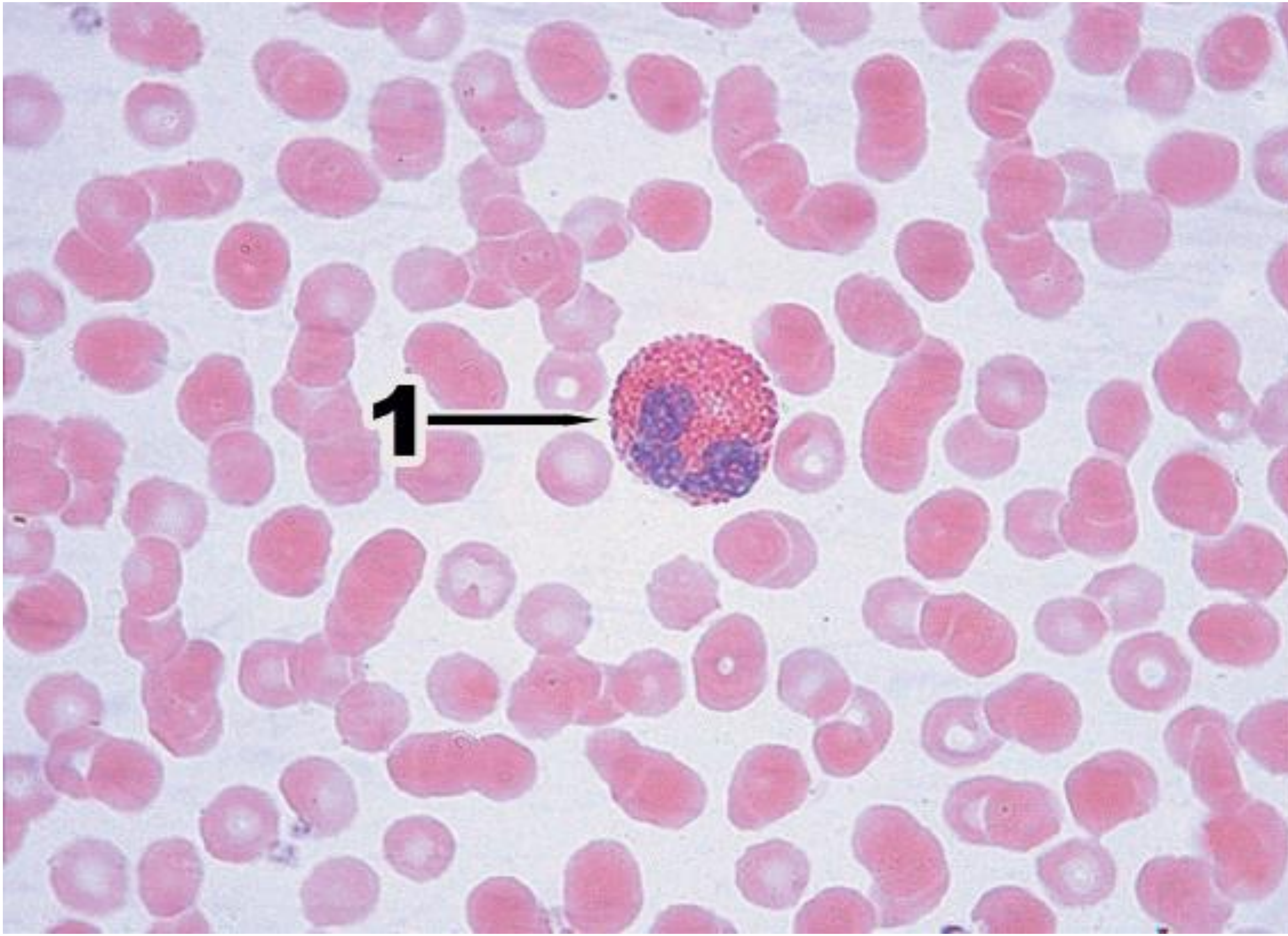
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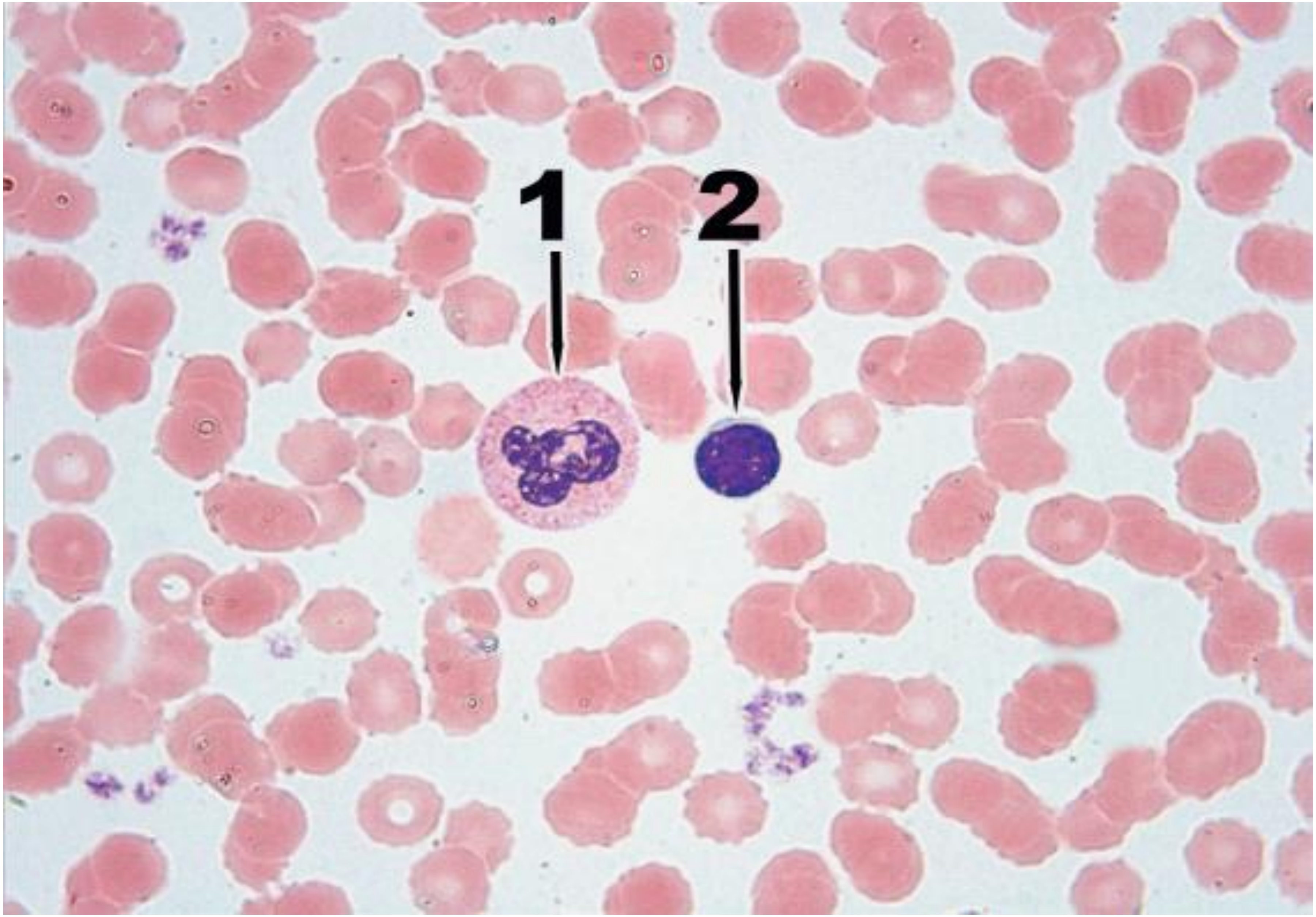
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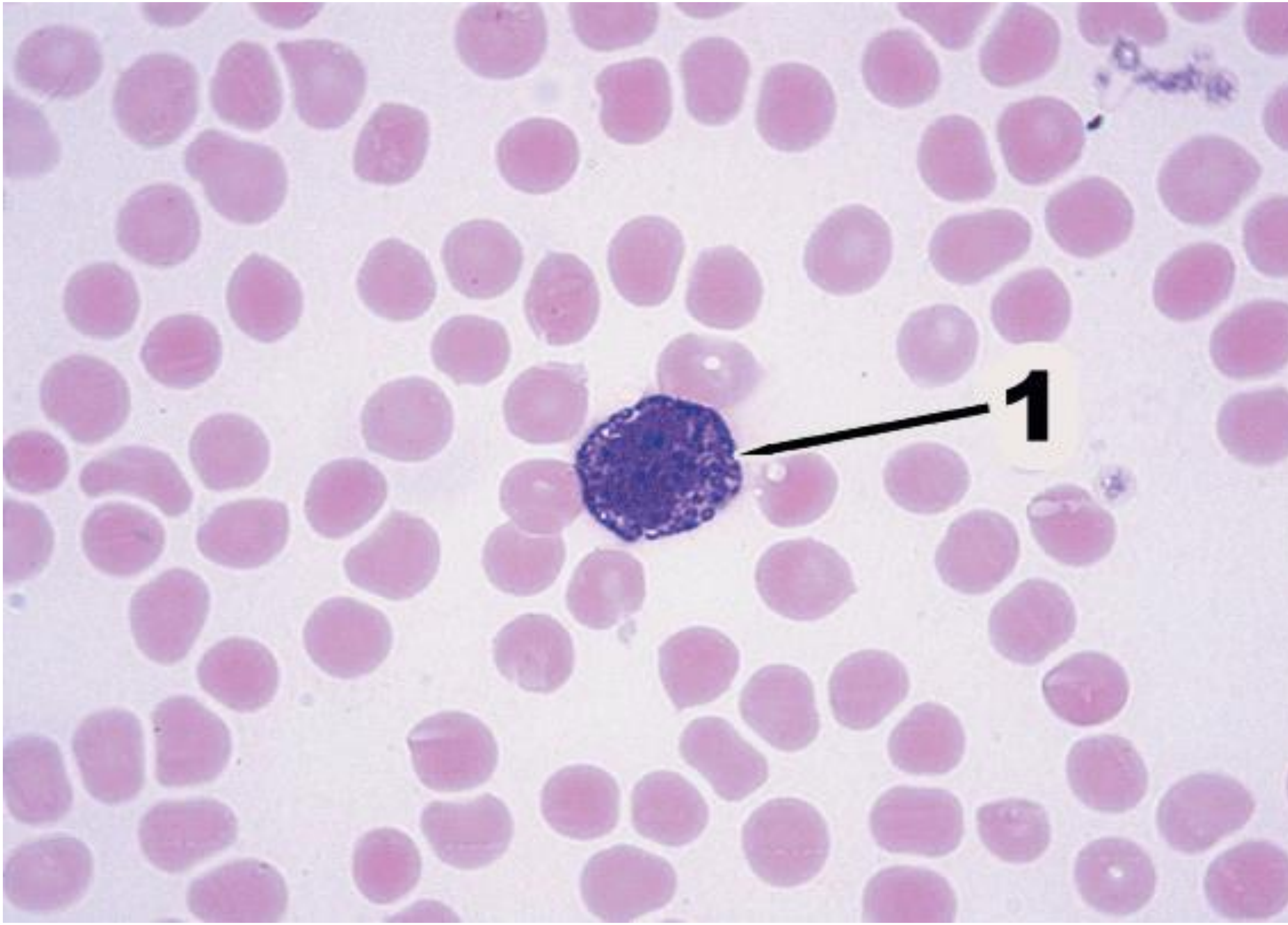
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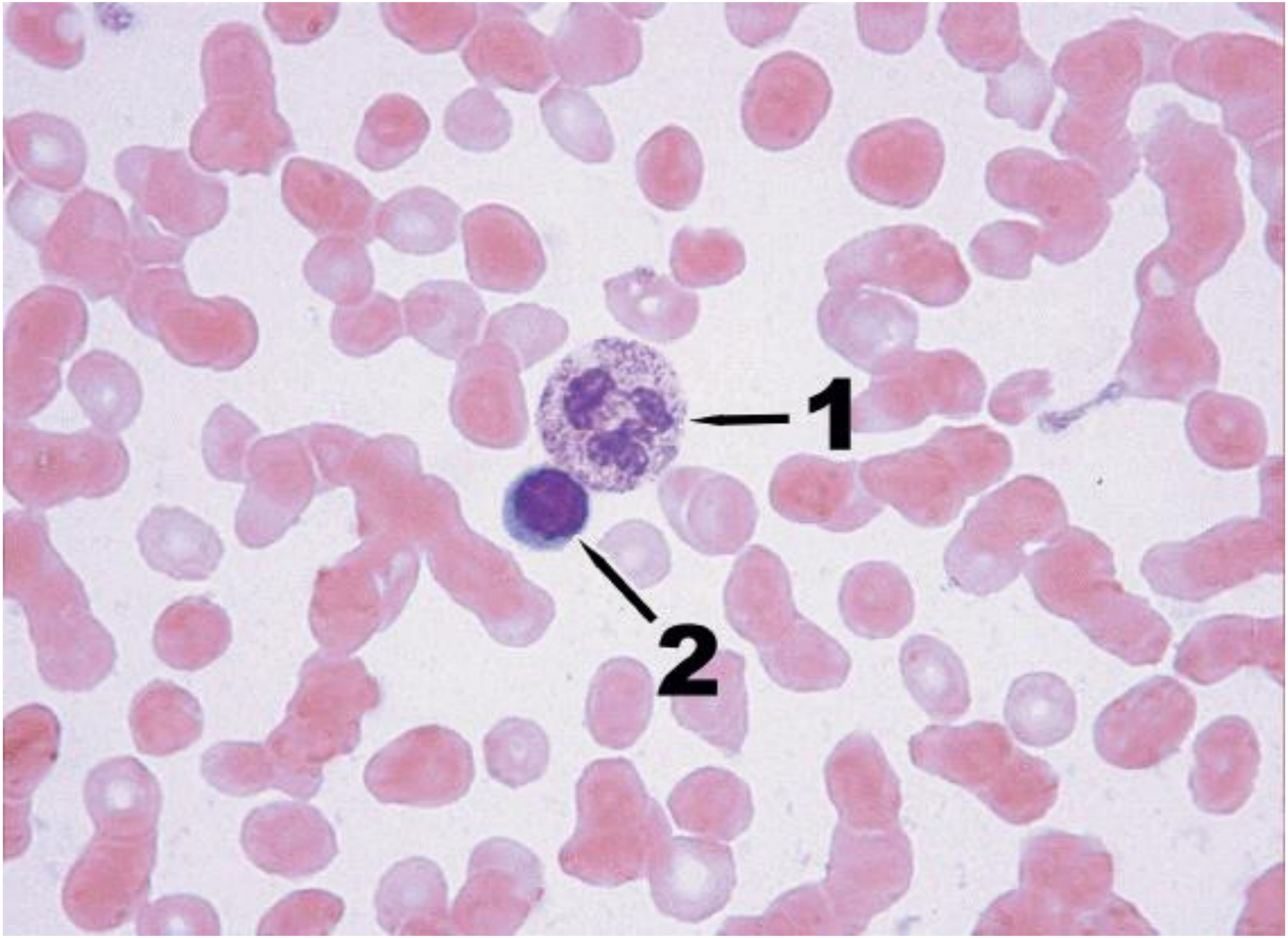
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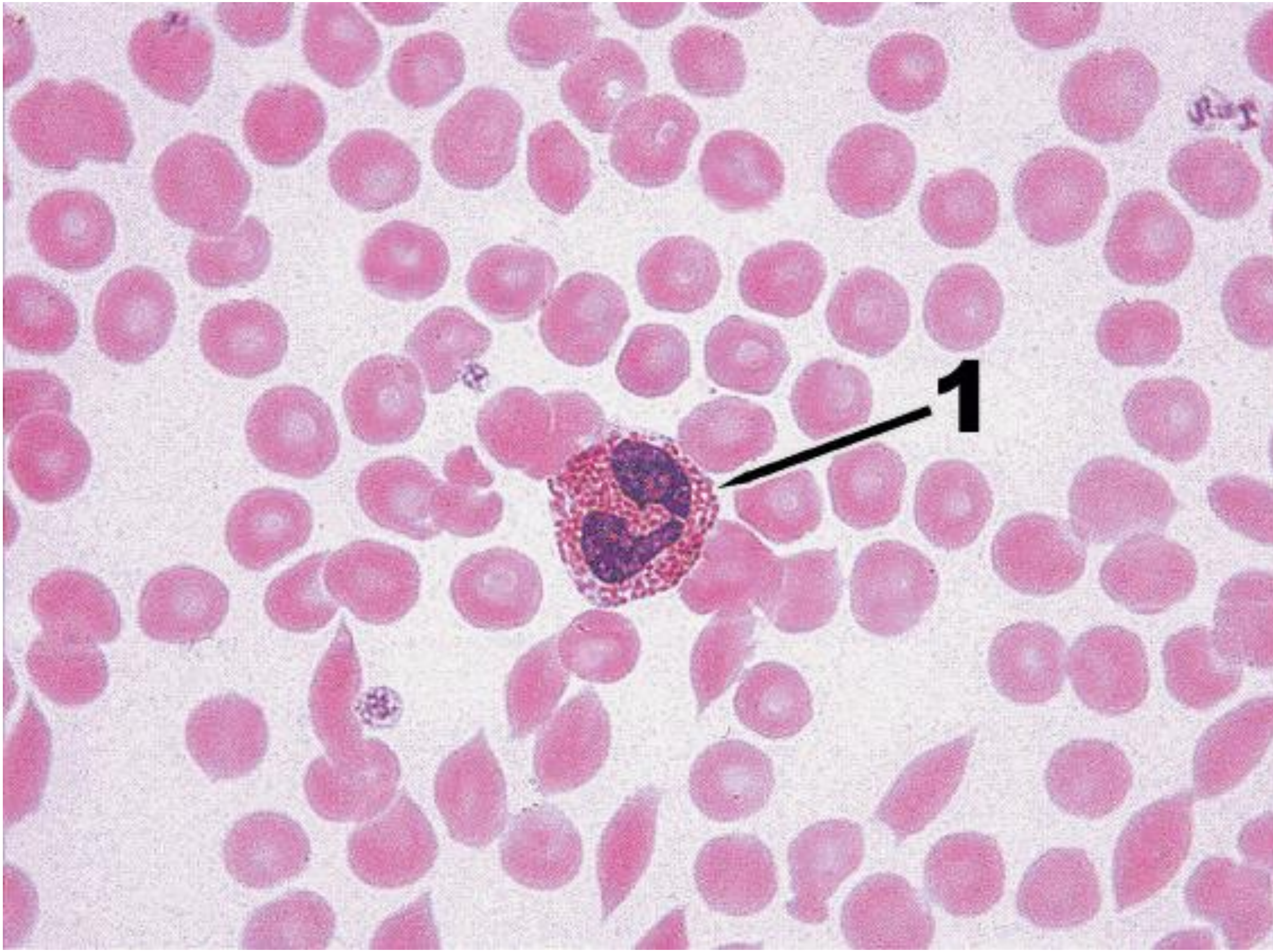
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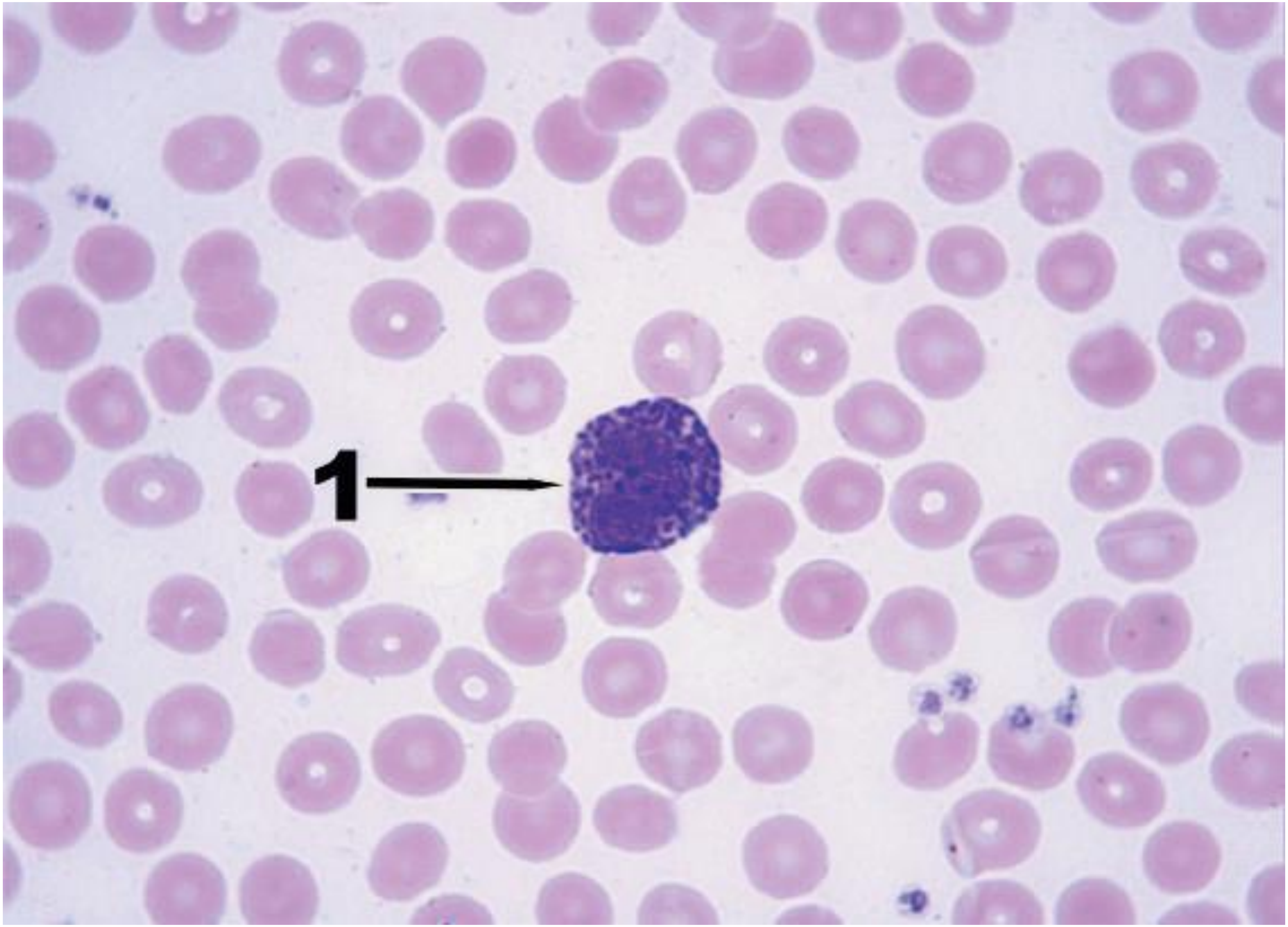
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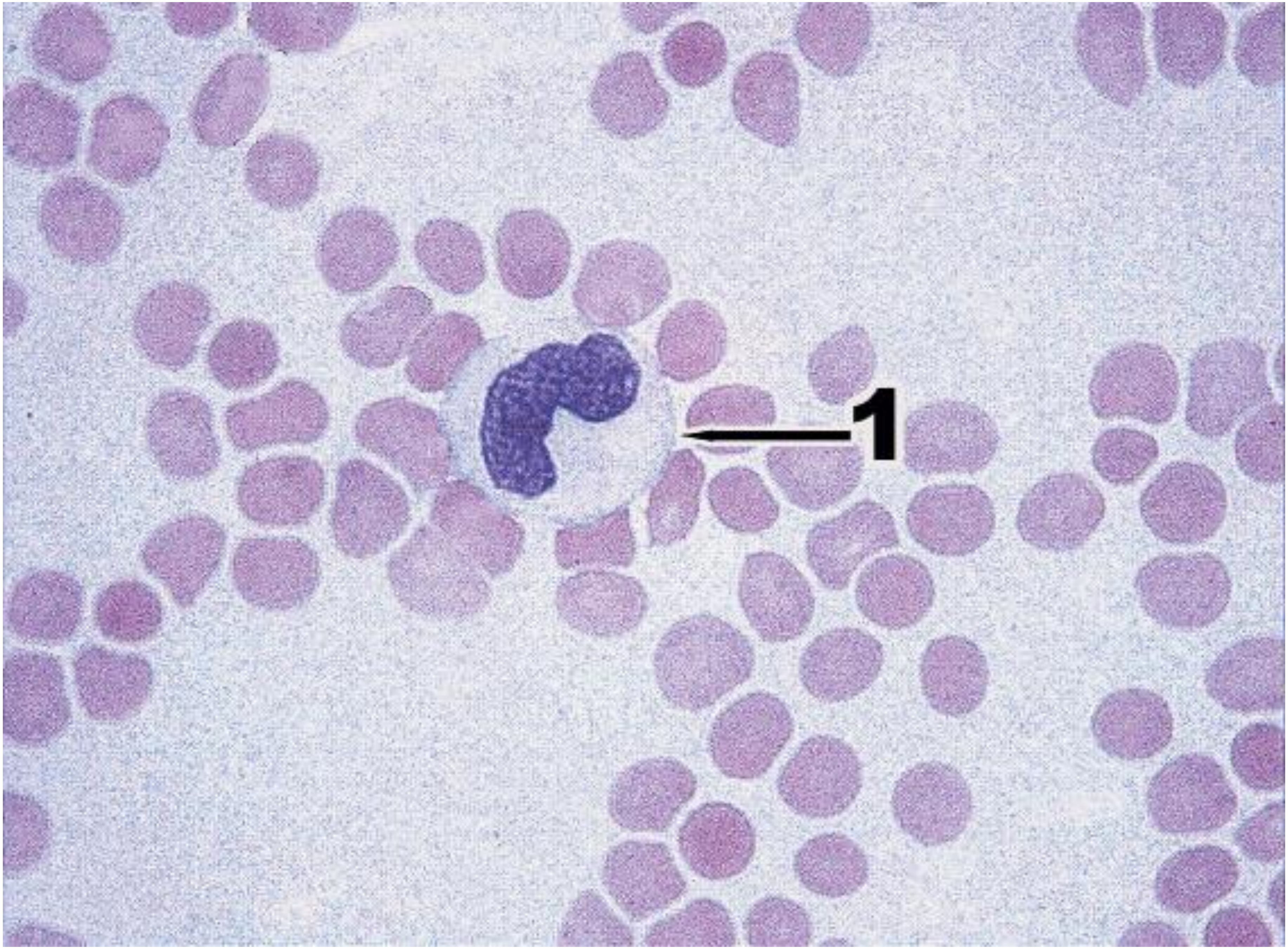

1

HEMATO
-POIESIS

Al-Farabi Kazakh National University
Higher School of Medicine

Hemapoiesis (Hematopoiesis)

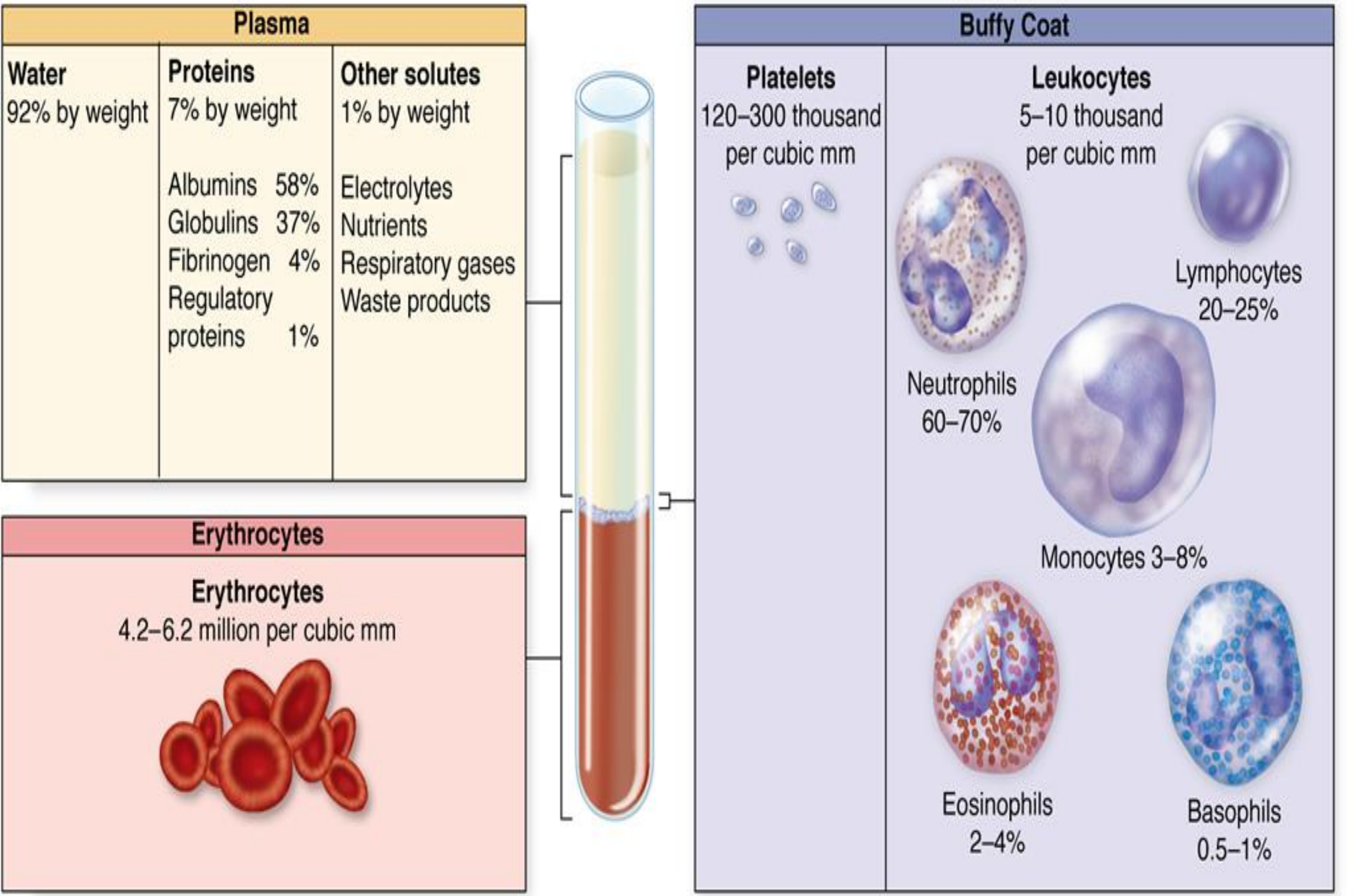
Hemo = Hemato = Blood

Poiesis = Production

Hemopoiesis system

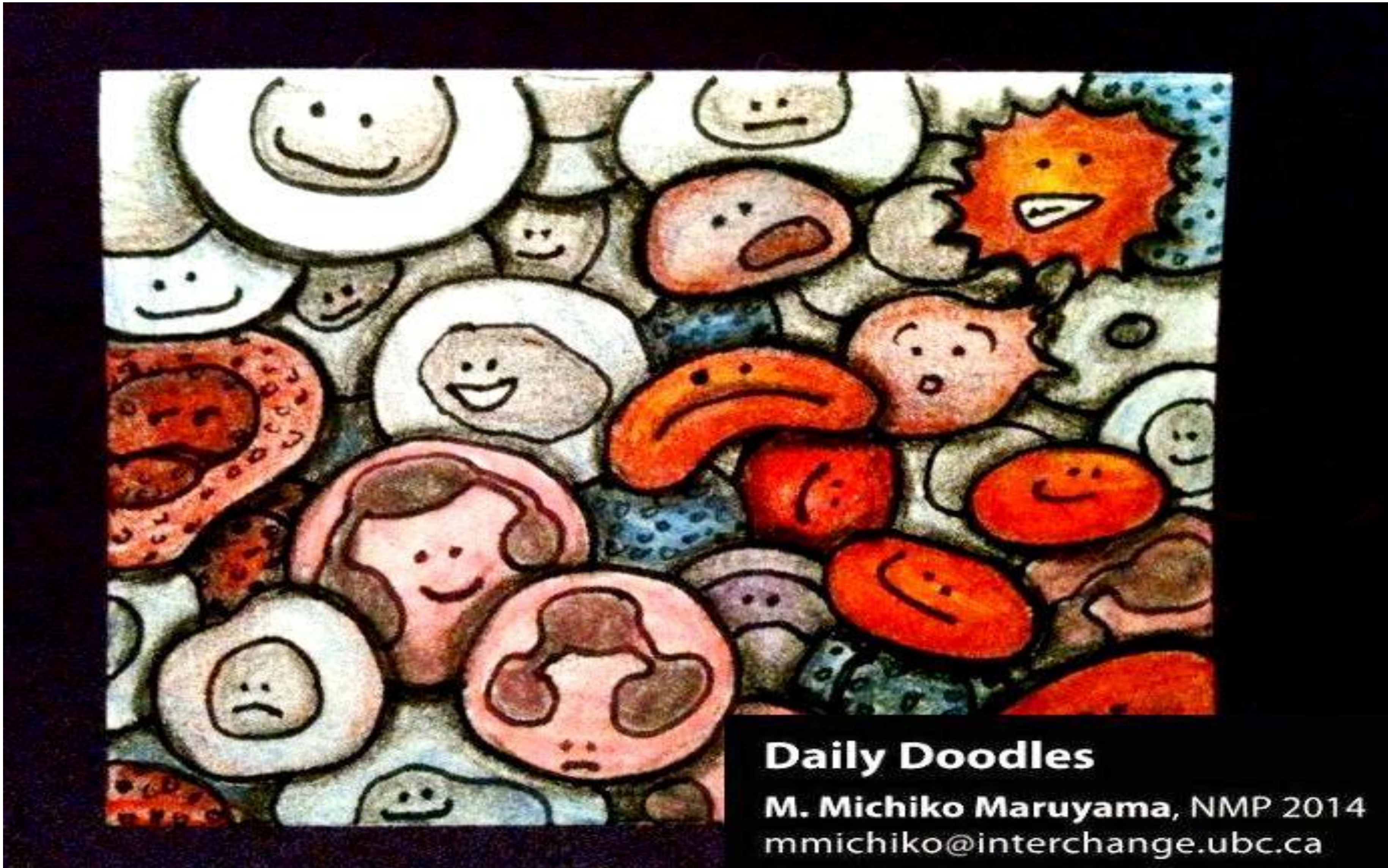
- Bone marrow
- Spleen
- Liver
- Thymus
- Lymph node

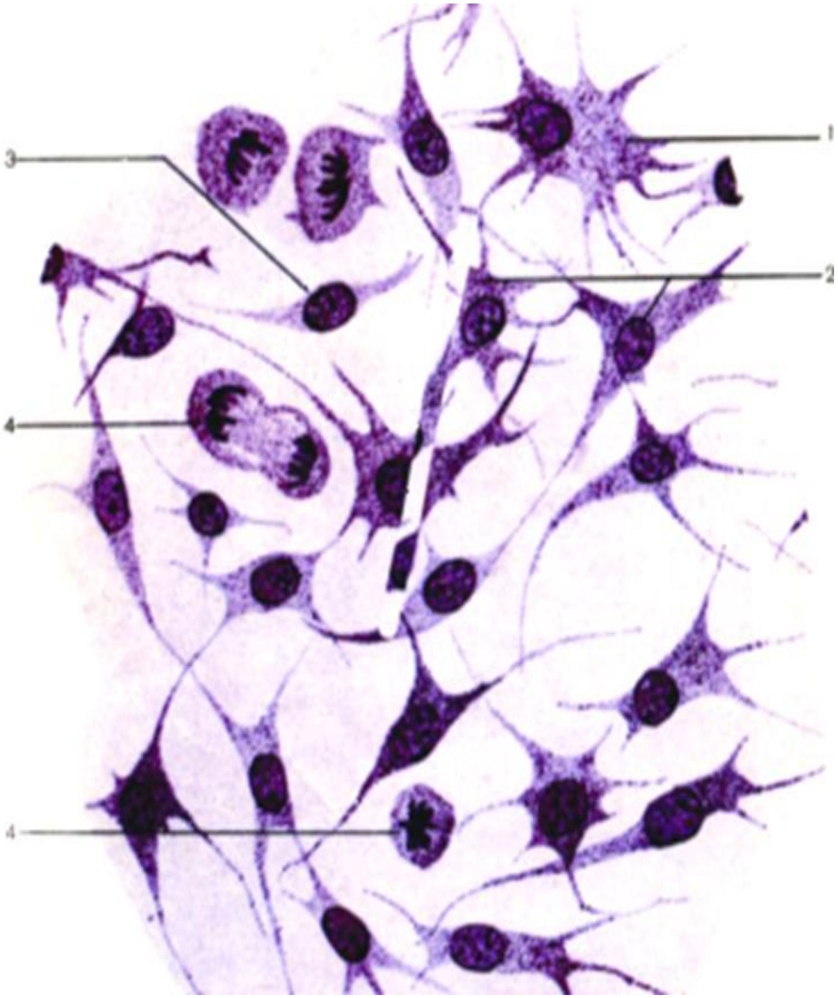
http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells



Plasma
Water
92% by weight
Proteins
7% by weight
Albumins 58%
Globulins 37%
Fibrinogen 4%
Regulatory proteins 1%
Other solutes
1% by weight
Electrolytes
Nutrients
Respiratory gases
Waste products
Erythrocytes
Erythrocytes
4.2–6.2 million per cubic mm
Buffy Coat
Platelets
120–300 thousand per cubic mm
Leukocytes
5–10 thousand per cubic mm
Lymphocytes 20–25%
Neutrophils 60–70%
Monocytes 3–8%
Eosinophils 2–4%
Basophils 0.5–1%

