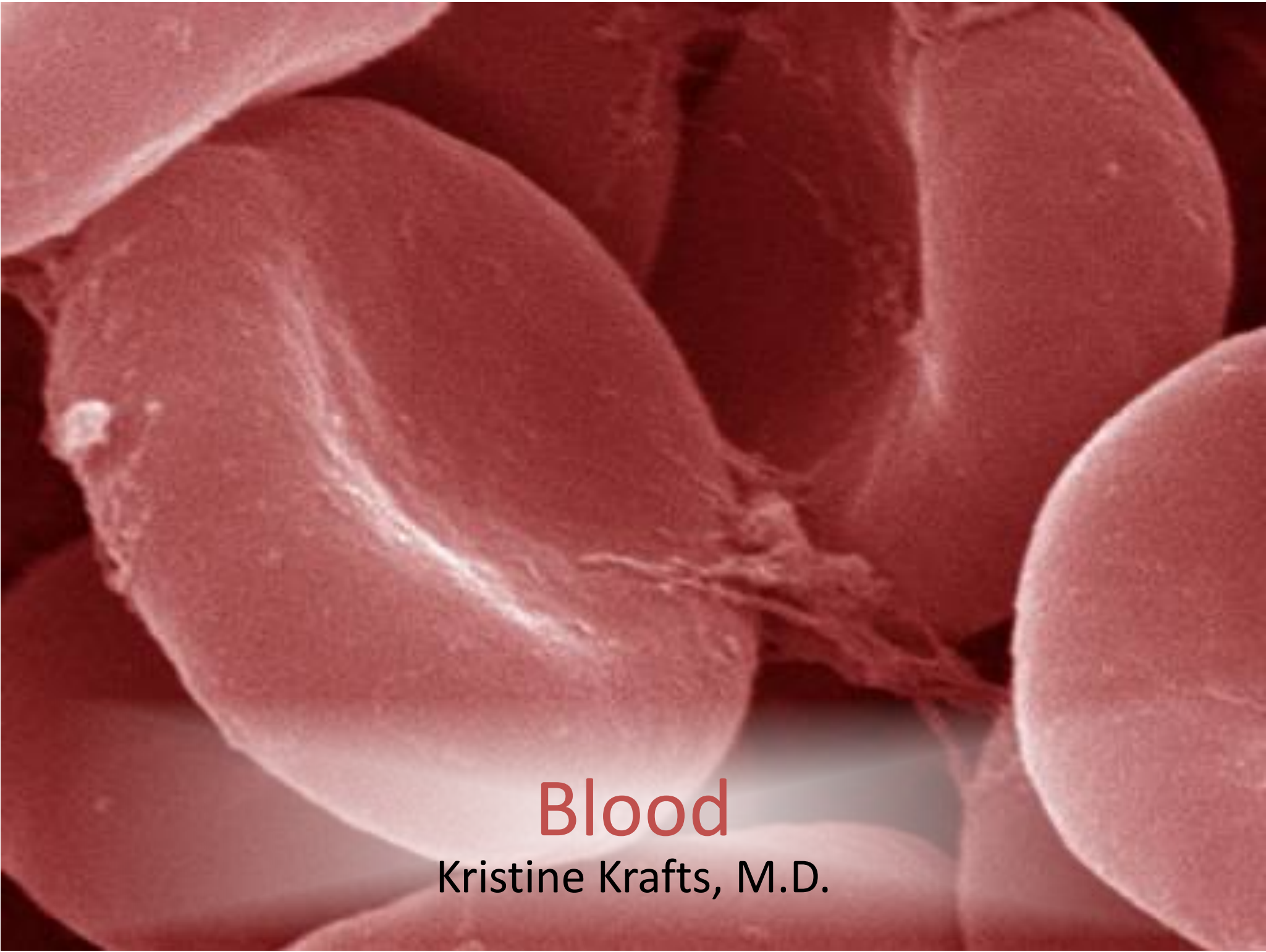




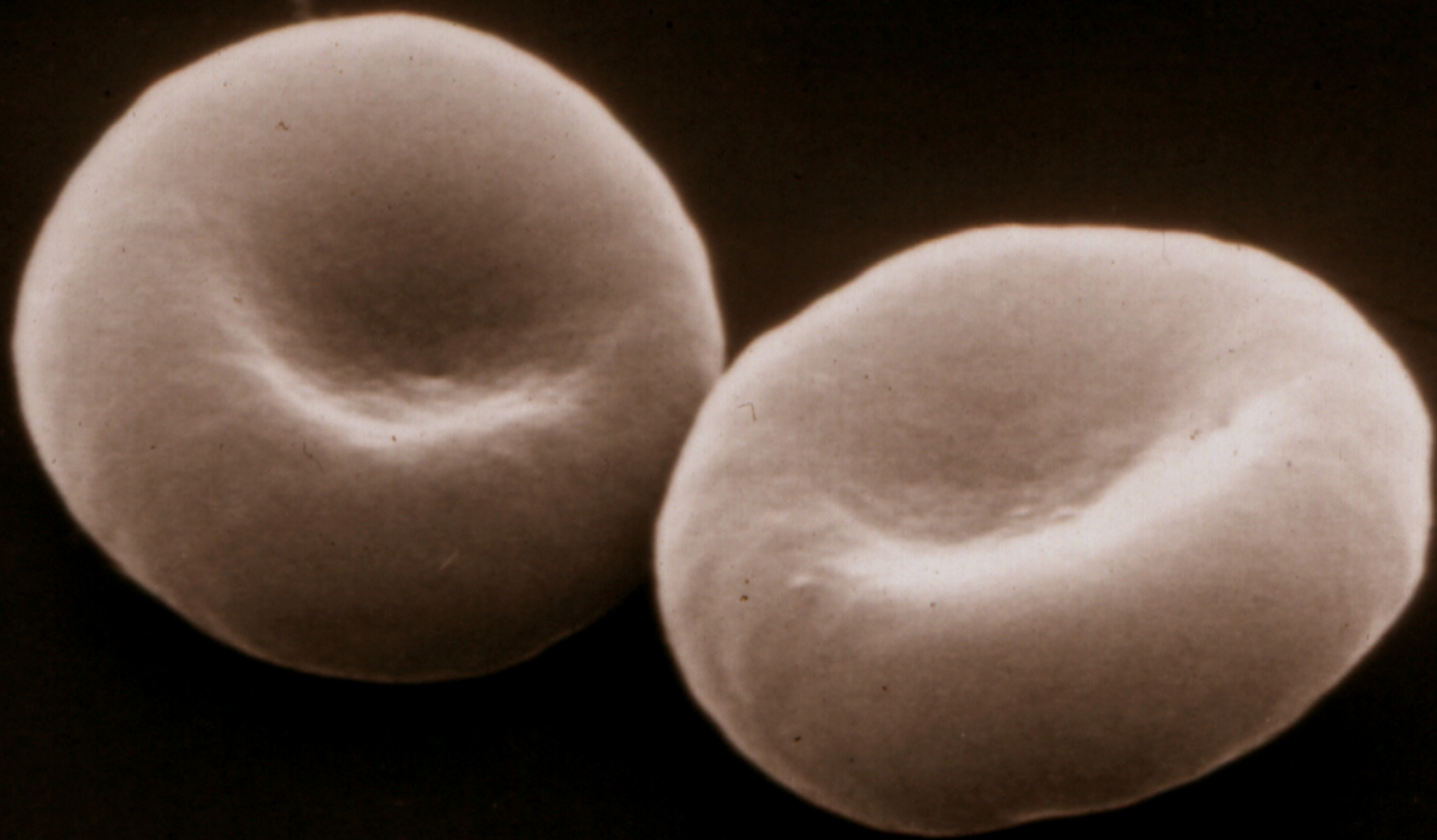
Blood

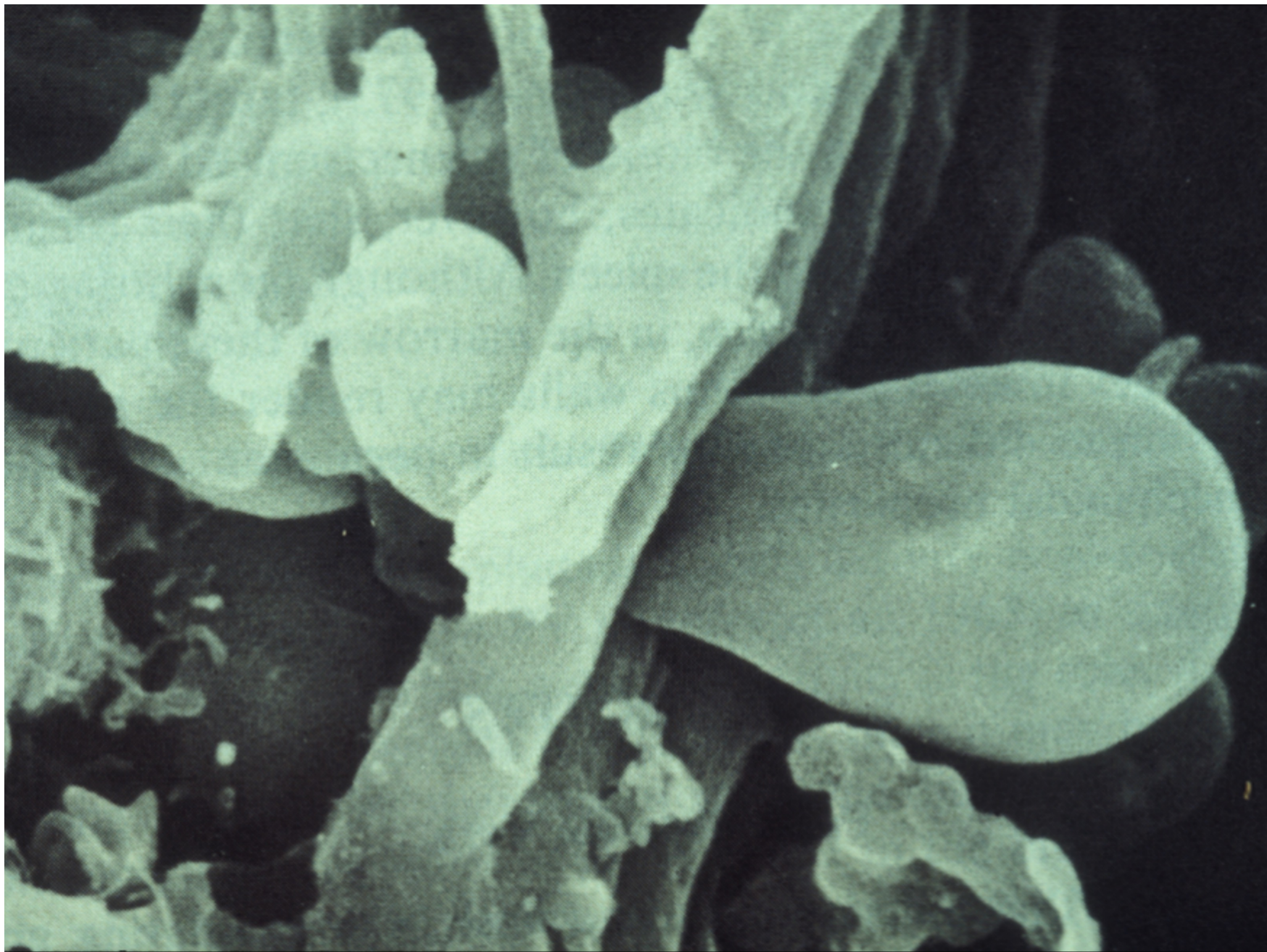
Kristine Krafts, M.D.

A dark, atmospheric photograph of a landscape. The sky is filled with heavy, dark clouds, with a faint light source visible near the horizon, creating a soft glow. Below the horizon, a body of water reflects the light from the sky, creating a shimmering effect. The overall tone is mysterious and contemplative.

The most beautiful thing we can experience is the mysterious.
It is the source of all true art and science.
-Albert Einstein







Blood Lecture Objectives

- Be able to identify and describe the major function(s) of the following:
 - Erythrocytes (RBCs)
 - Granulocytes (neutrophils, eosinophils, basophils)
 - Agranulocytes (lymphocytes, monocytes)
 - Platelets
- Know the approximate percentage of each type of leukocyte present in normal blood.
- Be able to describe the differences between plasma and serum.

Blood Lecture Outline

- Introduction
- Erythrocytes
- Platelets
- Leukocytes
 - Granulocytes
 - Agranulocytes

Blood Lecture Outline

- Introduction

Blood is a Specialized Connective Tissue

Composed of:

- Cells
- Plasma

Cells

- Red cells (erythrocytes)
- White cells (leukocytes)
- Platelets

Plasma contents

- Water: 92%
- Proteins: 7%
 - Albumin: 58%
 - Immunoglobulins: 37%
 - Fibrinogen: 4%
 - Other proteins: 1%
- Other stuff: 1% (electrolytes, nutrients, respiratory gases, waste products)

Plasma vs. Serum

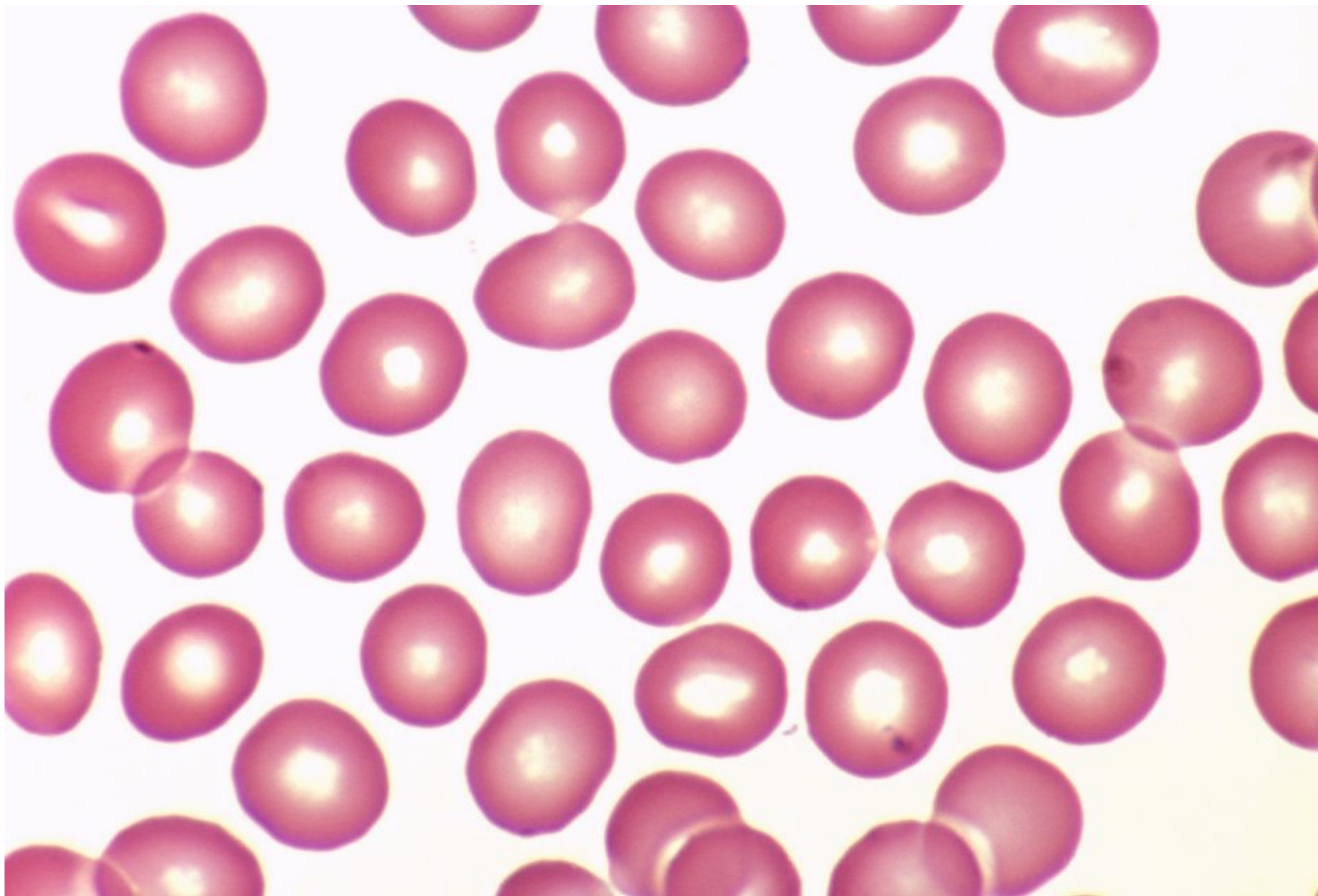
- Plasma clots, serum does not clot
- Serum = plasma minus clotting factors
(it's what's left after plasma clots)