Haematopoietic Family Photo

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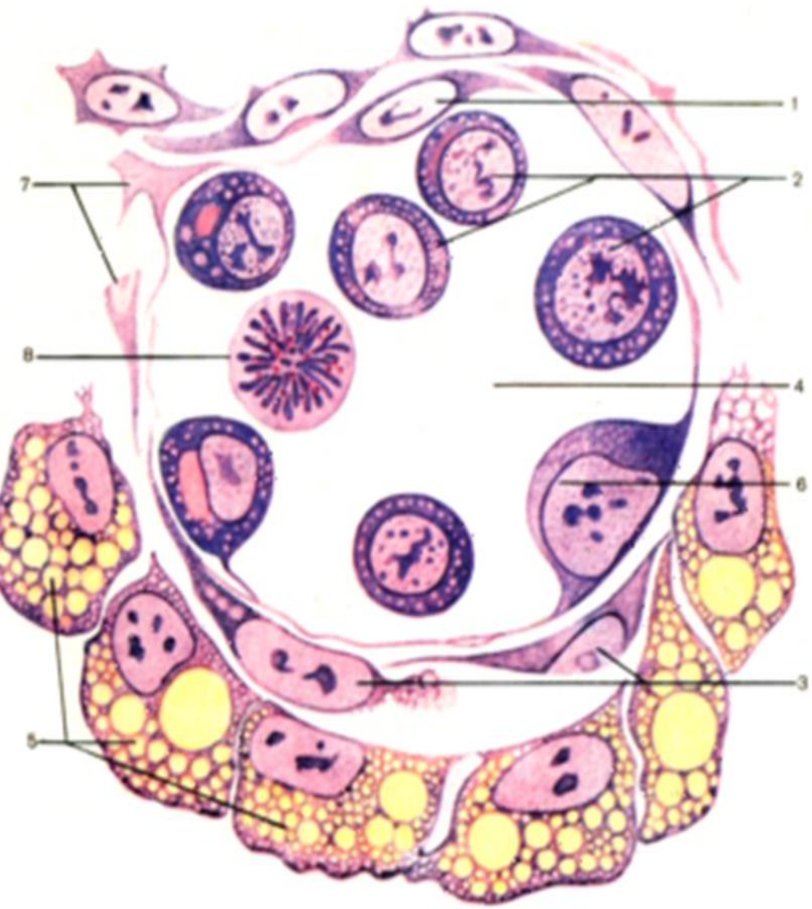
2
3
4
4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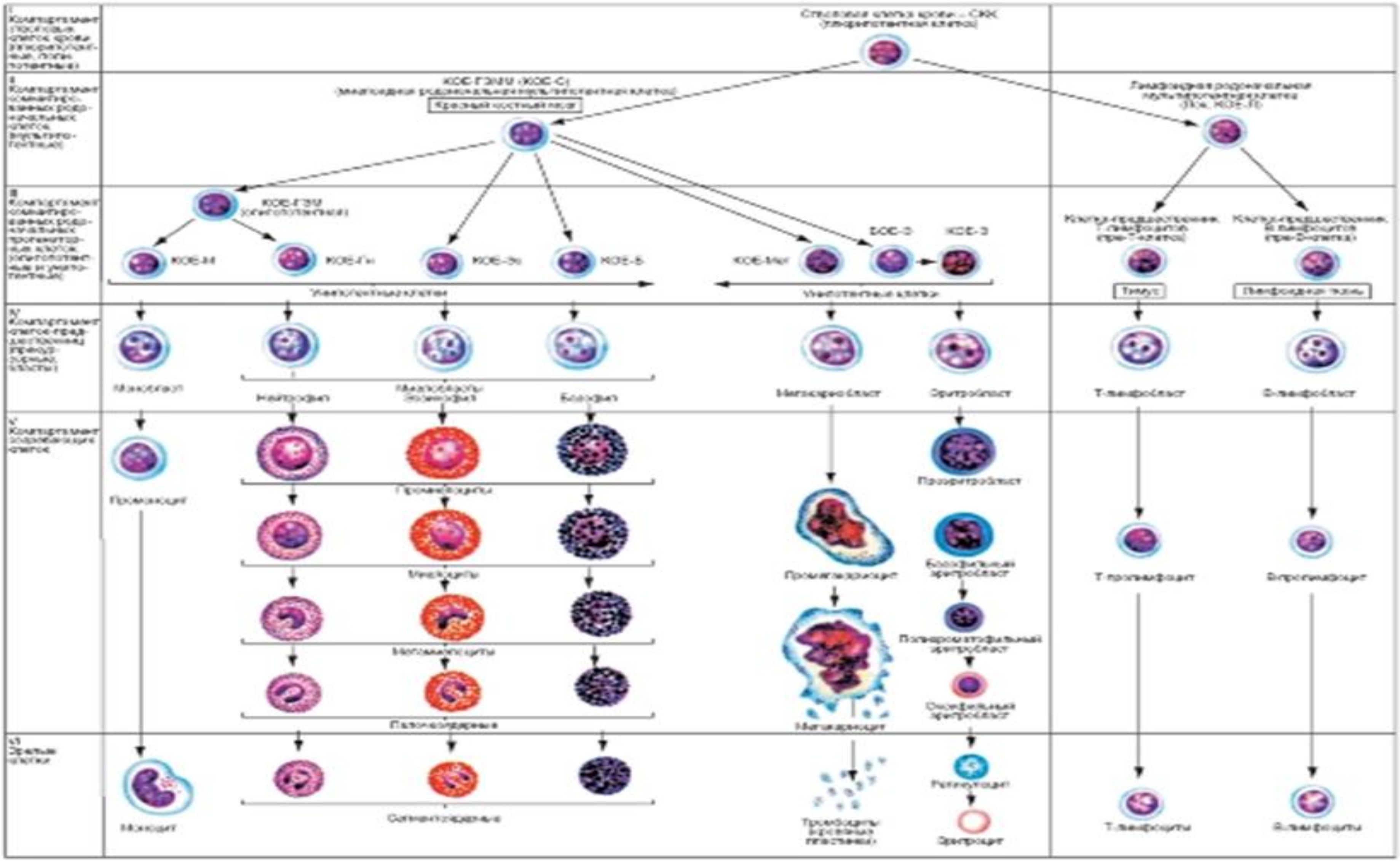
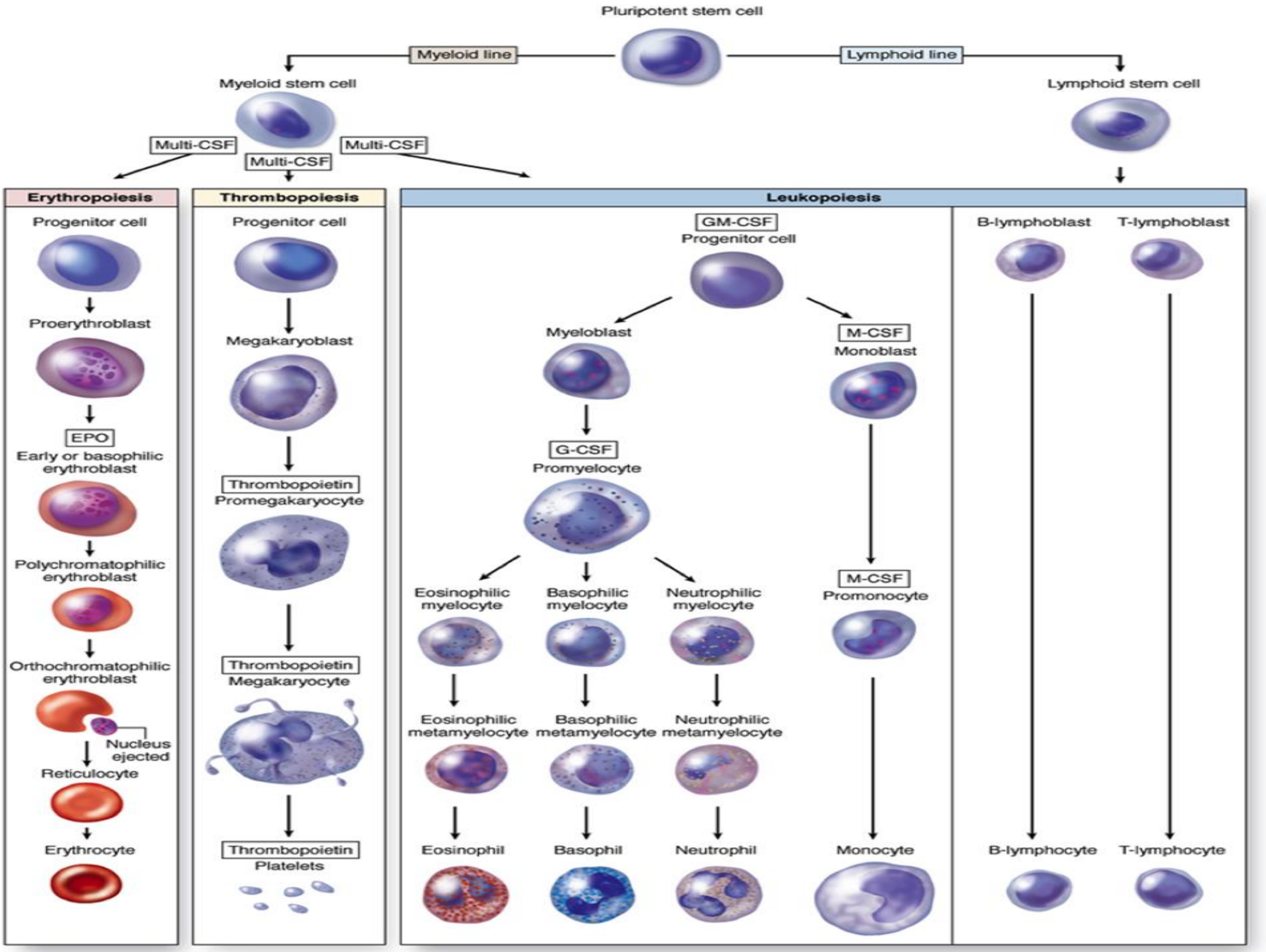
A GENERAL MODEL OF HEMATOPOIESIS





Pluripotent stem cell
Myeloid line
Lymphoid line
Myeloid stem cell
Lymphoid stem cell
Multi-CSF
Multi-CSF
Multi-CSF
Erythropoiesis
Thrombopoiesis
Leukopoiesis
Progenitor cell
Proerythroblast
EPO
Early or basophilic erythroblast
Polychromatophilic erythroblast
Orthochromatophilic erythroblast
Nucleus ejected
Reticulocyte
Erythrocyte
Progenitor cell
Megakaryoblast
Thrombopoietin
Promegakaryocyte
Thrombopoietin
Megakaryocyte
Thrombopoietin
Platelets
GM-CSF
Progenitor cell
Myeloblast
M-CSF
Monoblast
G-CSF
Promyelocyte
Eosinophilic myelocyte
Basophilic myelocyte
Neutrophilic myelocyte
M-CSF
Promonocyte
Eosinophilic metamyelocyte
Basophilic metamyelocyte
Neutrophilic metamyelocyte
Eosinophil
Basophil
Neutrophil
Monocyte
B-lymphoblast
T-lymphoblast
B-lymphocyte
T-lymphocyte

"All blood elements develop from one origin cell – stem cell"

Monophyletic theory, A. A. Maksimov

The term **"stem cell"** Maksimov proposed in 1908.

http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells

Classification

Stem cells can be classified into four broad categories, based on their ability to differentiate:

Stem Cells

Totipotent stem cells are found only in early embryos. Each cell can form a complete organism.

Pluripotent stem cells Obtained from the inner cell mass of the blastocyst, able to differentiate into almost all cells of the three germ layers – but not into an embryo.

Multipotent stem cells Found in most tissues, can produce a limited range of differentiated cell lineages appropriate to their location (e.g., Hematopoietic stem cells from the bone marrow). Limited in what the cells can become.

Unipotent cells capable of generating only one cell type (epidermal stem cells, adult liver stem cells).

http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells

Stages of Hemopoiesis

Include:

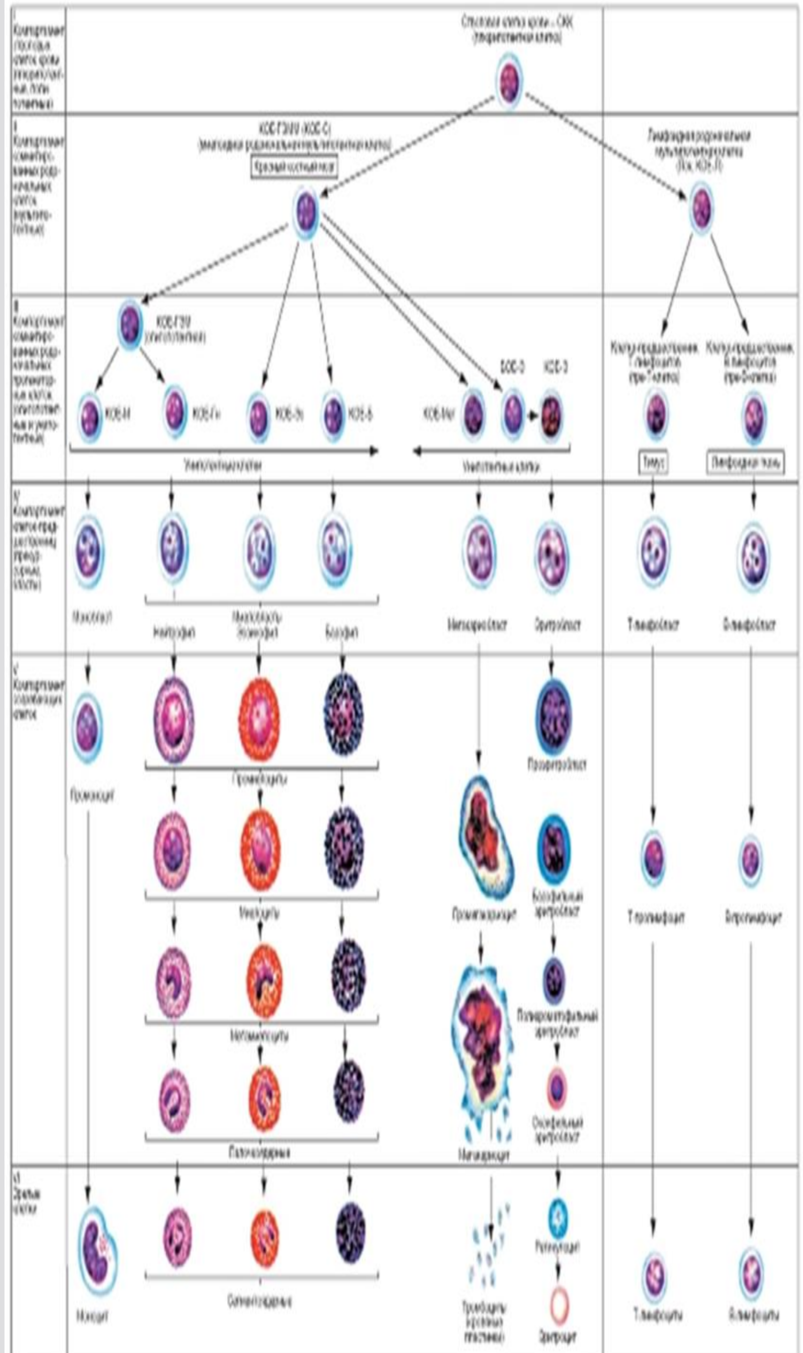
- Proliferation (reproduction by neoplasms);
- Differentiation (sequential process of mitosis during which cells acquire specific morpho-functional traits)
- Maturation of cells (process when the cell continues to evolve but no longer divided)

http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells

Classes of stem cells

By degree of maturity the cells are divided into 6 classes:

- 1 class – Stem cells (Pluripotent)
- 2 class – half-stem cells (Polipotent)
- 3 class – Unipotent cells (give rise to only one type formed elements)
- 4 class – Blasts (large cells)
- 5 class - Differentiating precursors
- 6 class - Mature formed elements circulating in the bloodstream

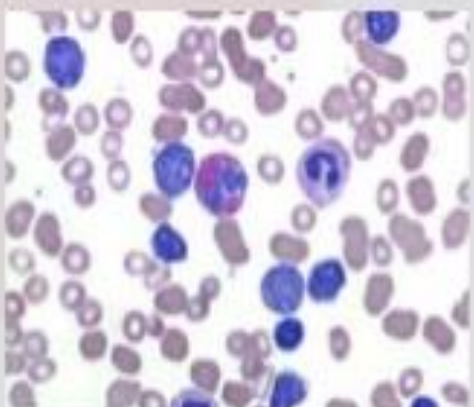


Immature vs Mature cells

During maturation cells changing its properties.

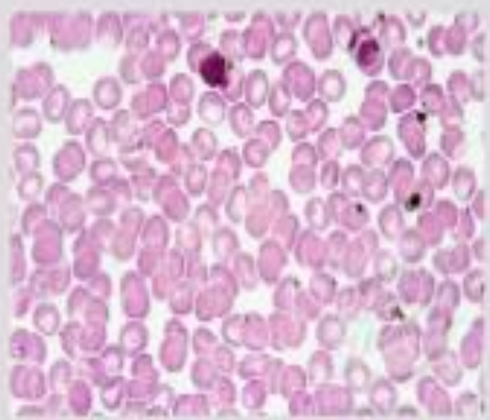
The immature blast cell:

- Large cell, high Nucleo-cytoplasmic ratio
- Large nucleus, fine chromatin & nucleoli
- Small amount of dark blue cytoplasm



With maturation:

- Cells become smaller
- Nuclear chromatin clumps, nucleoli disappear
- Hgb or granules appear
- N:C ratio decreases



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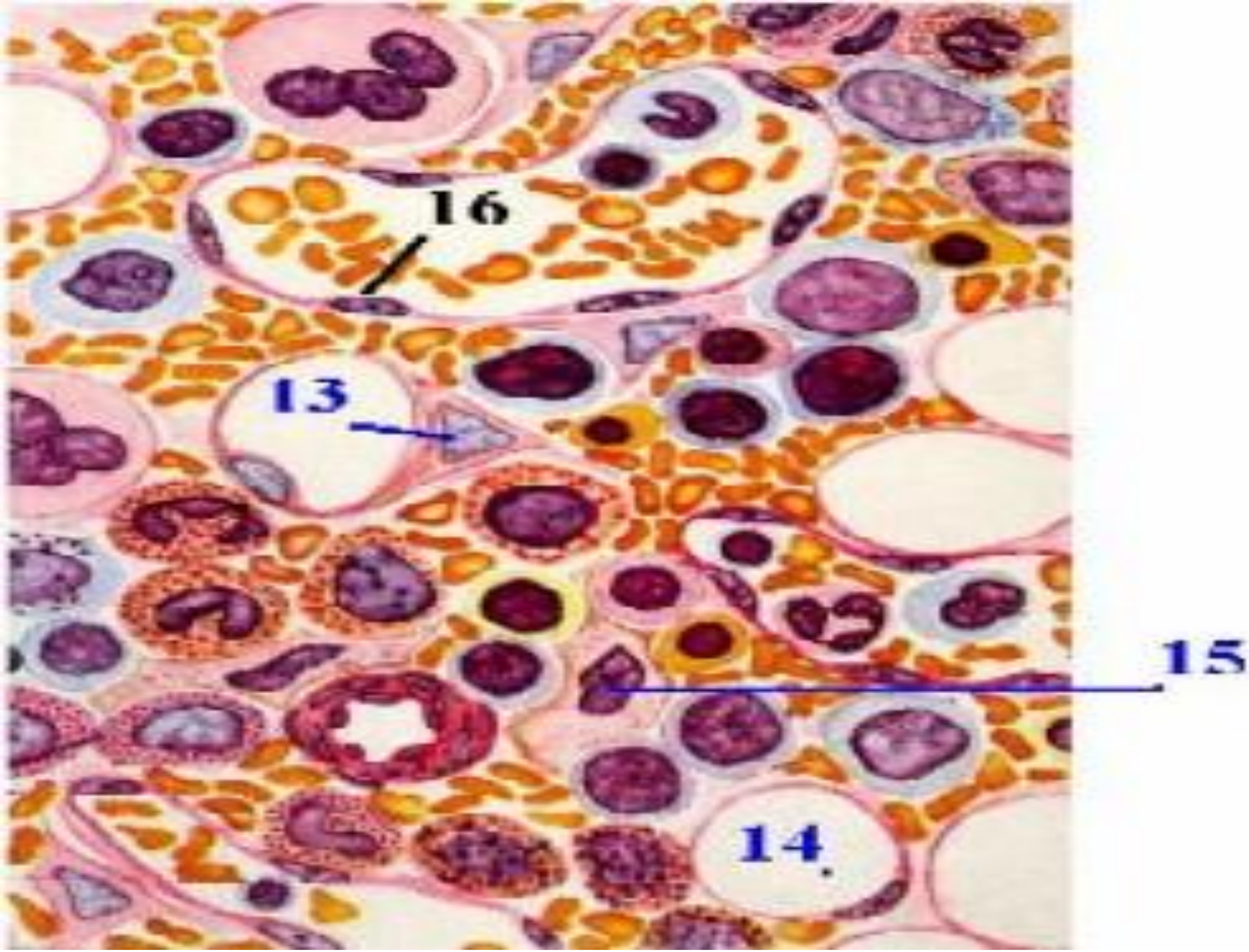
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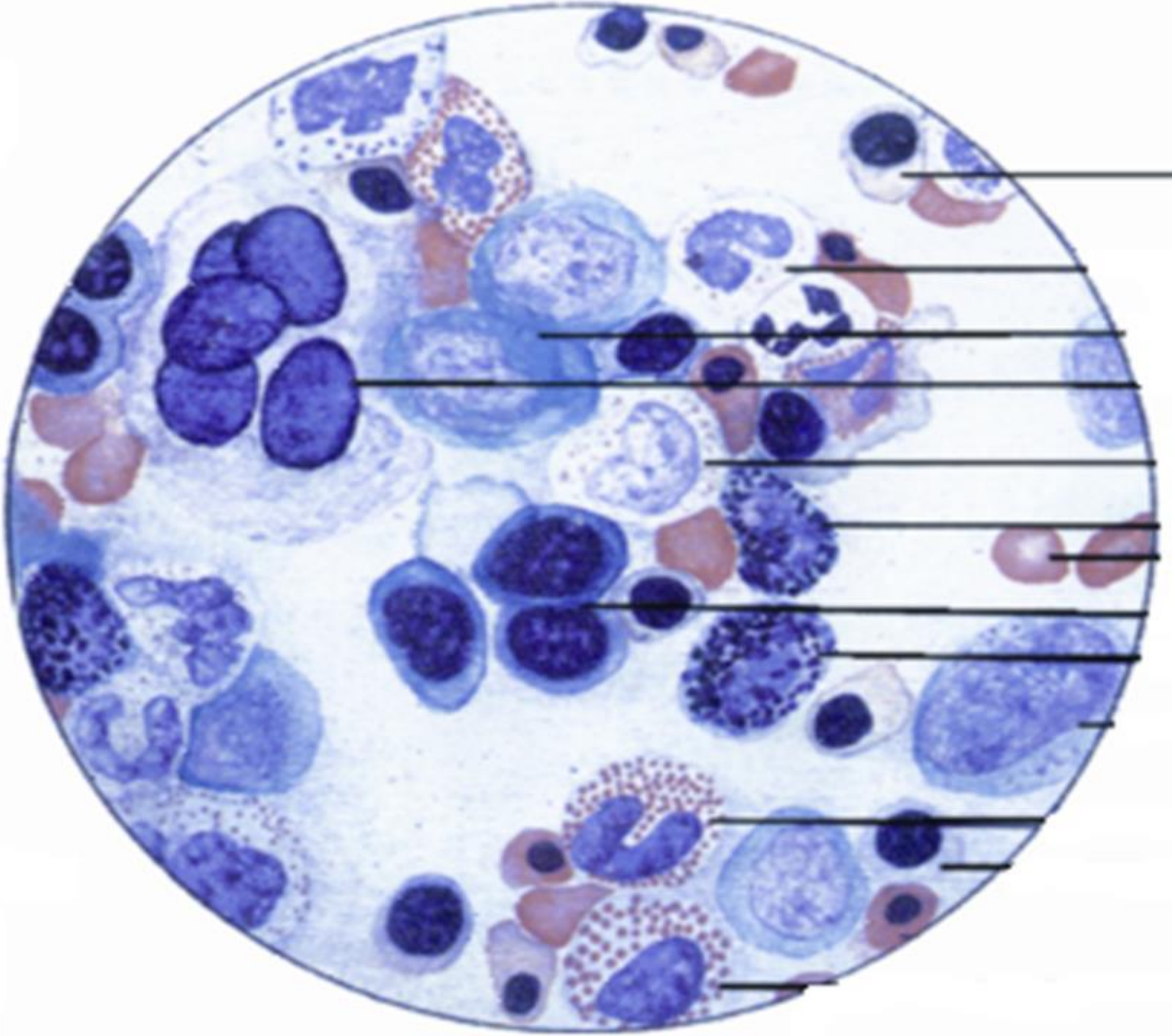
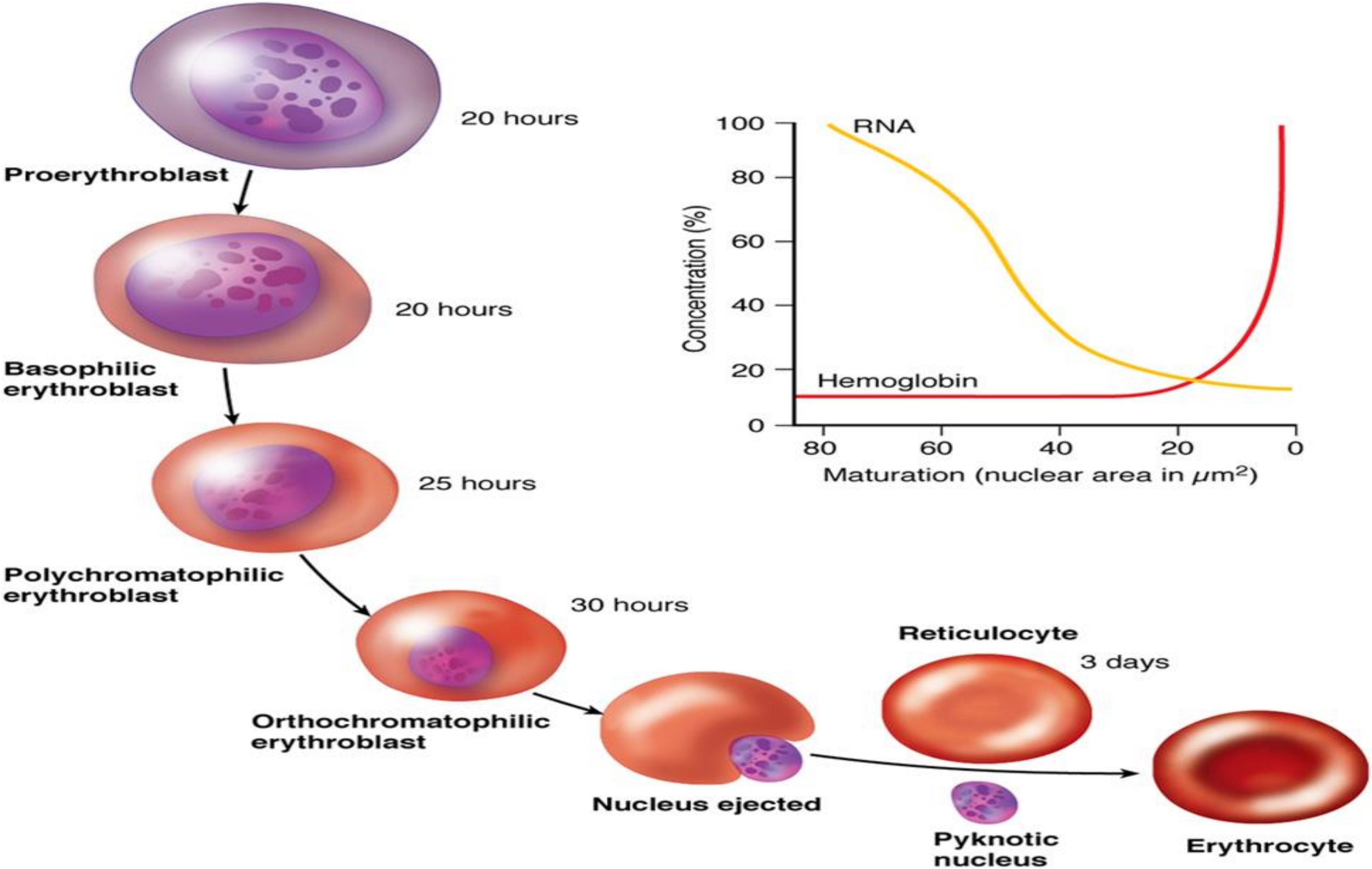


ERYTHROPOIESIS

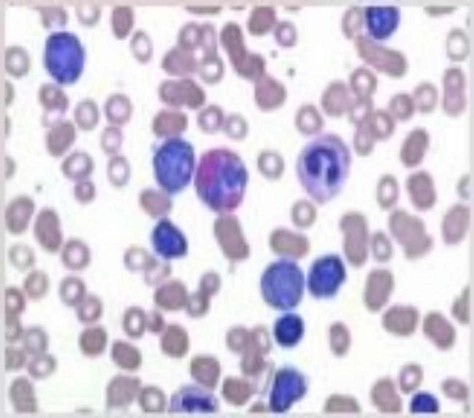


Immature vs Mature cells

During maturation cells changing its properties.

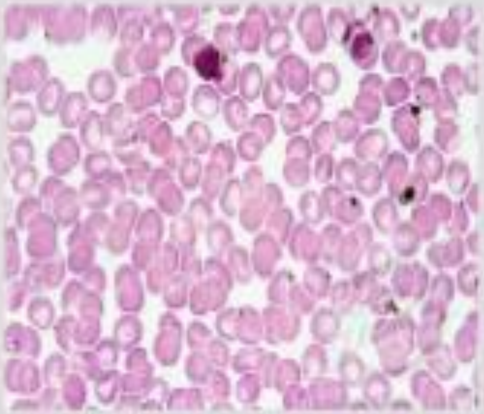
The immature blast cell:

- Large cell, high Nucleo-cytoplasmic ratio
- Large nucleus, fine chromatin & nucleoli
- Small amount of dark blue cytoplasm

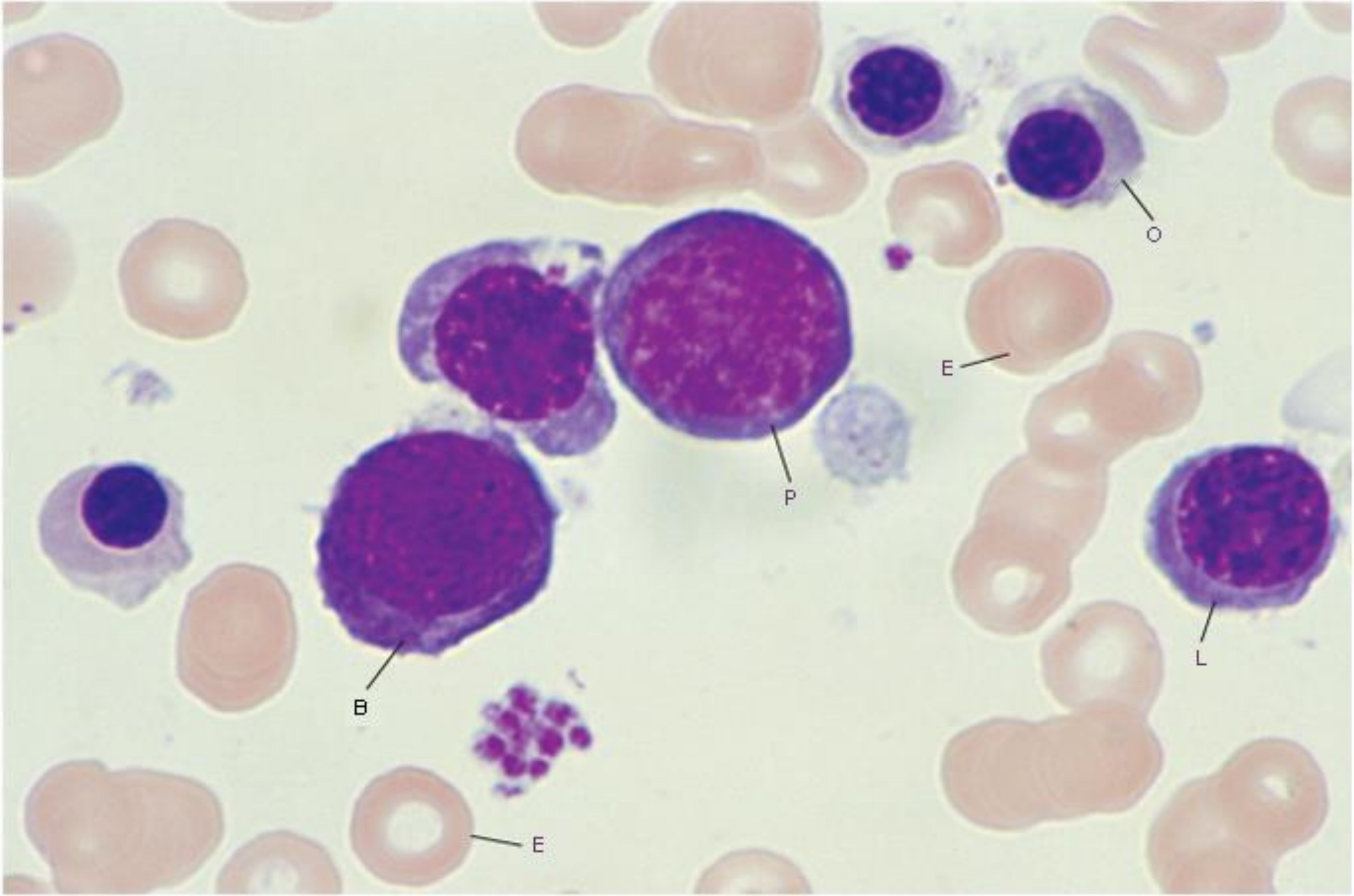


With maturation:

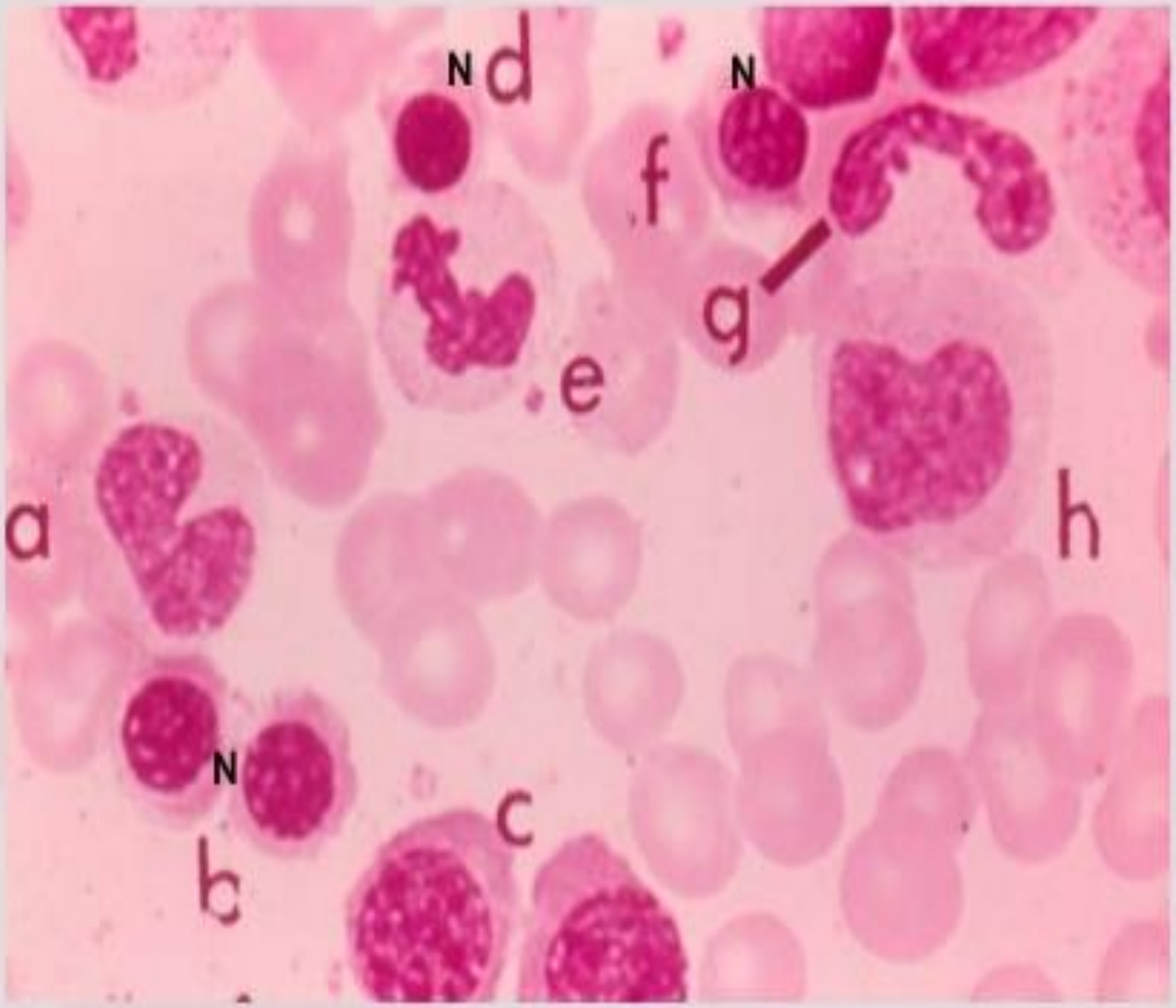
- Cells become smaller
- Nuclear chromatin clumps, nucleoli disappear
- Hgb or granules appear
- N:C ratio decreases



http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells



ERYTHROPOIESIS



Normoblast (erythroblast) is a type of red blood cell which still retains a cell nucleus. It is the immediate precursor of a normal erythrocyte.
Develop into erythrocyte.

Human bone marrow: Normoblasts (b, d, f) differing in sizes and degree of chromatin clumping, late erythroblasts (c). W-G x 400.

http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells

Hemopoietic growth factors

A hormone-like substances (protein) that stimulate bone marrow to produce blood cell and promote the proliferation of blood cells.

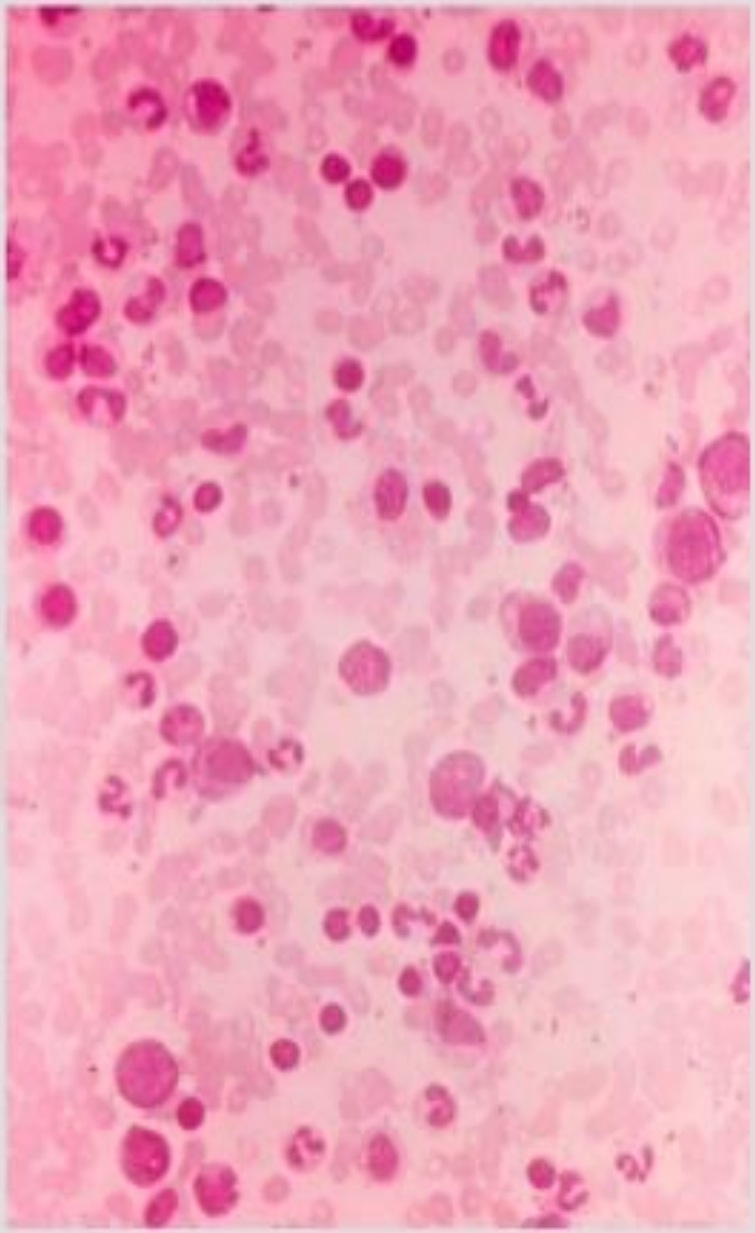
Erythropoietin (EPO)

- produces primarily by cells in the kidney that lie between the kidney tubules (peritubular interstitial cells)
- Control erythropoiesis - red blood cell production
- Required for a myeloid progenitor cell to become erythrocyte

Thrombopoietin (TPO)

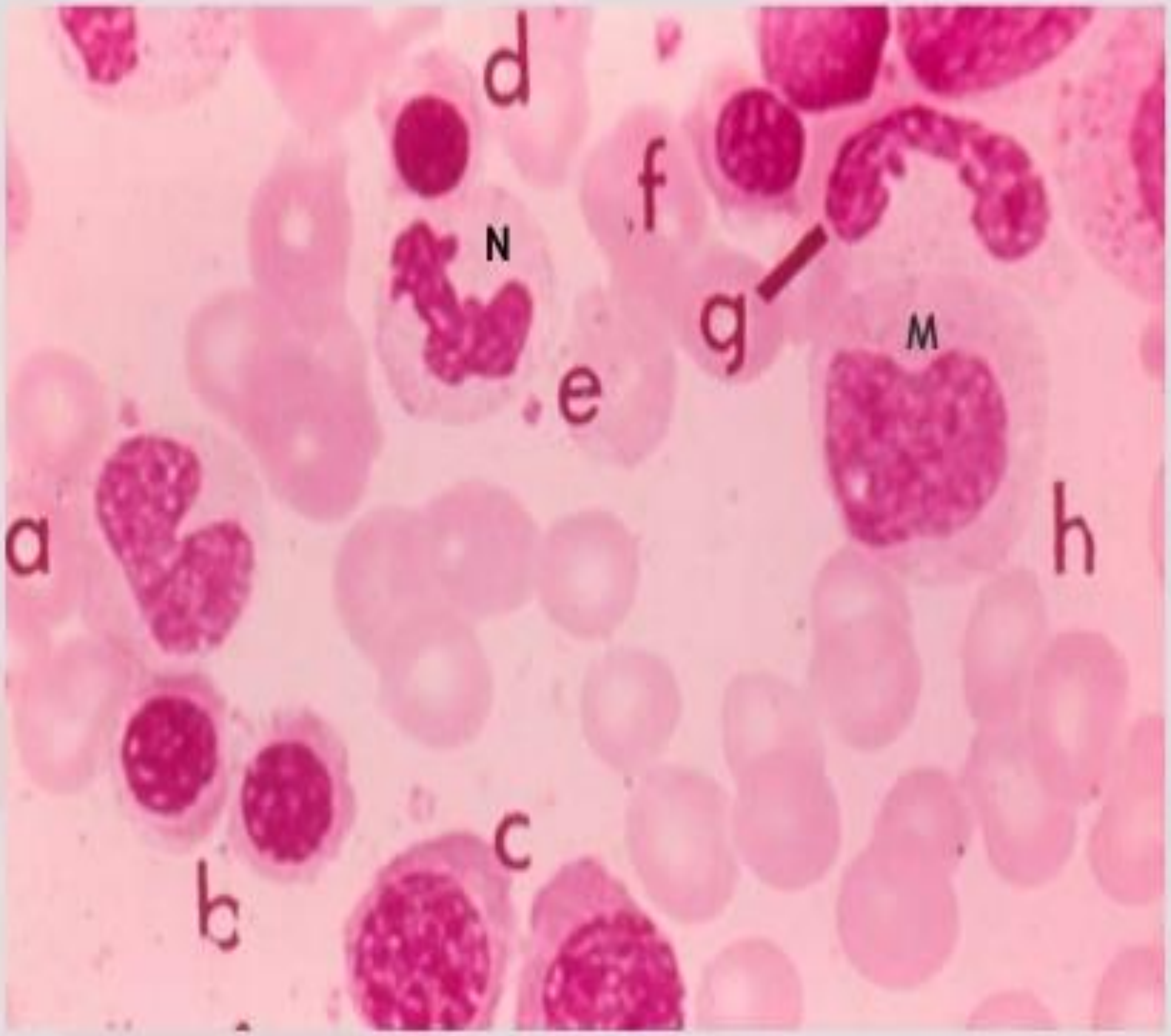
- Hormone produced by by the liver
- Stimulates the formation of platelets from megakaryocytes (megakaryocytopoiesis)

http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells



Bone marrow smear shows developing cells differing in sizes, nuclear shapes, contour and chromatin pattern, cytoplasm for basophilia and presence or absence of granules. Wrights – Giemsa x 200

http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells

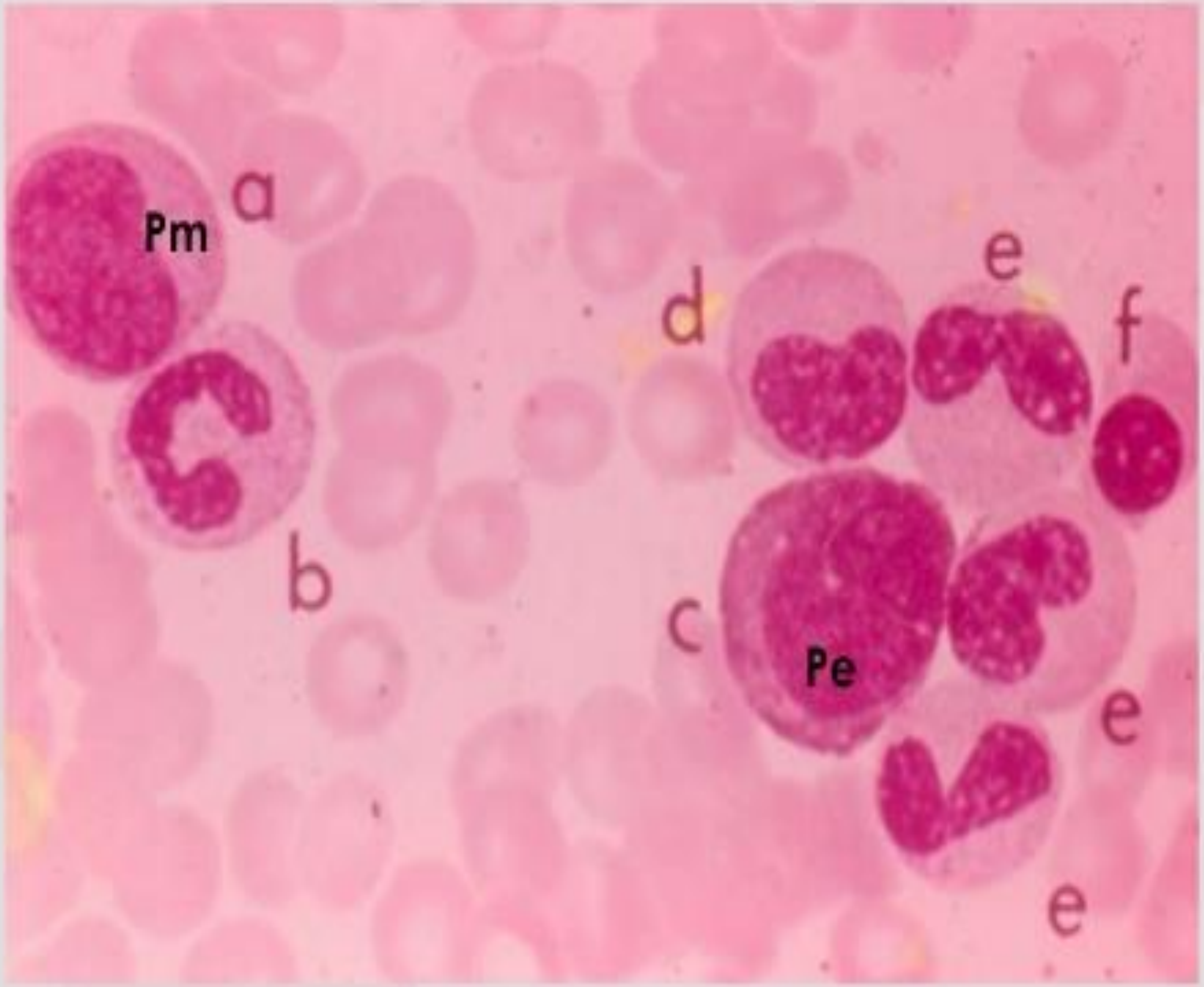


A **myelocyte** is a young cell of the **granulocytic series**, occurring normally in bone marrow, but not circulating in blood (except when caused by some disease). Develop into neutrophil.