Blood Lecture Outline

- Introduction
- Erythrocytes

Erythrocytes (Red Blood Cells)

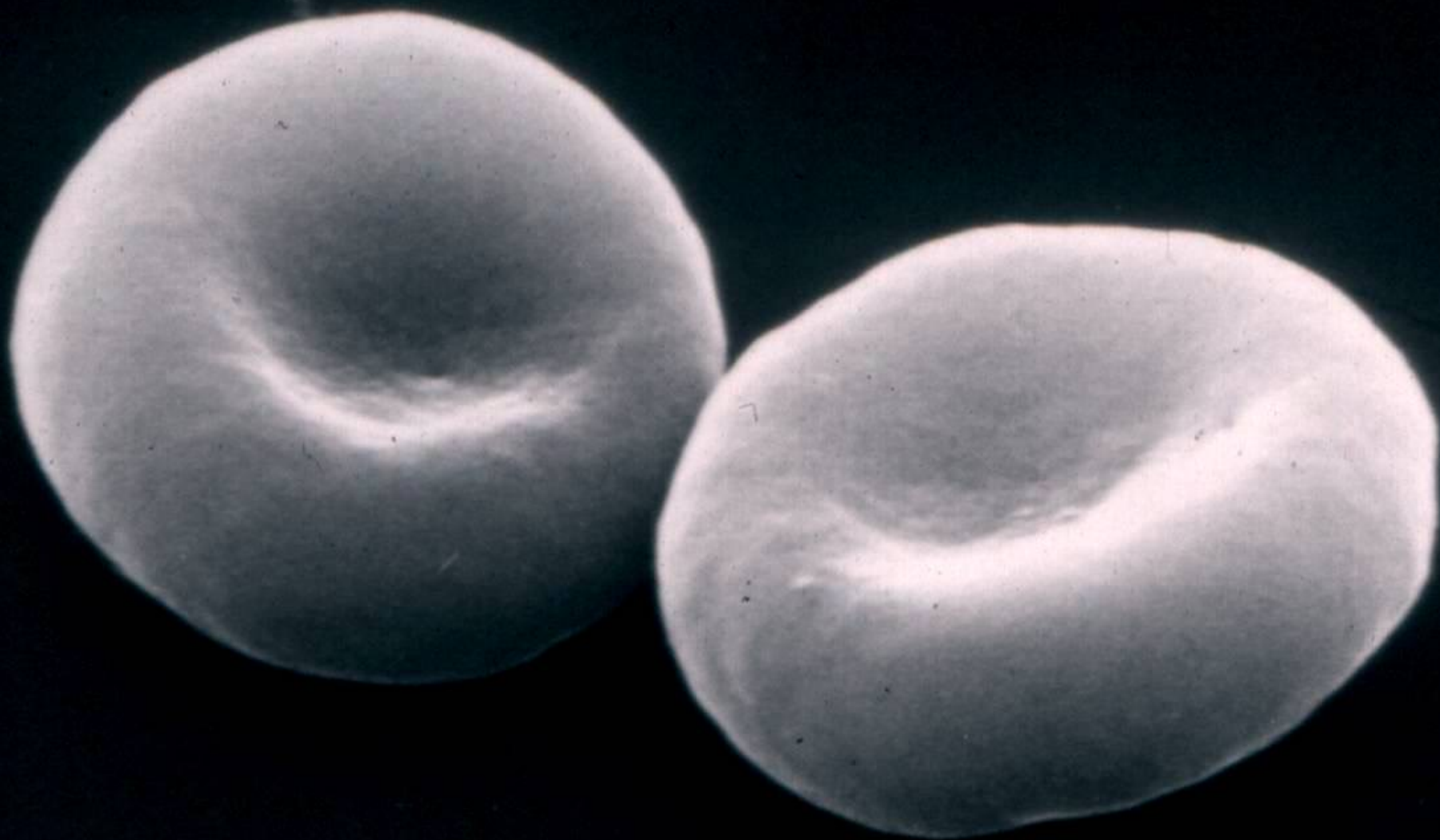
- Life span: 120 days
- Derived from red cell precursors in bone marrow
- Normal numbers
 - Male: $4.5-6 \times 10^{12}/L$
 - Female: $4-5 \times 10^{12}/L$

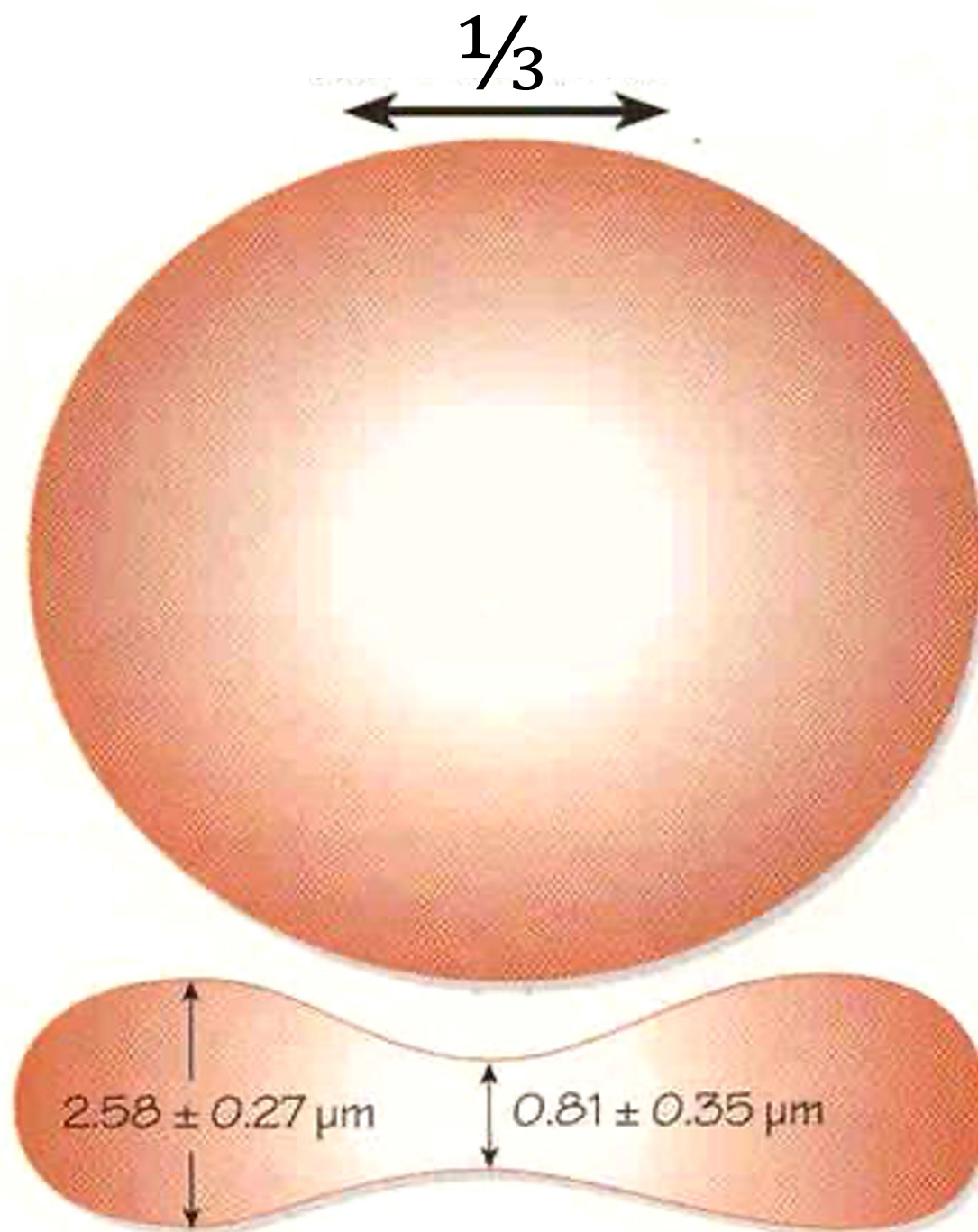


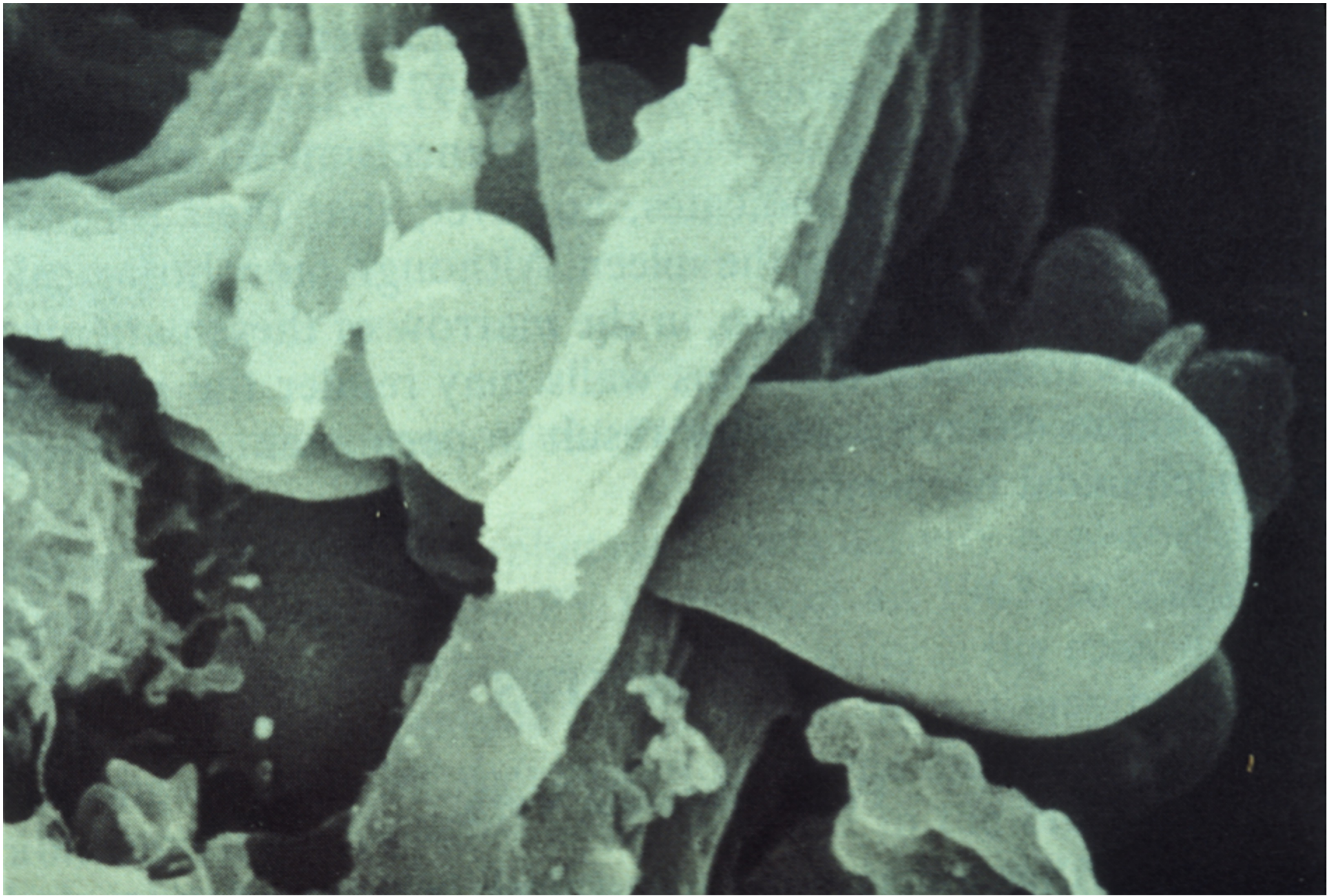
Normal red blood cells

Red Blood Cell Morphological Features

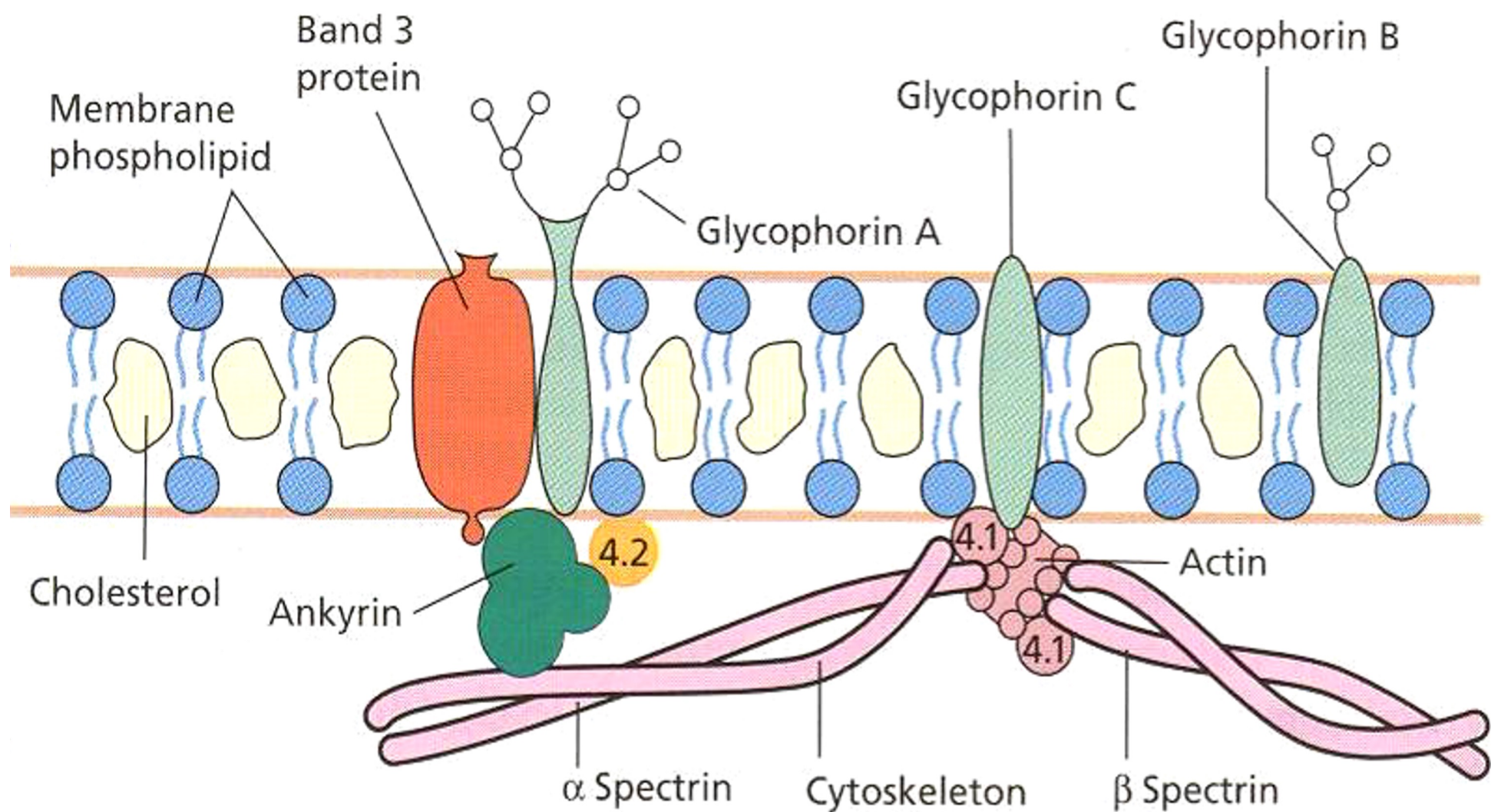
- Nicely designed biconcave disk shape
- Roughly 7 μm wide and 2 μm thick
- Cytoskeleton: spectrin, ankyrin, actin
- No nucleus
- Cytoplasm: water (65%); organelles (1%); hemoglobin (34%)