Neutrophils are normally found in the bloodstream. During the beginning (acute) phase of inflammation, particularly as a result of bacterial infection, environmental exposure, and some cancers, neutrophils are one of the first-responders of inflammatory cells to migrate towards the site of inflammation.

Human bone marrow:
Neutrophilic myelocyte (h), metamyelocyte (a), and mature (e) and band (g) neutrophil. W-G x 400.

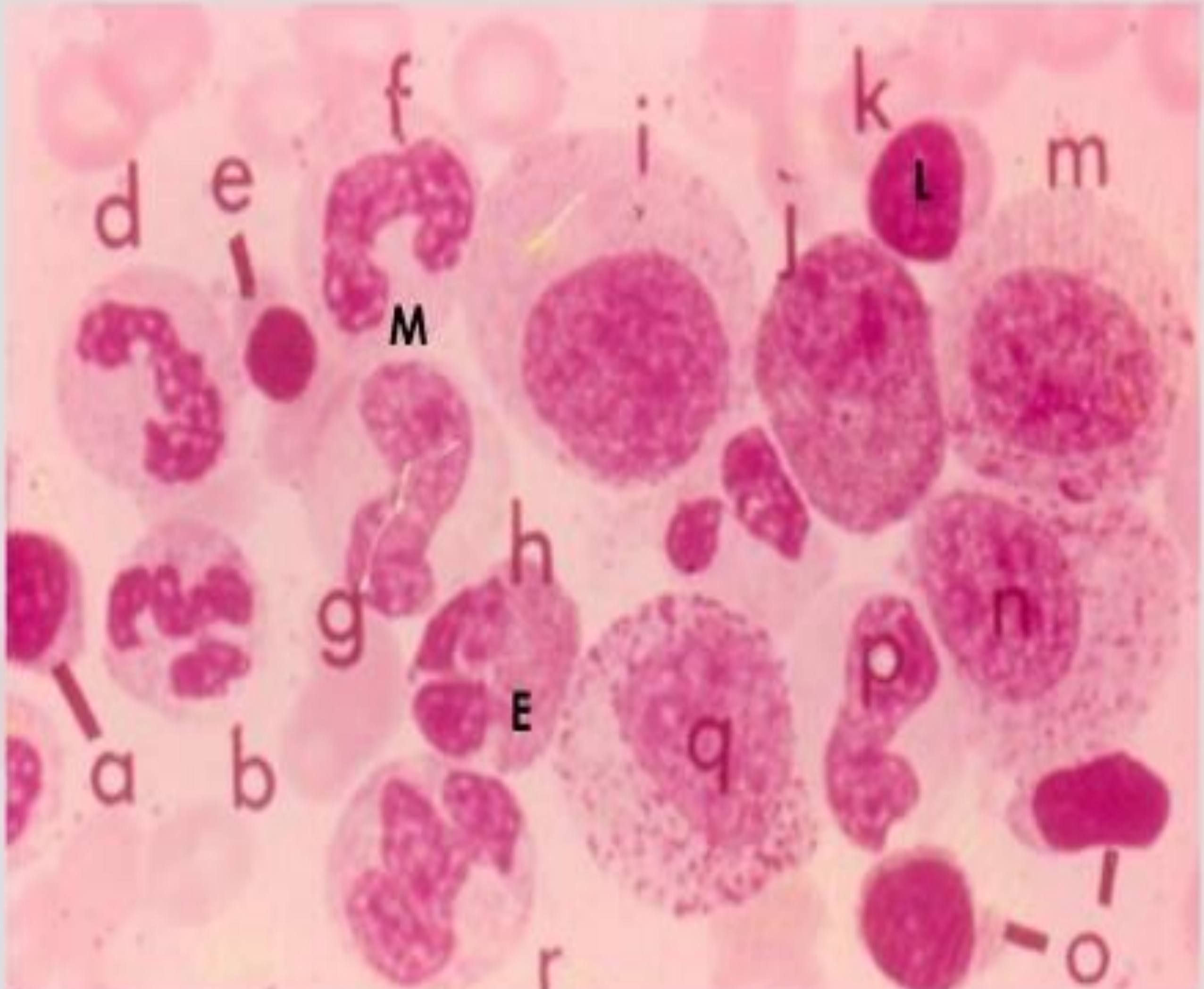
http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells



Human bone marrow: Very early neutrophilic promyelocyte (a) is very basophilic & chromatophilic, proerythroblast (c). Wrights-Giemsa x 400

Promyelocyte (or progranulocyte) is a granulocyte precursor, developing from the **myeloblast** and developing into the myelocyte. In the end of the 4th phase develop into **Basophil**.

http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells



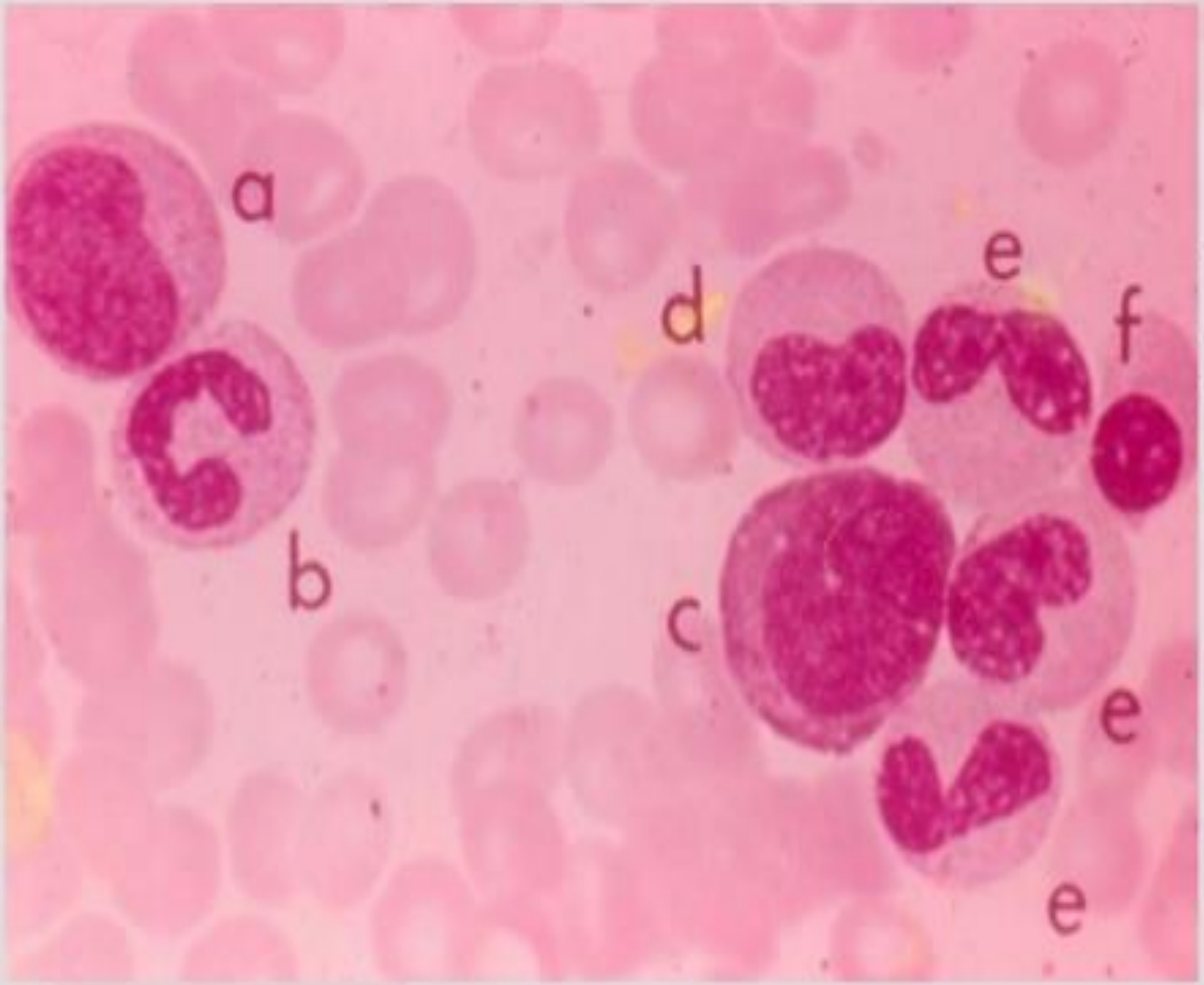
A **metamyelocyte** is a cell undergoing granulopoiesis, derived from a myelocyte, and leading to a band cell. Develop into eosinophil, neutrophil or basophil.

Eosinophils are white blood cells and one of the immune system components responsible for combating multicellular parasites and certain infections in vertebrates.

Lymphocytes are cellular components of the adaptive immune response.

Human bone marrow: Neutrophilic metamyelocytes (f, g), mature eosinophil (h), neutrophlic myelocyte (i), eosionophilic myelocyte (j), lymphocyte (k). W-Giemsa x 400

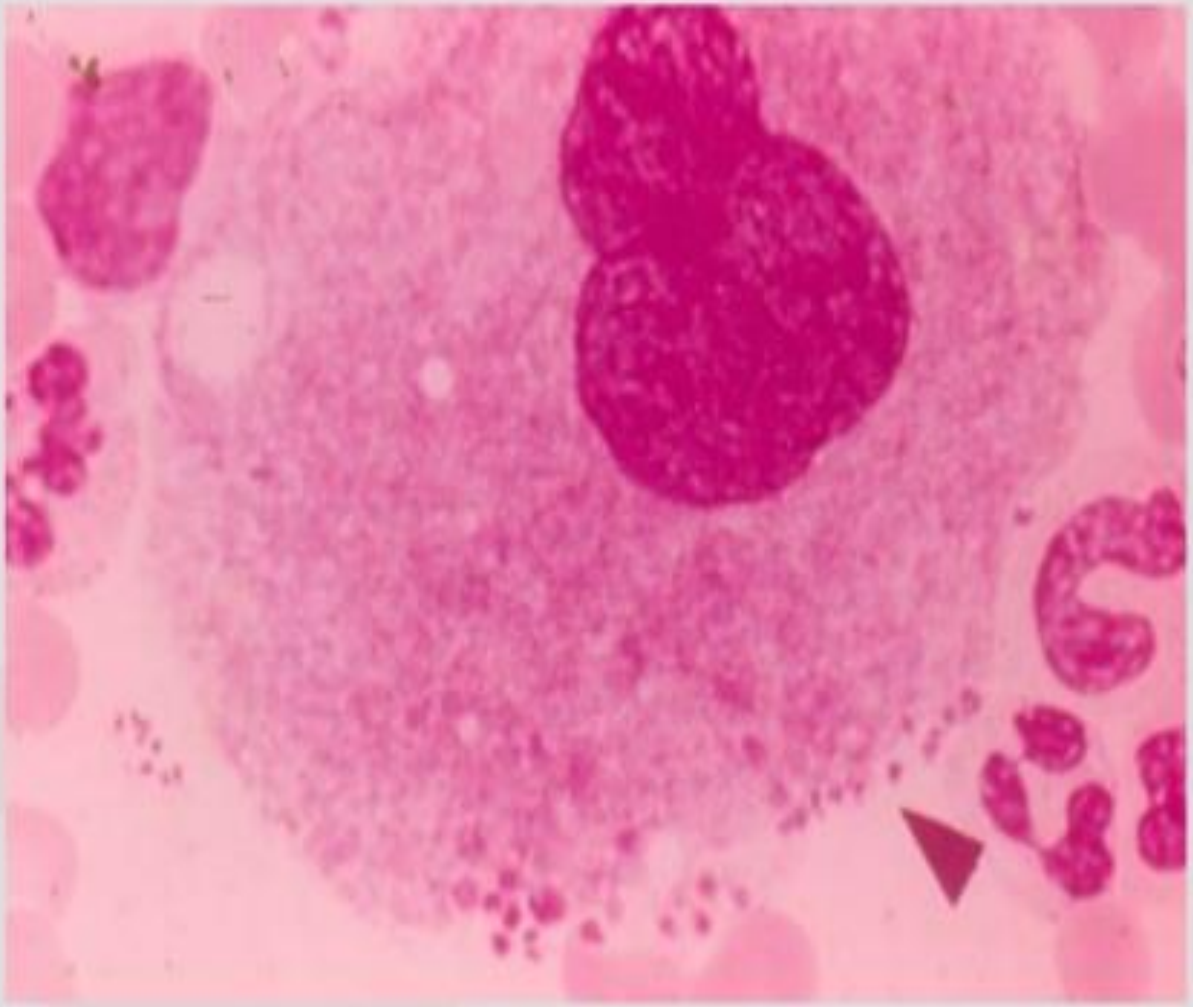
http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells



A **metamyelocyte** is a cell undergoing granulopoiesis, derived from a myelocyte, and leading to a band cell. Develop into **eosinophil, basophil or neutrophil.**

Human bone marrow: Band neutrophil (b), neutrophilic metamyelocytes (e), late neutrophilic myelocyte (d), normoblast (f). Wrights-Giemsa x 400.

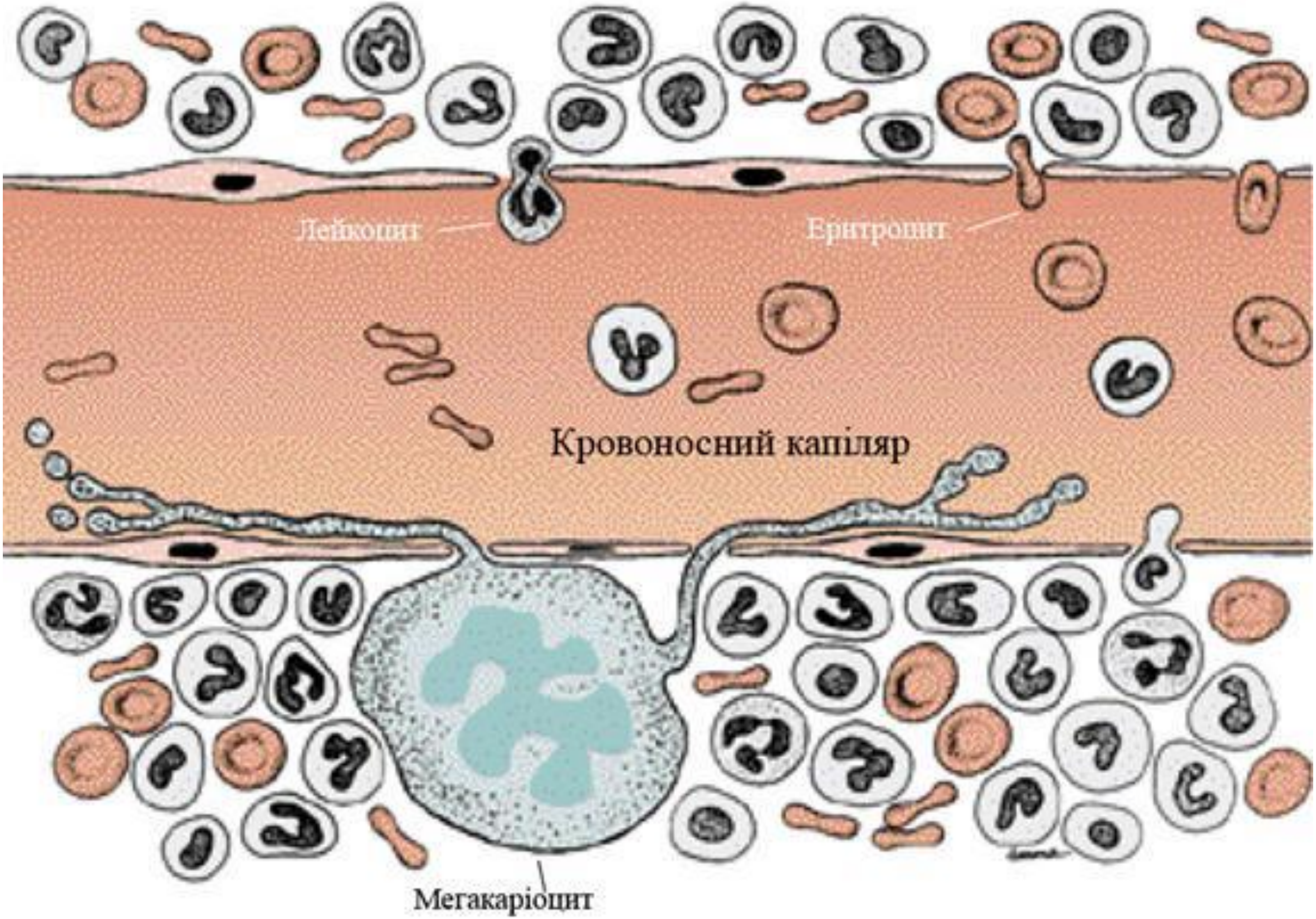
http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells

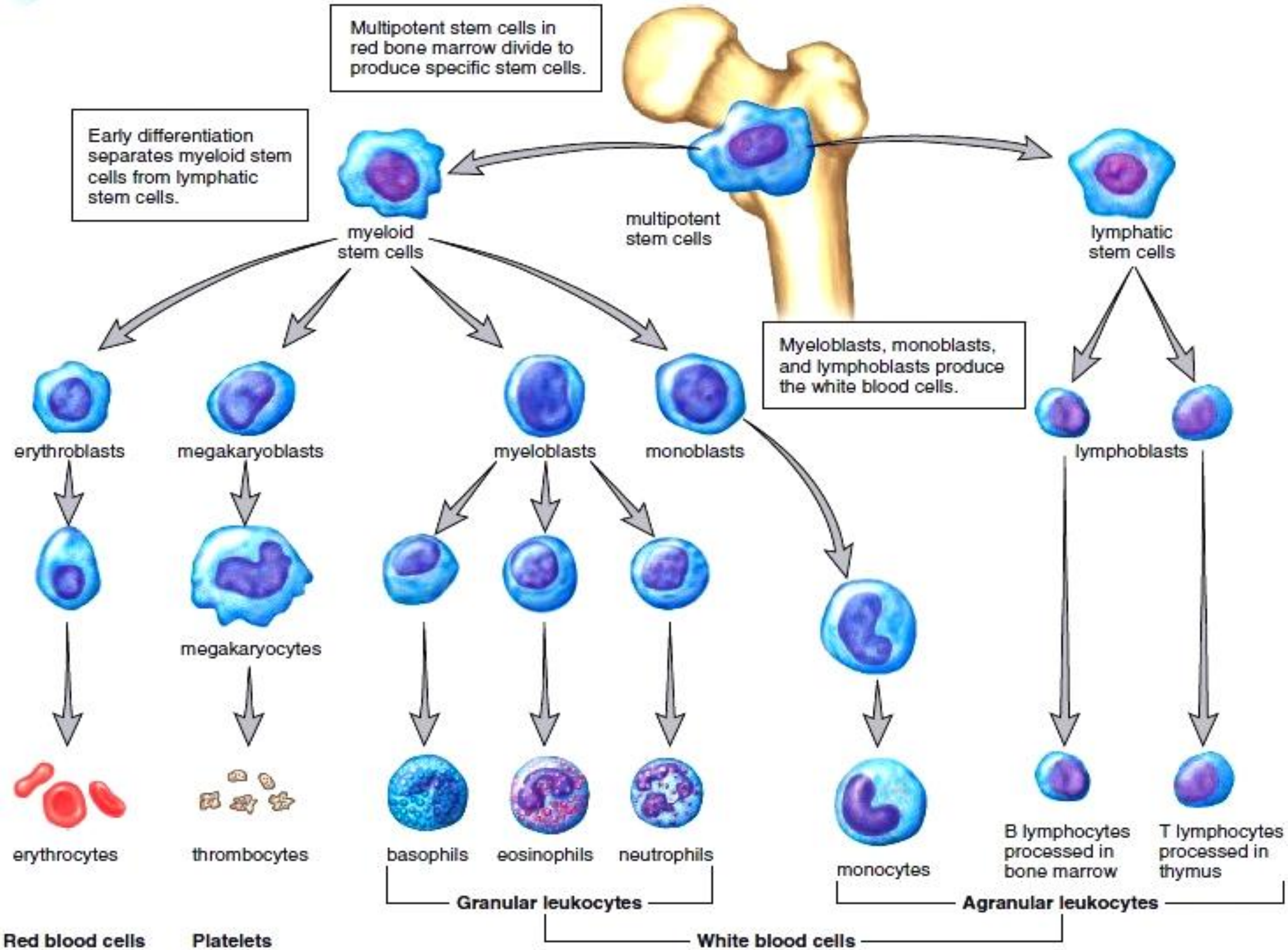


Megakaryocytes belong to **myeloid progenitor.**
Produced primarily by the liver, kidney, spleen, and bone marrow.
Develop into **thrombocytes.**

Human bone marrow: A megakaryocyte shedding its cytoplasm to form platelets (arrow).
W-G x 400.

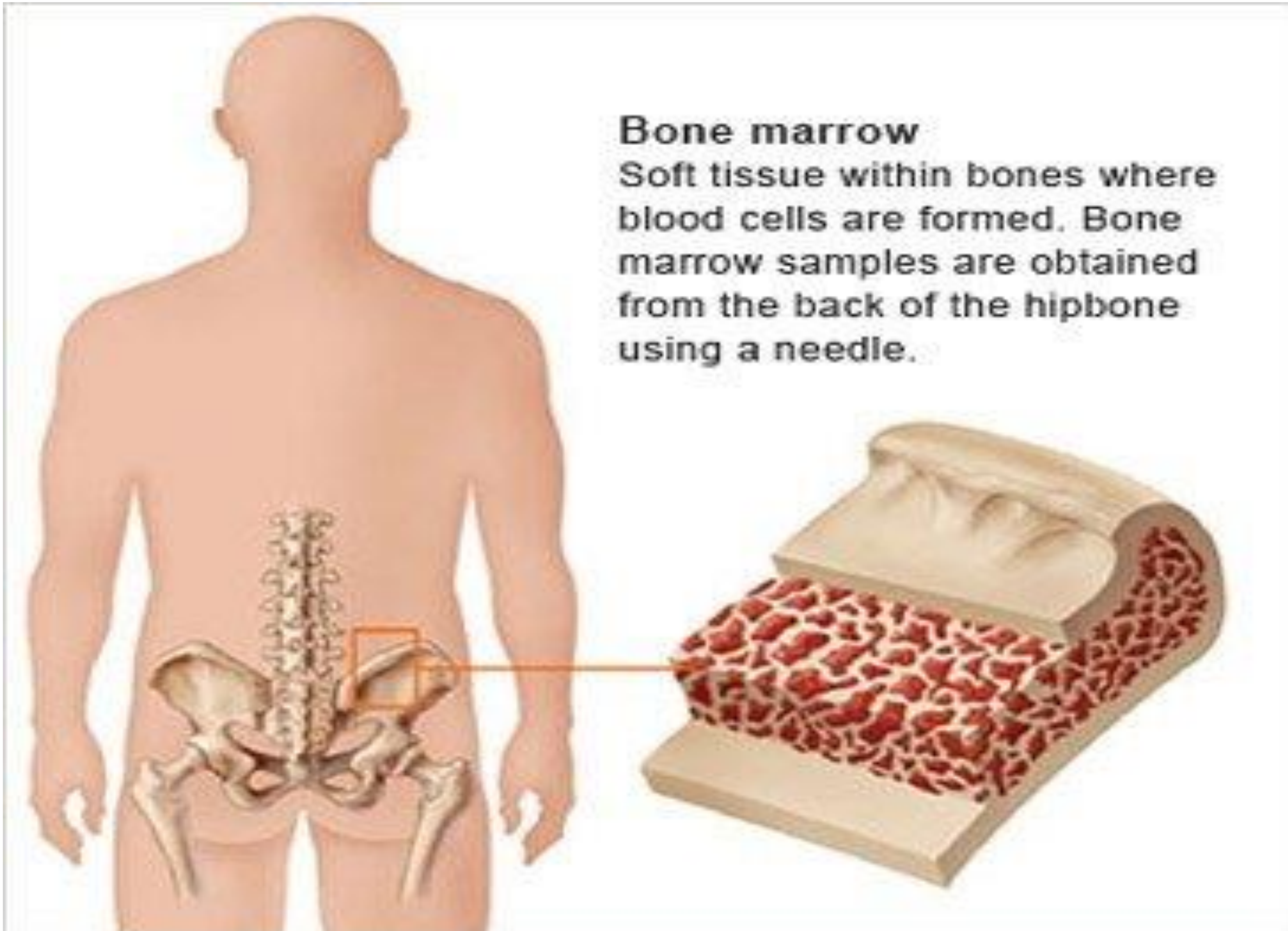
http://www.slideshare.net/TereshchenkoO/monophyletic-theory-of-erythropoiesis-stem-cells


Лейкоцит
Еритроцит
Кровоносний капіляр
Мегакаріоцит



Multipotent stem cells in red bone marrow divide to produce specific stem cells.
Early differentiation separates myeloid stem cells from lymphatic stem cells.
myeloid stem cells
multipotent stem cells
lymphatic stem cells
Myeloblasts, monoblasts, and lymphoblasts produce the white blood cells.
erythroblasts
megakaryoblasts
myeloblasts
monoblasts
lymphoblasts
megakaryocytes
erythrocytes
thrombocytes
basophils
eosinophils
neutrophils
monocytes
B lymphocytes processed in bone marrow
T lymphocytes processed in thymus
Granular leukocytes
Agranular leukocytes
Red blood cells
Platelets
White blood cells

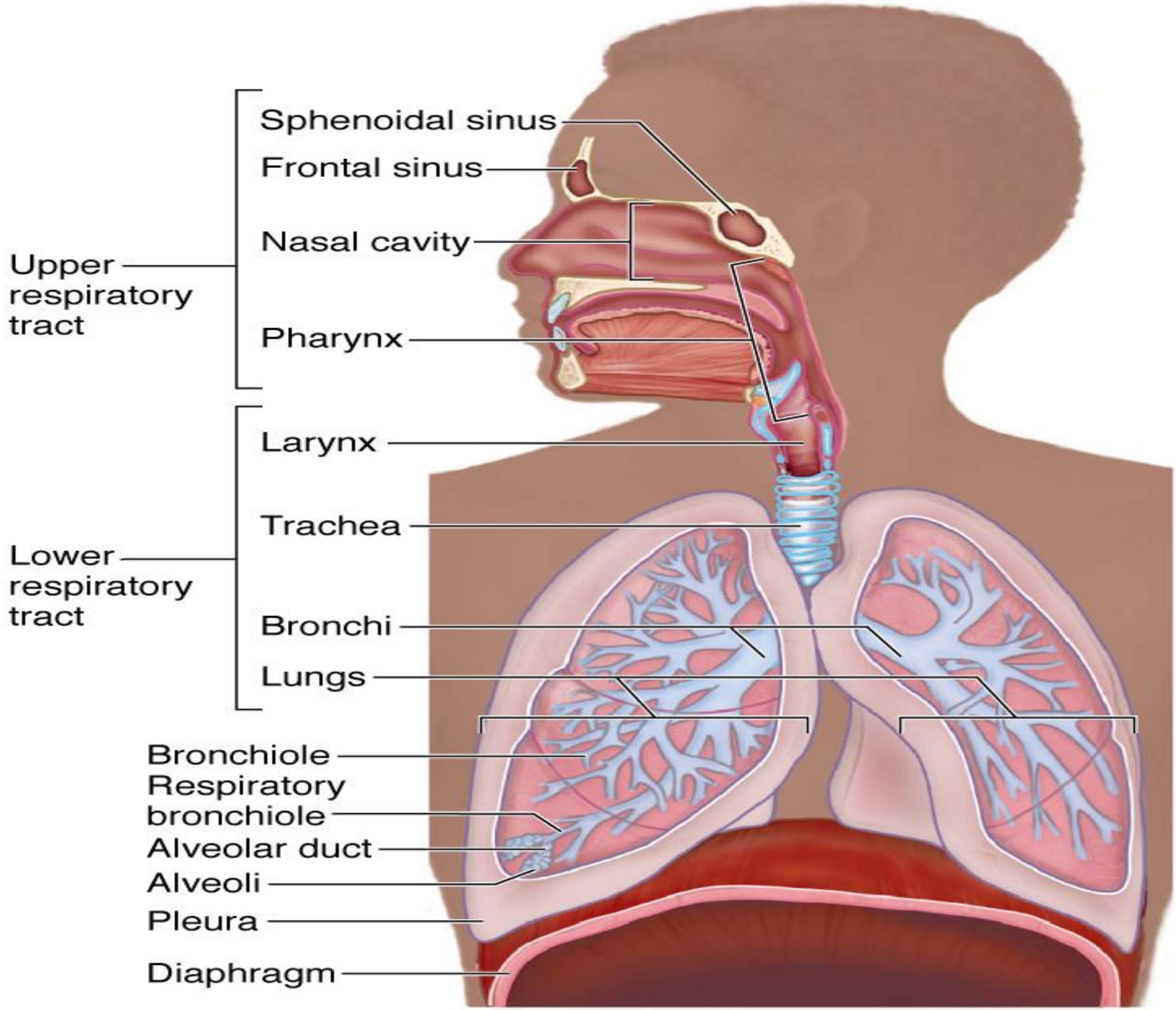

Красный костный мозг
Губчатое вещество
Жёлтый костный мозг



Bone marrow
Soft tissue within bones where blood cells are formed. Bone marrow samples are obtained from the back of the hipbone using a needle.

RESPIRATORY SYSTEM

Al-Farabi Kazakh National University
Higher School of Medicine


Upper respiratory tract
Sphenoidal sinus
Frontal sinus
Nasal cavity
Pharynx
Lower respiratory tract
Larynx
Trachea
Bronchi
Lungs
Bronchiole
Respiratory bronchiole
Alveolar duct
Alveoli
Pleura
Diaphragm

Olfactory Epithelium

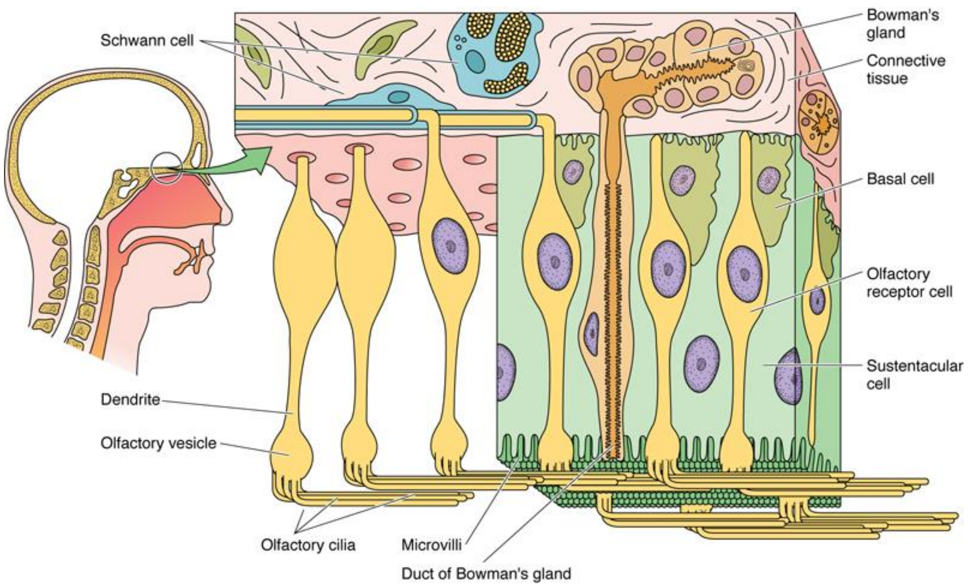


Figure 15–2 The olfactory epithelium, displaying basal, olfactory, and sustentacular cells.

The respiratory system has two major portions, the **conducting portion**, situated both outside and within the lungs, conveys air from the external milieu to the lungs and the **respiratory portion**, located strictly within the lungs, functions in the actual exchange of oxygen for carbon dioxide (external respiration).

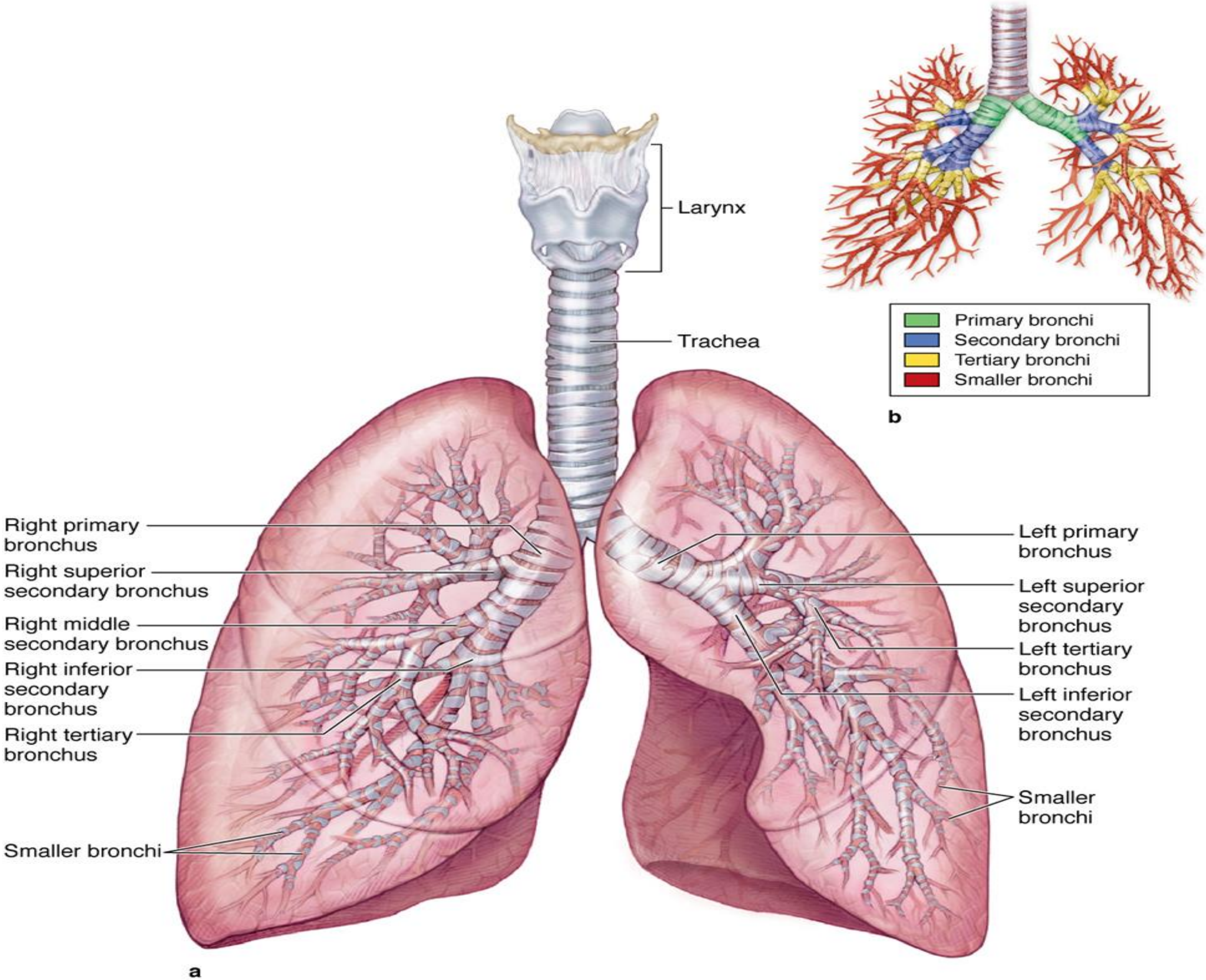
The roof of the nasal cavity, the superior aspect of the nasal septum, and the superior concha are covered by an **olfactory epithelium**. The underlying lamina propria houses serous fluid–secreting Bowman's glands, a rich vascular plexus, and collections of axons that arise from the olfactory cells of the **olfactory epithelium.** The olfactory epithelium is composed of three types of cells: olfactory, sustentacular, and basal cells.

Olfactory cells are bipolar neurons whose apical aspect, the distal terminus of its slender dendrite, is modified to form a bulb, the **olfactory vesicle**, which projects above the surface of the sustentacular cells. Six to eight long, nonmotile olfactory cilia extend from the olfactory vesicle and lie on the free surface of the epithelium. The basal region of the olfactory cell is its **axon**, which penetrates the basal lamina and joins similar axons to form bundles of nerve fibers that synapse with secondary neurons in the olfactory bulb.

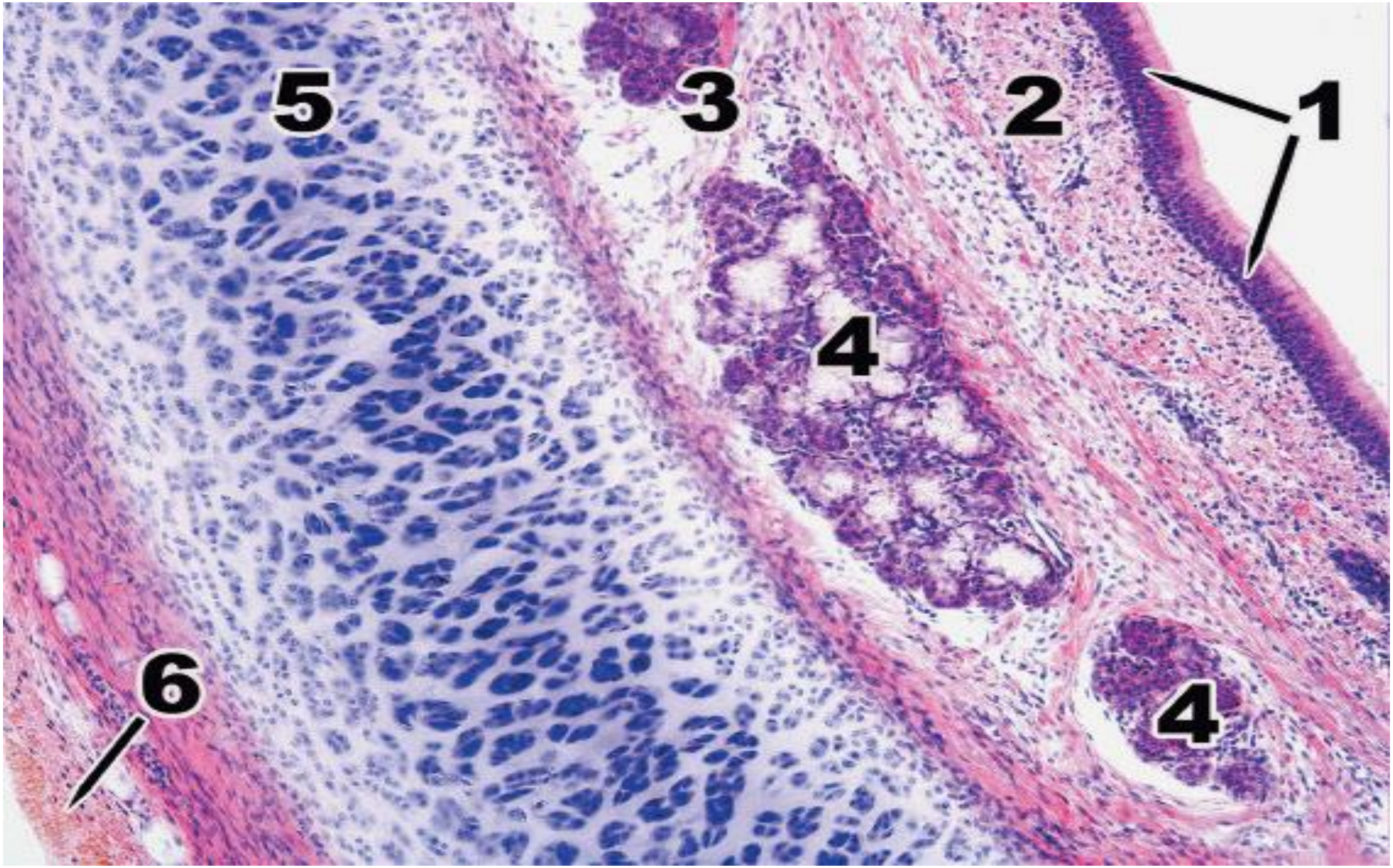
The tall, columnar **sustentacular cells** have secretory granules housing a yellow pigment characteristic of the color of the olfactory mucosa. These cells are believed to provide physical support, nourishment, and electrical insulation for the olfactory cells.

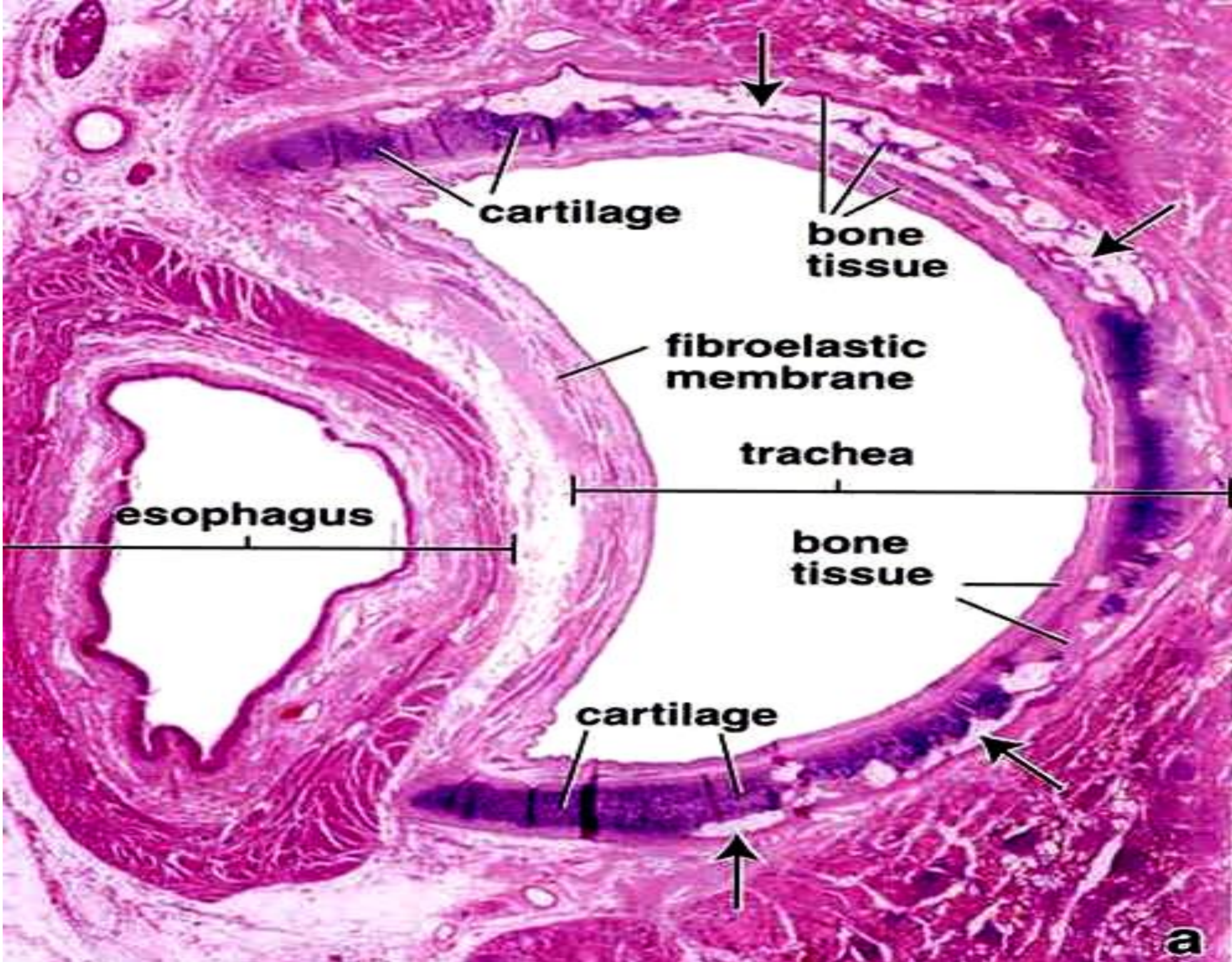
Basal cells have considerable proliferative capacity and can replace both sustentacular and olfactory cells. In a healthy person, the olfactory and sustentacular cells have a life span of less than a year.

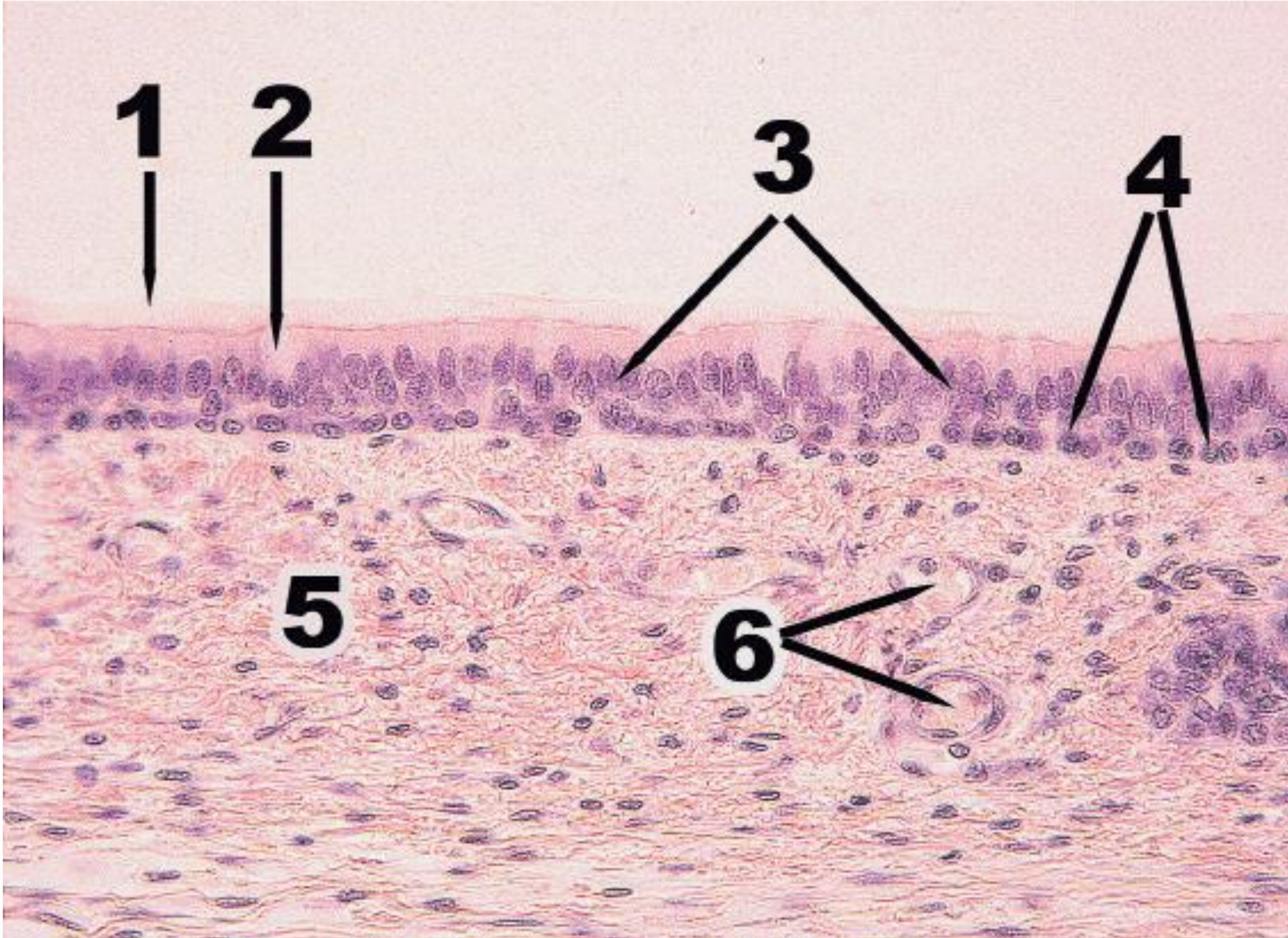
For more information see Olfactory Epithelium in Chapter 14 of Gartner and Hiatt: Color Textbook of Histology, 3rd ed. Philadelphia, W.B. Saunders, 2007.


Larynx
Trachea
Right primary bronchus
Right superior secondary bronchus
Right middle secondary bronchus
Right inferior secondary bronchus
Right tertiary bronchus
Smaller bronchi
Left primary bronchus
Left superior secondary bronchus
Left tertiary bronchus
Left inferior secondary bronchus
Smaller bronchi
a
Primary bronchi
Secondary bronchi
Tertiary bronchi
Smaller bronchi
b

TRACHEA




cartilage
bone
tissue
fibroelastic
membrane
trachea
esophagus
bone
tissue
cartilage
a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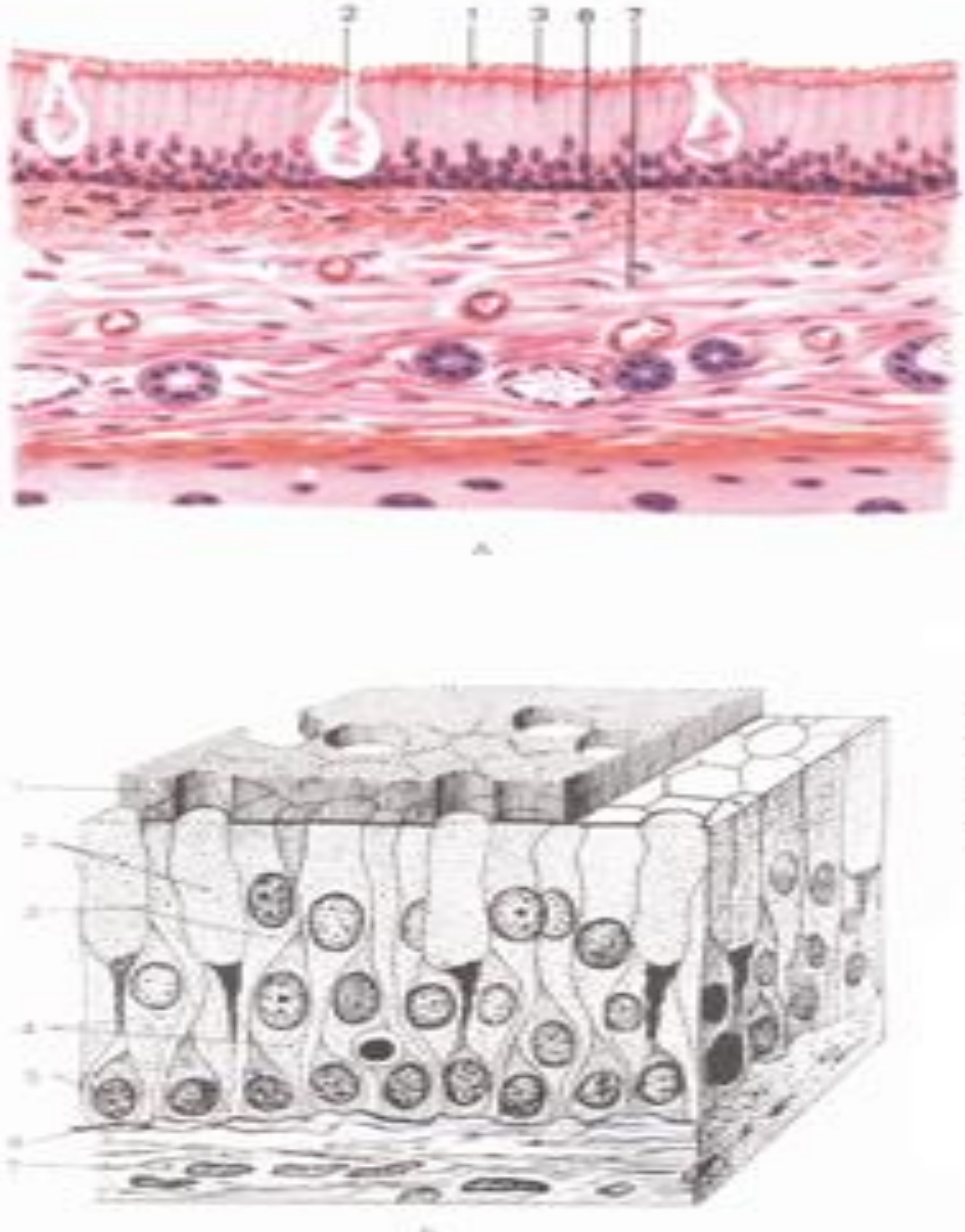


Көп қатарлы кірпікшелі эпителий.
А-бояуы: гематоксилин-эозин, х 400;
Б-үлгісі;
1-жасуша кірпікшелері; 2-бокал тәрізді безді жасушалар; 3-кірпікшелі жасушалар; 4-ұзын қыстырма жасушалар; 5-қысқа қыстырма жасушалар; 6-базальды мембрана; 7-дәнекер тіні (Н.В. Алмазов, Л.С. Сутулов бойынша).

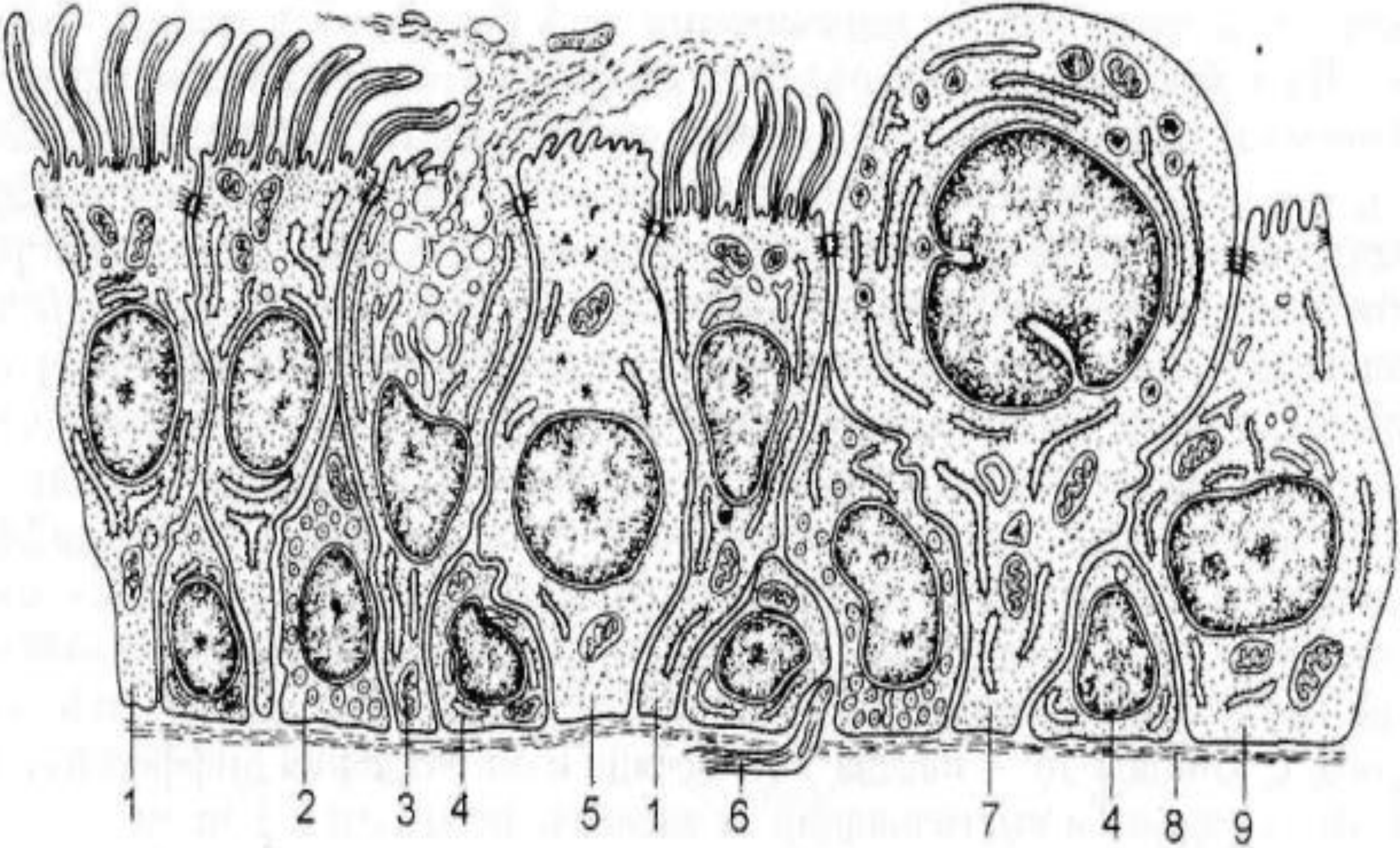
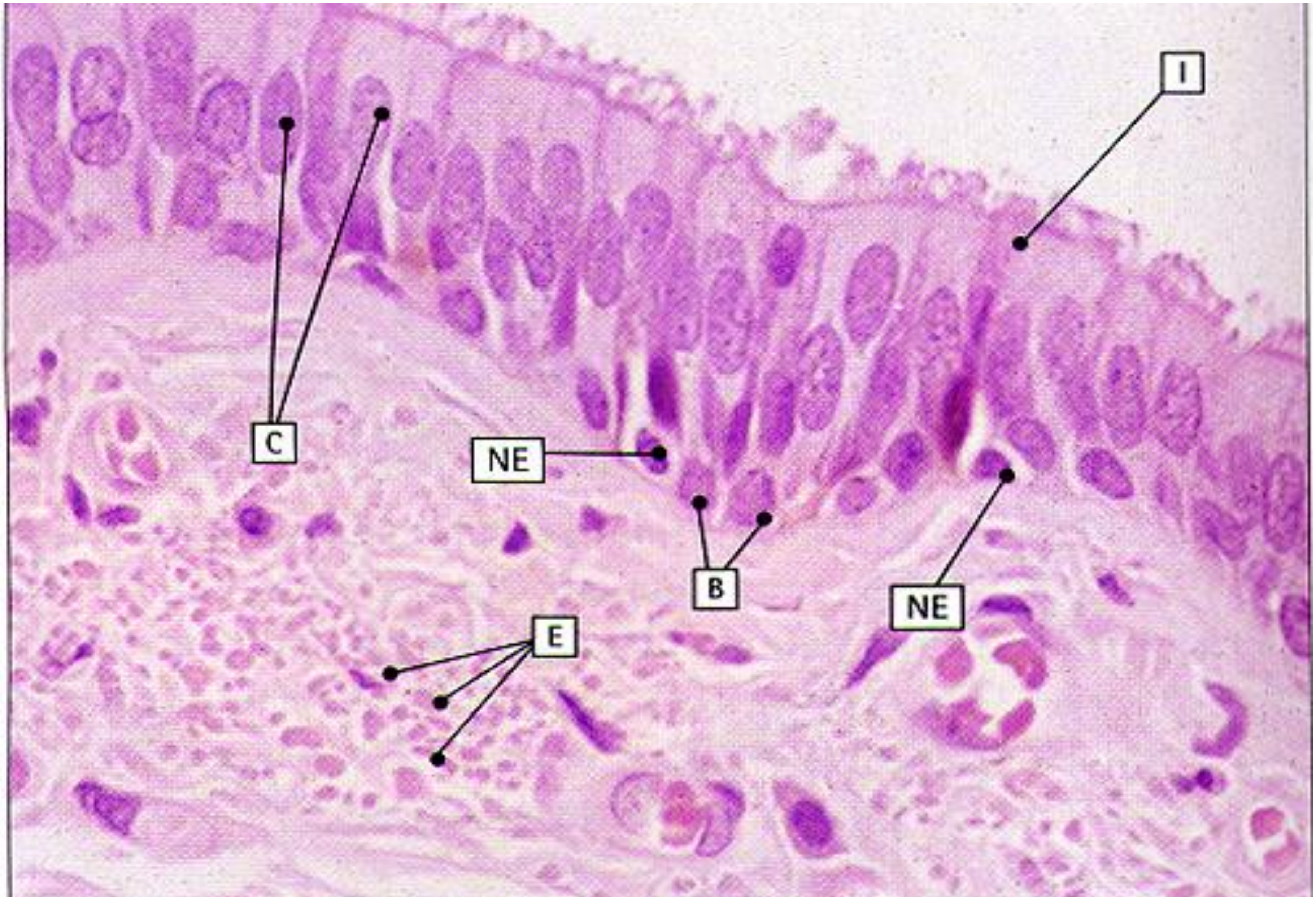


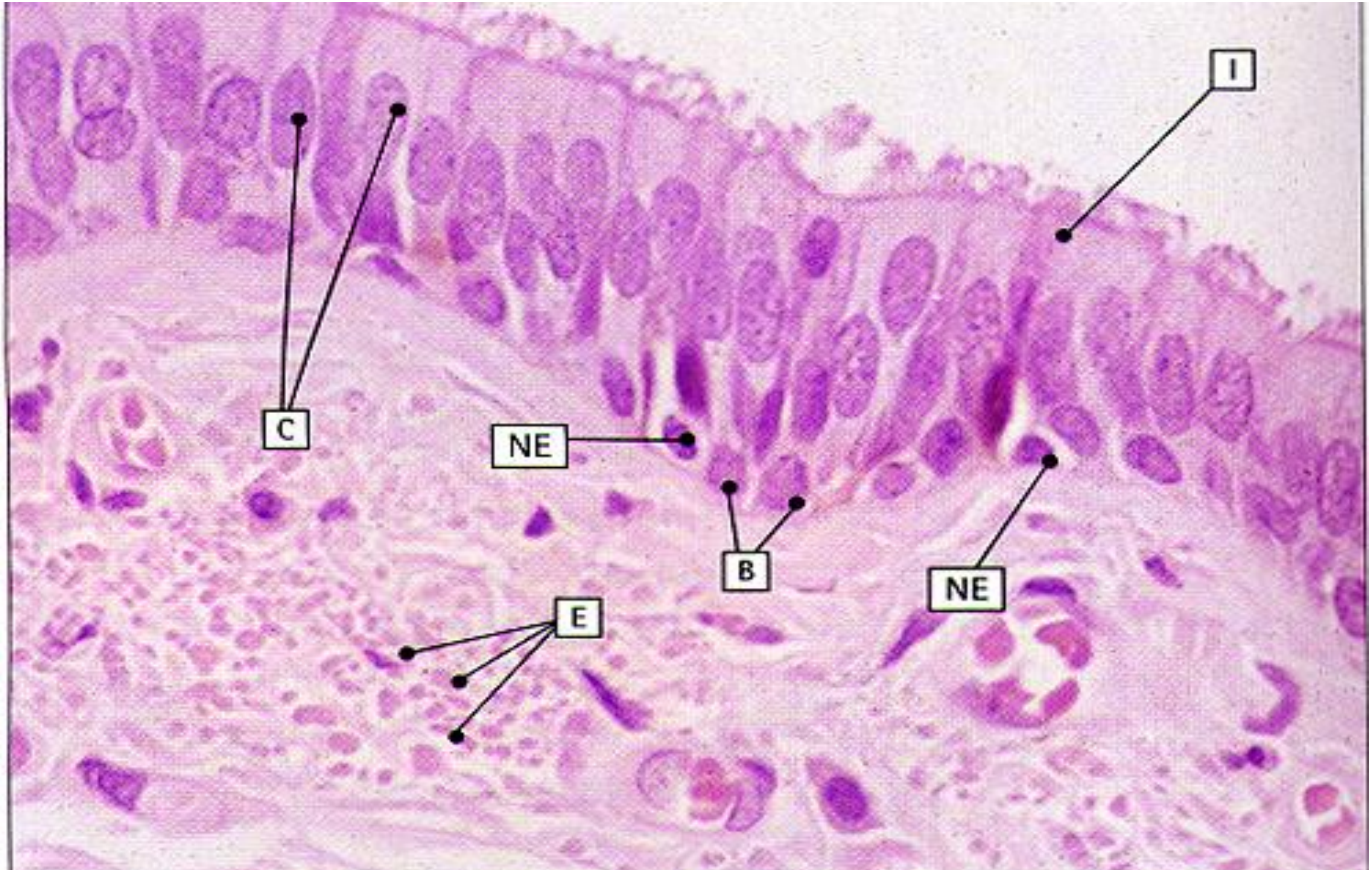
Рис. 296. Эпителиальные клетки слизистой оболочки воздухоносных путей (схема по Ю.И.Афанасьеву).

1 — реснитчатые клетки; 2 — нейроэндокринные клетки; 3 — бокаловидные клетки; 4 — камбиальные клетки; 5 — безреснитчатые клетки; 6 — нервное волокно; 7 — секреторные клетки (клетки Клара); 8 — базальная мембрана; 9 — хемочувствительные клетки.

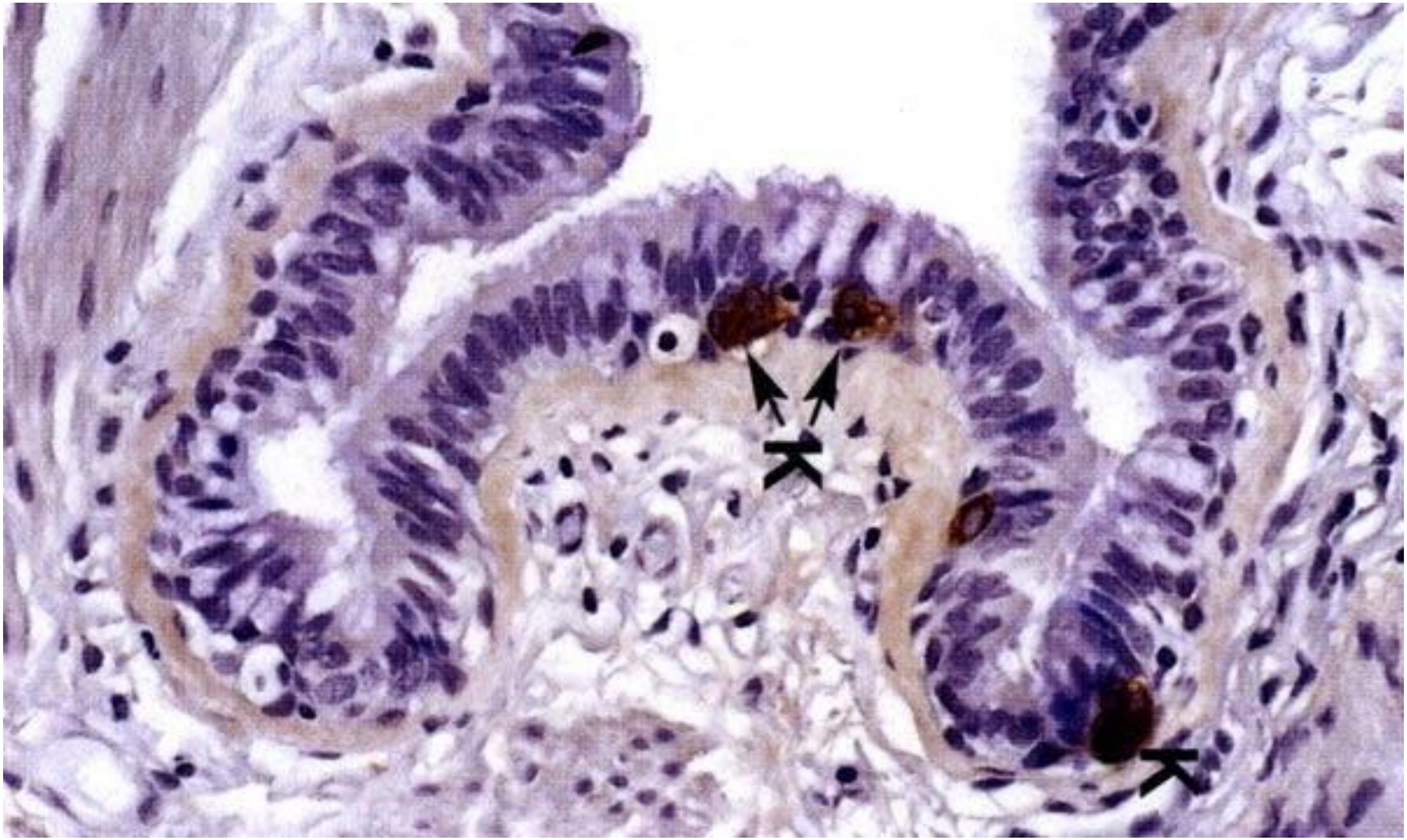
Basal cells

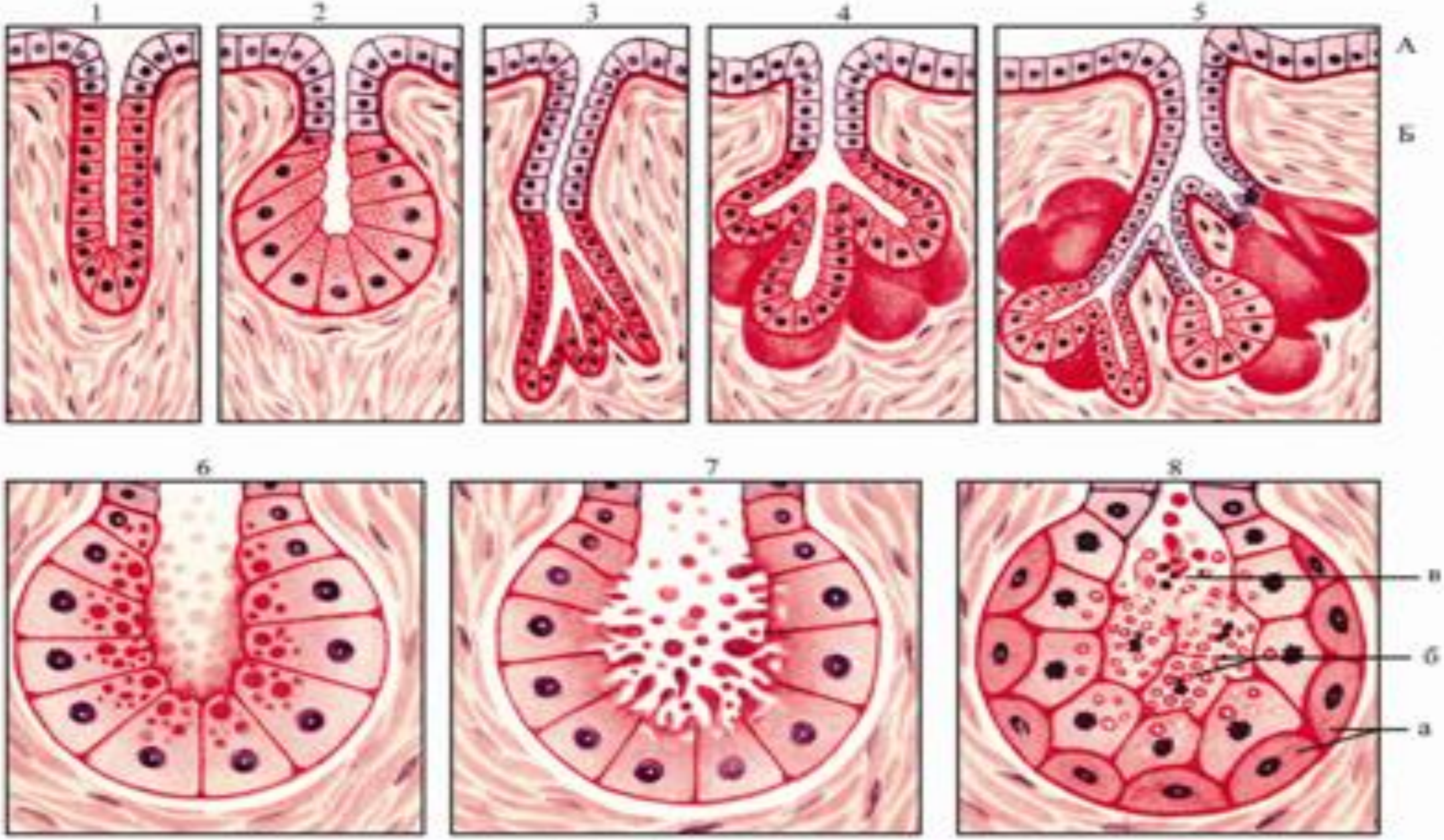


Brush cells



Endocrine (small dranule) cells





Экзокринді, экзоэпителиалды бездердің құрылысы мен секрециясы. Өзектер мен эпителийдің үстіңгі беткейі күлгін-көк түске, секреторлық бөлімдері қызыл түске боялған.

А- эпителий, Б- дәнекер тін.