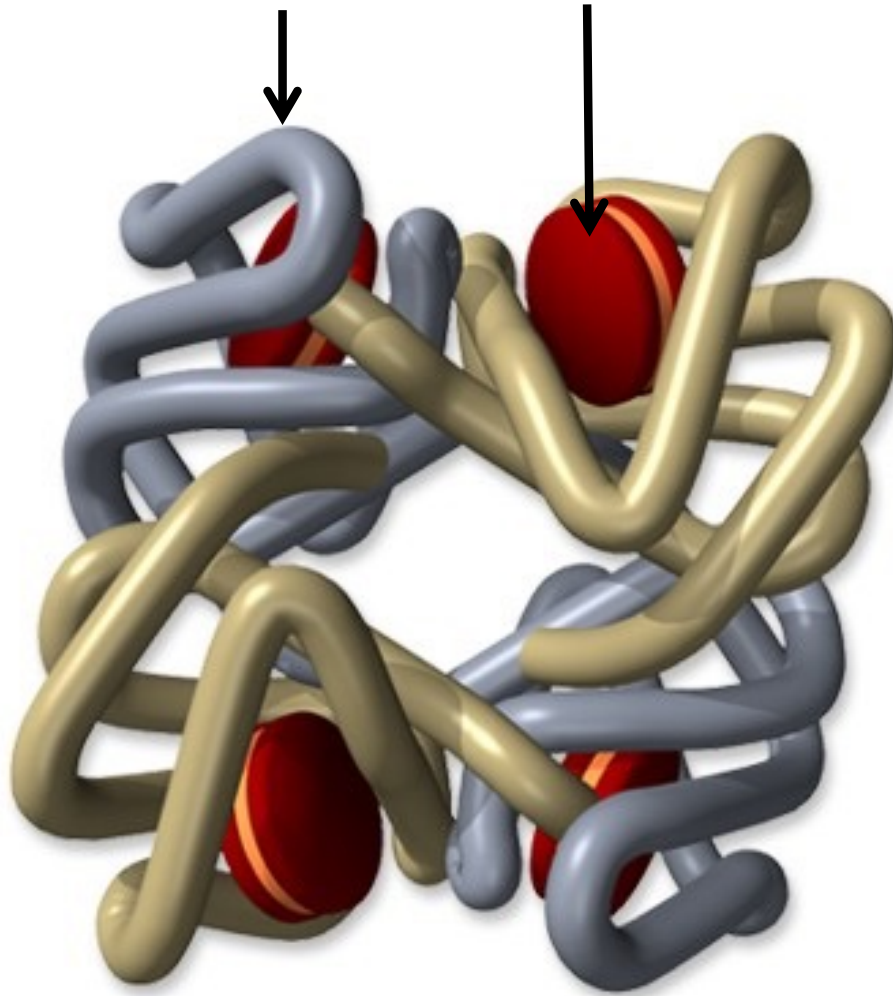


Pliable membrane allows cells to squeeze through tiny spaces.

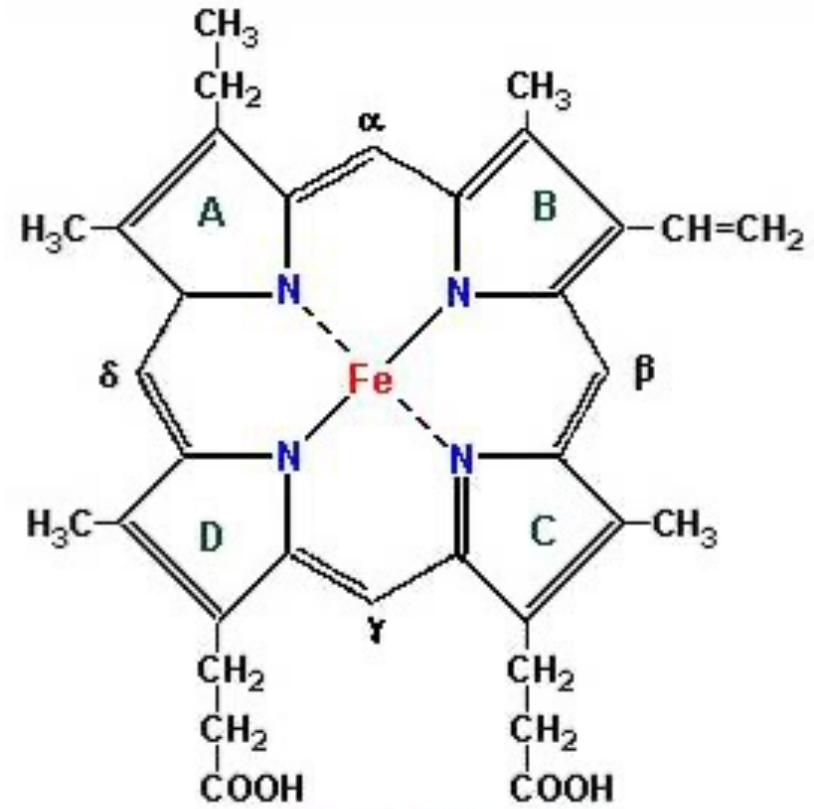


4 globin chains

4 heme molecules



Hemoglobin



Heme molecule
(carries O₂)

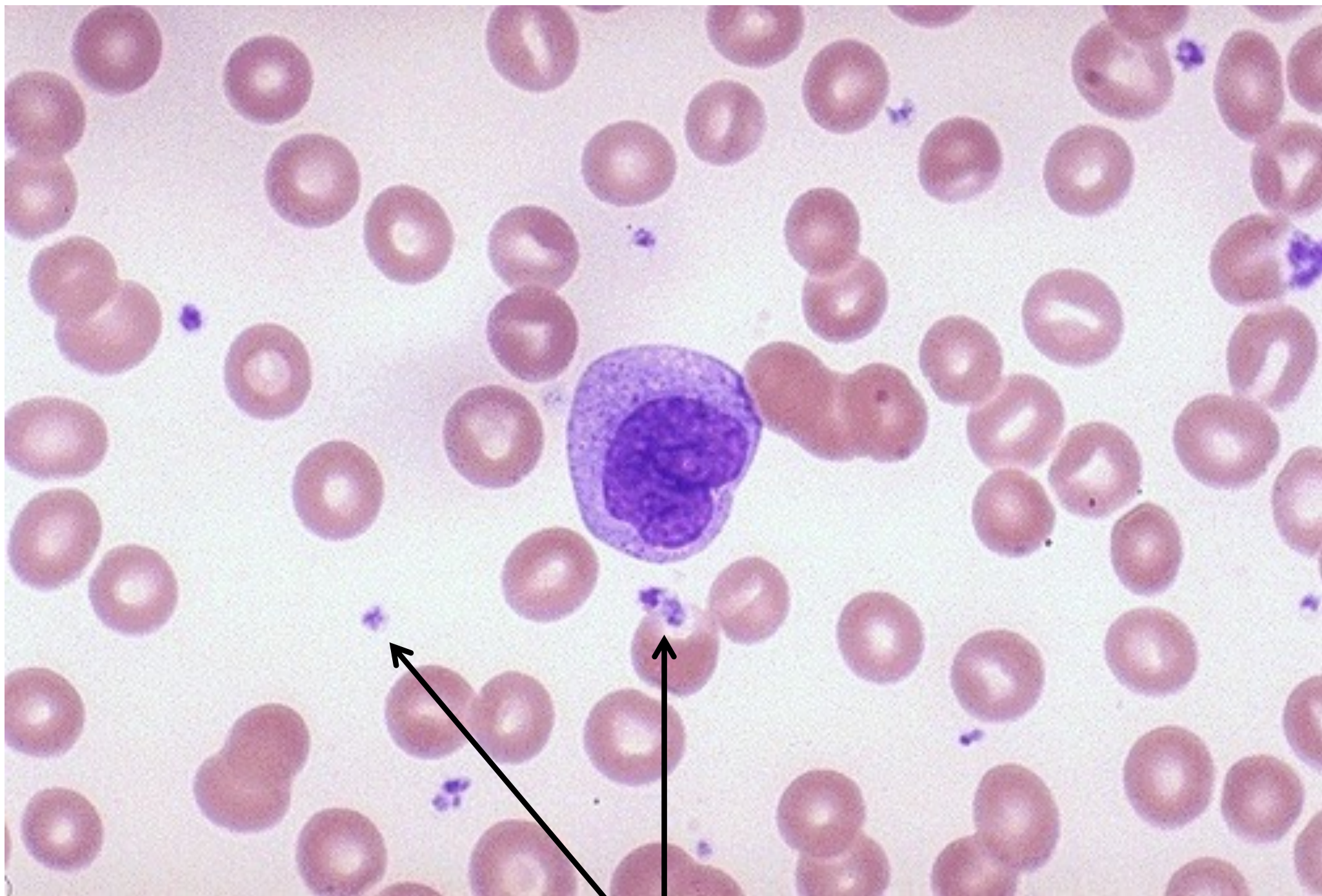
Main red cell function: transport oxygen using hemoglobin

Blood Lecture Outline

- Introduction
- Erythrocytes
- Platelets

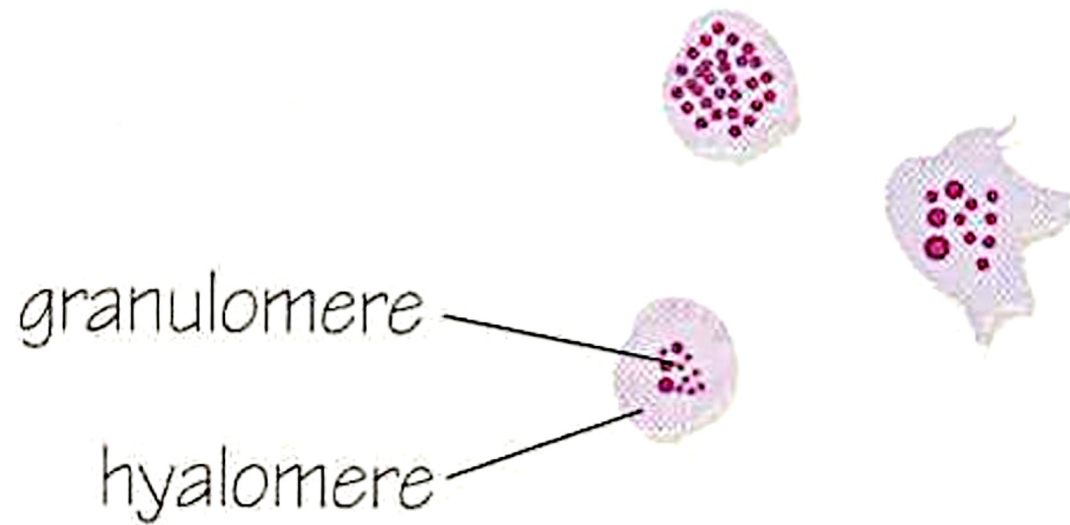
Platelets

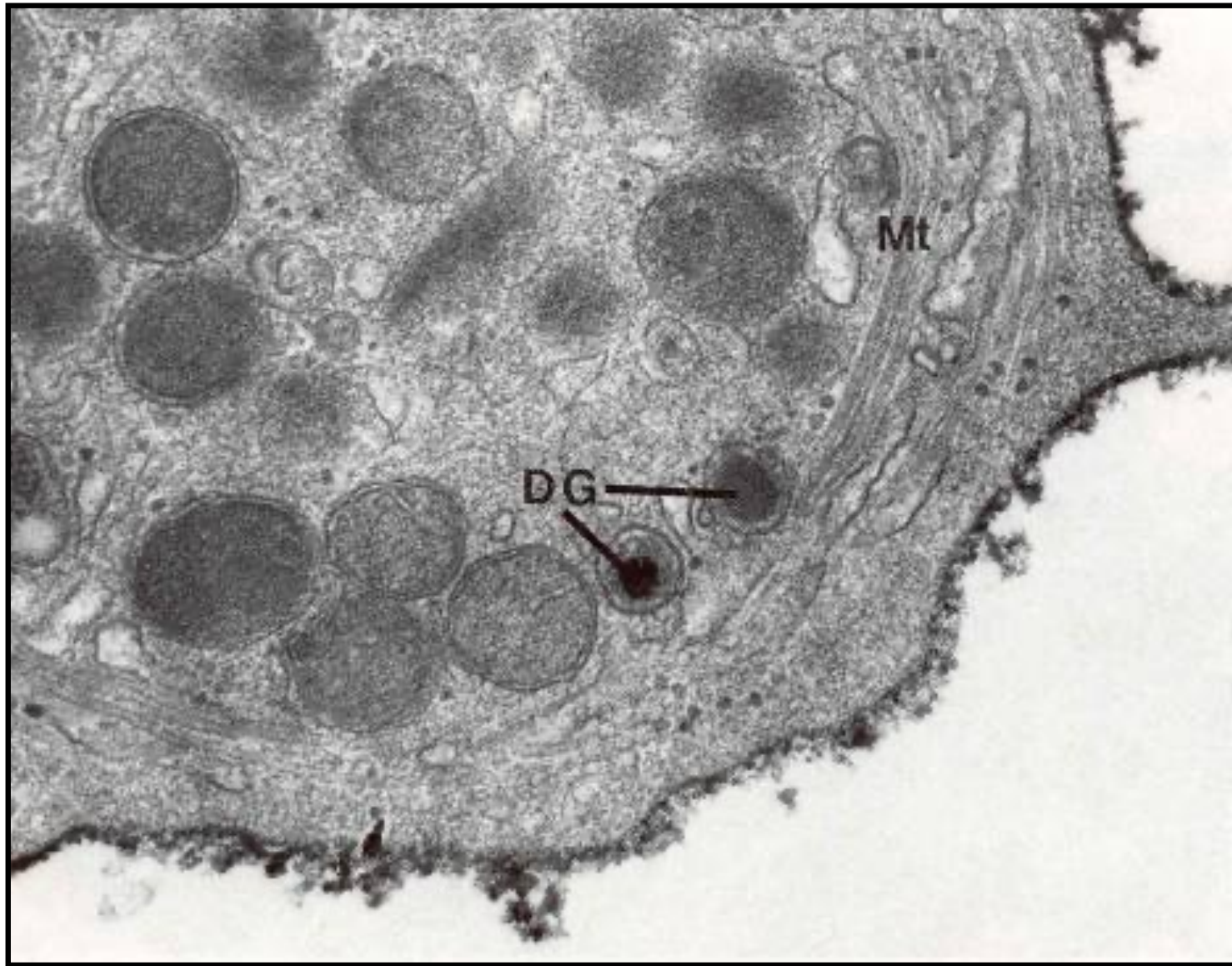
- Life span: 8-10 days
- Derived from megakaryocytes in bone marrow
- Normal number: $150-450 \times 10^9/L$
- About 2 μm in diameter
- Granulomere and hyalomere regions
- No nucleus
- Function: help blood to clot