1- қарапайым тармақталған түтікше безі, 2- қарапайым тармақталмаған альвеолалы без, 3- секреторлық бөлімі тармақталған қарапайым түтікше безі, 4- секреторлық бөлімі тармақталған қарапайым альвеолалы без, 5- күрделі альвеолалы түтікше безі; 6- мерокринді секреция; 7- апокринді секреция; 8- голокринді секреция; а- базальді клеткалар; б- тіршілігін жойған клеткалар; в- ыдырау сатысындағы клетка

AIRWAYS- BRONCHI

- large bronchi

  5 - 15 мм

- middle size bronchi

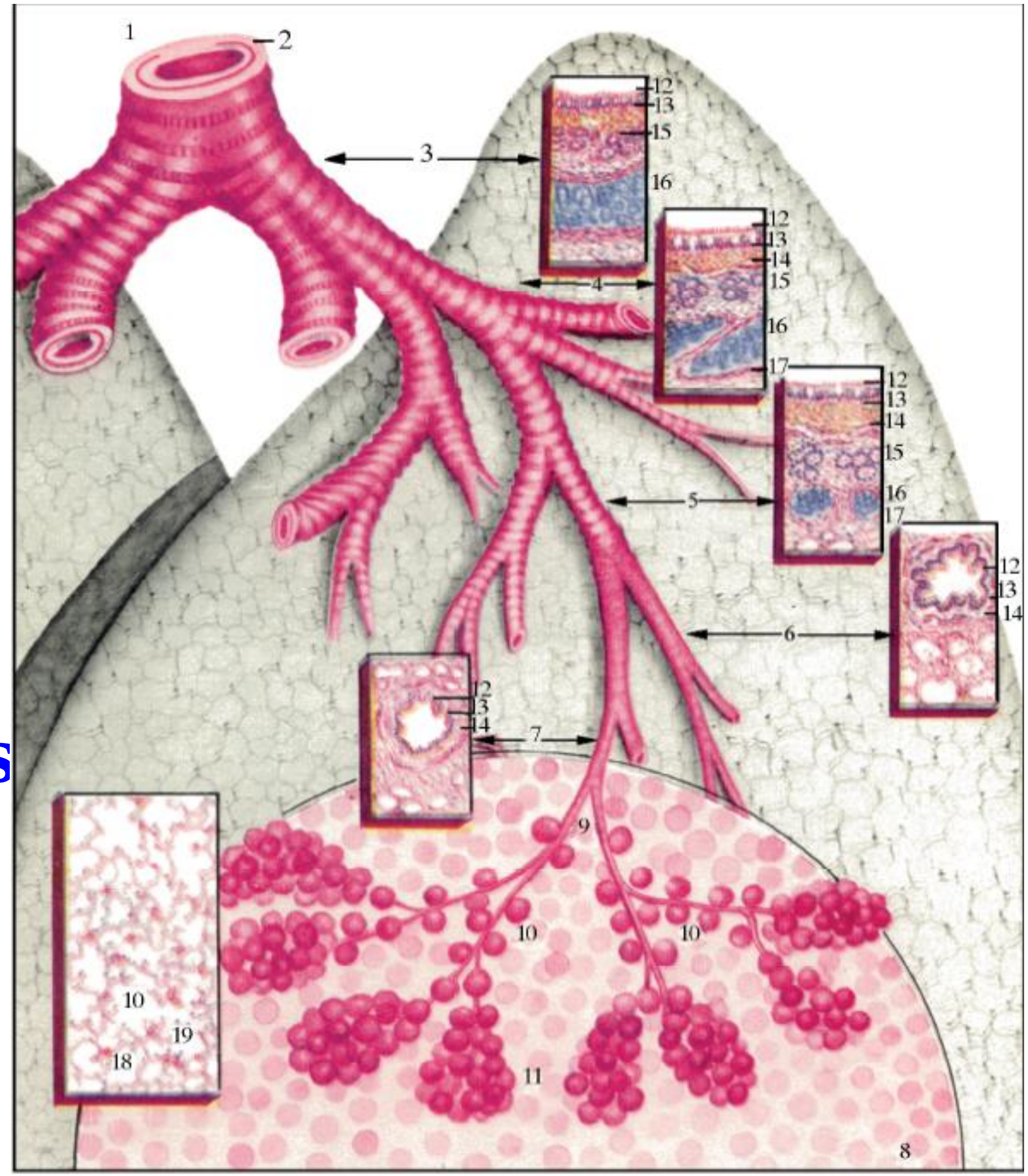
  2 - 5 мм

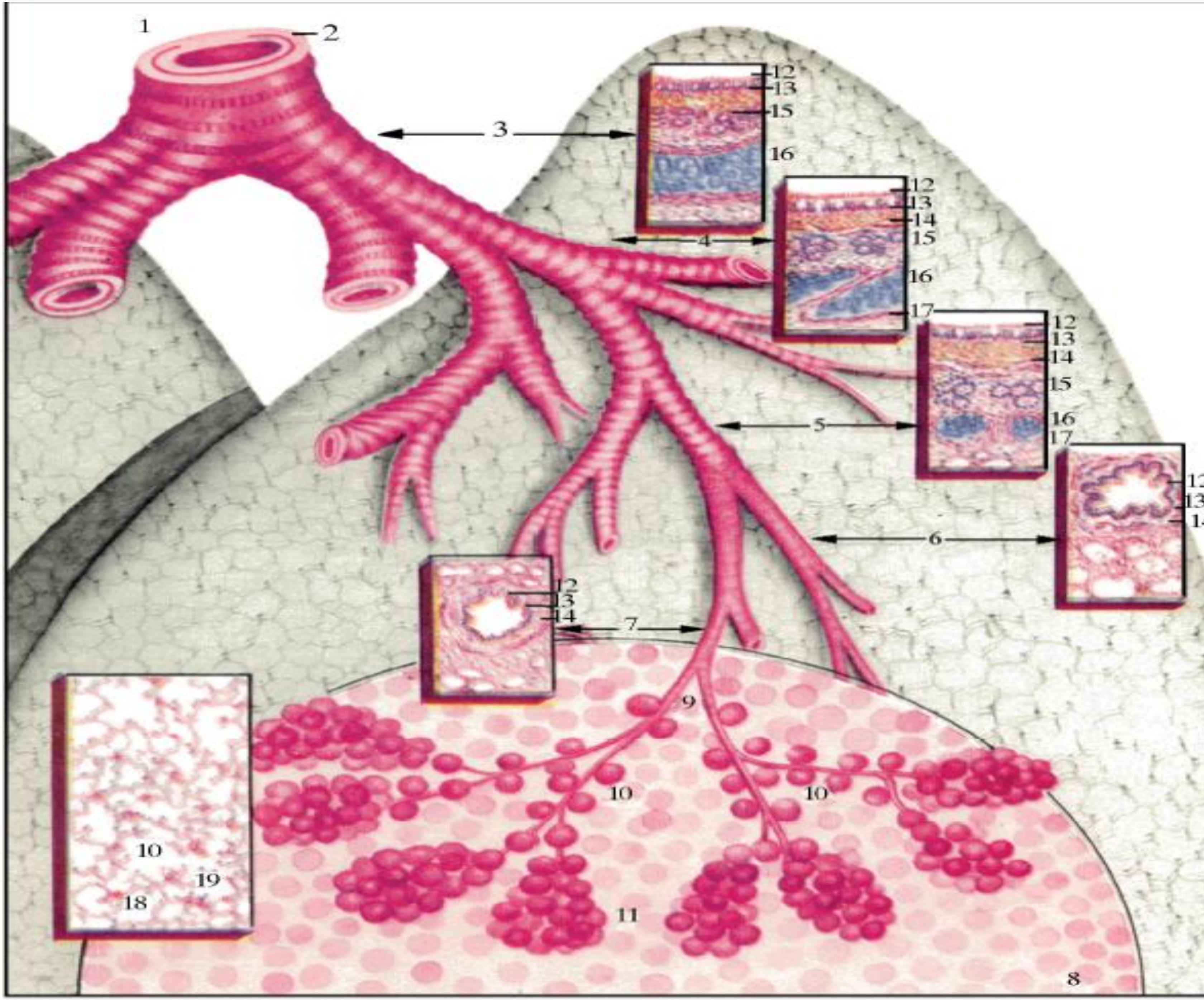
- small bronchi -

  1 - 2 мм

- terminal bronchioles

  0,5 мм

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Bronchi and Bronchioles

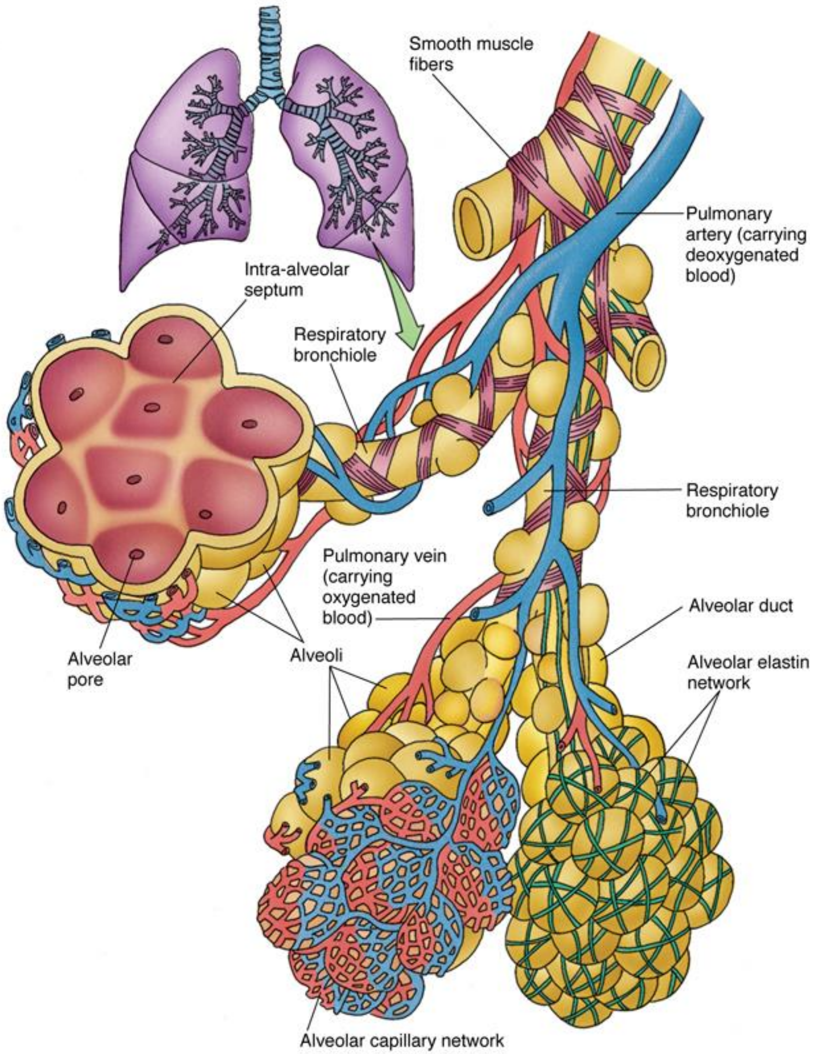


Figure 15–7 The respiratory system, displaying bronchioles, terminal bronchioles, respiratory bronchioles, alveolar ducts, alveolar pores, and alveoli.

The **bronchial tree** (conducting portion) begins at the bifurcation of the trachea, as the right and left primary bronchi, which arborize. The bronchial tree is composed of airways located outside the lungs, the primary bronchi, and airways located inside the lungs, the intrapulmonary bronchi, bronchioles, and terminal bronchioles.

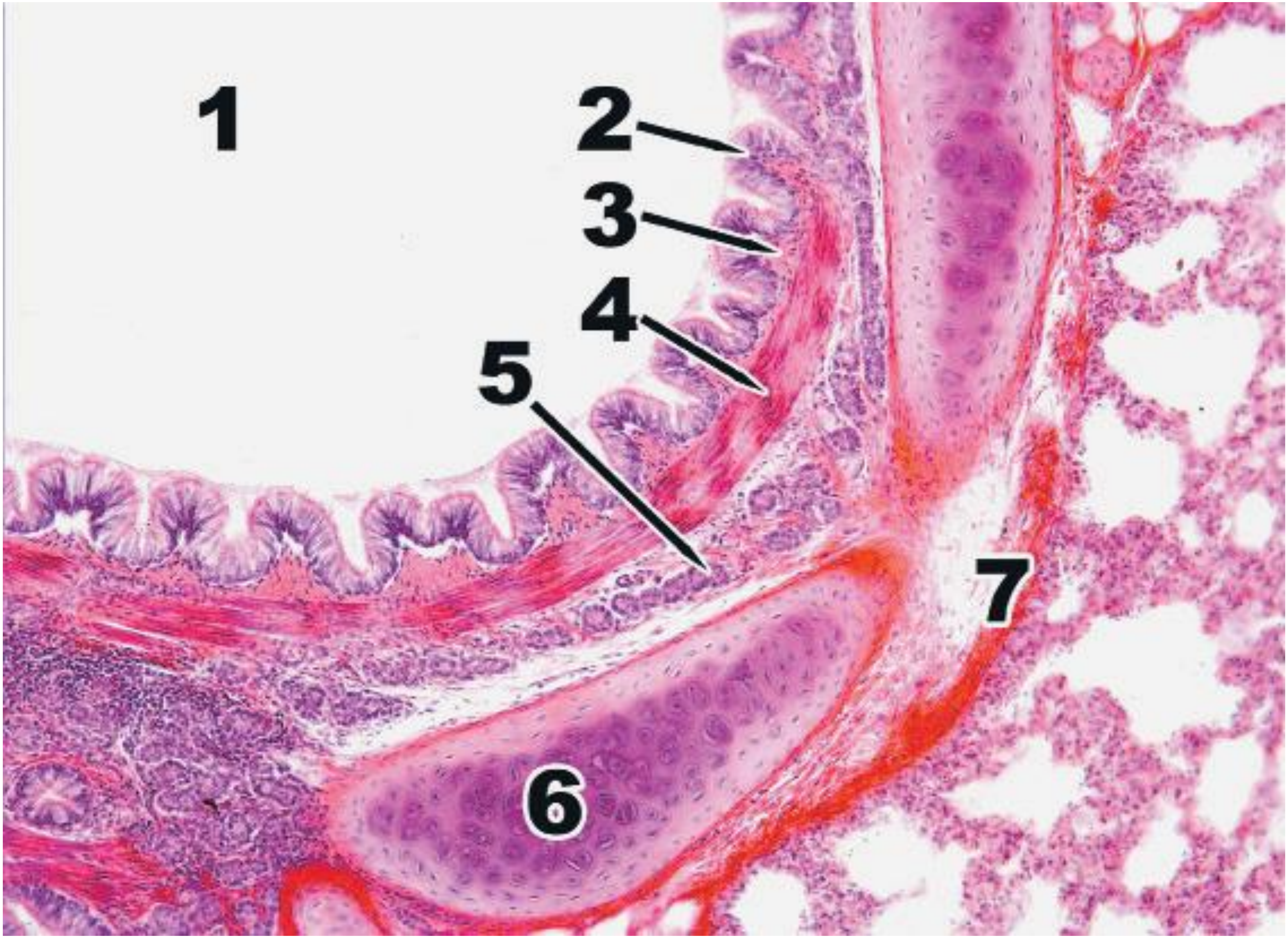
Primary bronchi are identical to the trachea, except that bronchi are smaller in diameter and their walls are thinner.

Intrapulmonary bronchi are similar to primary bronchi, except that the cartilage C-rings are replaced by irregular plates of hyaline cartilage that completely surround the lumina of the intrapulmonary bronchi. The smooth muscle is located at the interface of the fibroelastic lamina propria and submucosa as two distinct smooth muscle layers spiraling in opposite directions. Elastic fibers, radiate from the adventitia to connect with elastic fibers arising from other parts of the bronchial tree.

Each **bronchiole** supplies air to a pulmonary lobule. Their epithelial lining ranges from ciliated simple columnar with occasional goblet cells in larger bronchioles to simple cuboidal (many with cilia) with occasional **Clara cells** and no goblet cells in smaller bronchioles.

Terminal bronchioles are lined by Clara cells and cuboidal cells. The thin lamina propria consists of fibroelastic connective tissue and is surrounded by one or two layers of smooth muscle cells. Elastic fibers radiate from the adventitia and bind to elastic fibers radiating from other members of the bronchial tree.

For more information see Bronchial Tree in Chapter 14 of Gartner and Hiatt: Color Textbook of Histology, 3rd ed. Philadelphia, W.B. Saunders, 2007.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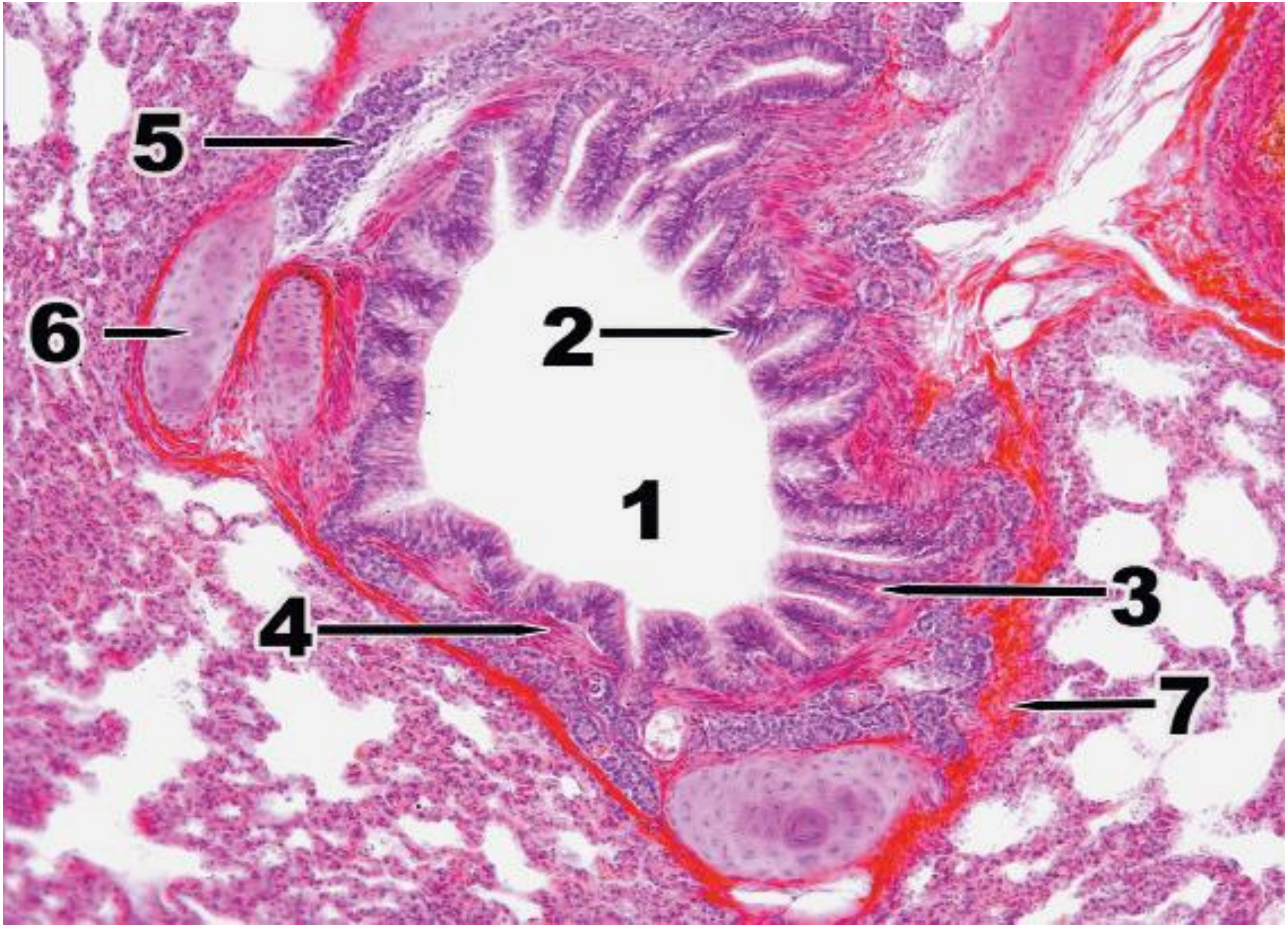
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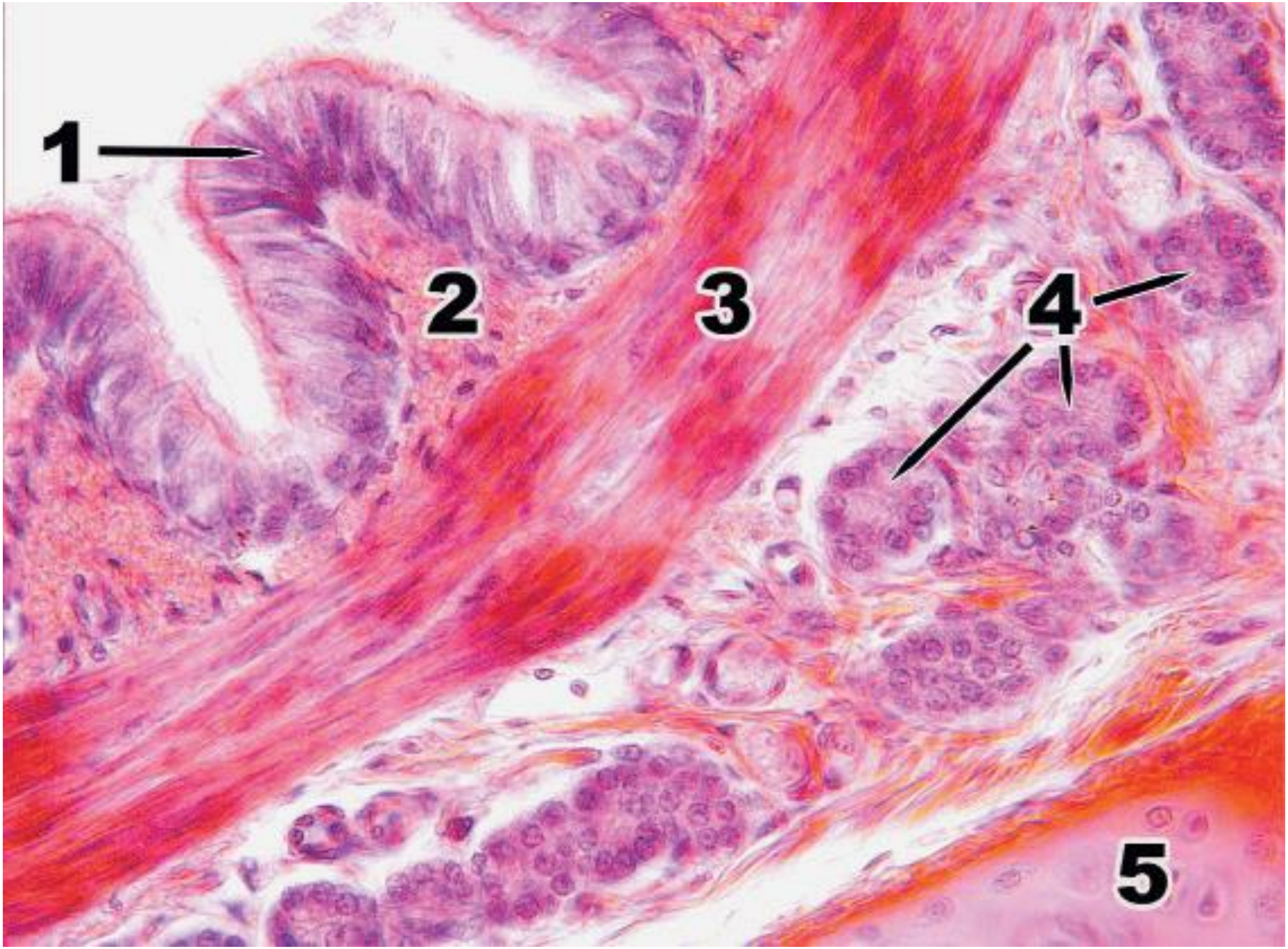
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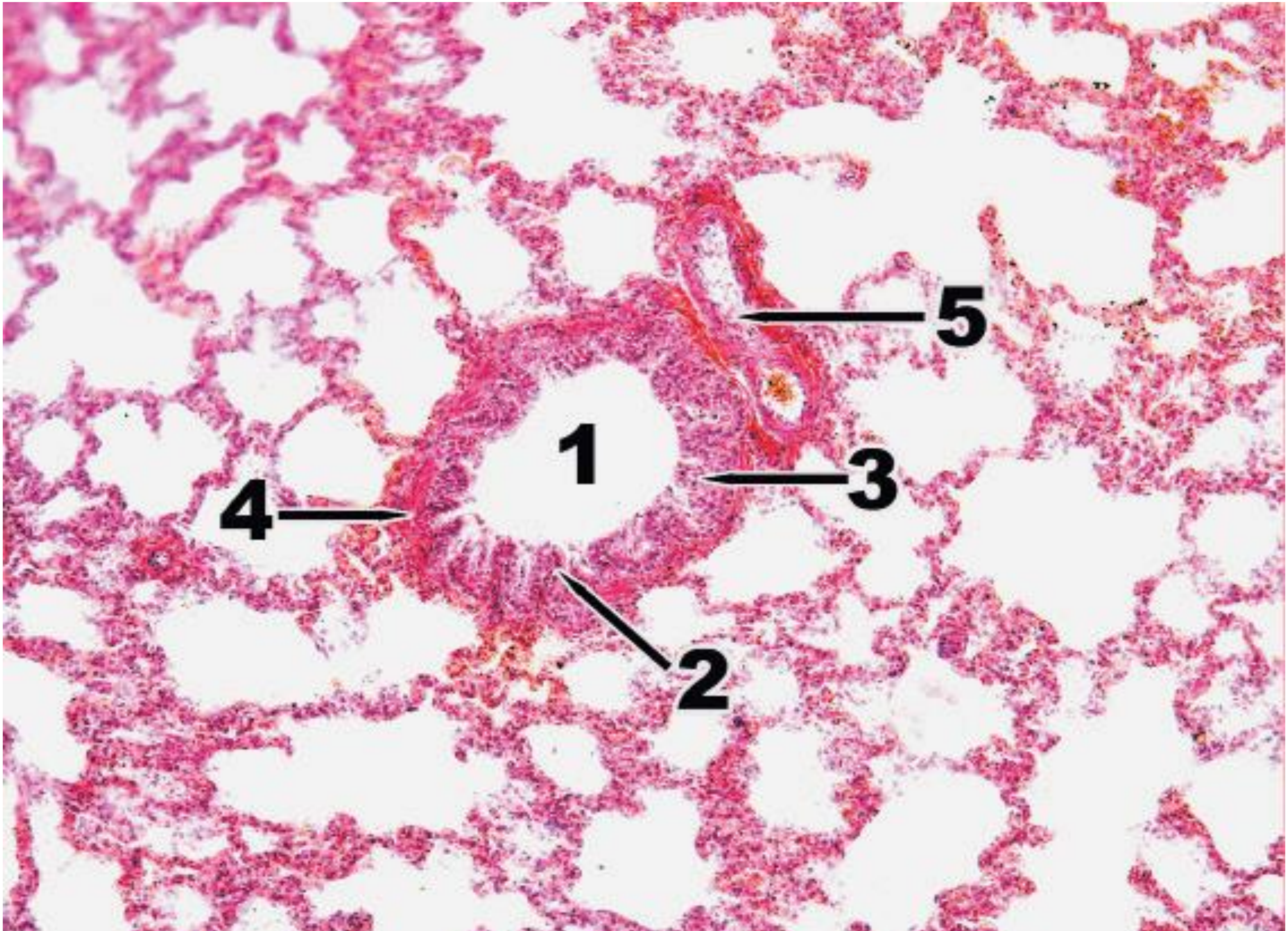
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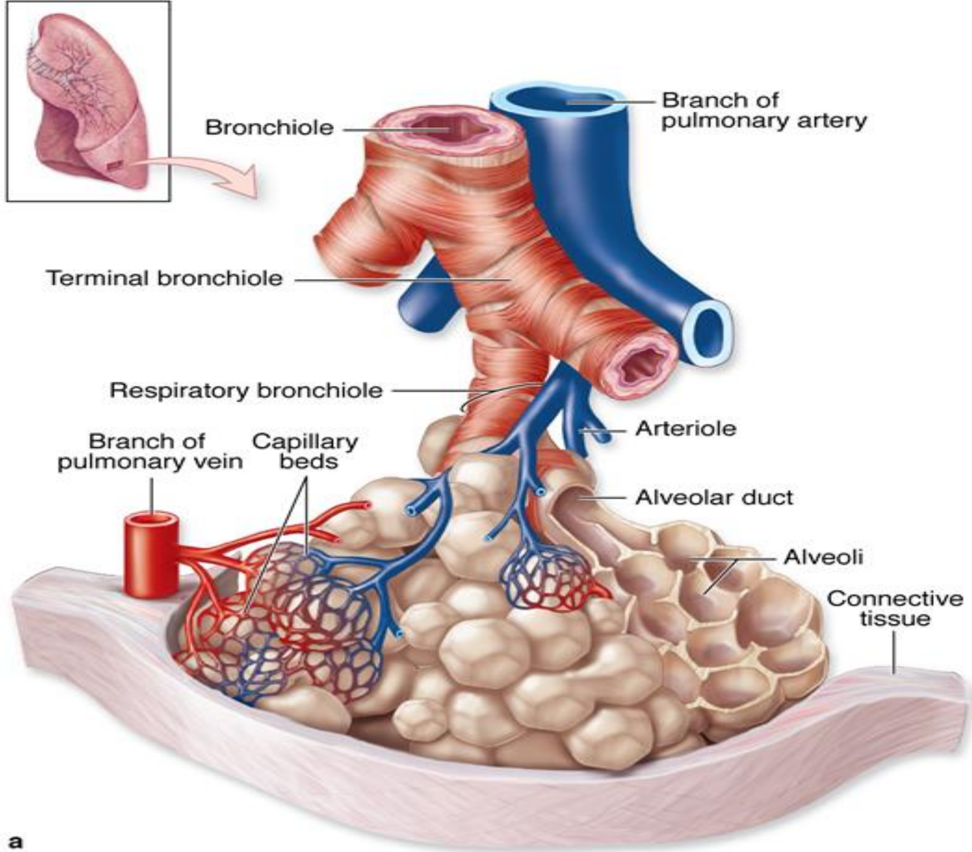
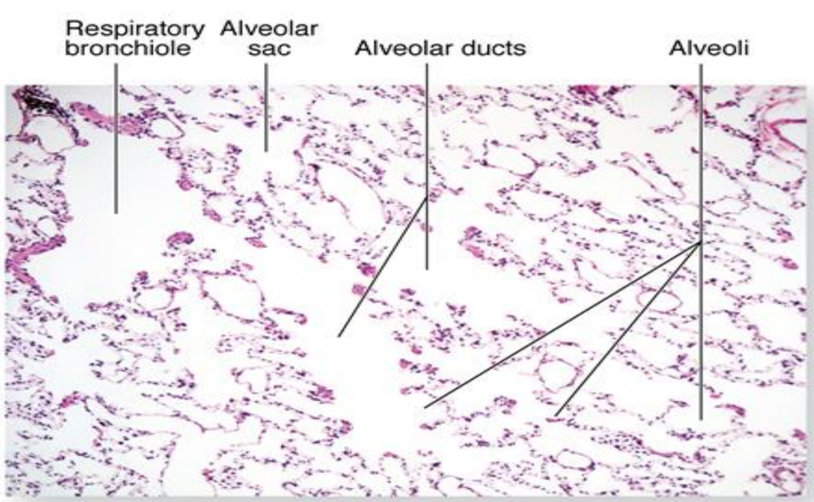
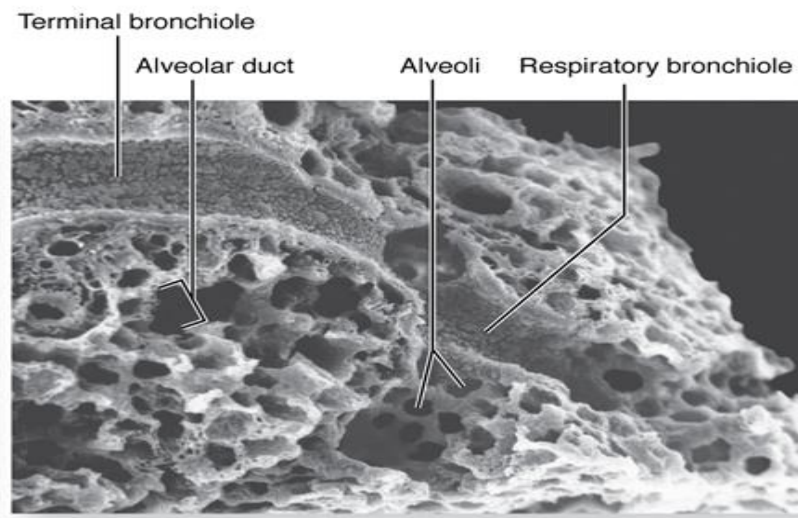

Bronchiole
Branch of pulmonary artery
Terminal bronchiole
Respiratory bronchiole
Arteriole
Branch of pulmonary vein
Capillary beds
Alveolar duct
Alveoli
Connective tissue

a

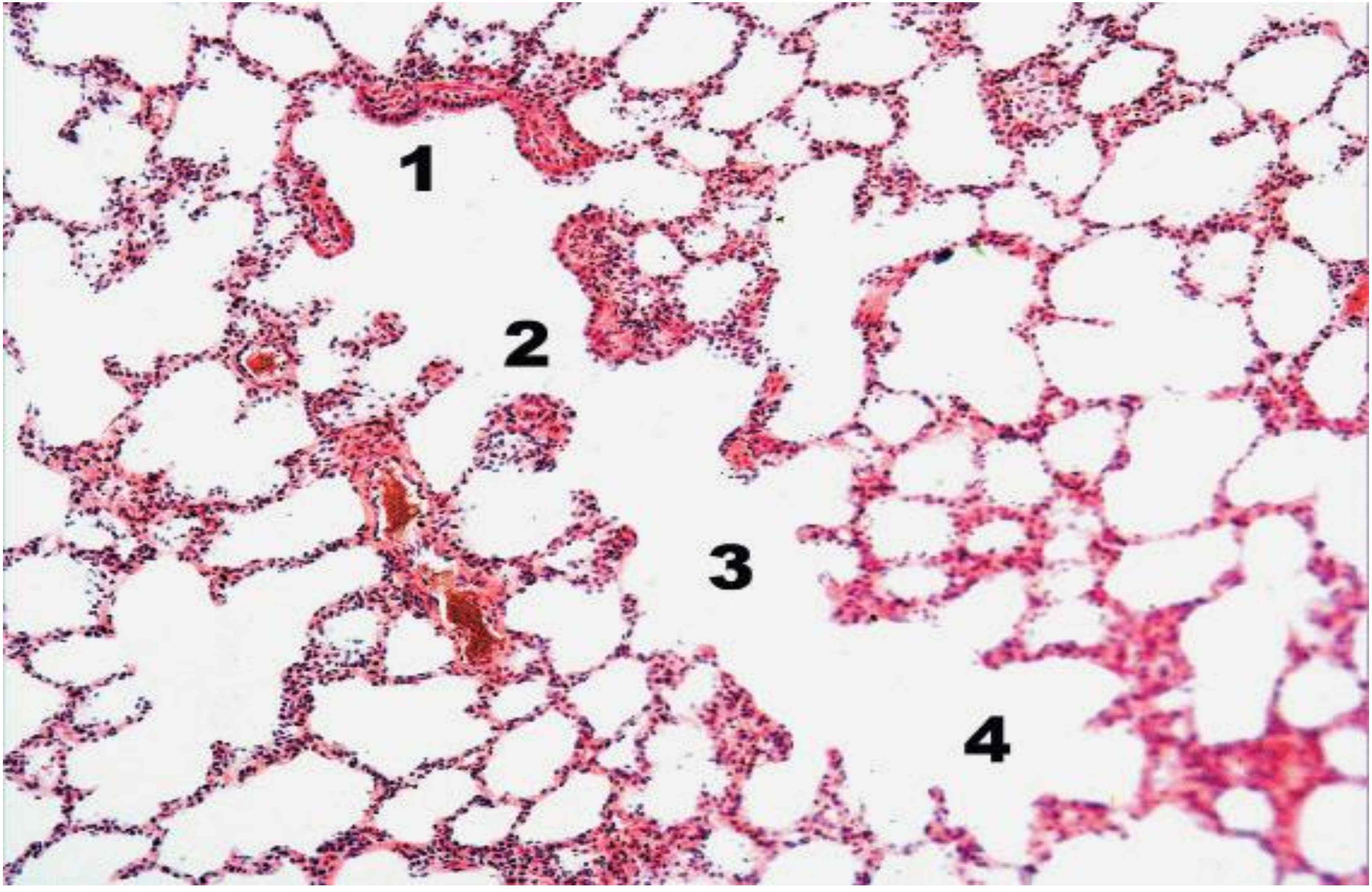

Respiratory bronchiole
Alveolar sac
Alveolar ducts
Alveoli

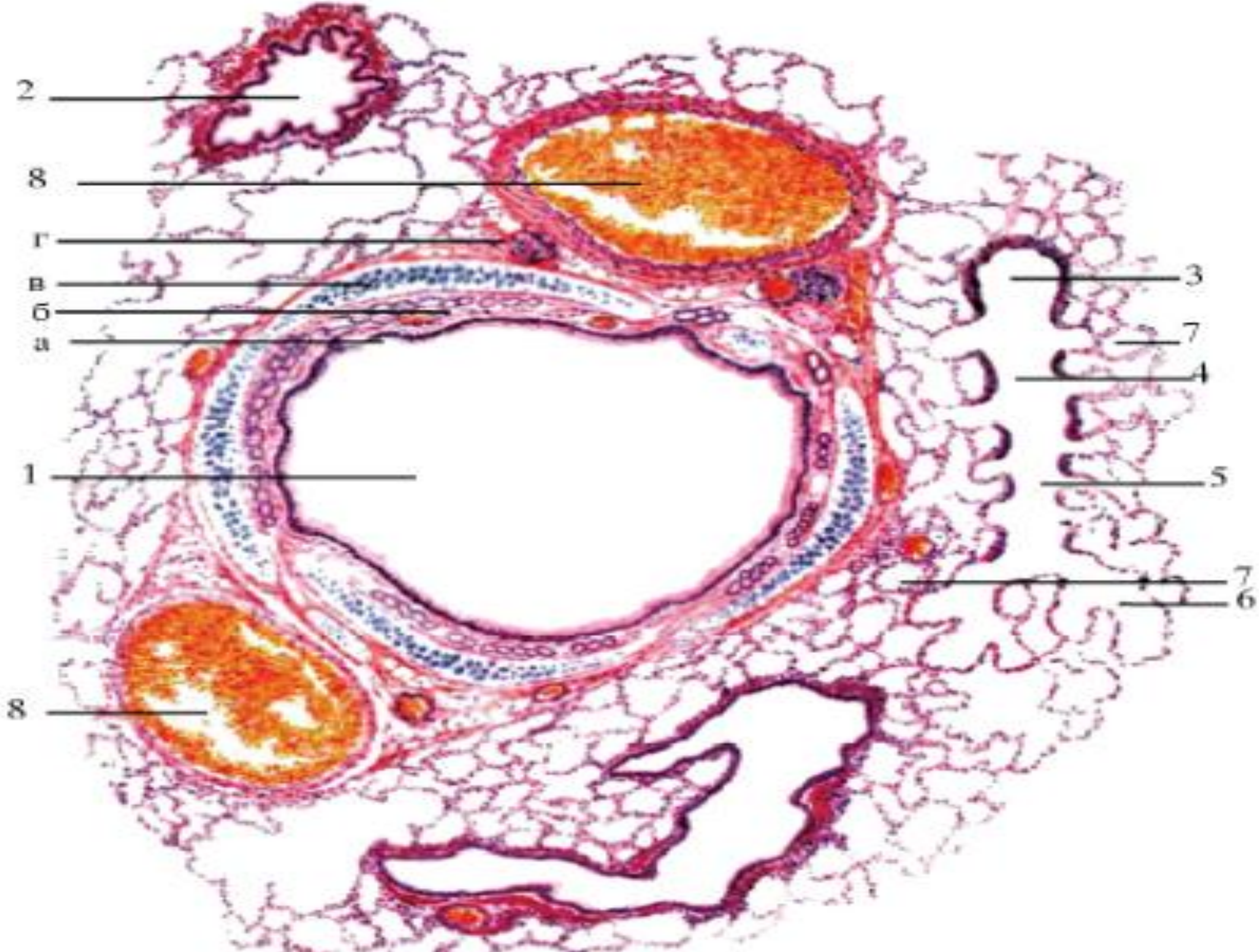
b


Terminal bronchiole
Alveolar duct
Alveoli
Respiratory bronchiole

c

TERMINAL BRONCHIOLES

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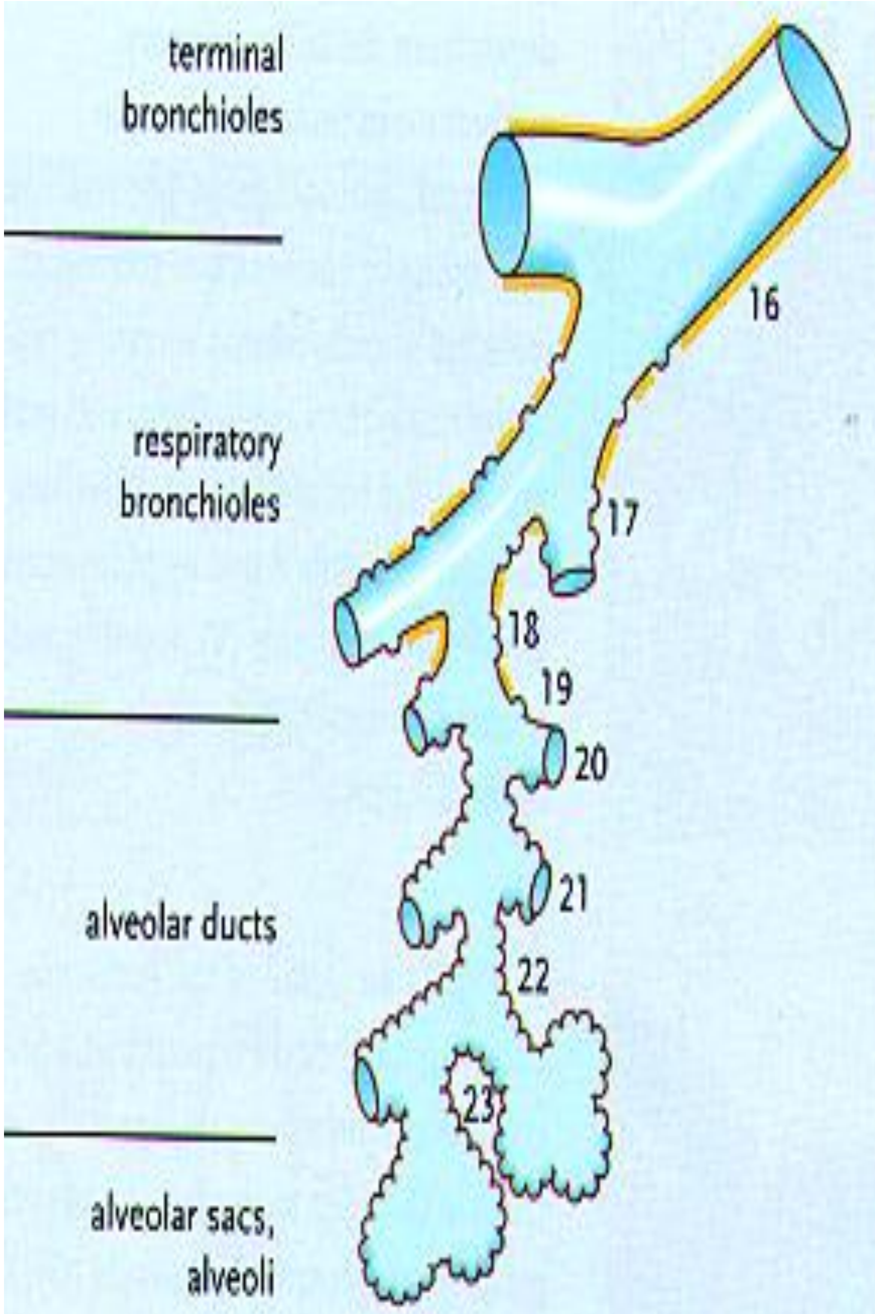
terminal
bronchioles
16
respiratory
bronchioles
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alveolar ducts
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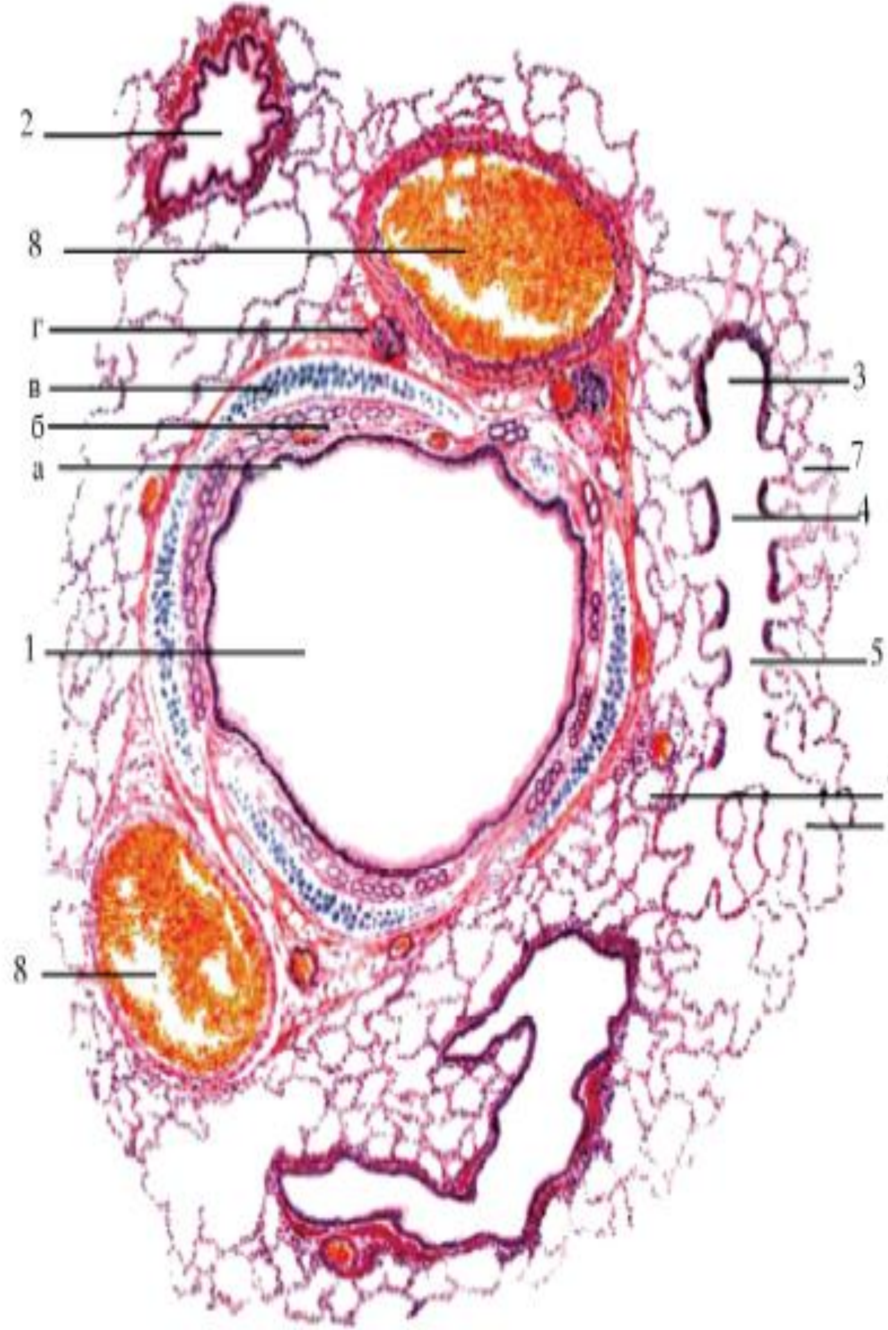
23
alveolar sacs,
alveoli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Respiratory Portion