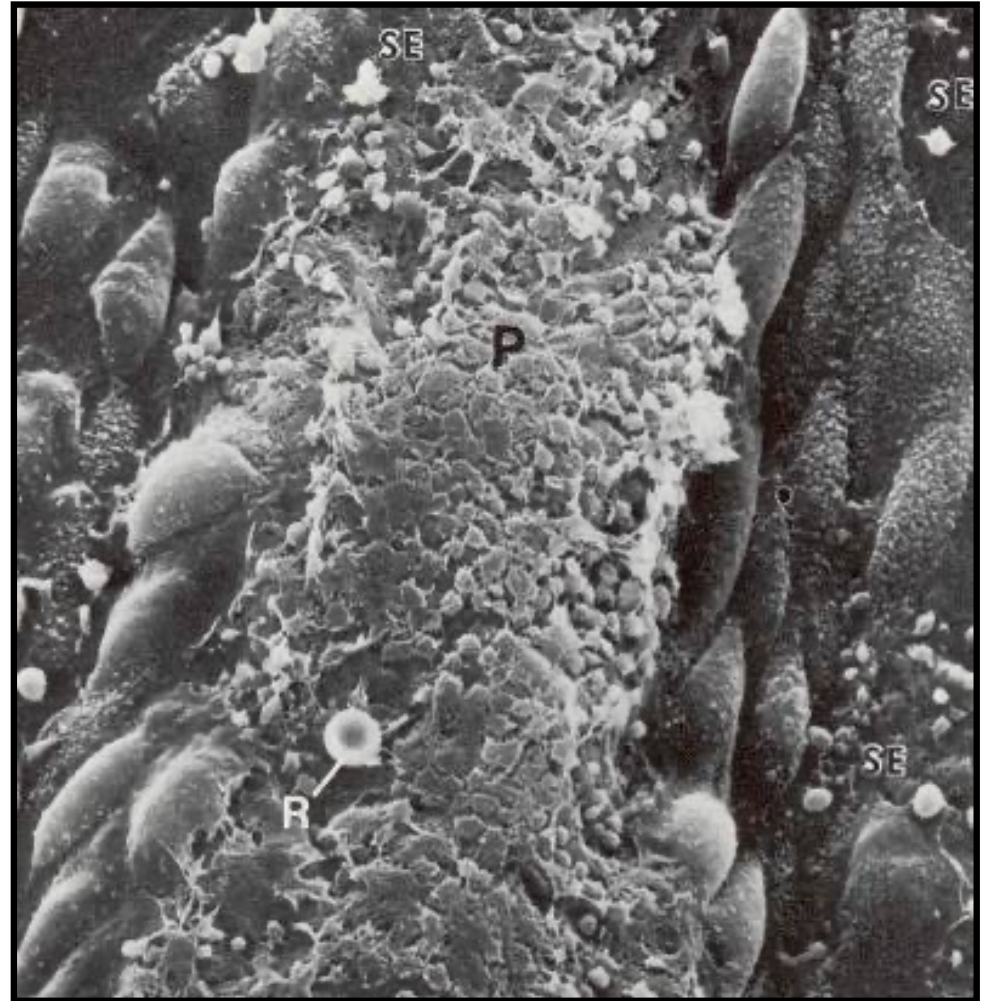
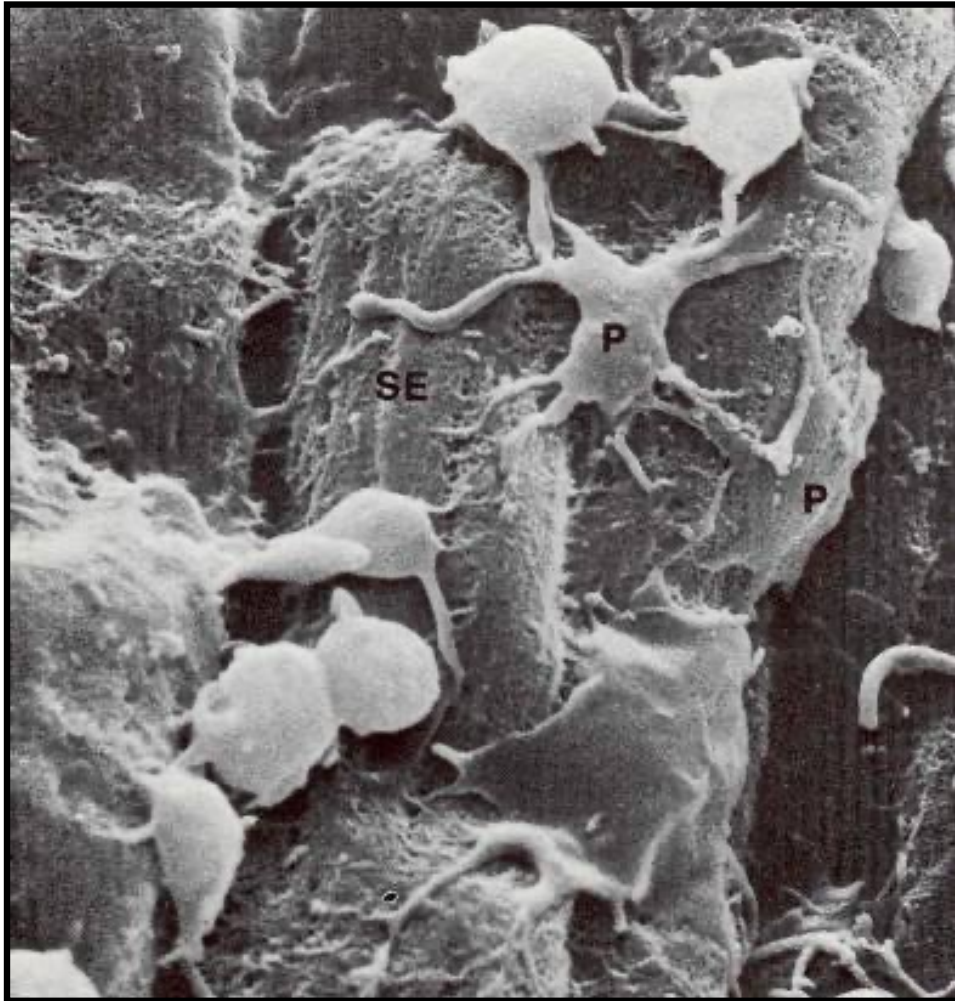
Normal platelets

Normal Platelets





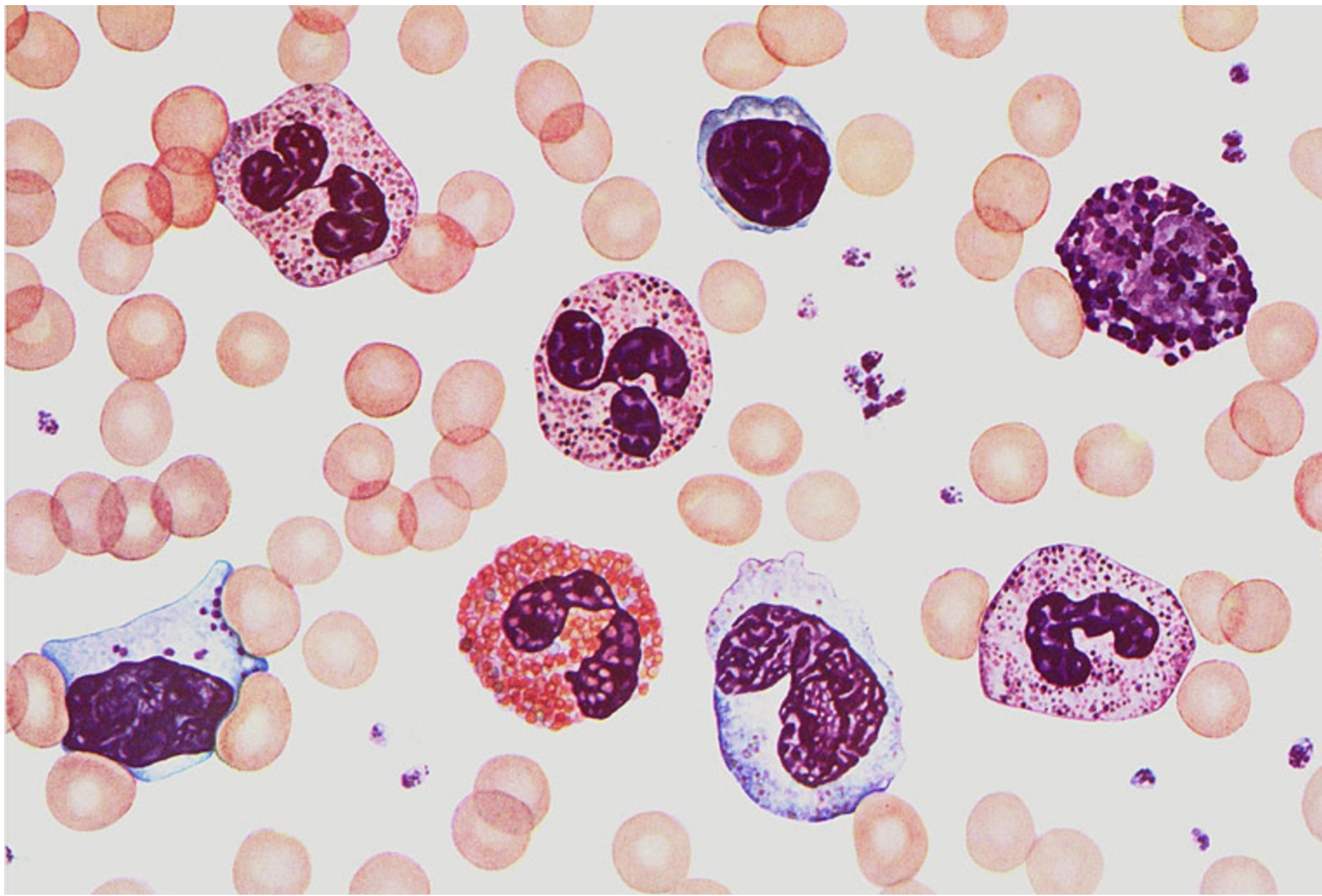
Platelets look boring but have a ton of stuff inside (granules) and outside (receptors)



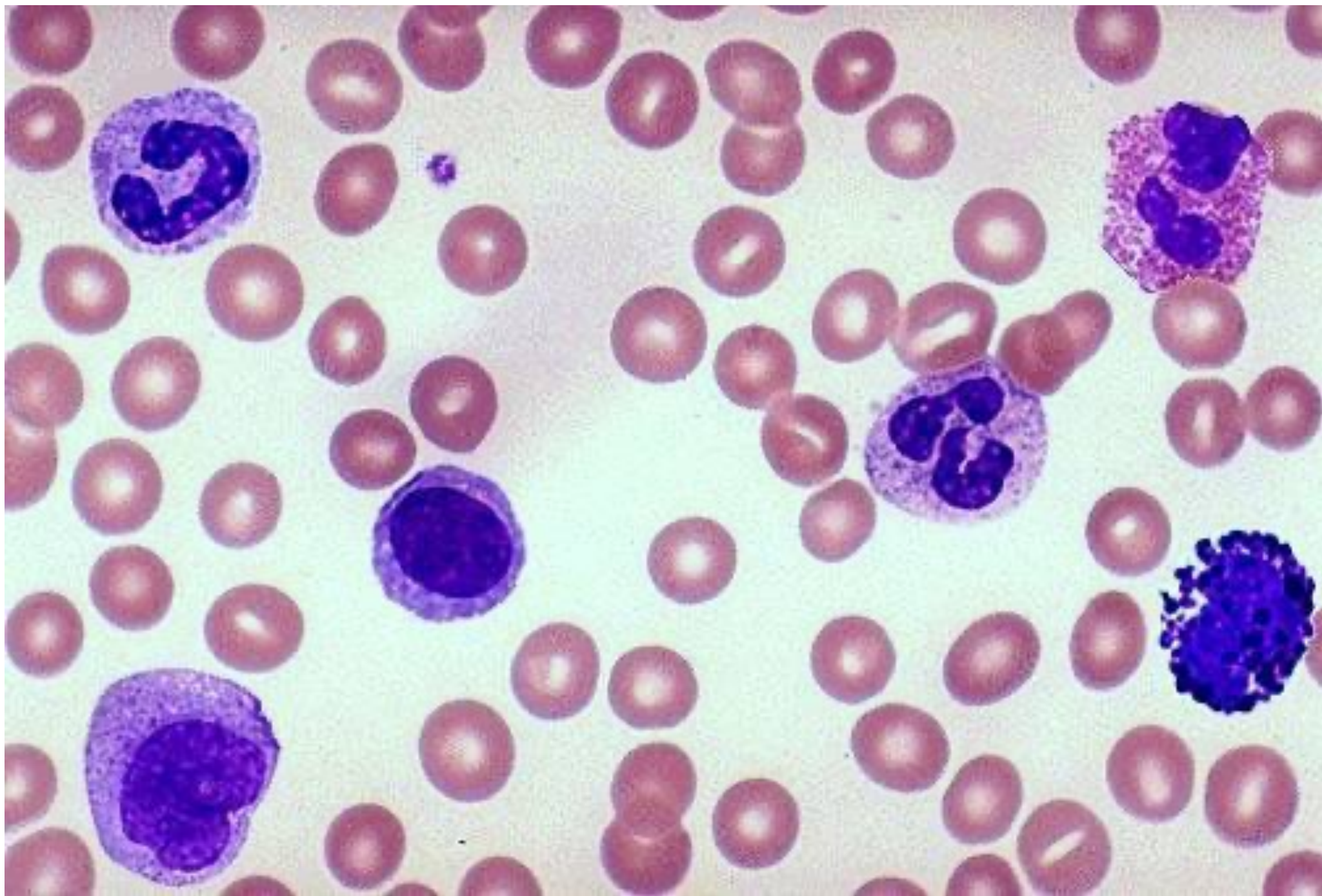
Platelets forming a clot

Blood Lecture Outline

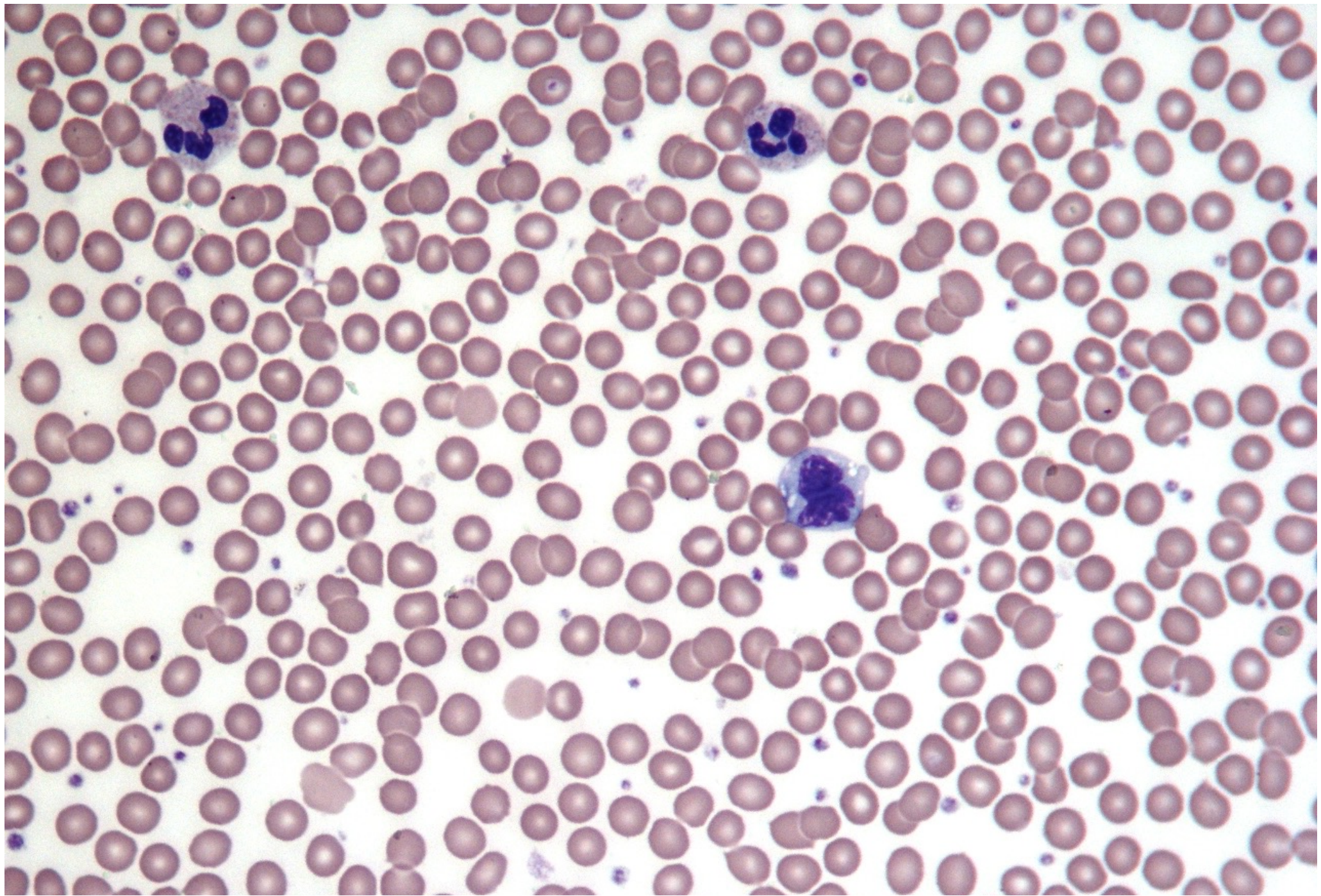
- Introduction
- Erythrocytes
- Platelets
- Leukocytes