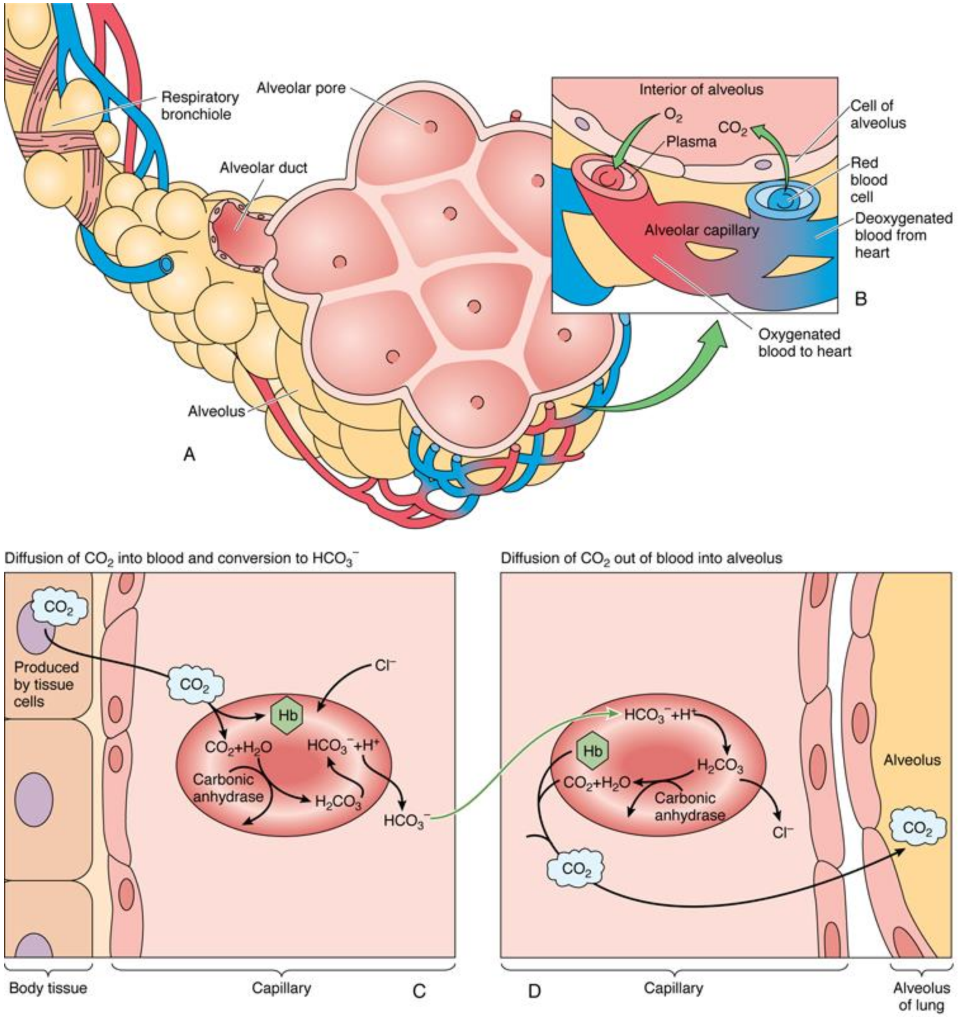


Figure 15–11 A, A respiratory bronchiole, alveolar sac, alveolar pore, and alveoli. **B,** Interalveolar septum. **C,** Carbon dioxide uptake from body tissues by erythrocytes and plasma. **D,** Carbon dioxide release by erythrocytes and plasma in the lung. (Compare **A** with the alveolar duct shown in Fig. 15-10.)

The **respiratory portion** of the respiratory system is composed of respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli.

Respiratory bronchioles are similar to terminal bronchioles, but their wall is interrupted by **alveoli,** where gaseous exchange (O_2 for CO_2) can occur. Subsequent to several branchings, each respiratory bronchiole terminates in an alveolar duct

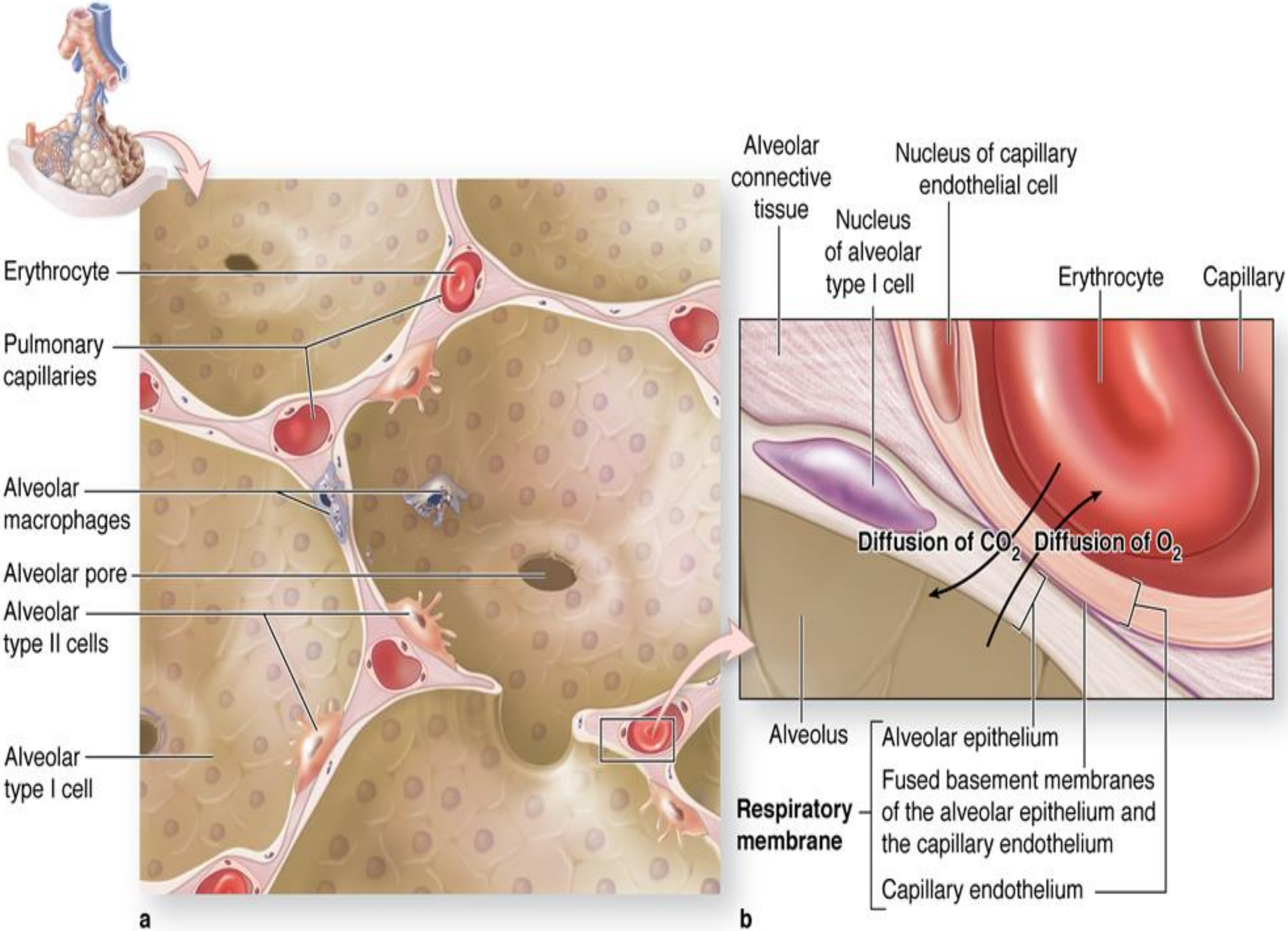
Alveolar ducts do not have walls of their own. Each alveolar duct usually ends as a blind outpouching composed of two or more small clusters of alveoli, in which each cluster is known as an **alveolar sac.** These alveolar sacs thus open into a common space, which some investigators call the **atrium.**

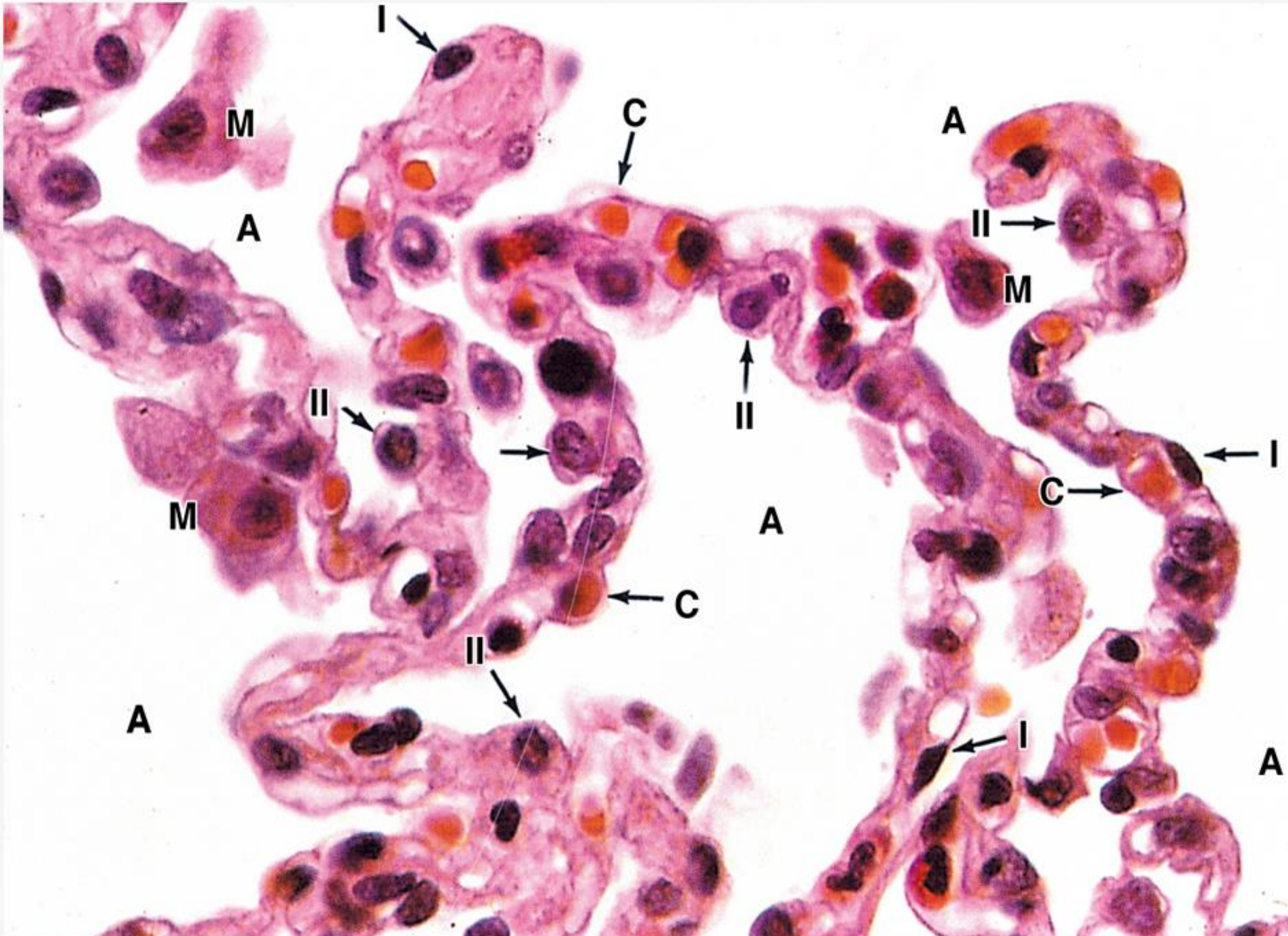
Alveoli are small air sacs composed of highly attenuated type I pneumocytes and larger type II pneumocytes.

The region between adjacent alveoli is known as the **interalveolar septum.** It is occupied by an extensive capillary bed composed of **continuous capillaries.**

The thinnest regions of the interalveolar septum where gases can be exchanged are called the **blood-gas barriers** The narrowest blood-gas barrier, where the type I pneumocyte is in intimate contact with the endothelial lining of the capillary and the basal laminae of the two epithelia become fused, is most efficient for the exchange of O_2 (in the alveolar lumen) for CO_2 (in the blood). These regions are composed of surfactant (manufactured by type II pneumocytes), type I pneumocytes, basal lamina, endothelial cells.

For more information see Respiratory Portion of the Respiratory System in Chapter 14 of Gartner and Hiatt: Color Textbook of Histology, 3rd ed. Philadelphia, W.B. Saunders, 2007.


Erythrocyte
Pulmonary capillaries
Alveolar macrophages
Alveolar pore
Alveolar type II cells
Alveolar type I cell
a
Alveolar connective tissue
Nucleus of alveolar type I cell
Nucleus of capillary endothelial cell
Erythrocyte
Capillary
Diffusion of CO_2
Diffusion of O_2
Alveolus
Alveolar epithelium
Fused basement membranes of the alveolar epithelium and the capillary endothelium
Capillary endothelium
Respiratory membrane
b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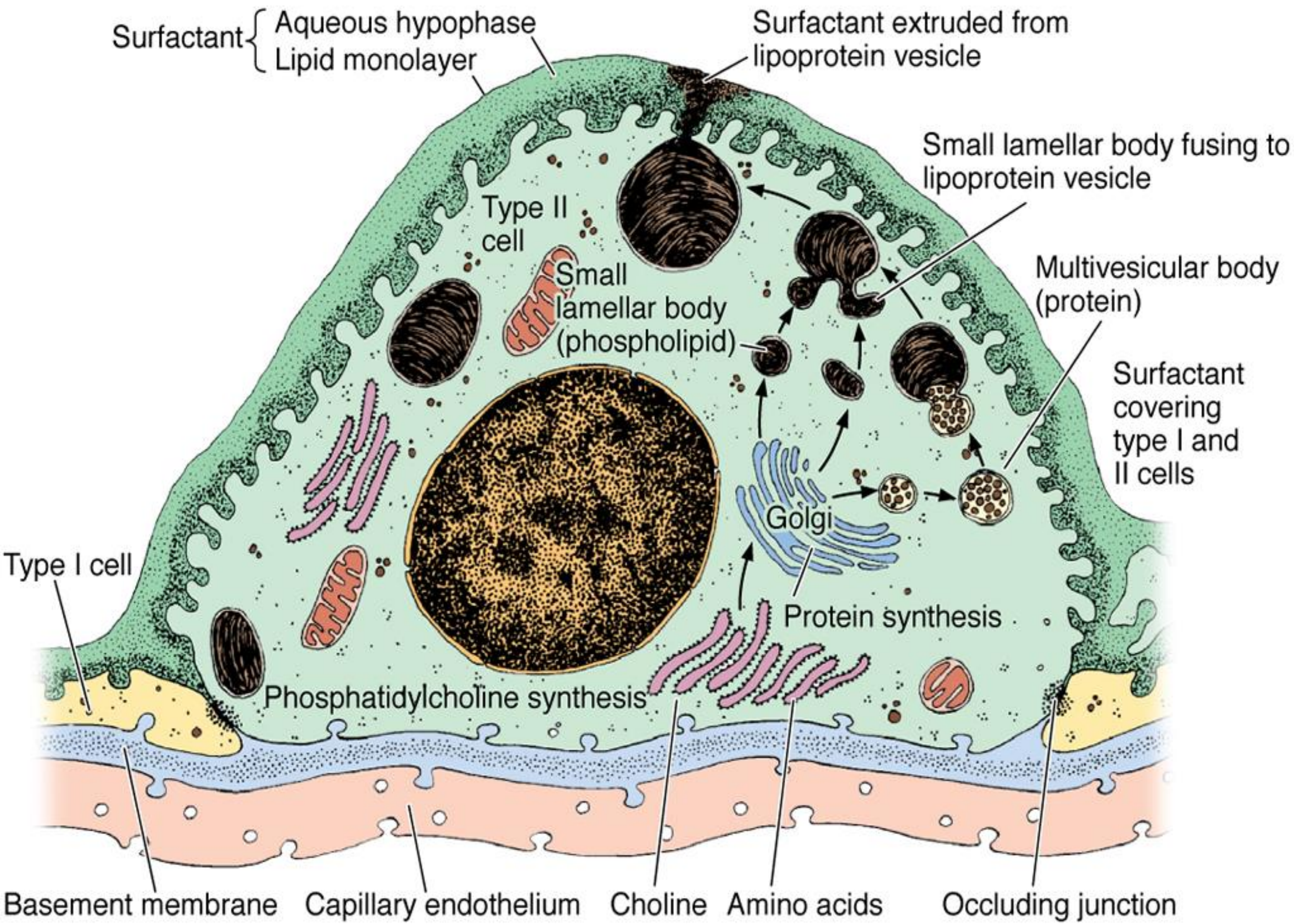
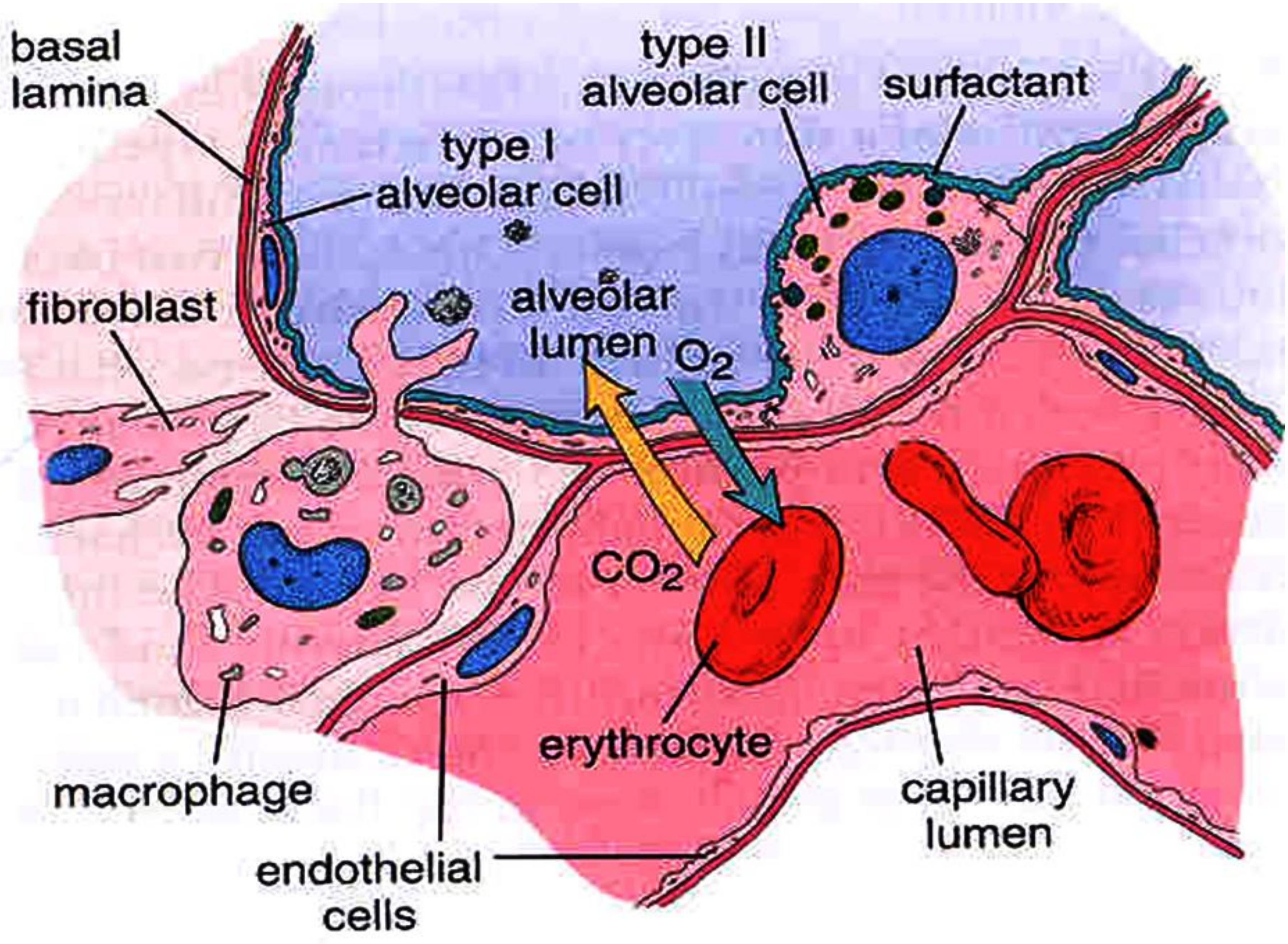
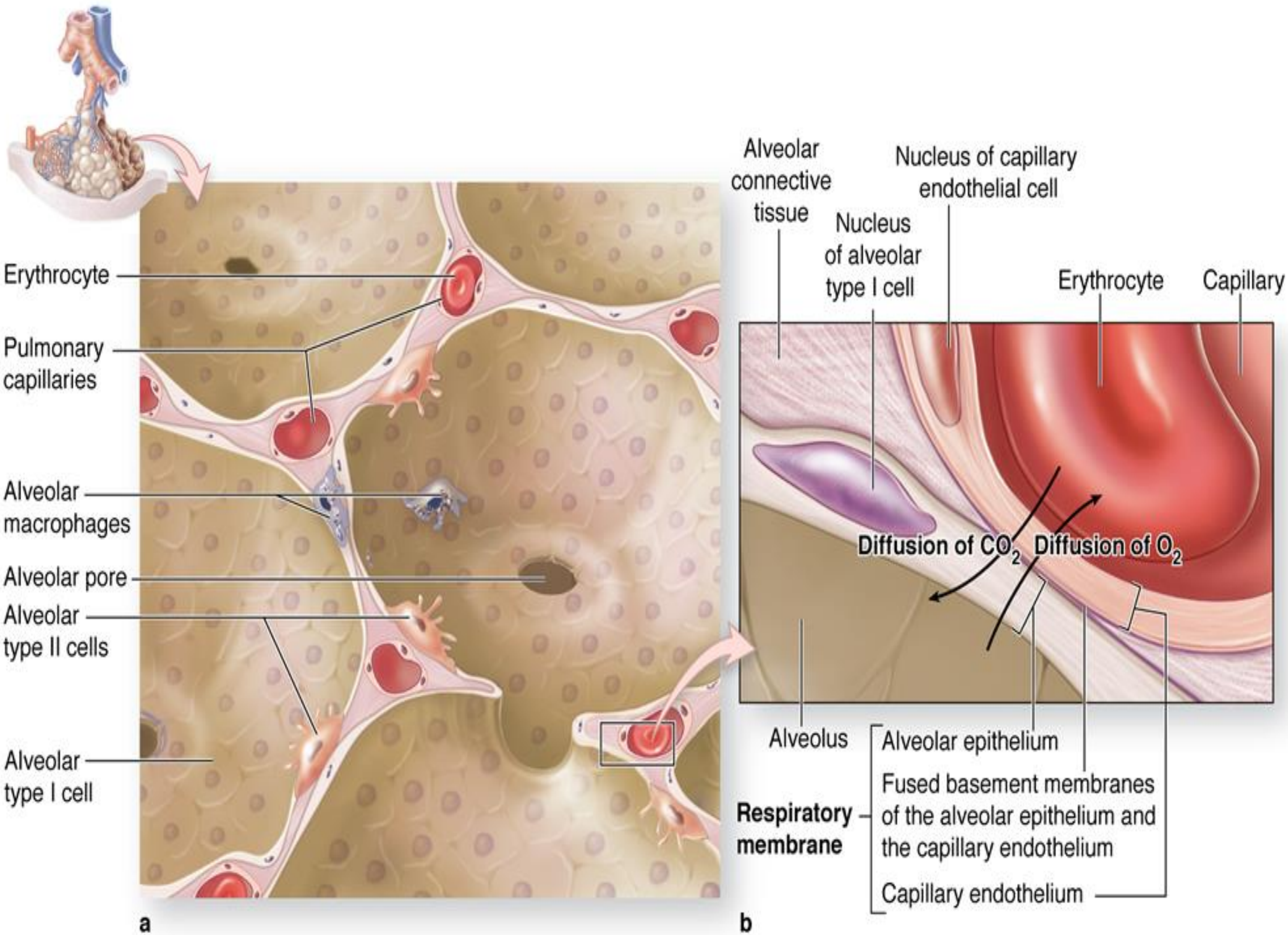
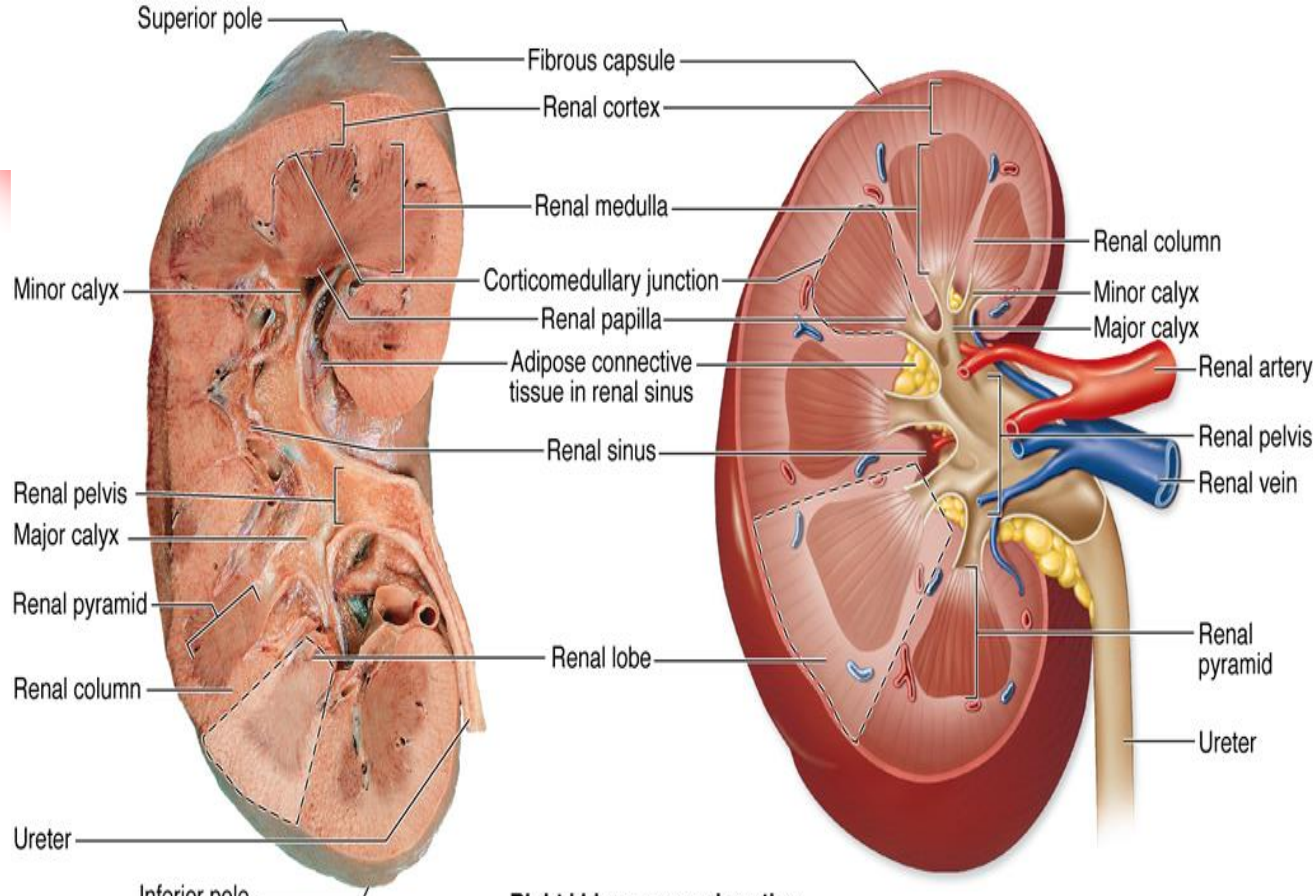

Surfactant
Aqueous hypophase
Lipid monolayer
Surfactant extruded from lipoprotein vesicle
Small lamellar body fusing to lipoprotein vesicle
Type II cell
Small lamellar body (phospholipid)
Multivesicular body (protein)
Surfactant covering type I and II cells
Golgi
Type I cell
Protein synthesis
Phosphatidylcholine synthesis
Basement membrane
Capillary endothelium
Choline
Amino acids
Occluding junction


basal
lamina
type II
alveolar cell
surfactant
type I
alveolar cell
fibroblast
alveolar
lumen
O_2
CO_2
macrophage
erythrocyte
capillary
lumen
endothelial
cells

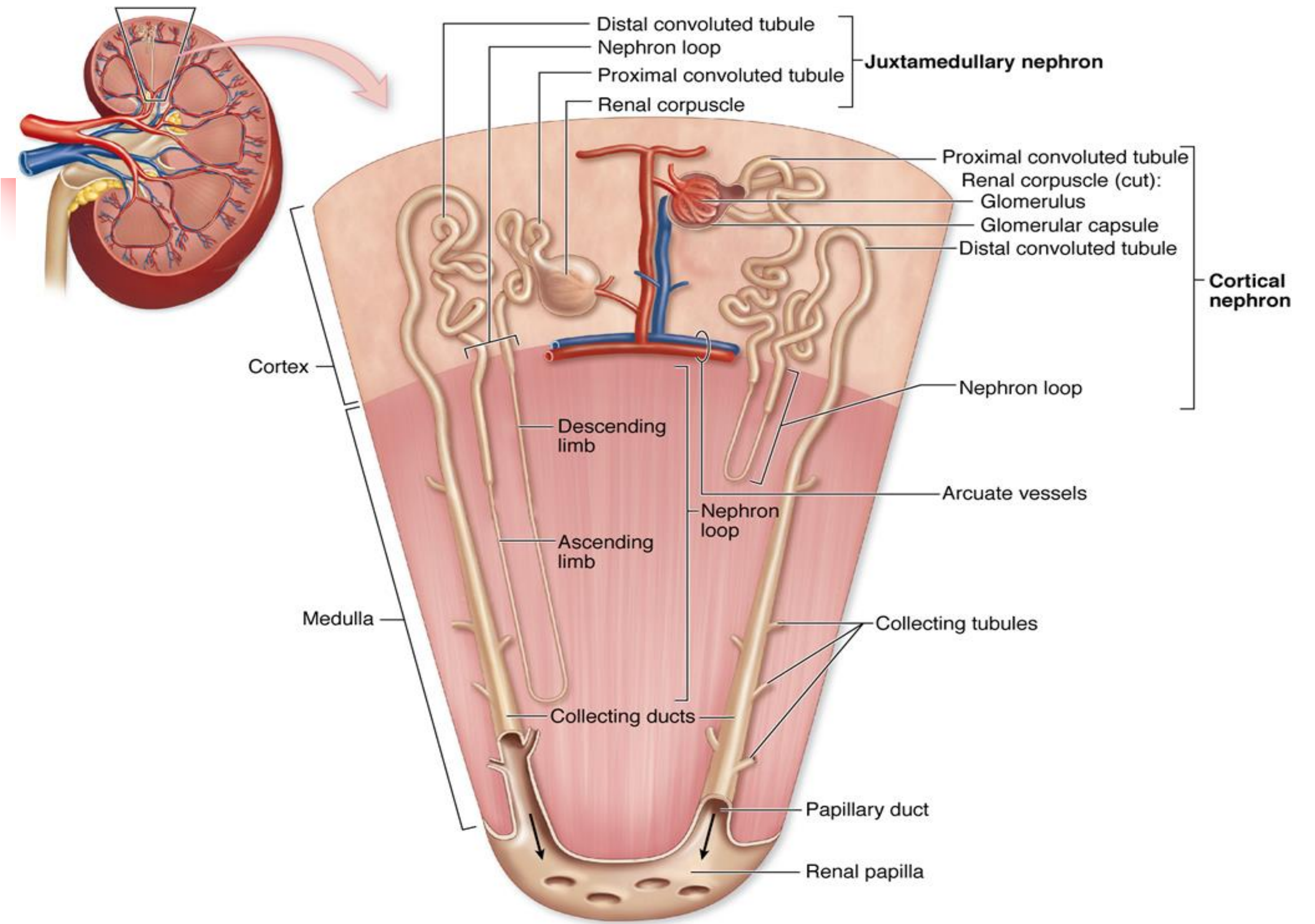

Erythrocyte
Pulmonary capillaries
Alveolar macrophages
Alveolar pore
Alveolar type II cells
Alveolar type I cell
a
Alveolar connective tissue
Nucleus of alveolar type I cell
Nucleus of capillary endothelial cell
Erythrocyte
Capillary
Diffusion of CO_2
Diffusion of O_2
Alveolus
Respiratory membrane
Alveolar epithelium
Fused basement membranes of the alveolar epithelium and the capillary endothelium
Capillary endothelium
b

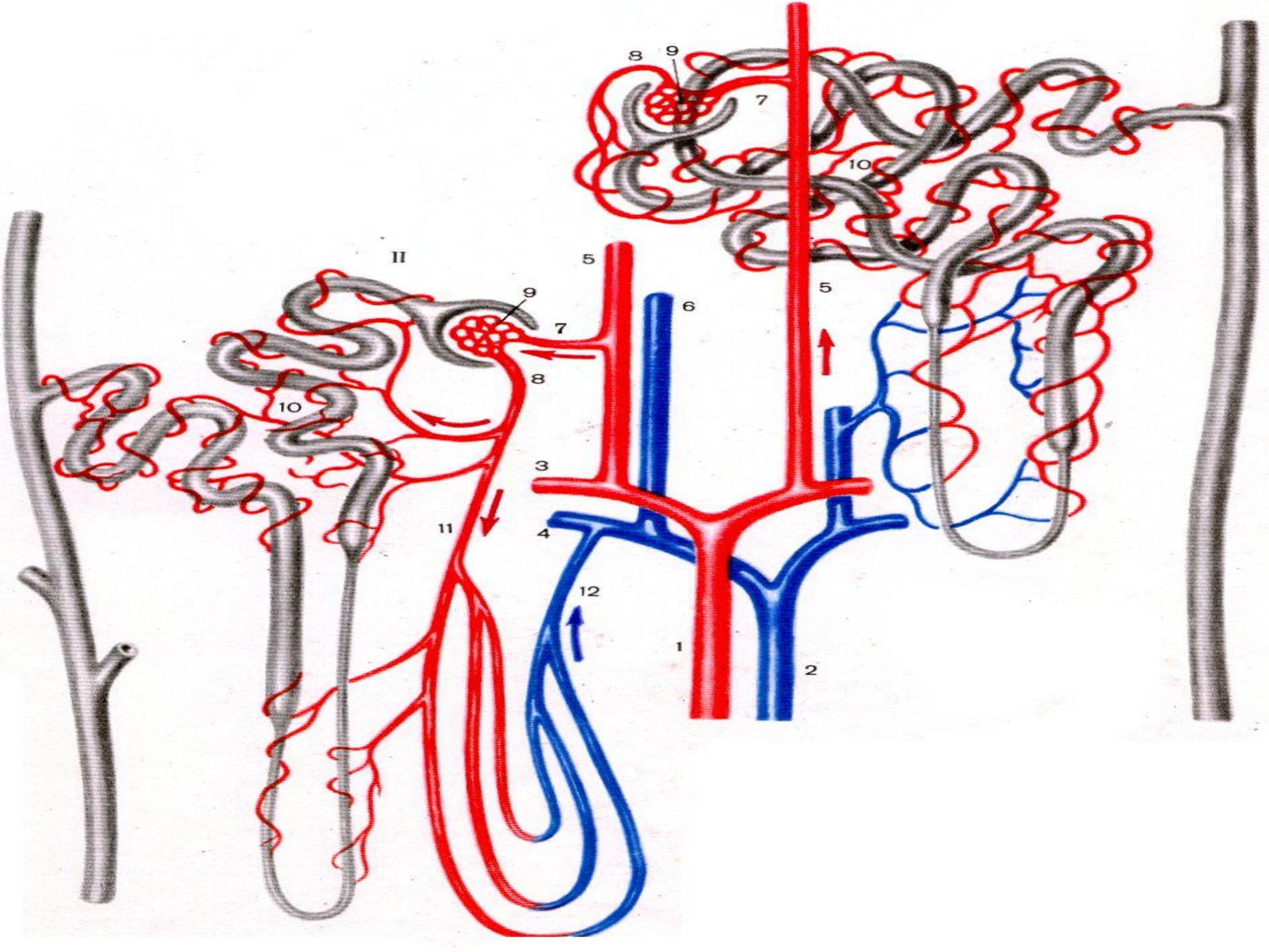
URINARY SYSTEM

l-Farabi Kazakh National University
Higher School of Medicine



Right kidney, coronal section


Distal convoluted tubule
Nephron loop
Proximal convoluted tubule
Renal corpuscle
Juxtamedullary nephron
Proximal convoluted tubule
Renal corpuscle (cut):
Glomerulus
Glomerular capsule
Distal convoluted tubule
Cortical nephron
Cortex
Descending limb
Nephron loop
Arcuate vessels
Ascending limb
Nephron loop
Medulla
Collecting tubules
Collecting ducts
Papillary duct
Renal papilla