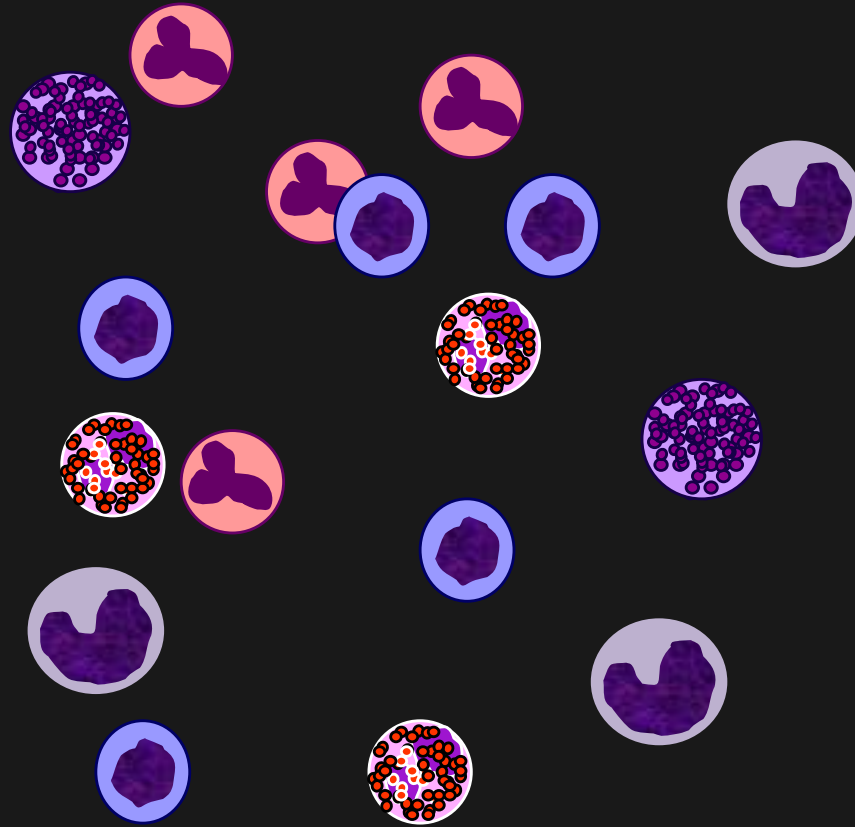
White blood cells (nice drawing)



White blood cells (real blood smear)

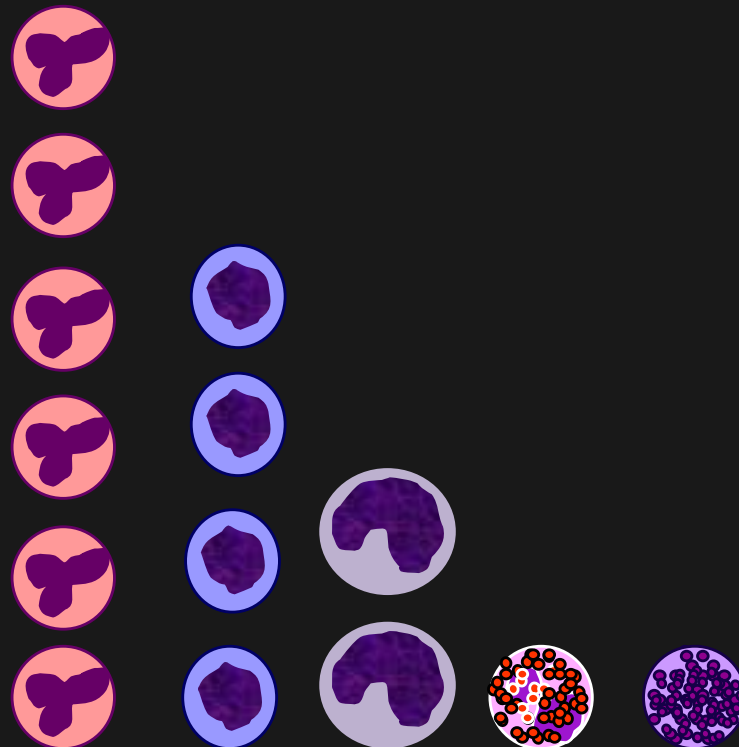


White blood cells (another real blood smear)



White blood cell count (WBC)

Just gives you the total number of white blood cells (normal is about $4-11 \times 10^9/L$).



White blood cell differential (“diff”)

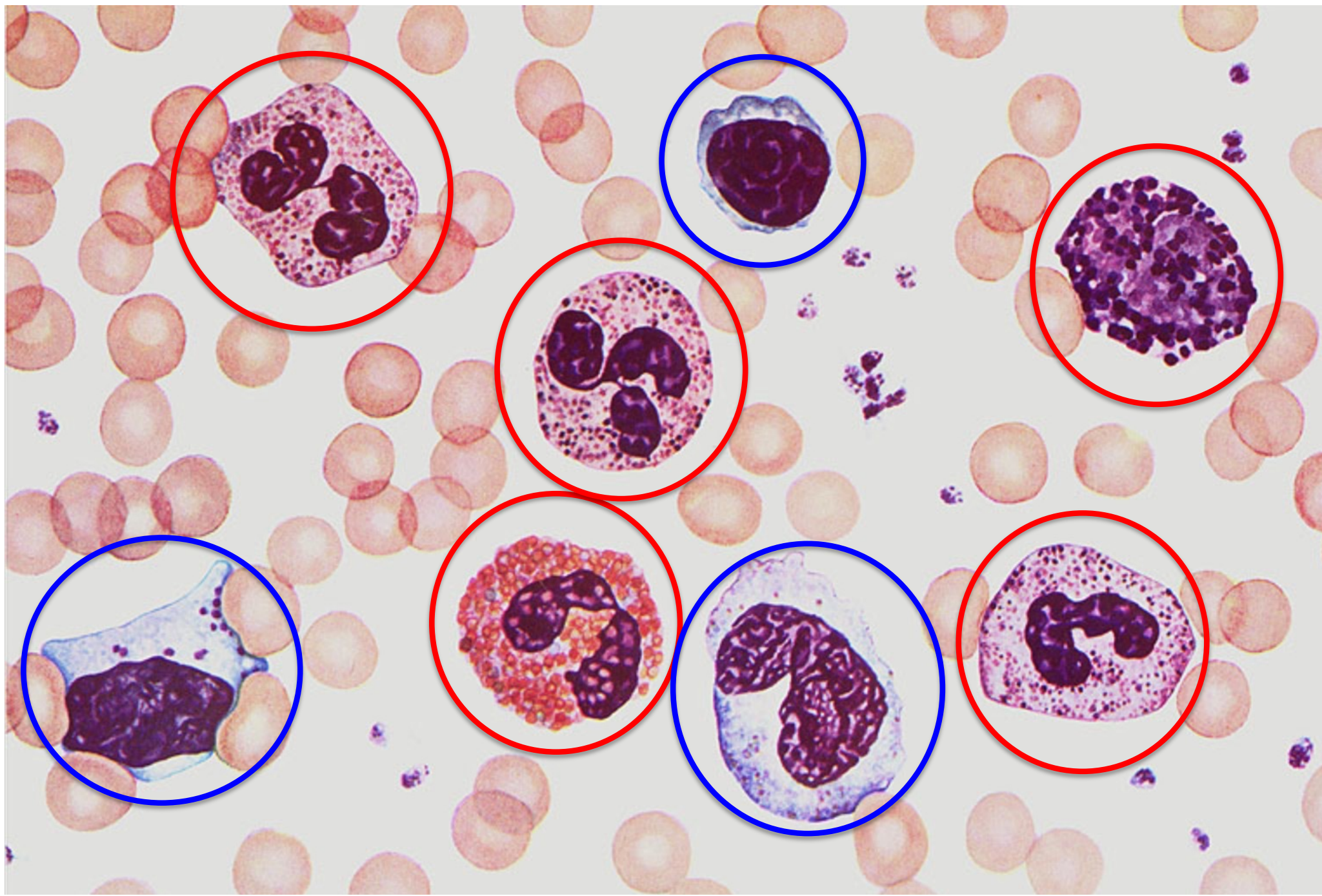
Tells you how many of each type of white cell are present (normally, neutrophils are the most numerous, and basophils are the least numerous).

Leukocytes

- Granulocytes
 - Neutrophils
 - Eosinophils
 - Basophils
- Agranulocytes
 - Lymphocytes
 - Monocytes

Wait, agranulocytes have granules?!

- Yes! Both granulocytes and agranulocytes have cytoplasmic granules called **azurophilic** granules.
- But granulocytes also have **specific** granules that define them as cells (neutrophilic, eosinophilic and basophilic granules)



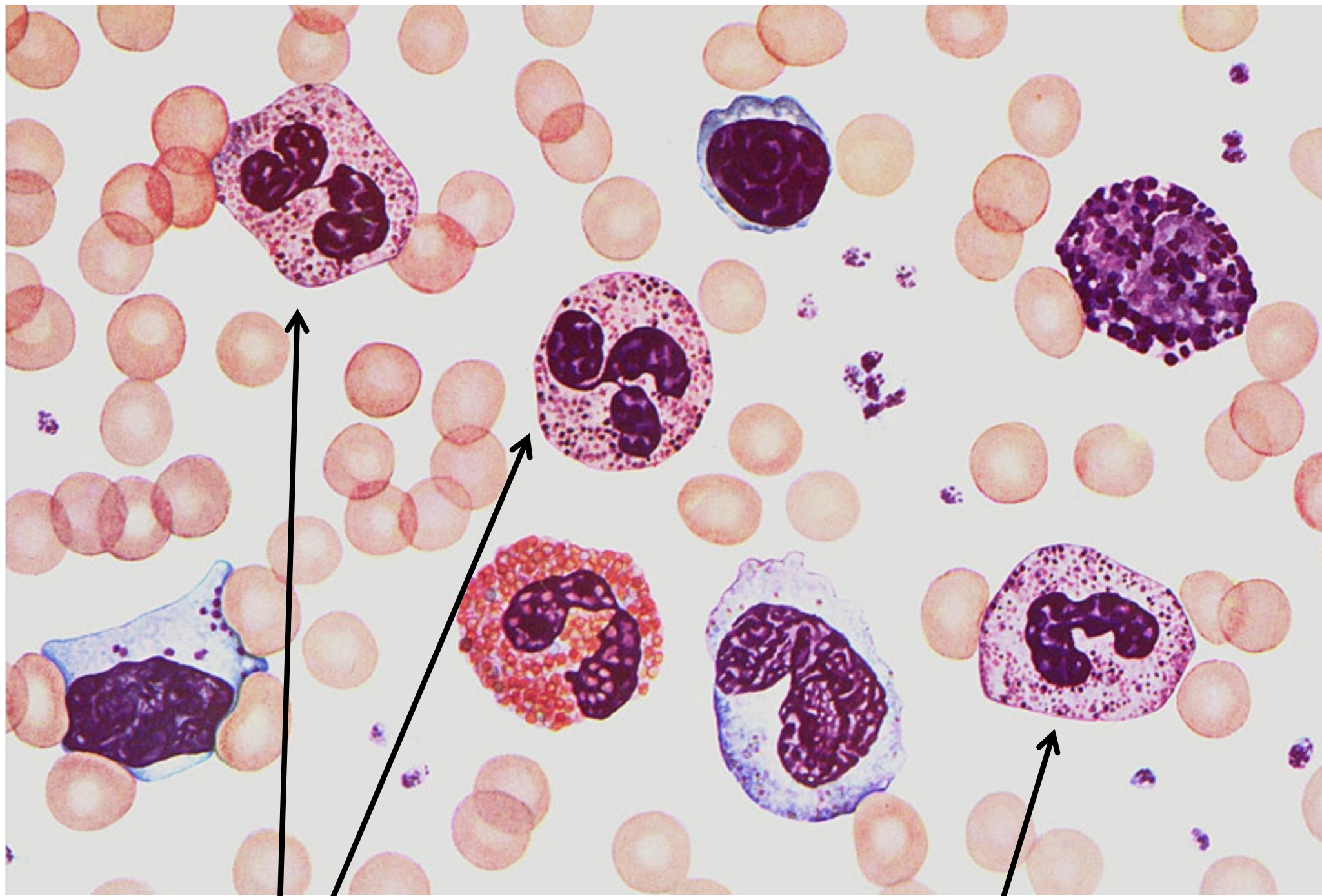
Granulocytes vs. agranulocytes

Blood Lecture Outline

- Introduction
- Erythrocytes
- Platelets
- Leukocytes
 - Granulocytes

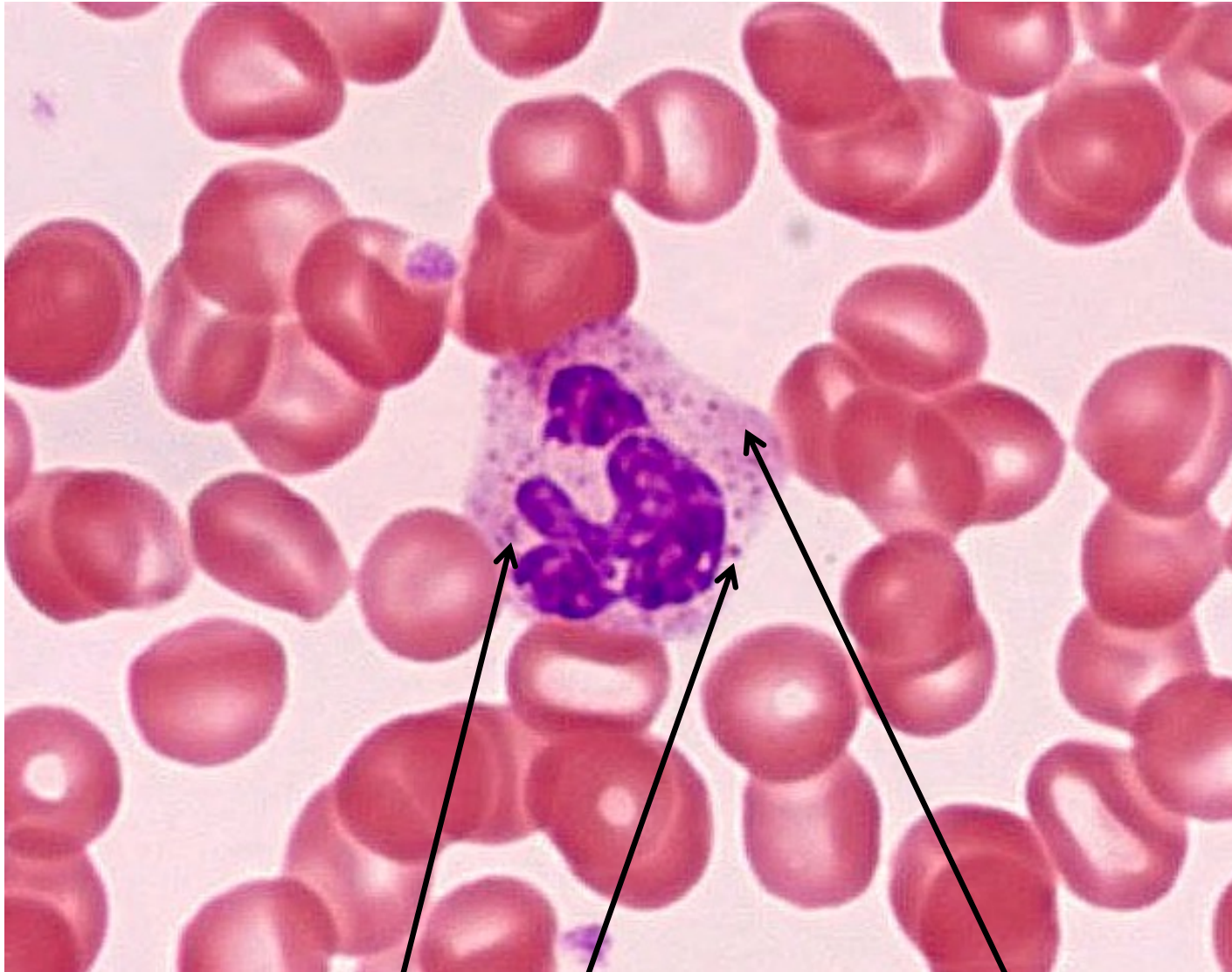
Neutrophils

- 45-75% of differential count (between $2-8 \times 10^9/L$)
- About 15 μm in diameter
- Multi-lobed nucleus...
- ...hence their other name: “polymorphonuclear leukocyte” (PMN)
- Two kinds of granules:
 - Azurophilic (primary, purple) granules (a few)
 - Neutrophilic (secondary, pink) granules (lots)