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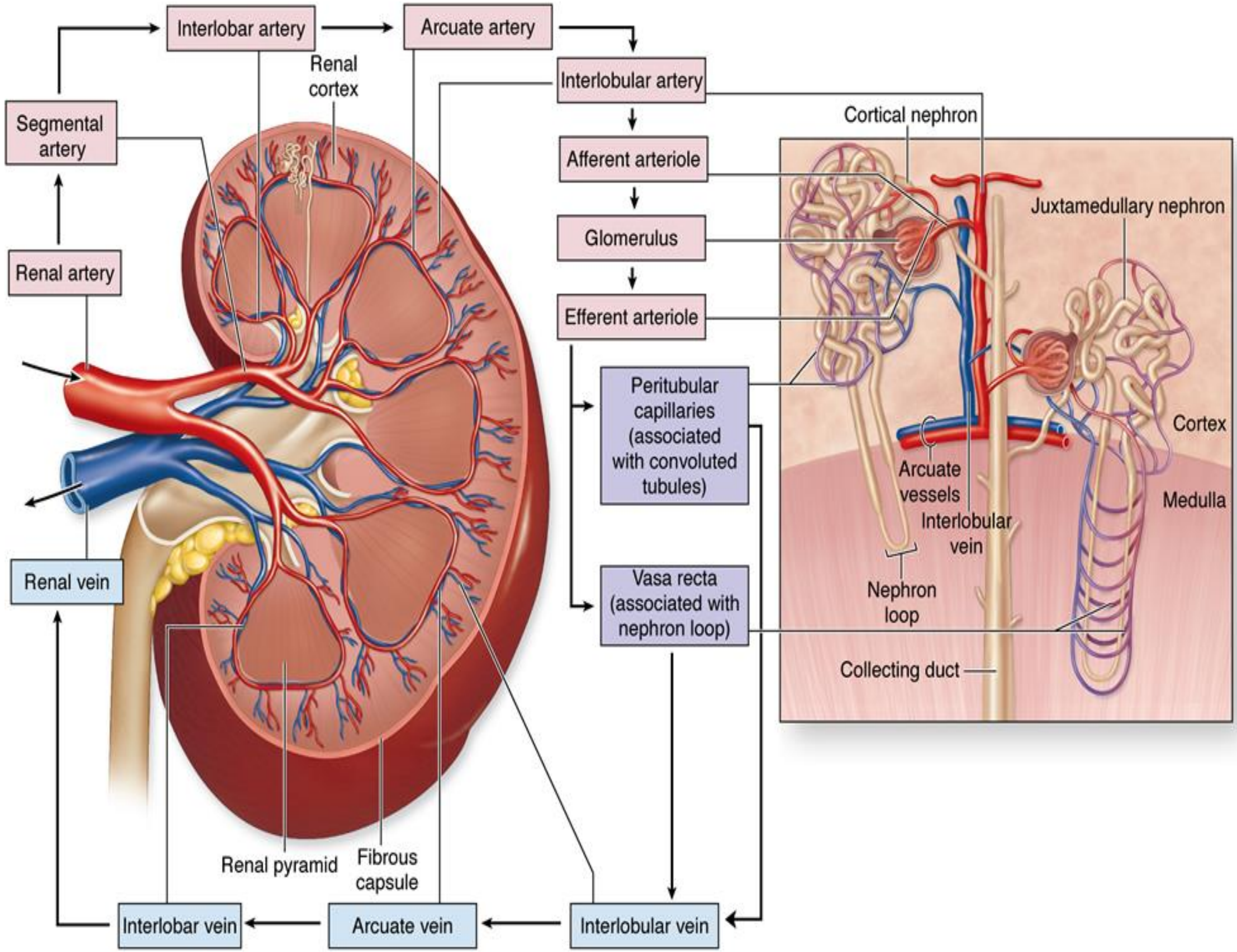


Interlobar artery
Arcuate artery
Renal cortex
Interlobular artery
Segmental artery
Cortical nephron
Afferent arteriole
Juxtamedullary nephron
Glomerulus
Renal artery
Efferent arteriole
Peritubular capillaries (associated with convoluted tubules)
Cortex
Arcuate vessels
Medulla
Interlobular vein
Nephron loop
Renal vein
Vasa recta (associated with nephron loop)
Collecting duct
Renal pyramid
Fibrous capsule
Interlobar vein
Arcuate vein
Interlobular vein

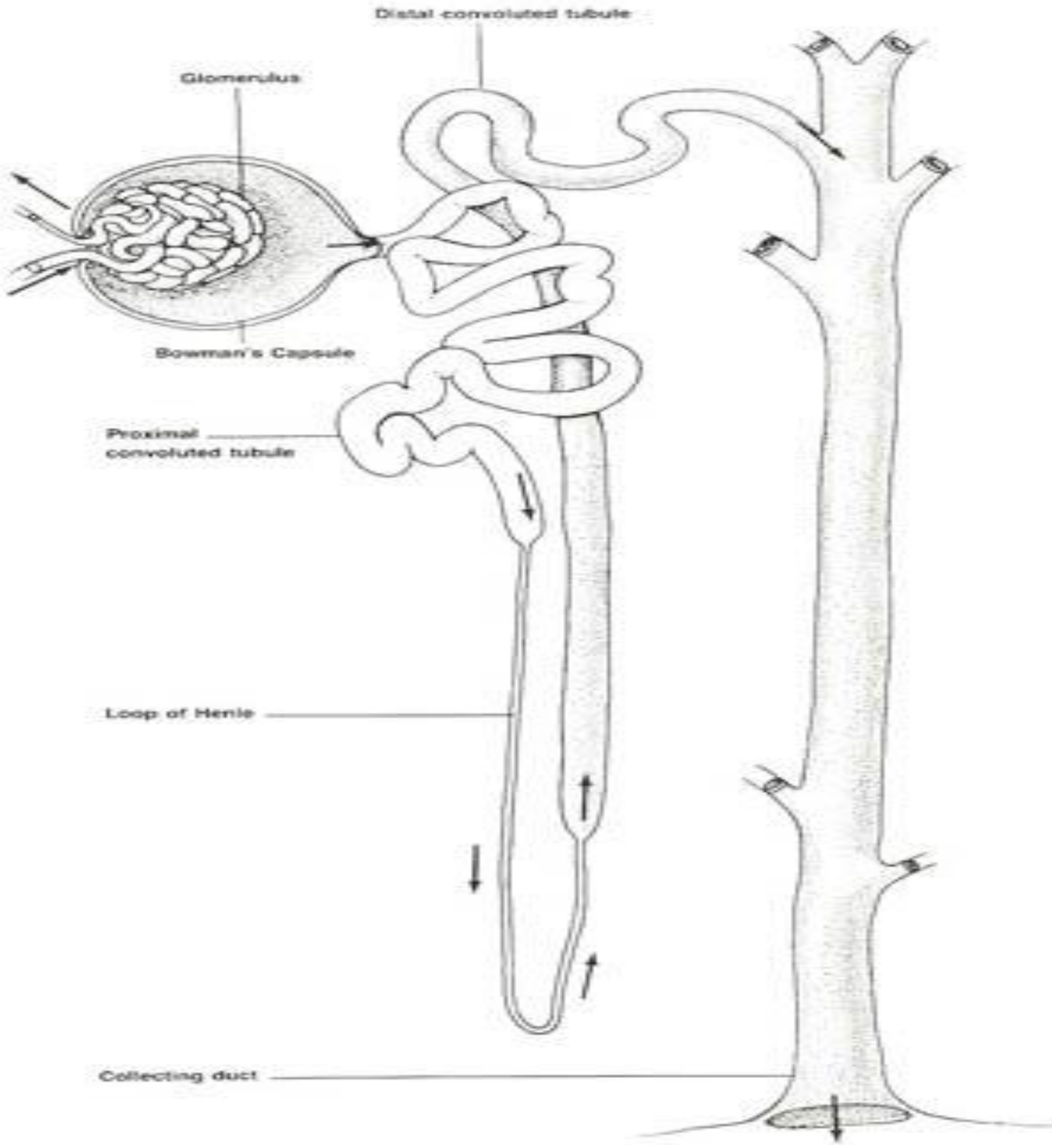


FIG. 15–3. Drawing of a "typical" nephron.

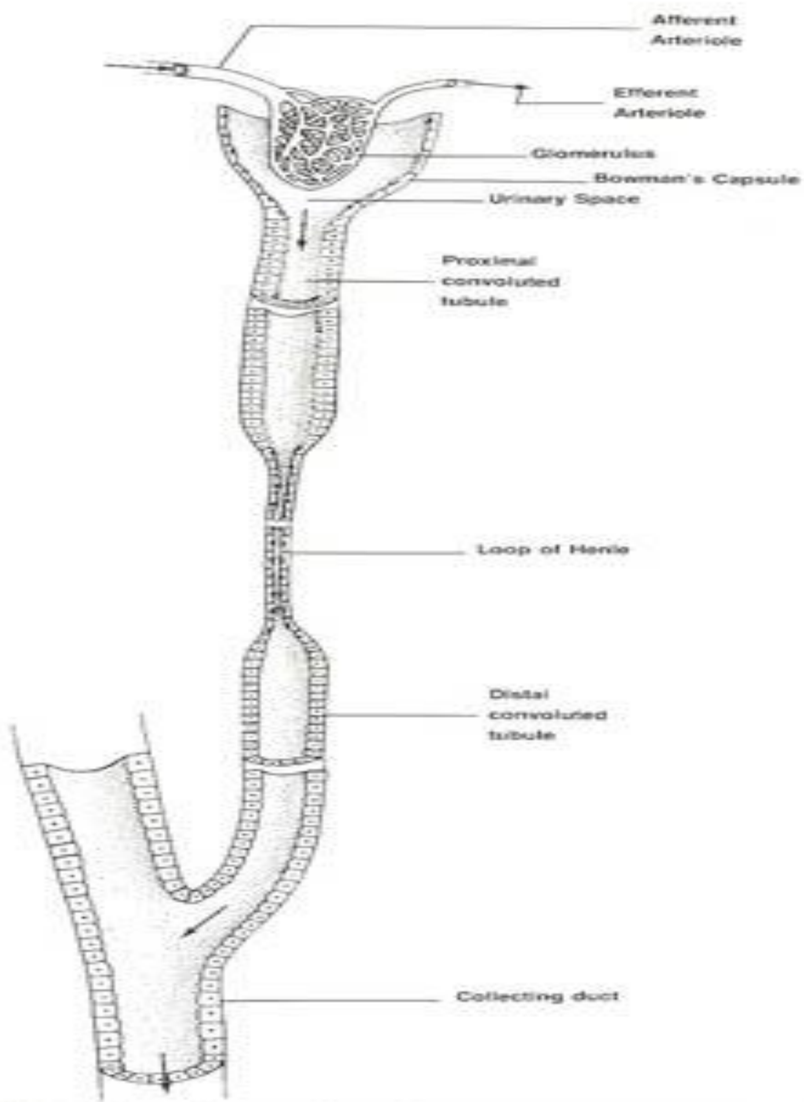
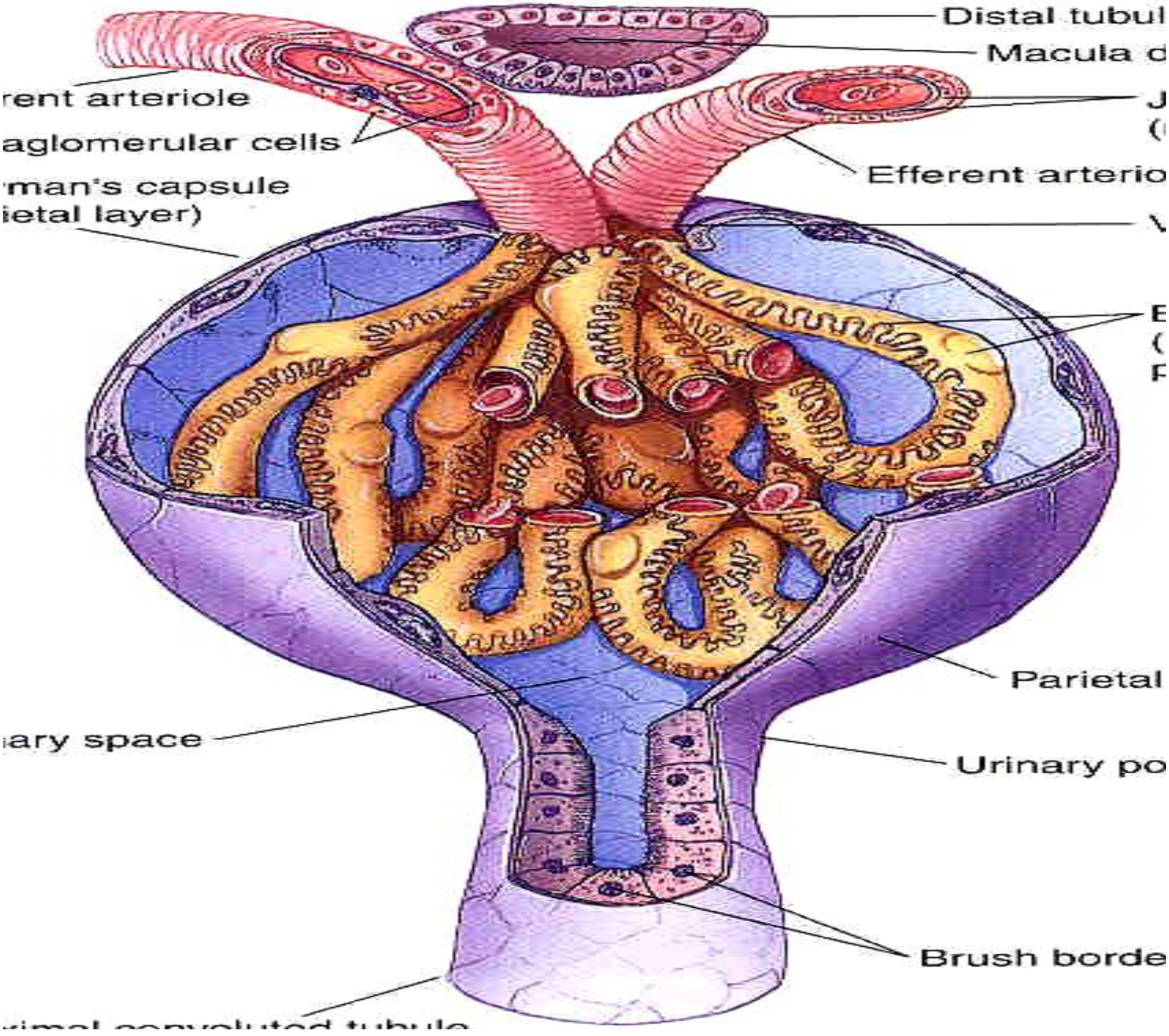


FIG. 15-2. A cutaway drawing of a nephron, straightened out and shortened, that shows the relative positions of the parts of a nephron along its length.



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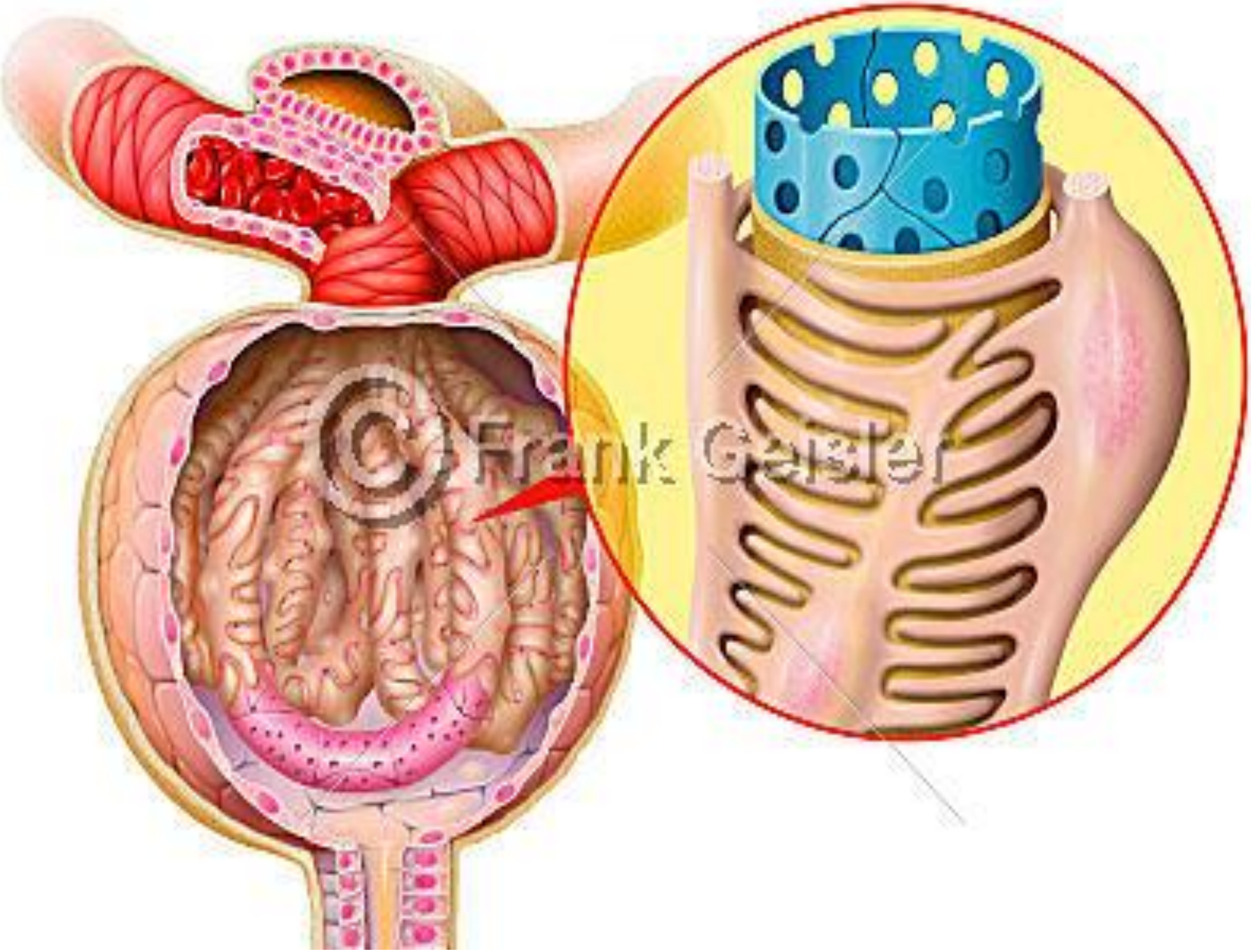
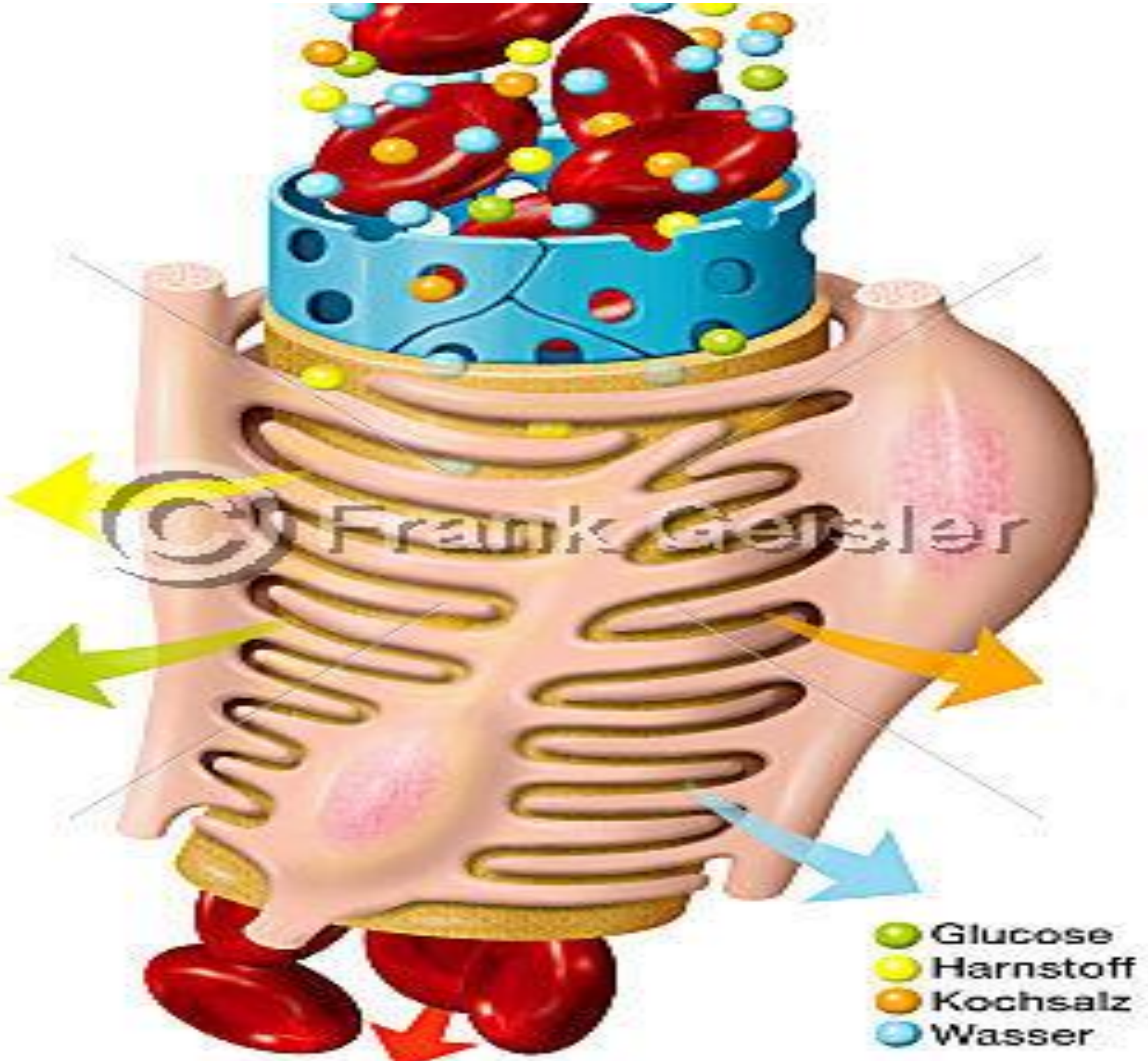
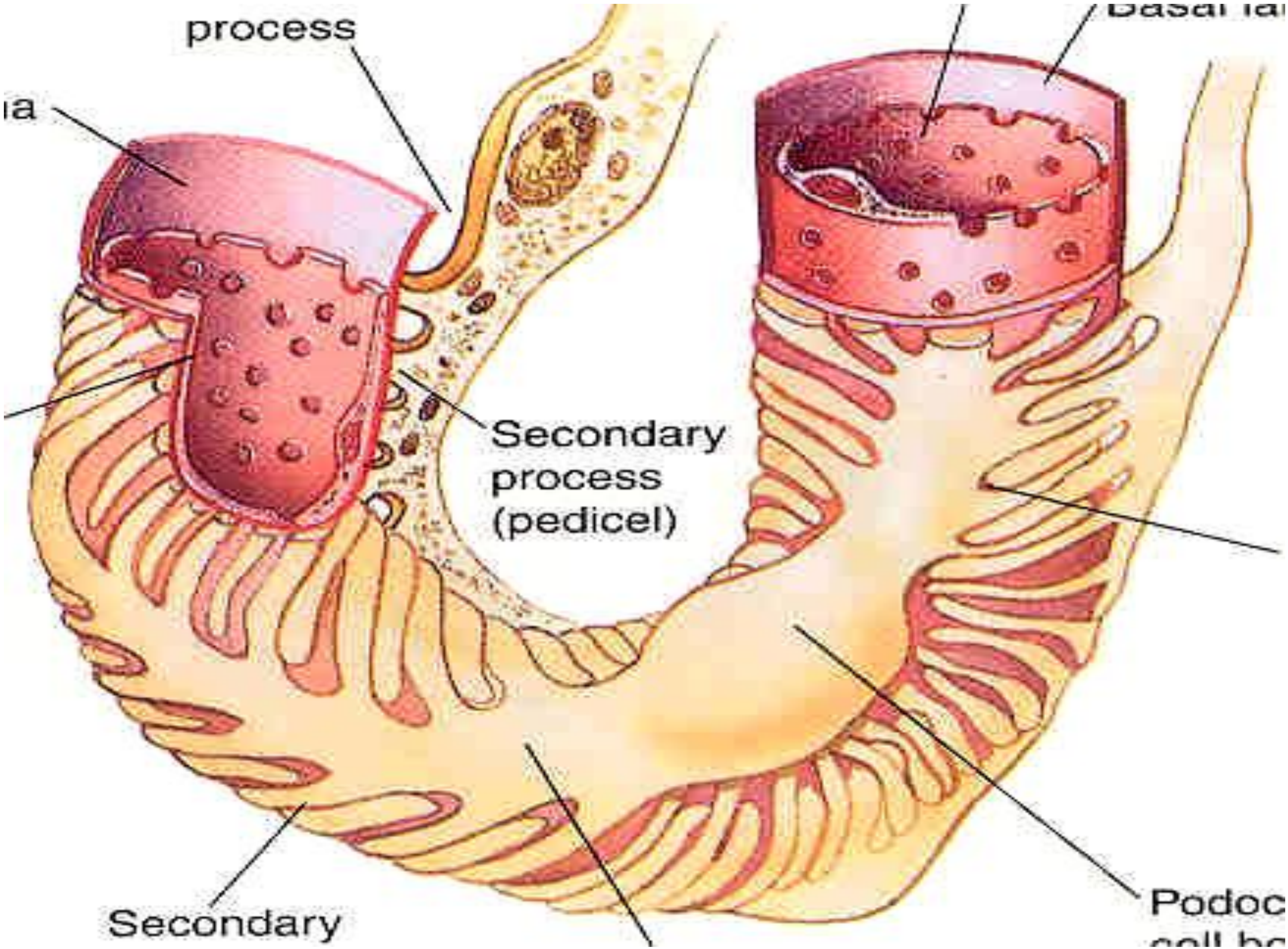




Glucose
Harnstoff
Kochsalz
Wasser


process
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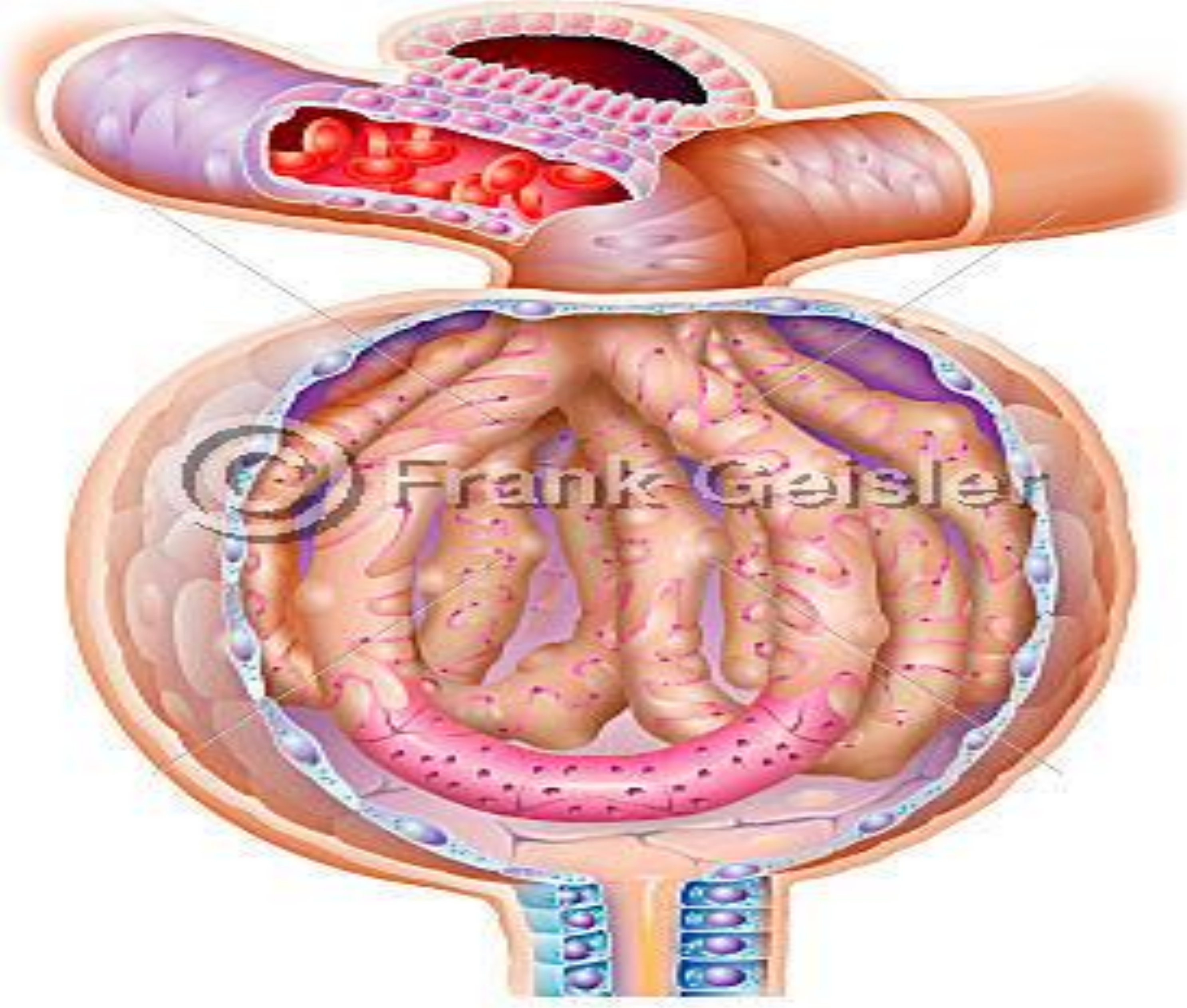
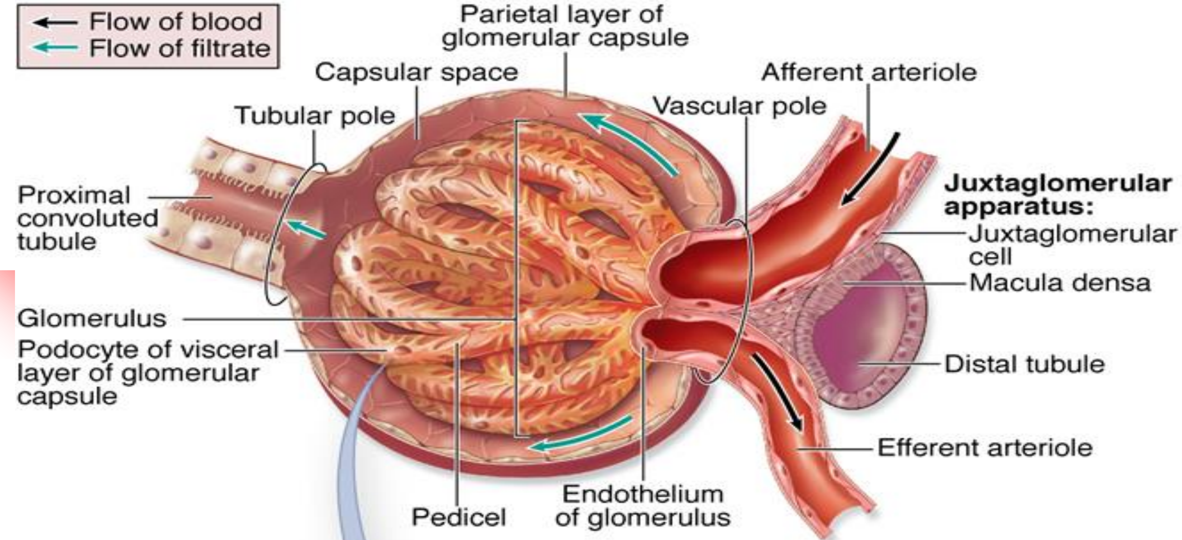
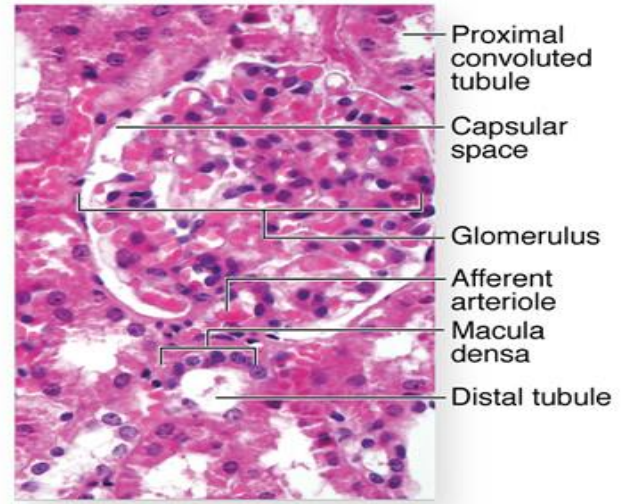
Secondary