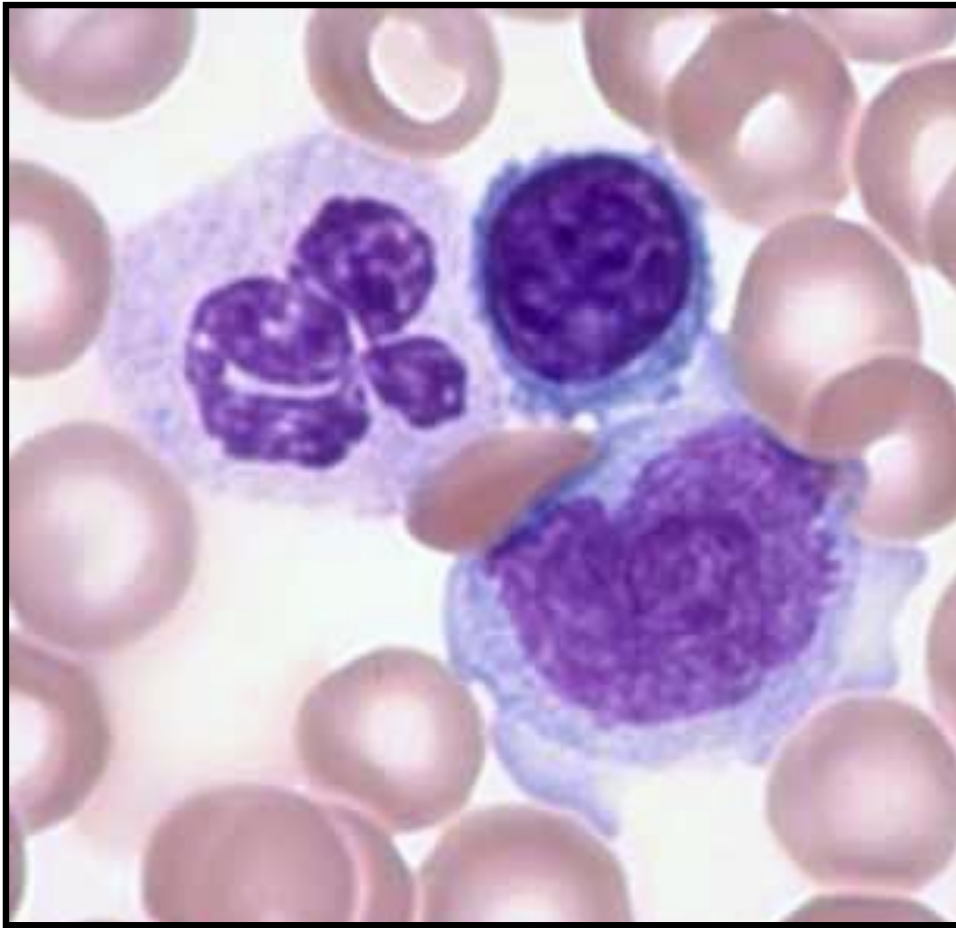


Normal neutrophils

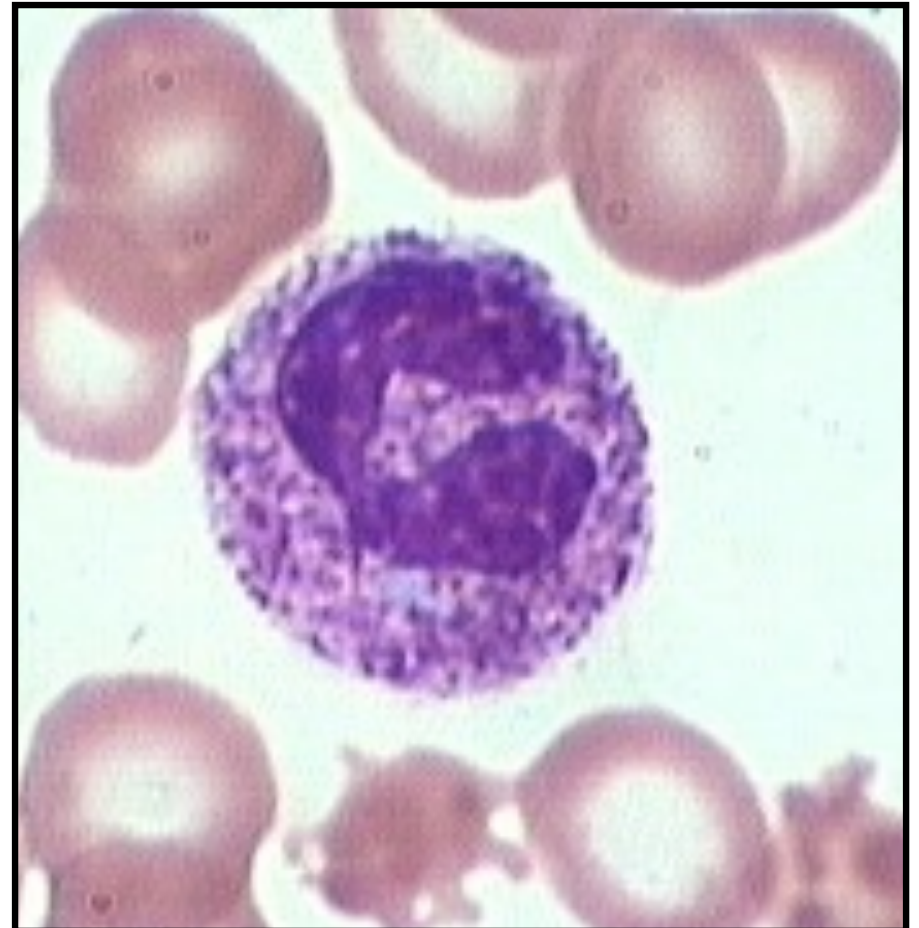
Immature neutrophil



Neutrophil: azurophilic vs. neutrophilic granules
(hard to see on screen!)

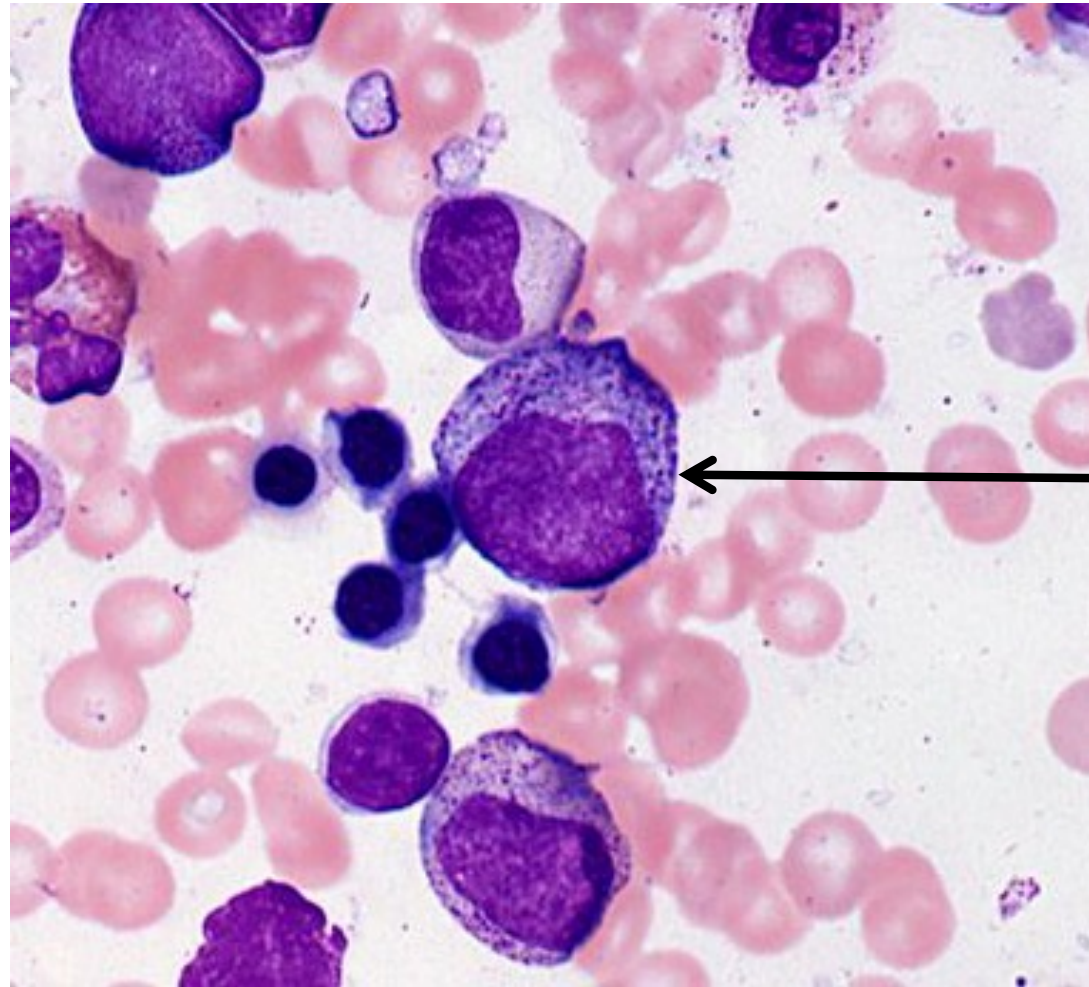


Normal neutrophil
(top left)



Neutrophil from patient
with bacterial infection

Azurophilic granules become much more prominent during bacterial infection.



promyelocyte

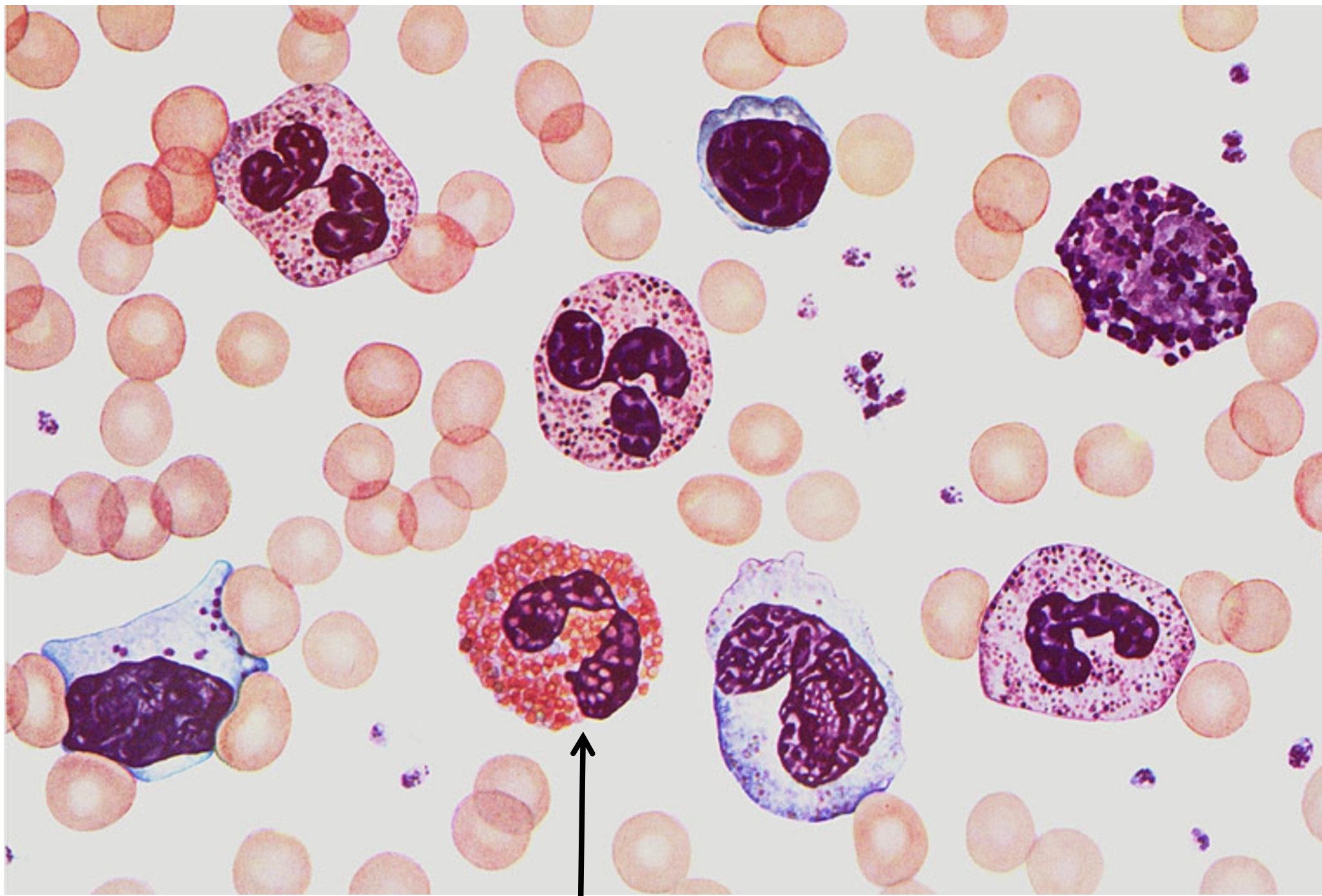
Azurophilic granules first appear in less mature neutrophils called promyelocytes. Promyelocytes divide, distributing their azurophilic granules evenly (which means more mature neutrophils have fewer azurophilic granules).

Neutrophil Functions

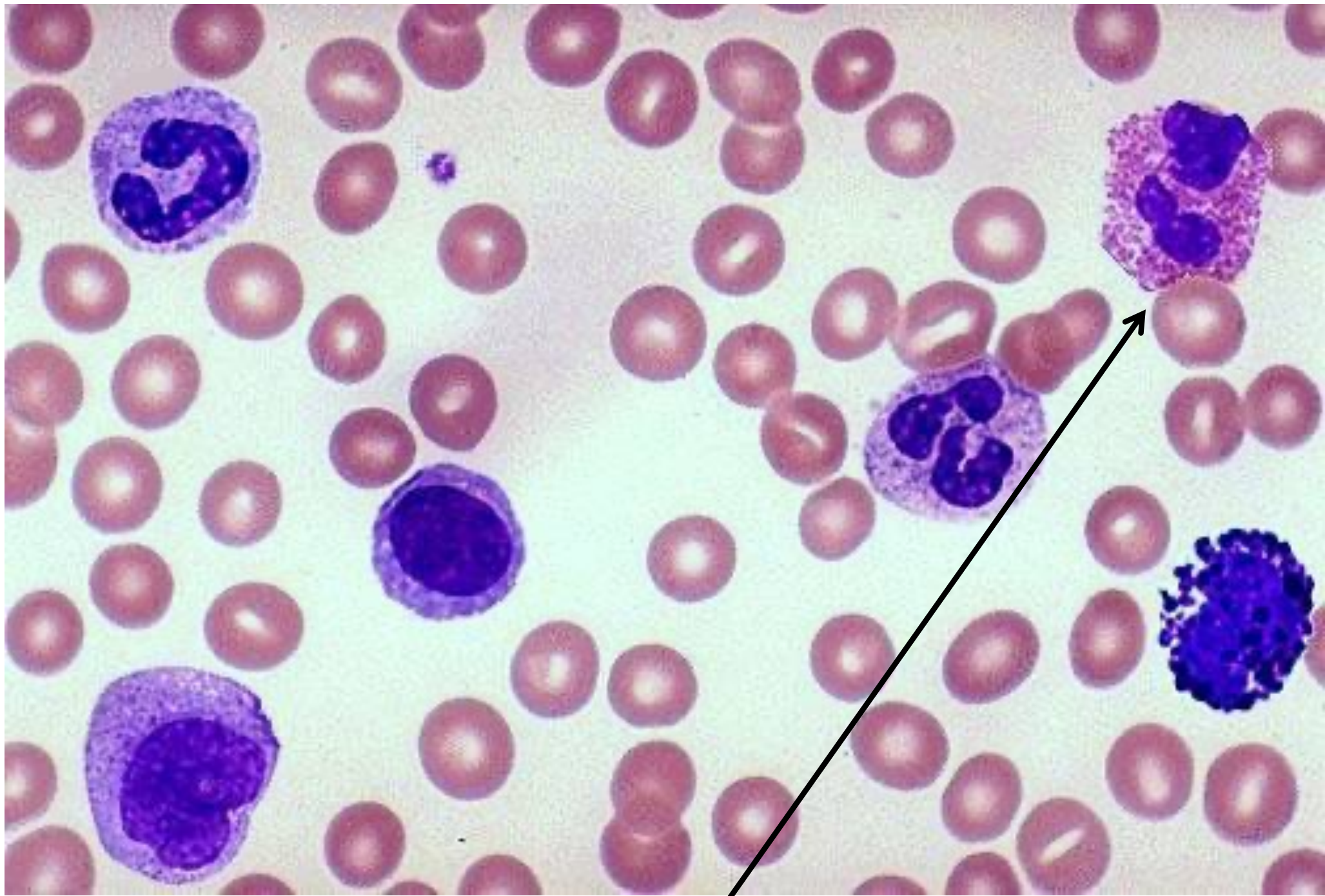
- First line of defense against invaders (bacteria, foreign objects)
- Spend a few hours in blood, then migrate quickly to site of infection where they spend a few days
- Kill invaders by phagocytosis and by enzymatic destruction (nasty!)
- Then take off and let others (macrophages) clean up the mess

Eosinophils

- 1-4% of differential count (about $0.5 \times 10^9/\text{L}$)
- About 15 μm in diameter
- Large, gorgeous, orange-red (eosinophilic) granules in cytoplasm
- Greek *eos* = first blush of dawn
- Bi-lobed nucleus



Eosinophil



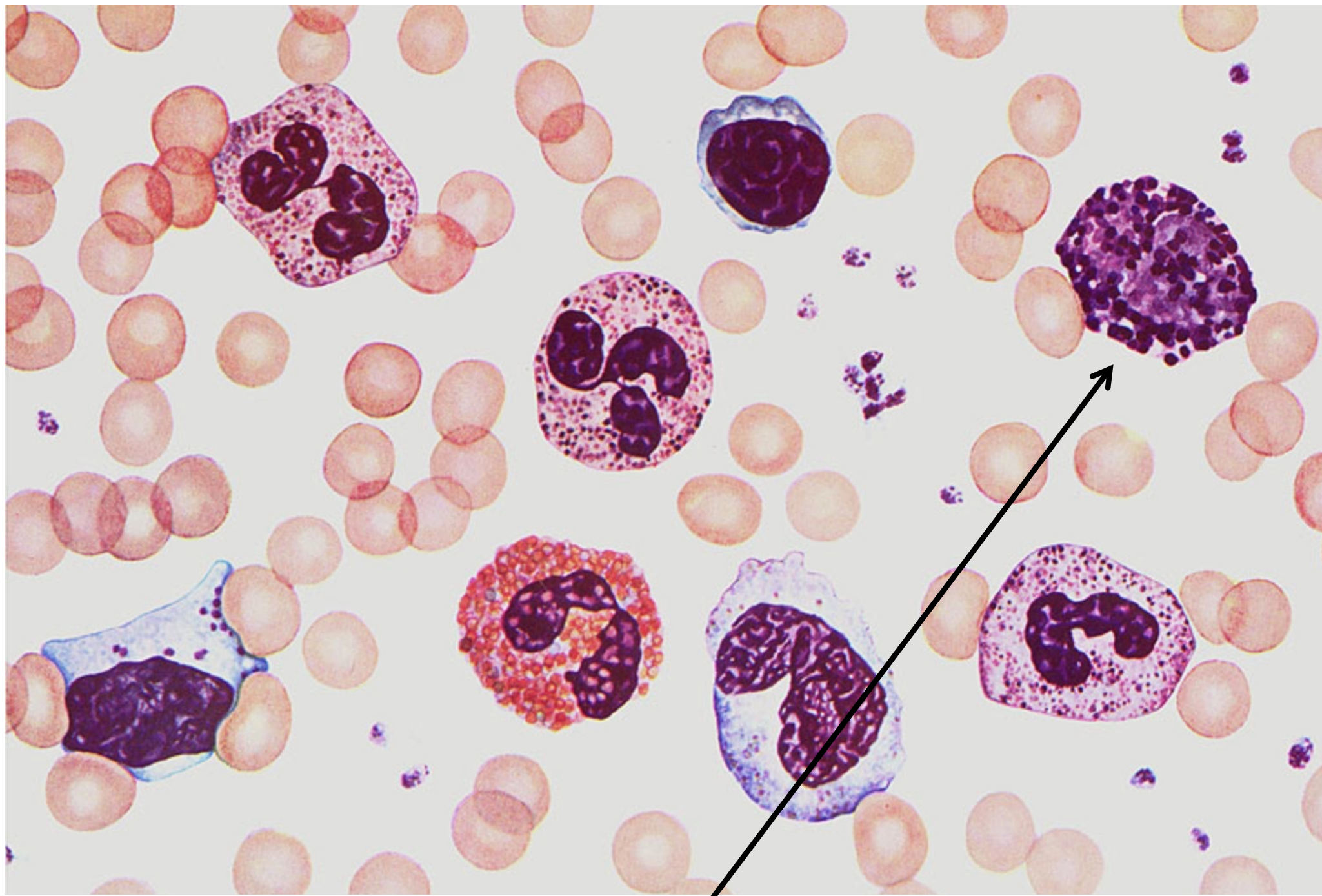
Eosinophil in real life

Eosinophil Functions

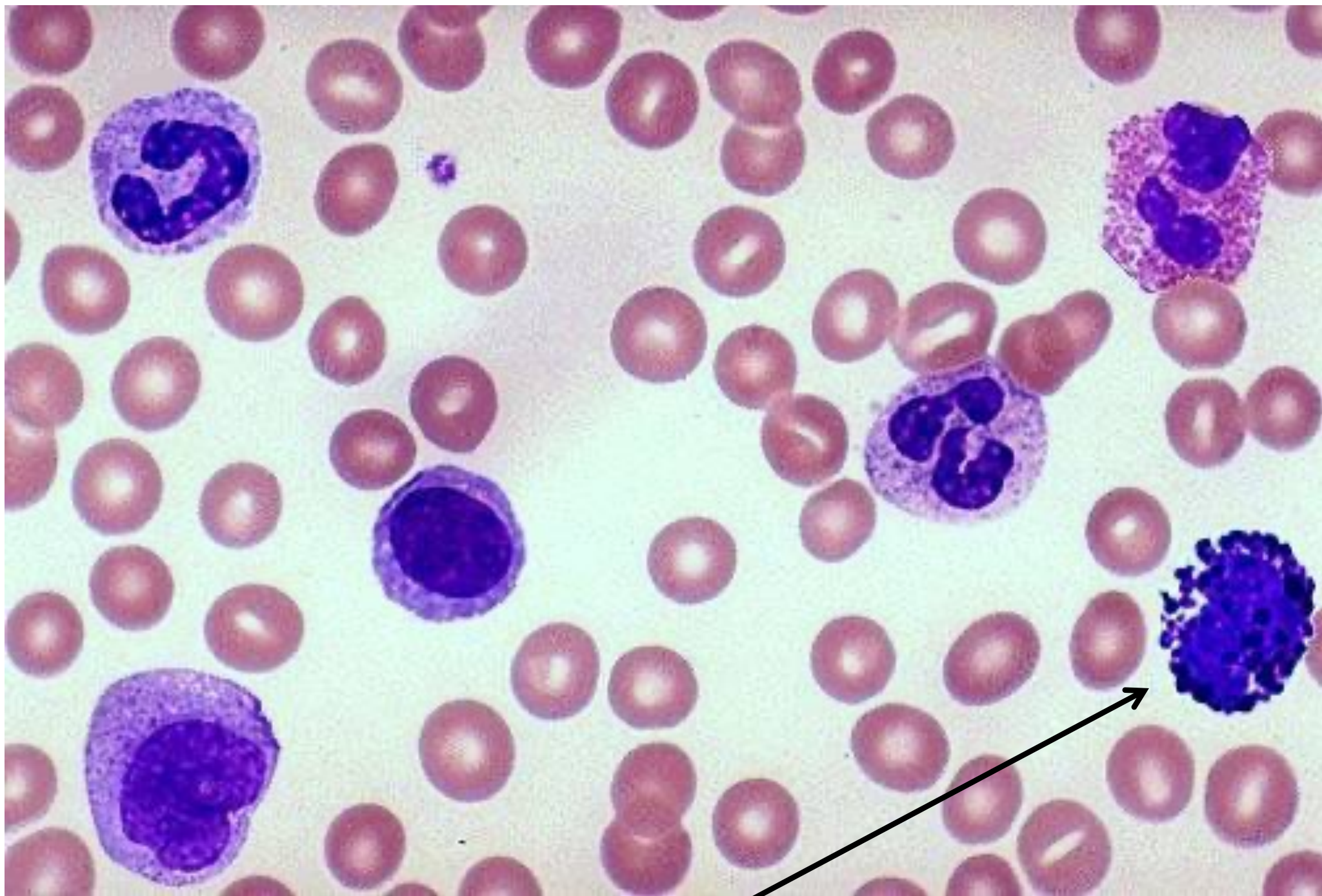
- Major cell involved in allergic reactions (like hay fever and asthma)
- Good at killing parasites (granules contain major basic protein)
- Also involved in drug reactions
- Help modulate immune responses

Basophils

- Less than 1% of differential count (less than $0.3 \times 10^9/L$)
- About 10 μm in diameter
- Tons of large, deep blue (basophilic) granules in cytoplasm
- Irregularly-shaped nucleus (hard to see under all those granules)
- Functions: fight infection, mediate allergic responses