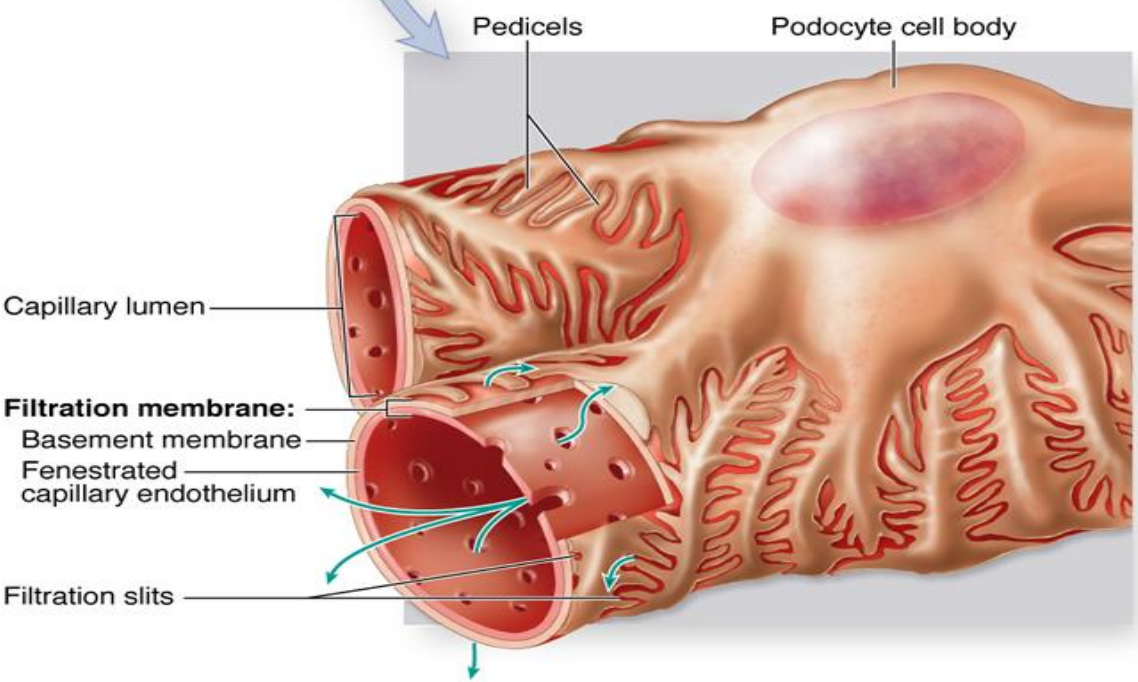




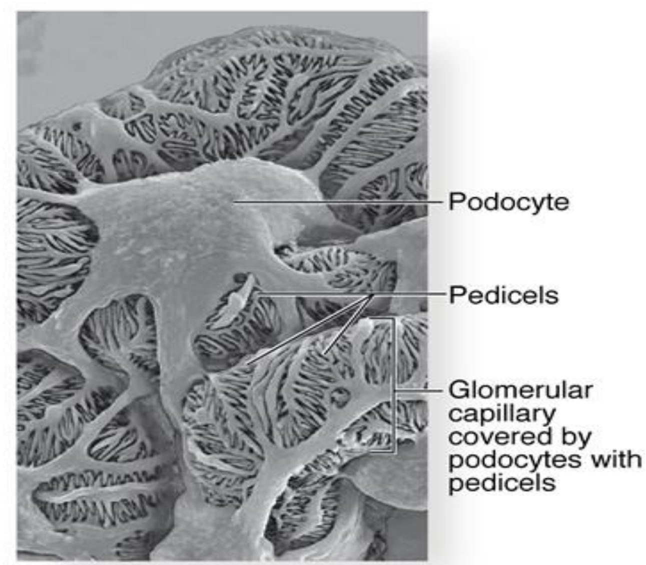
a Renal corpuscle



b Histology of renal corpuscle



c Glomerular capillaries & podocyte



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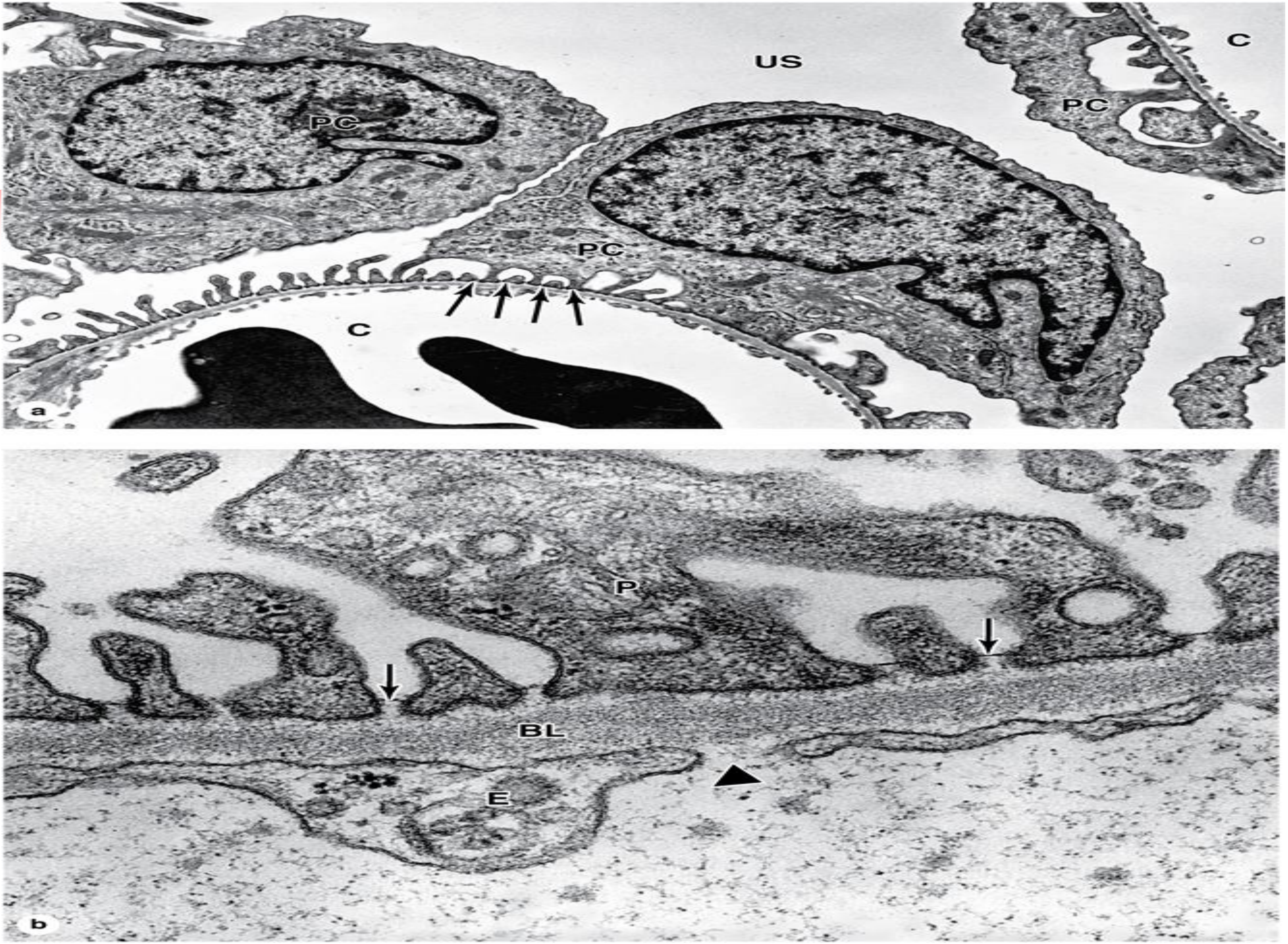
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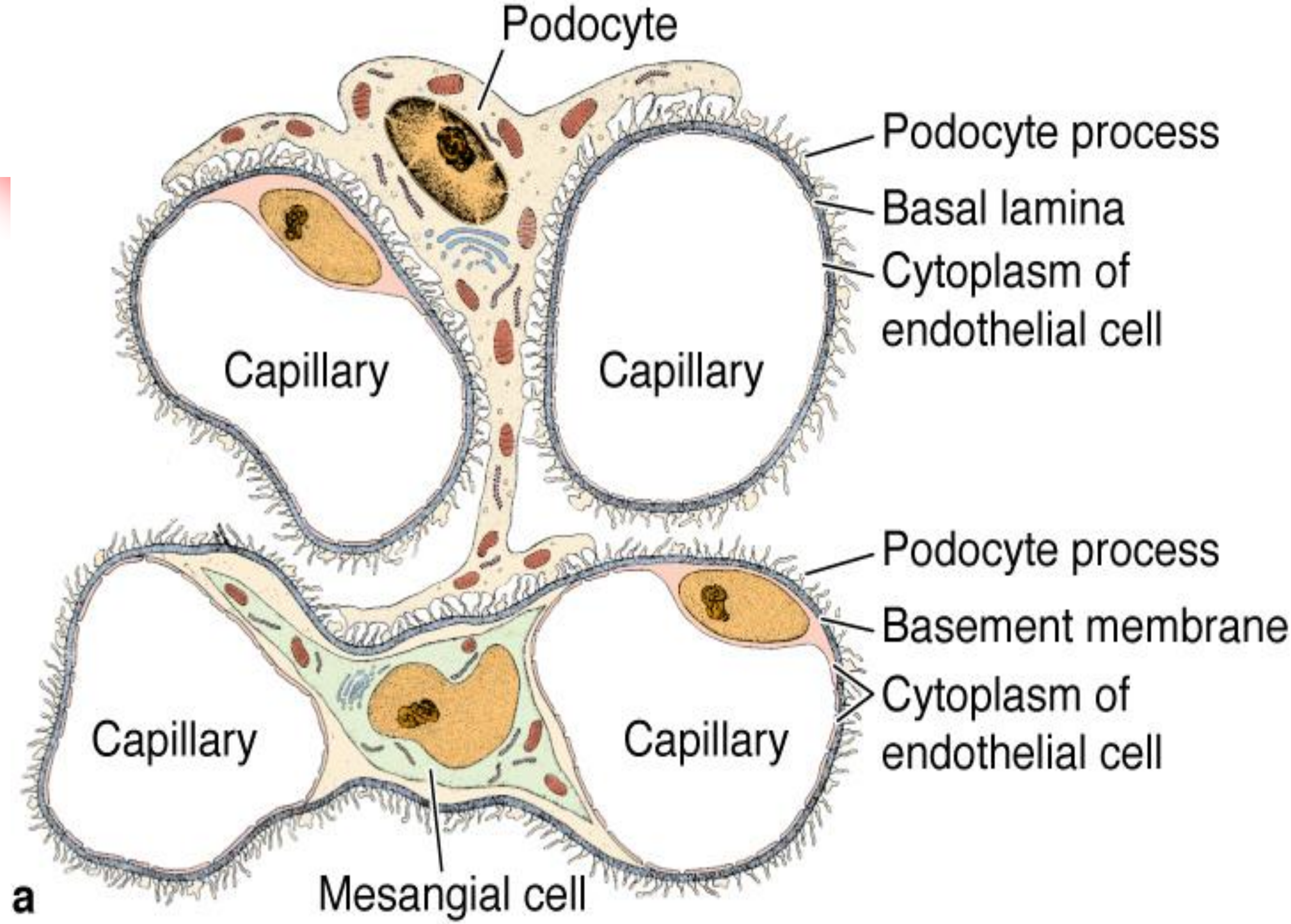
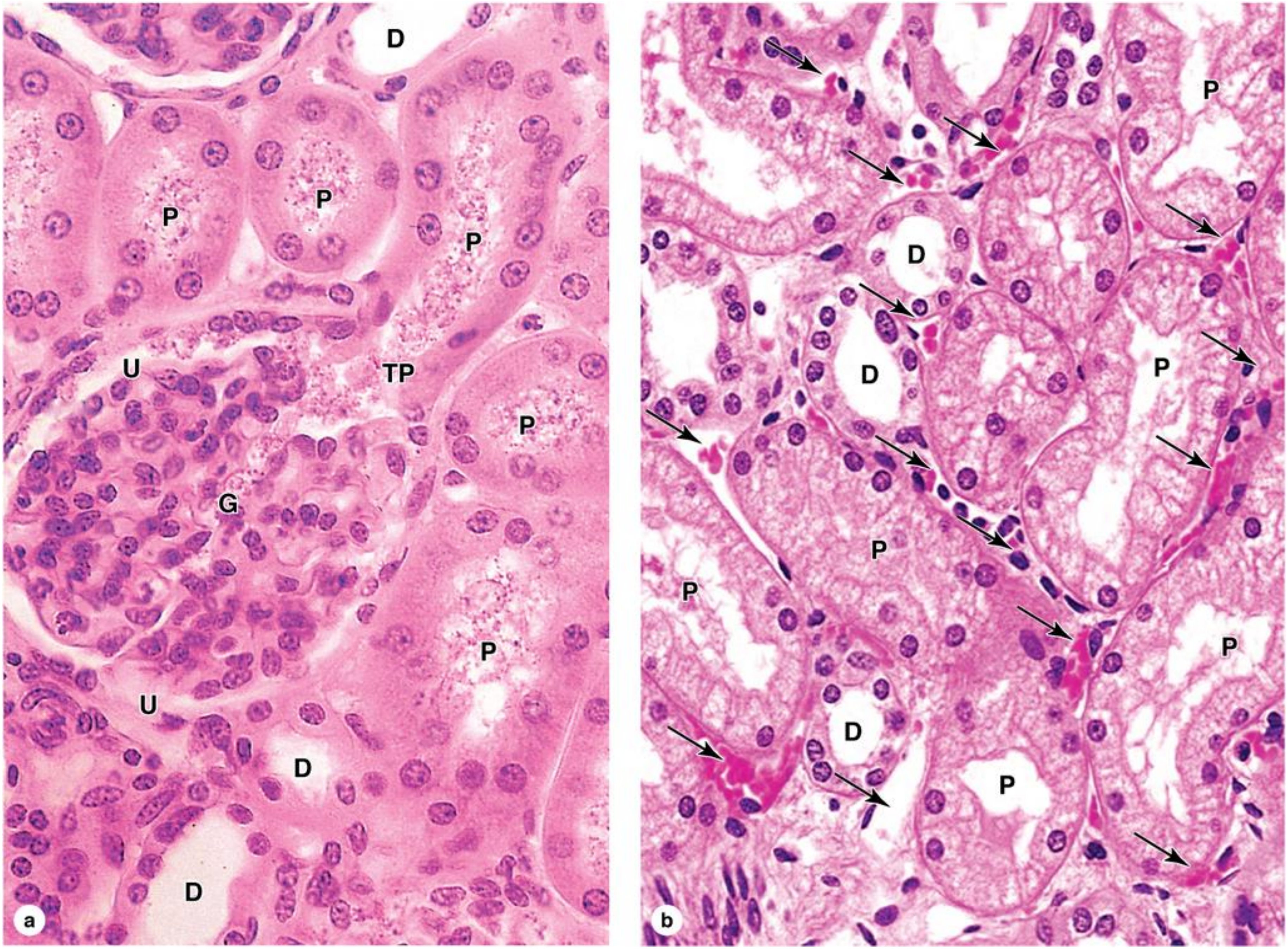

Podocyte
Podocyte process
Basal lamina
Cytoplasm of endothelial cell
Capillary
Capillary
Podocyte process
Basement membrane
Cytoplasm of endothelial cell
Capillary
Capillary
Mesangial cell
a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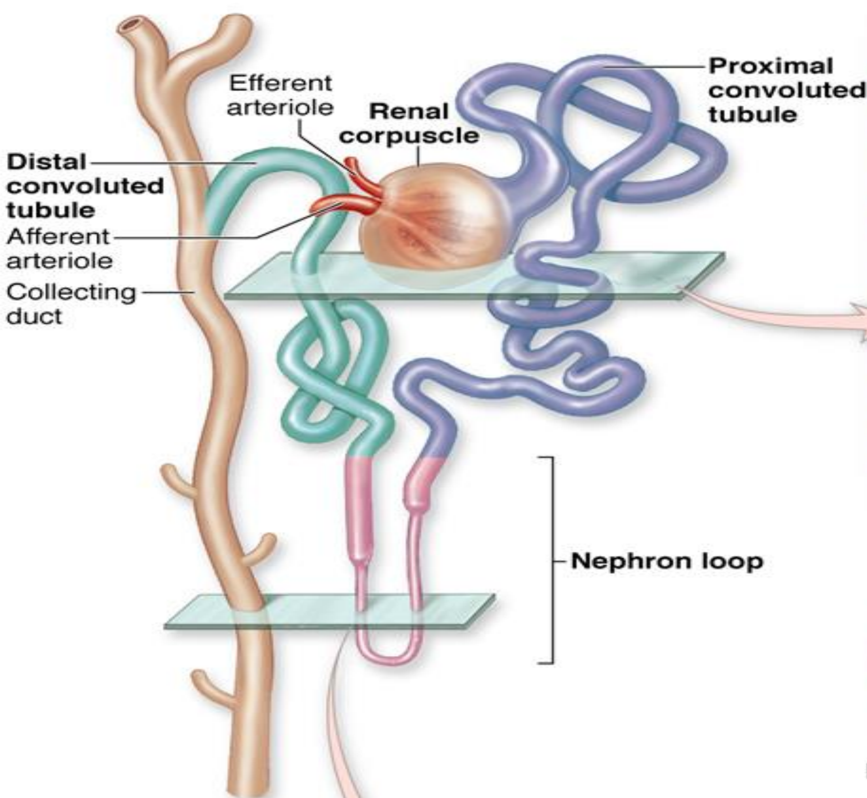
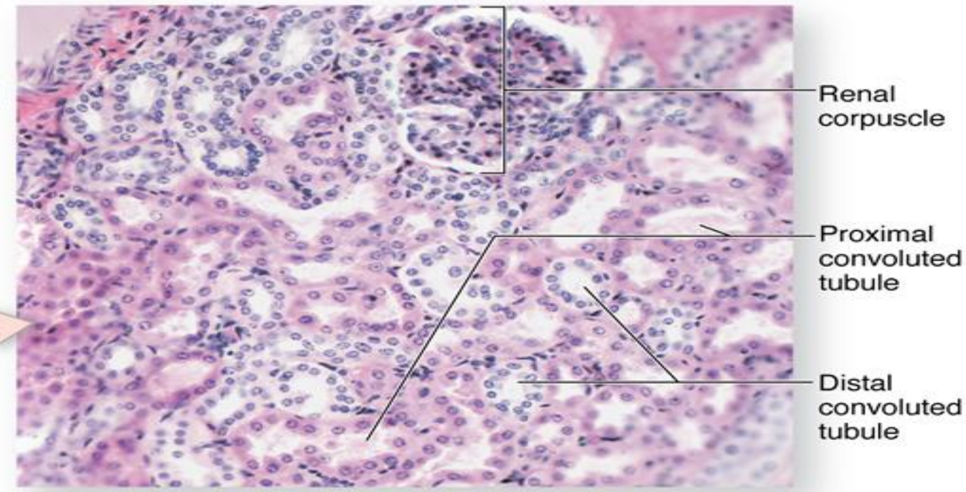
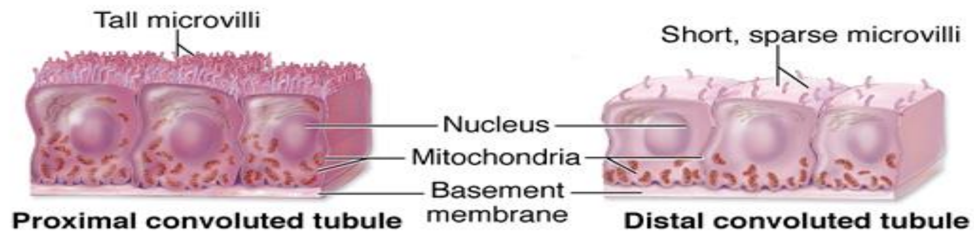


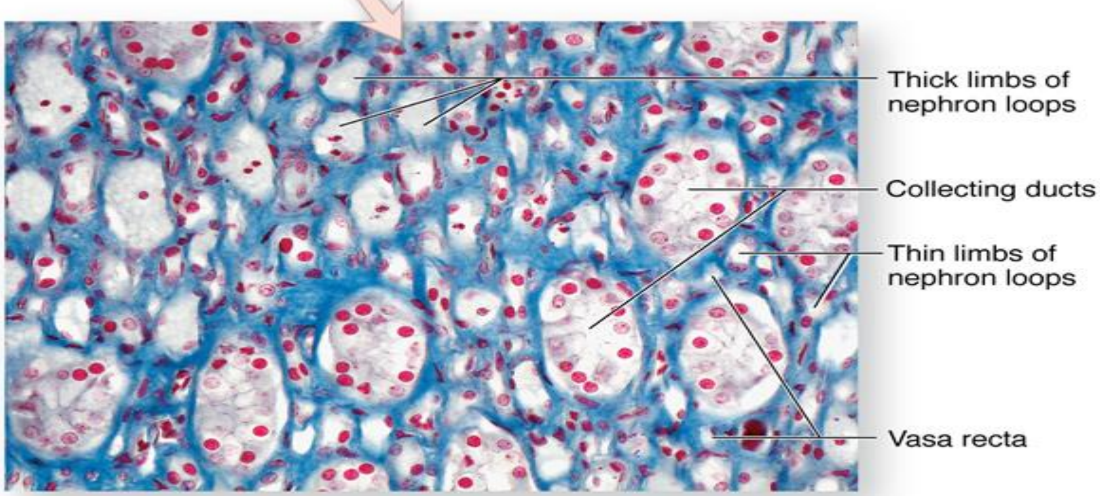
a Nephron components



b Renal cortex

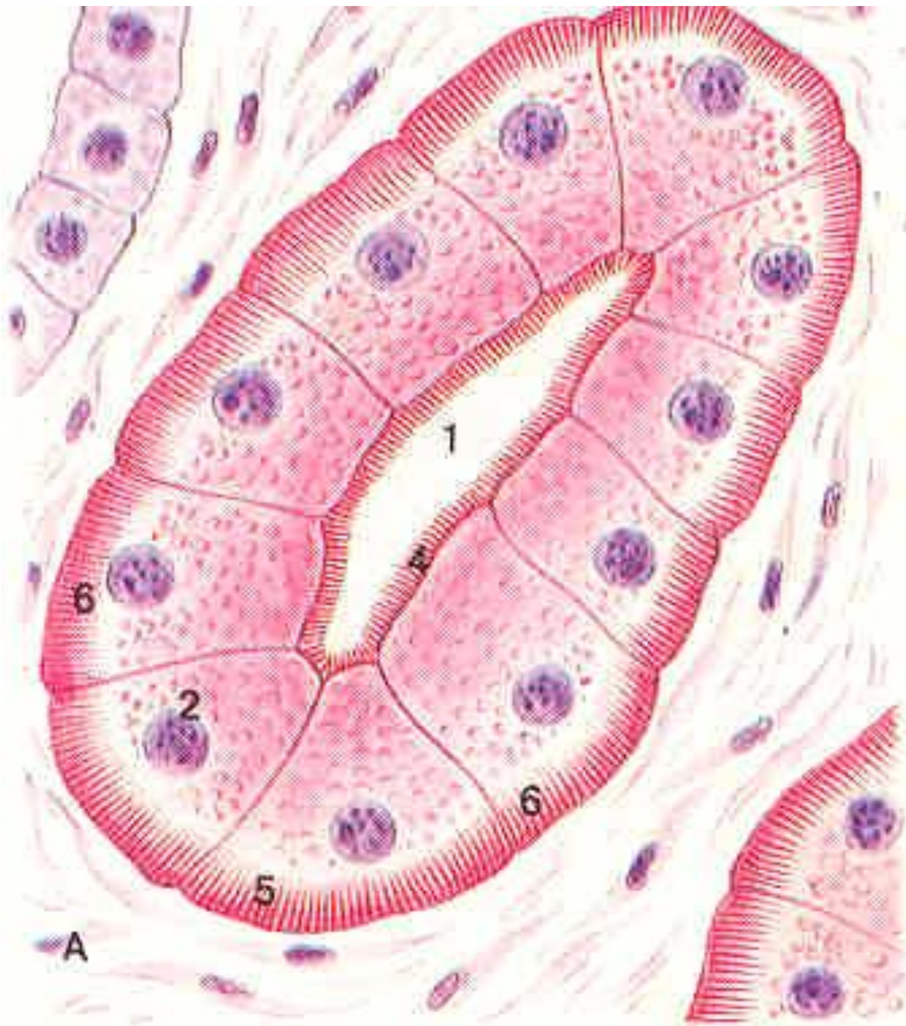


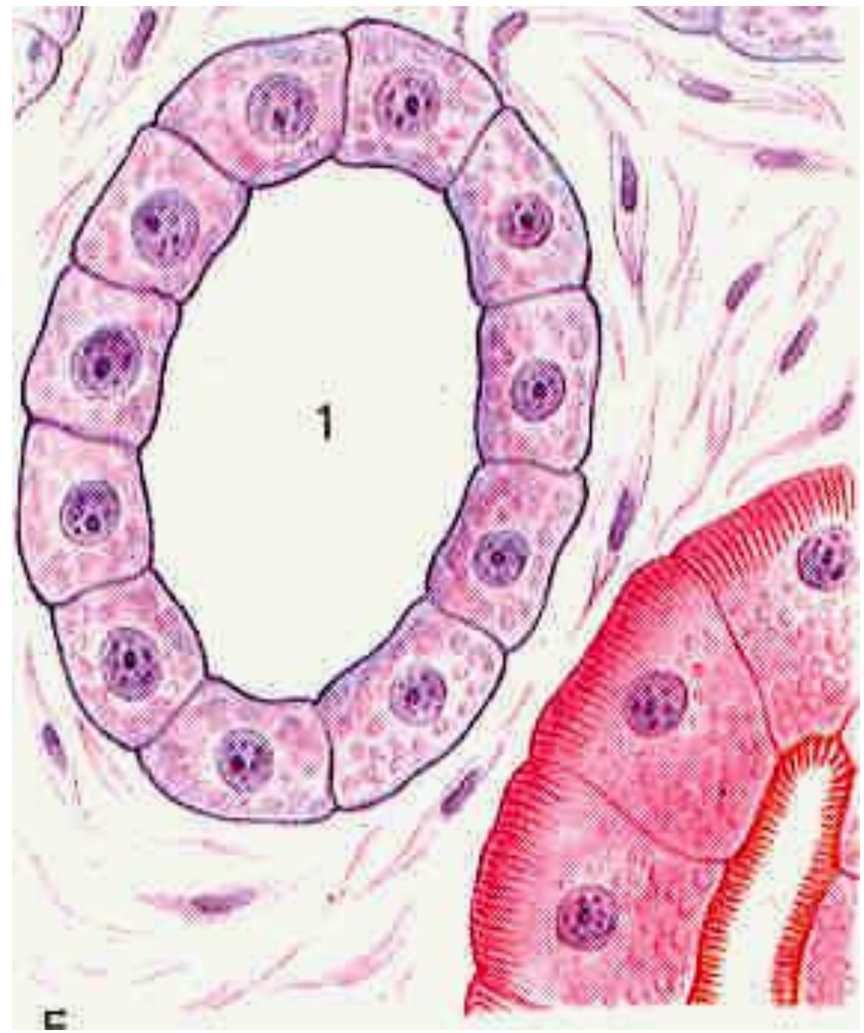
c Convoluted tubule epithelia



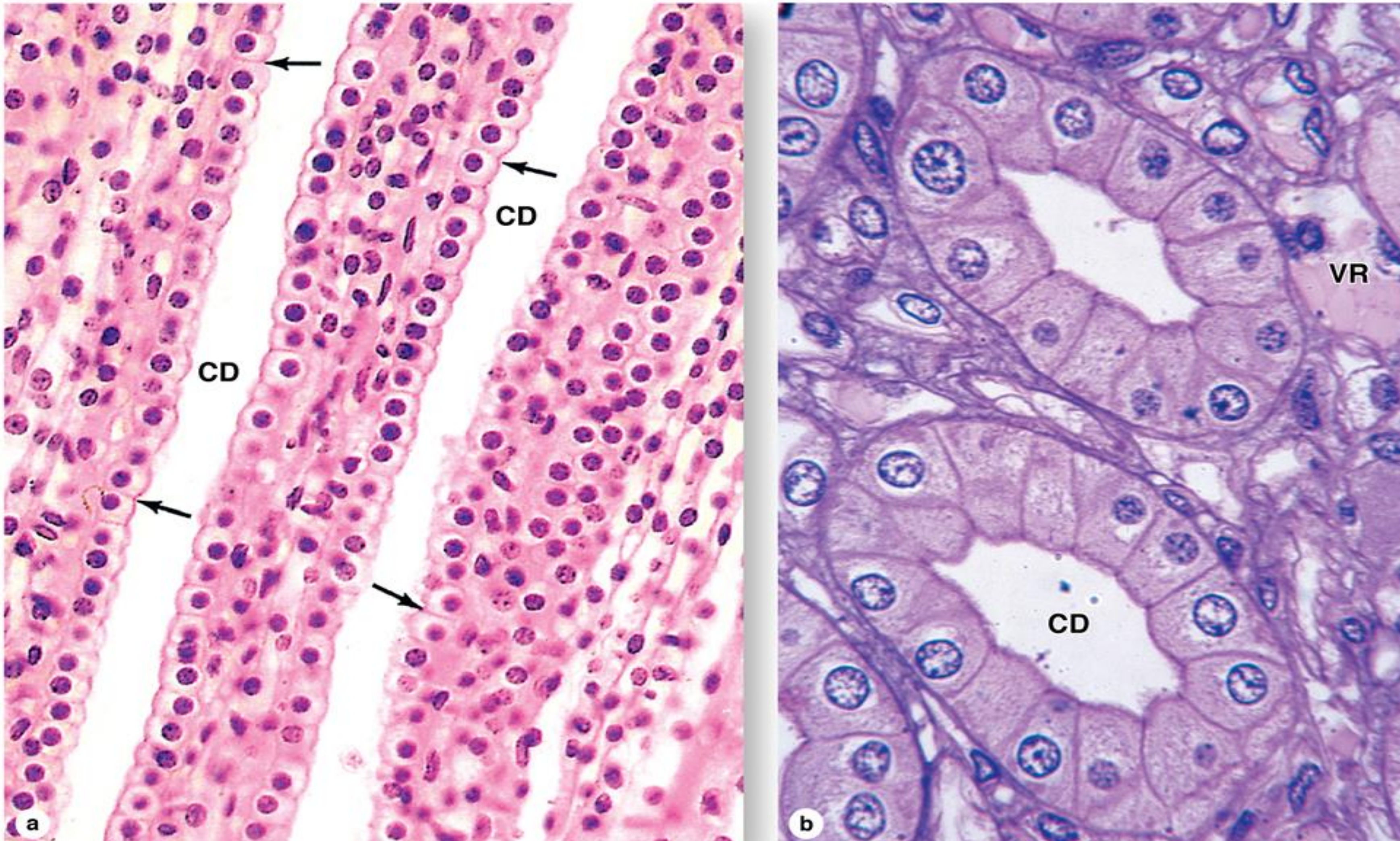
d Cross-section of renal medulla

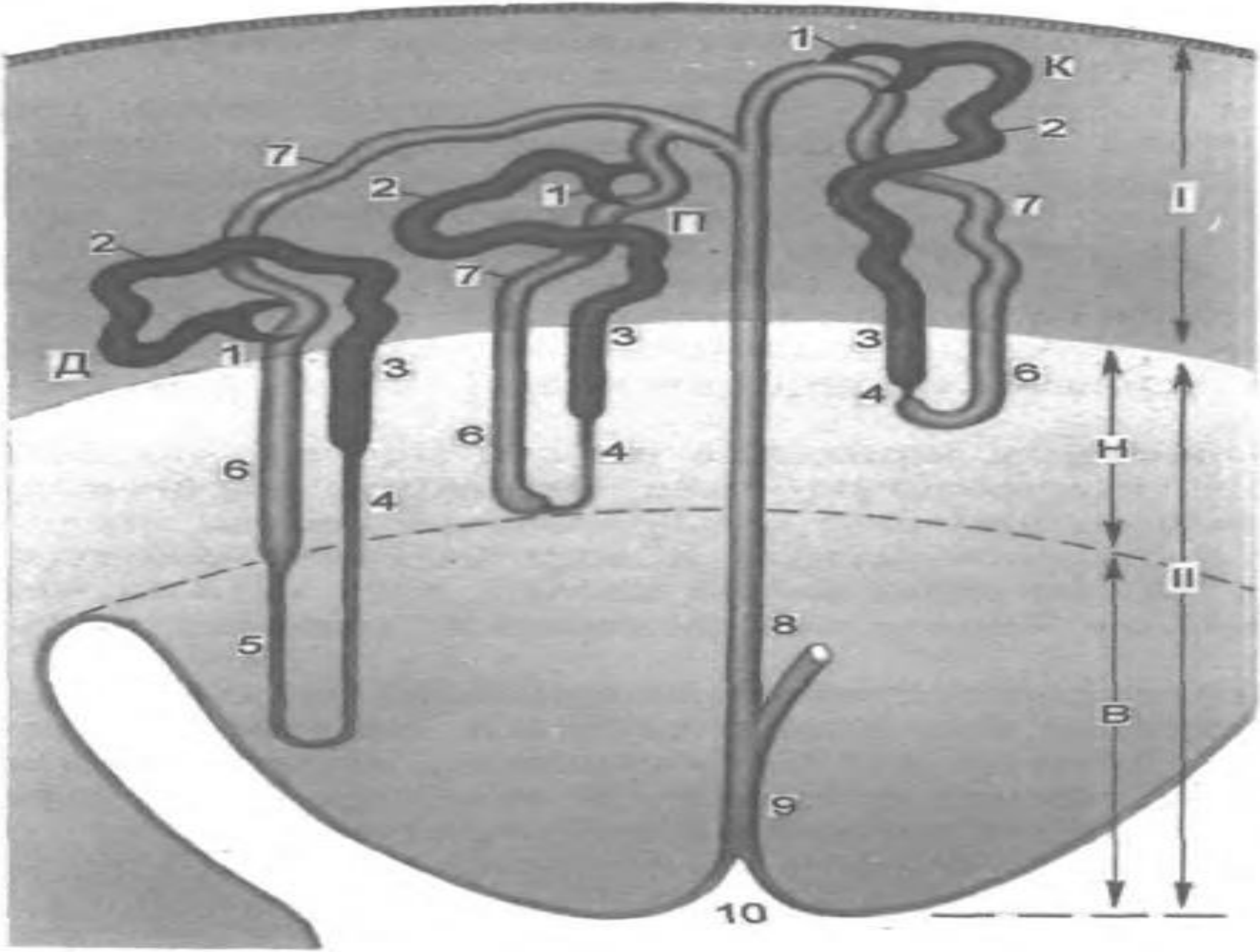
Proximal and Distal Convoluted tubules





Collecting Ducts

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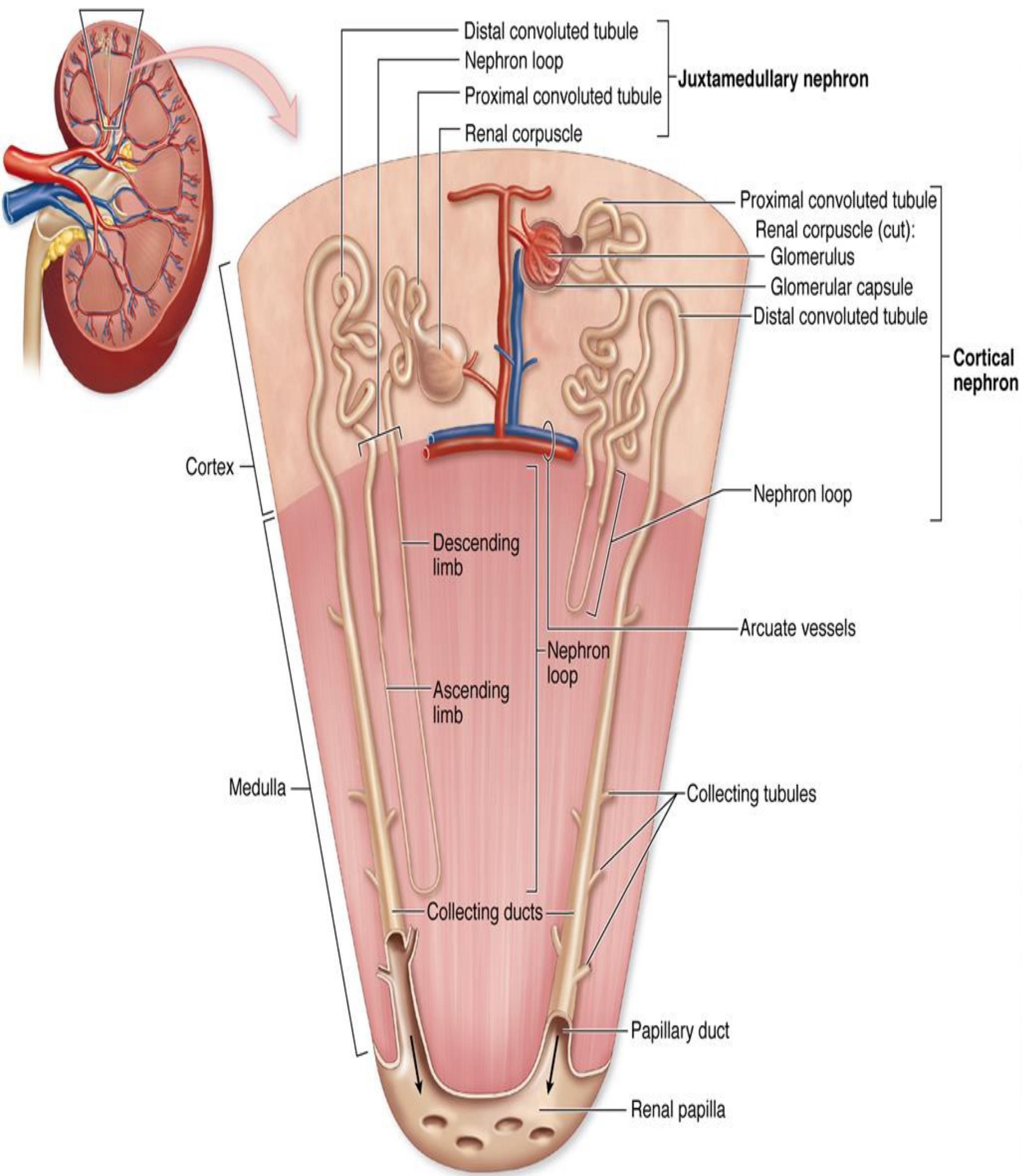
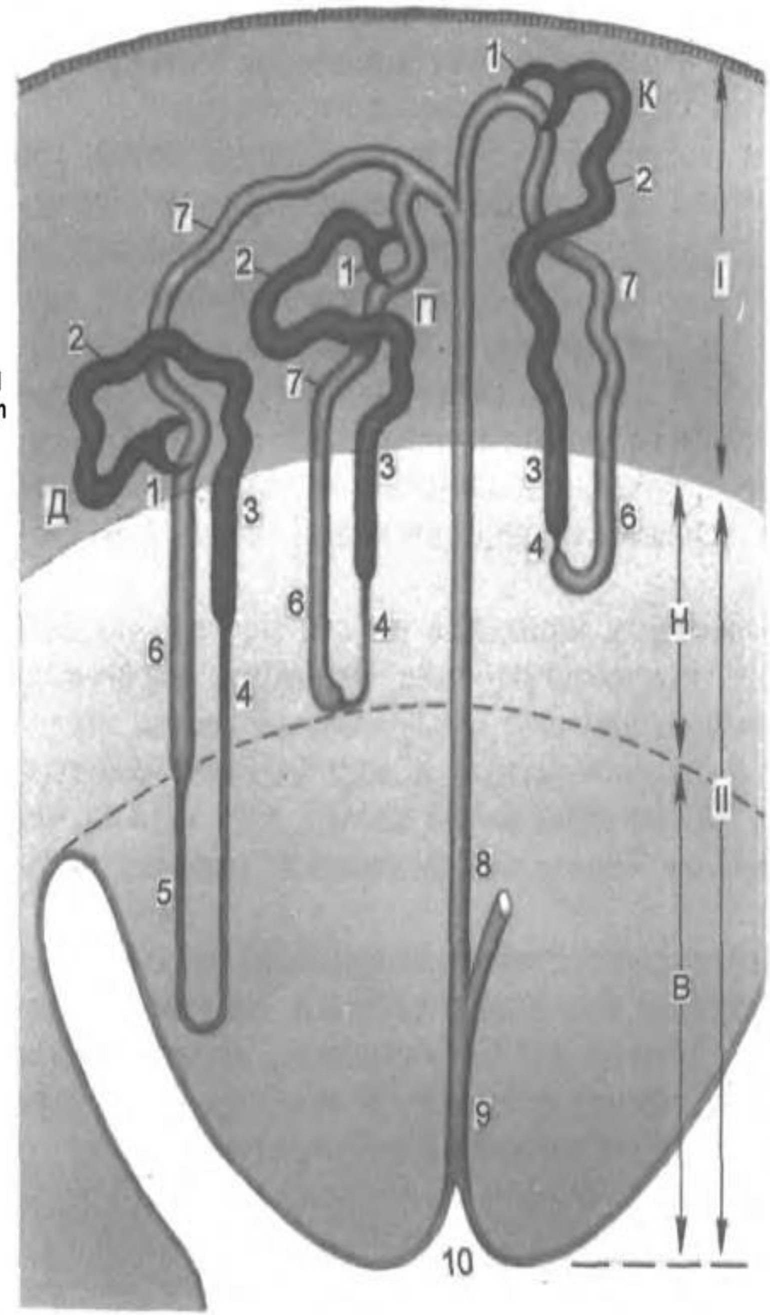

Distal convoluted tubule
Nephron loop
Proximal convoluted tubule
Renal corpuscle
Juxtamedullary nephron
Proximal convoluted tubule
Renal corpuscle (cut):
Glomerulus
Glomerular capsule
Distal convoluted tubule
Cortical nephron
Cortex
Nephron loop
Descending limb
Arcuate vessels
Nephron loop
Ascending limb
Medulla
Collecting tubules
Collecting ducts
Papillary duct
Renal papilla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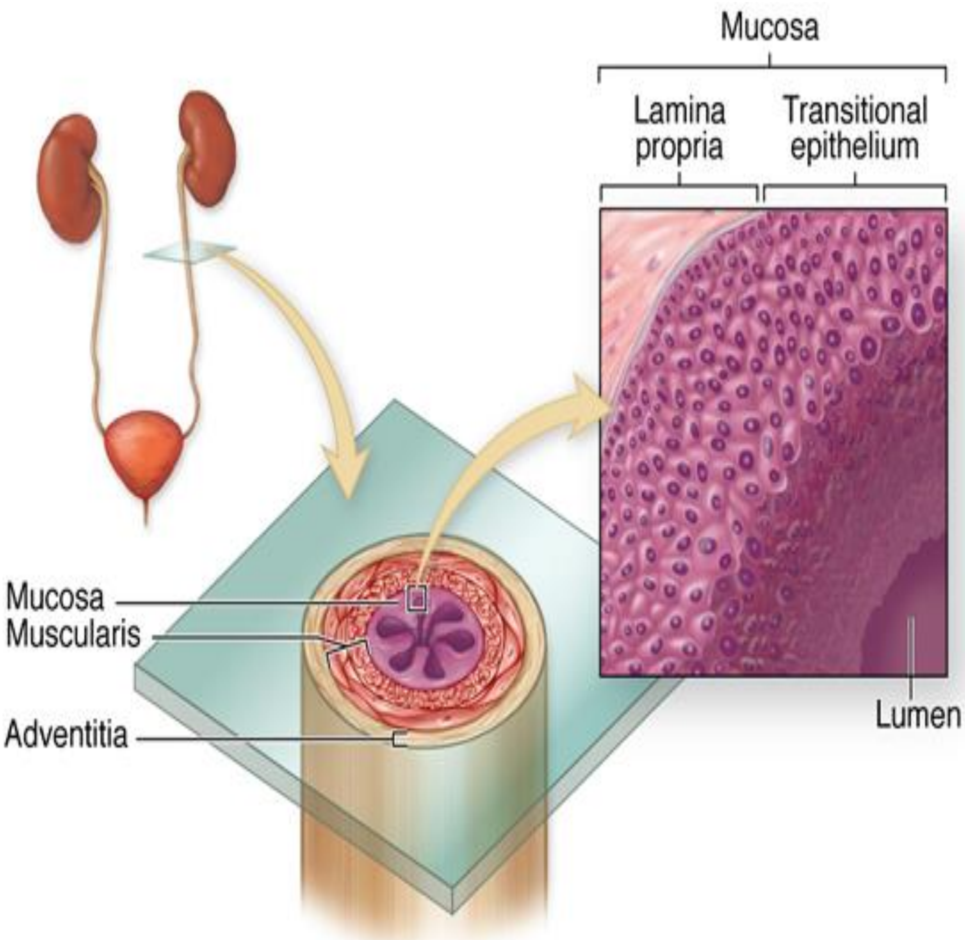
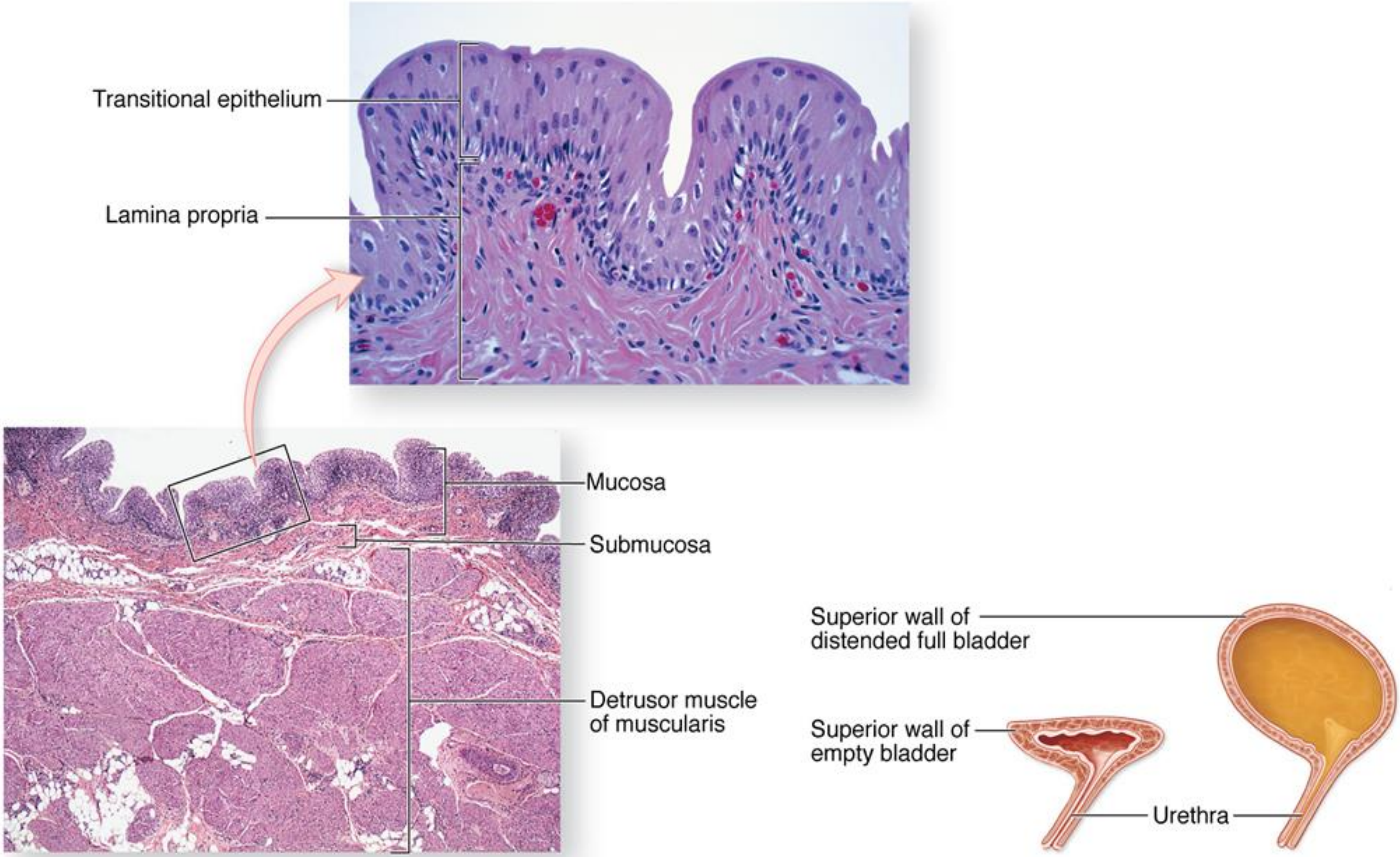
Ureters



a Ureter cross section

b

Urinary Bladder



a

b

Urinary Bladder