Basophil



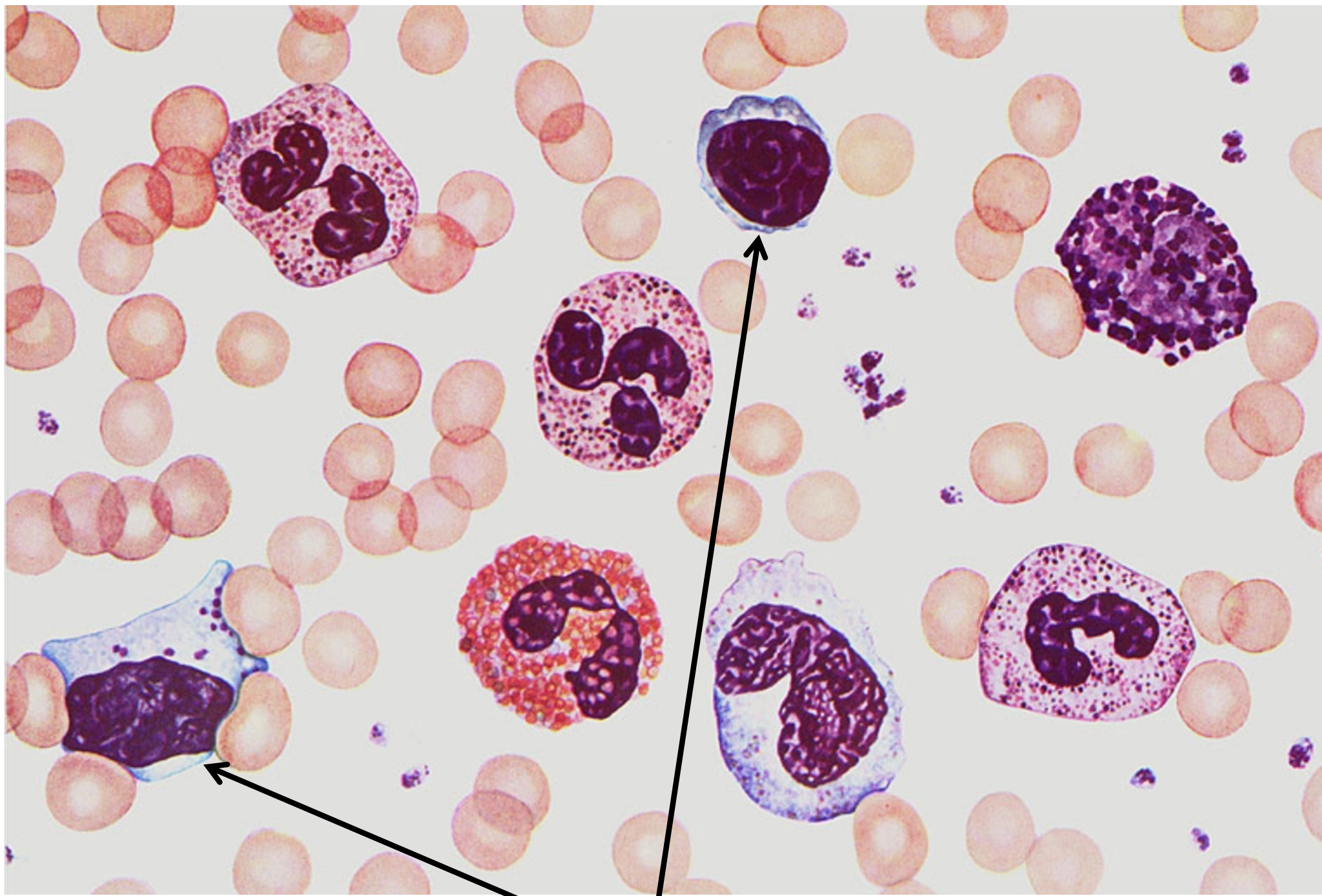
Basophil in real life

Blood Lecture Outline

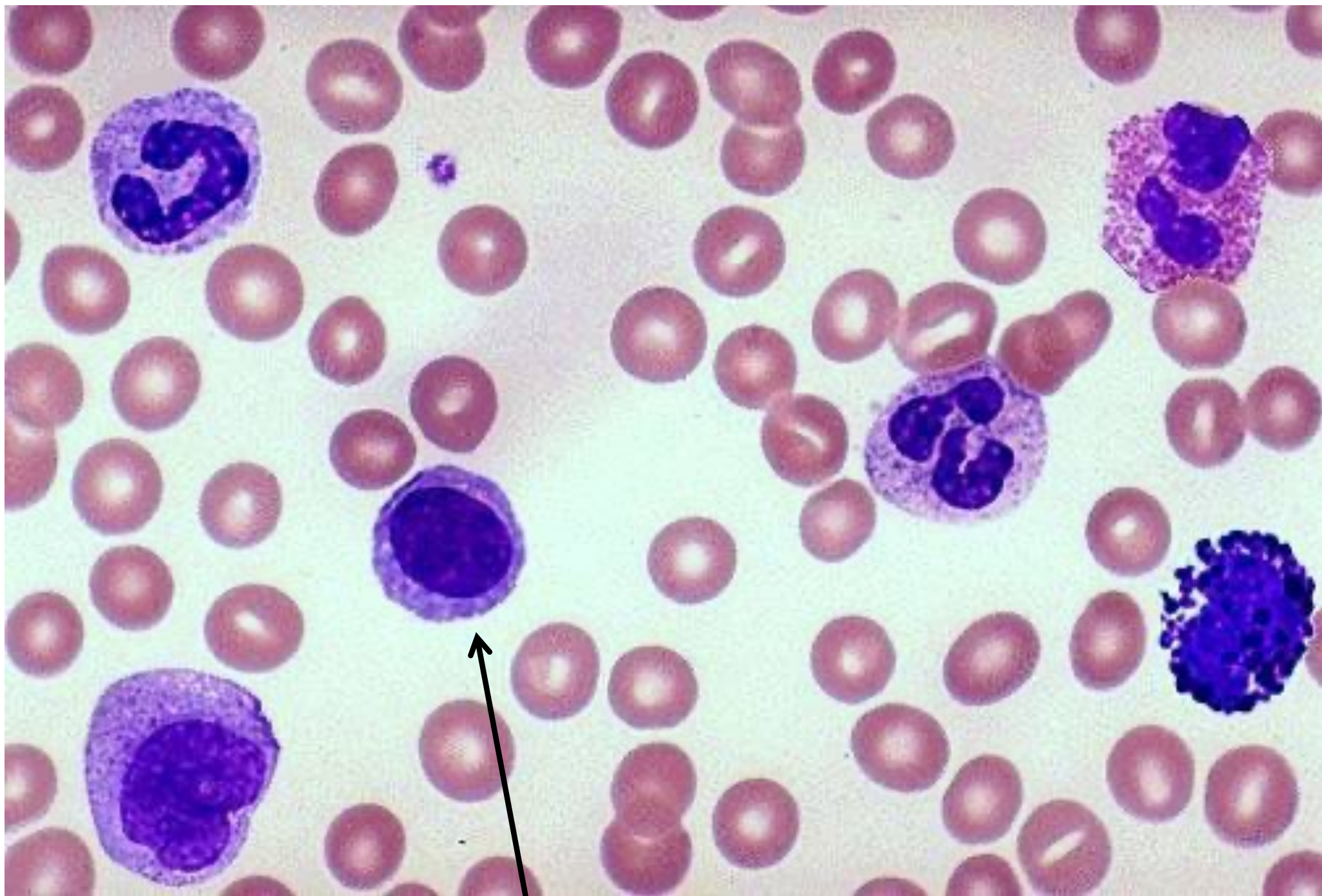
- Introduction
- Erythrocytes
- Platelets
- Leukocytes
 - Granulocytes
 - Agranulocytes

Lymphocytes

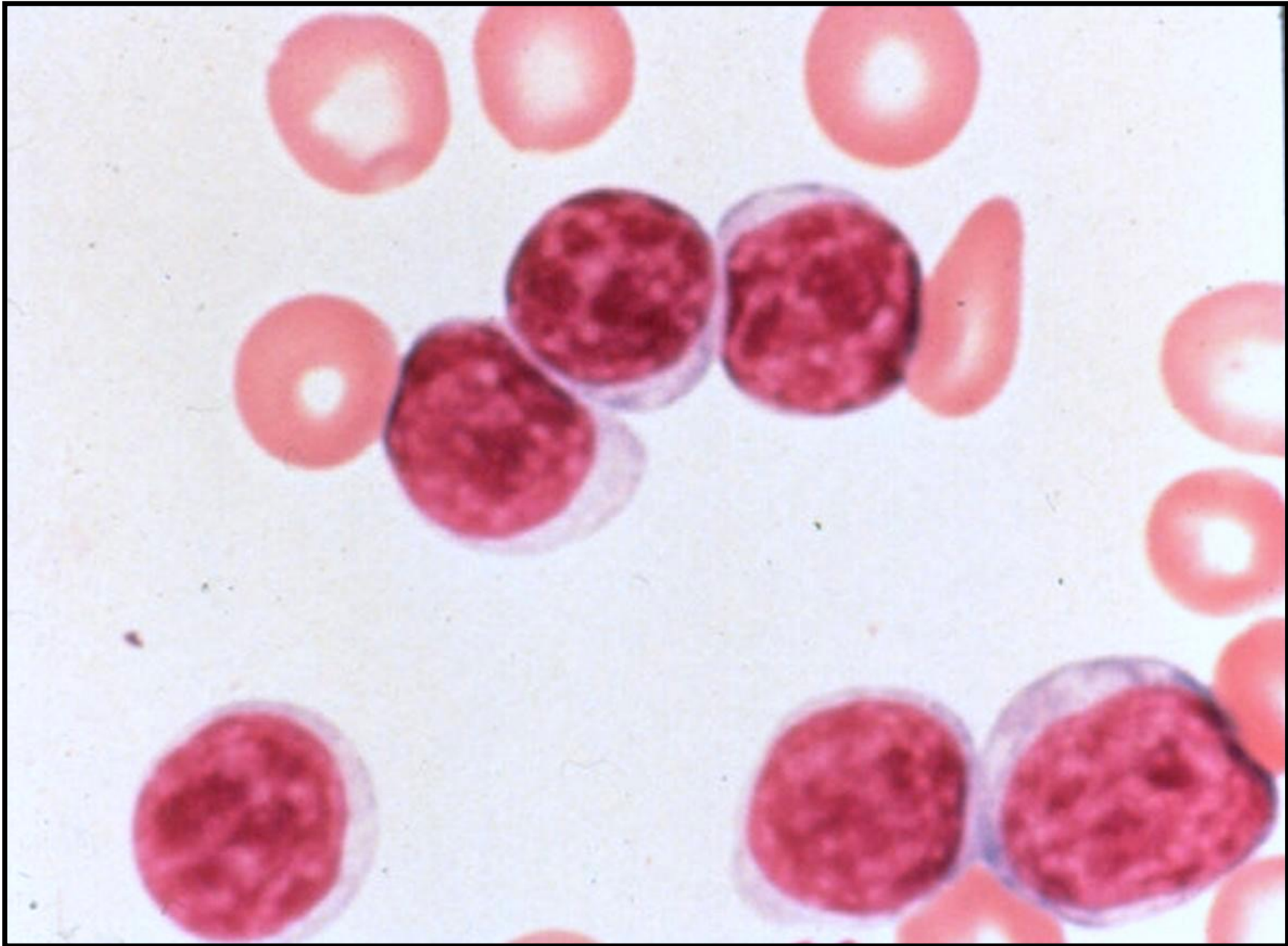
- 20-50% of differential count (between $1-4 \times 10^9/L$)
- Most lymphocytes are small (6-12 μm) but some are larger (up to 20 μm)
- Nucleus: dark staining; “clumpy and smudgy”
- Two main types (which look pretty much the same):
 - B-lymphocytes
 - T-lymphocytes



Normal lymphocytes

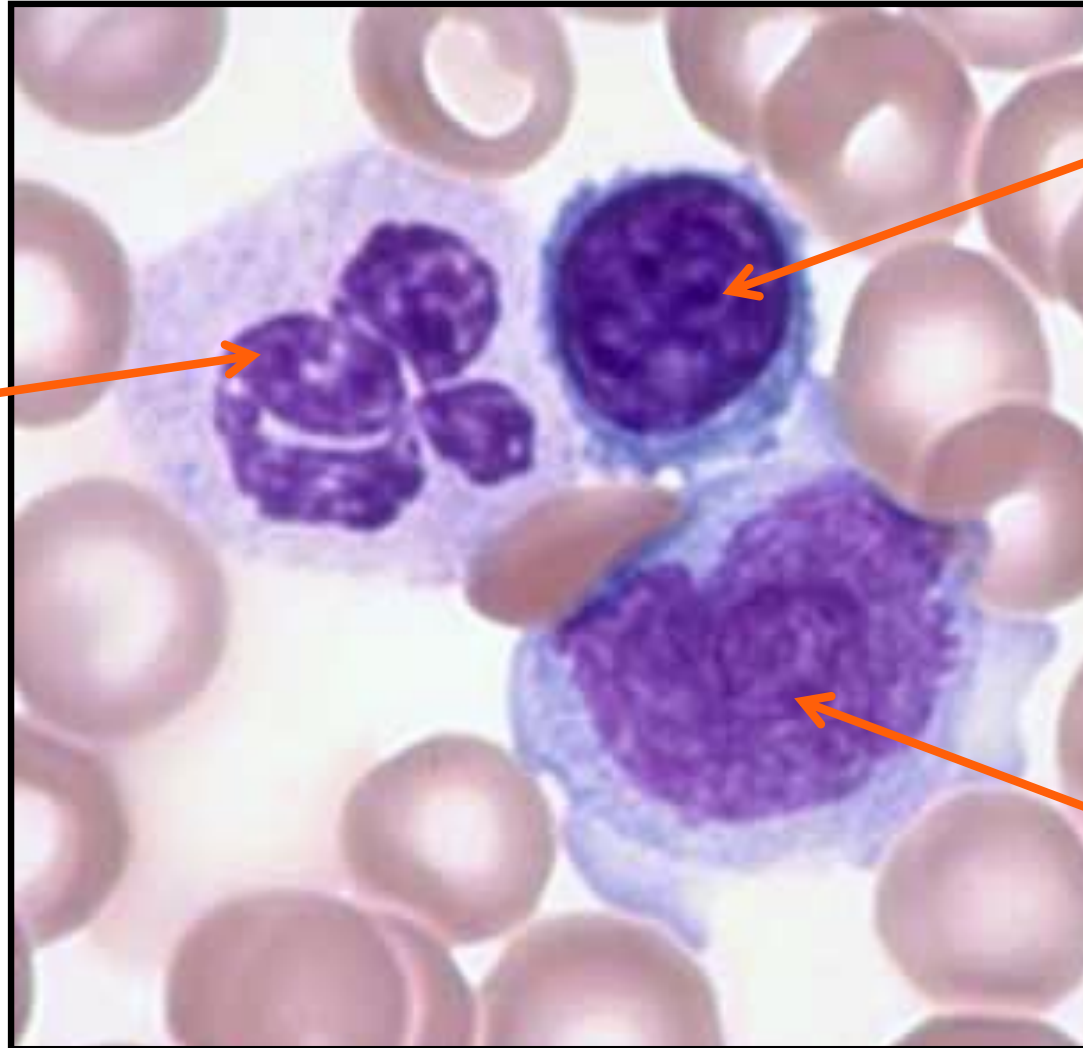


Small lymphocyte in real life



Lymphocyte chromatin pattern: clumpy *and* smudgy

**Neutrophil
chromatin:**
distinct clumps
(with white
space between
clumps)



**Lymphocyte
chromatin:**
clumpy but
also smudgy
(no white
space between
clumps)

**Monocyte
chromatin:**
not really
clumpy

B-Lymphocytes

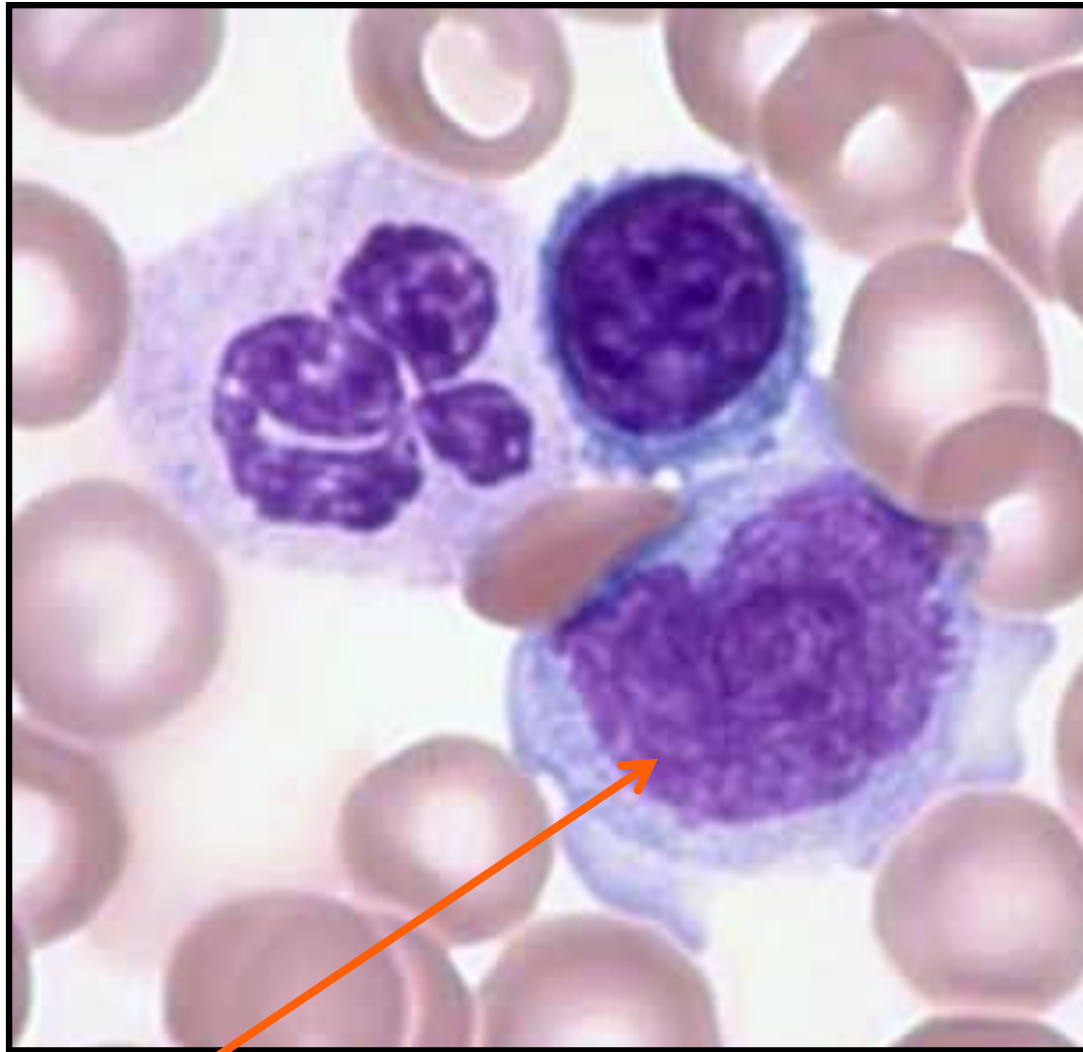
- 15% of circulating lymphocytes
- Develop in **b**ursa of Fabricius (in birds) and in **b**one marrow (in humans)
- Further maturation occurs in lymphatic tissues (lymph nodes and spleen)
- Ultimately, become either plasma cells (which make antibodies) or memory cells (which “remember” previous infections)

T-Lymphocytes

- About 85% of circulating lymphocytes
- Develop and mature in **t**hymus
- Also found in bone marrow and lymphoid tissues, along with B cells
- Ultimately, most become either cytotoxic T cells (which kill infected cells) or helper T cells (which help other immune cells do their jobs)

Monocytes

- 1-8% of differential count (between $0.1-0.8 \times 10^9/L$)
- 12-20 μm in diameter
- Nucleus: indented, oval, kidney, or horseshoe-shaped. “Raked” chromatin.
- Cytoplasm: “dishwater” (gray-blue) color, sometimes with little vacuoles and/or tiny azurophilic granules



Monocyte: large cell with “dishwater” cytoplasm
and “raked” chromatin

Monocyte Function

- Differentiate into macrophages (histiocytes) in different organs
 - Foreign body giant cells (anywhere)
 - Kupffer cells (liver)
 - Microglial cells (brain)
 - Alveolar macrophages (lung)
- Second line of defense against invading organisms
- Help lymphocytes do their job; also phagocytic (eat up invaders and either get rid of them or present bits of them to lymphocytes)

Blood Lecture Outline

- Introduction
- Erythrocytes
- Platelets
- Leukocytes
 - Granulocytes
 - Agranulocytes