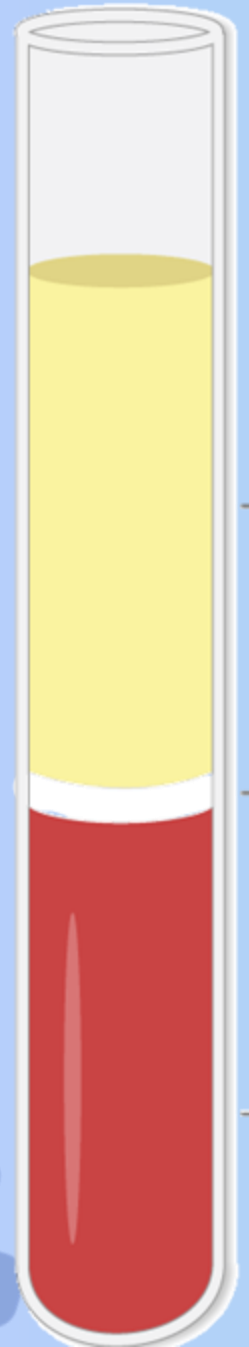
BLOOD COMPOSITION

Presented by Sam Gordon

HEMATOCRIT TUBE



- Blood sample is spun in a centrifuge → Separates into **three layers:**
  - **Plasma** (Top, ~55%)
  - **Buffy coat (WBCs & platelets)** (Middle, <1%)
  - **RBCs (Bottom, ~45%) → Hematocrit**

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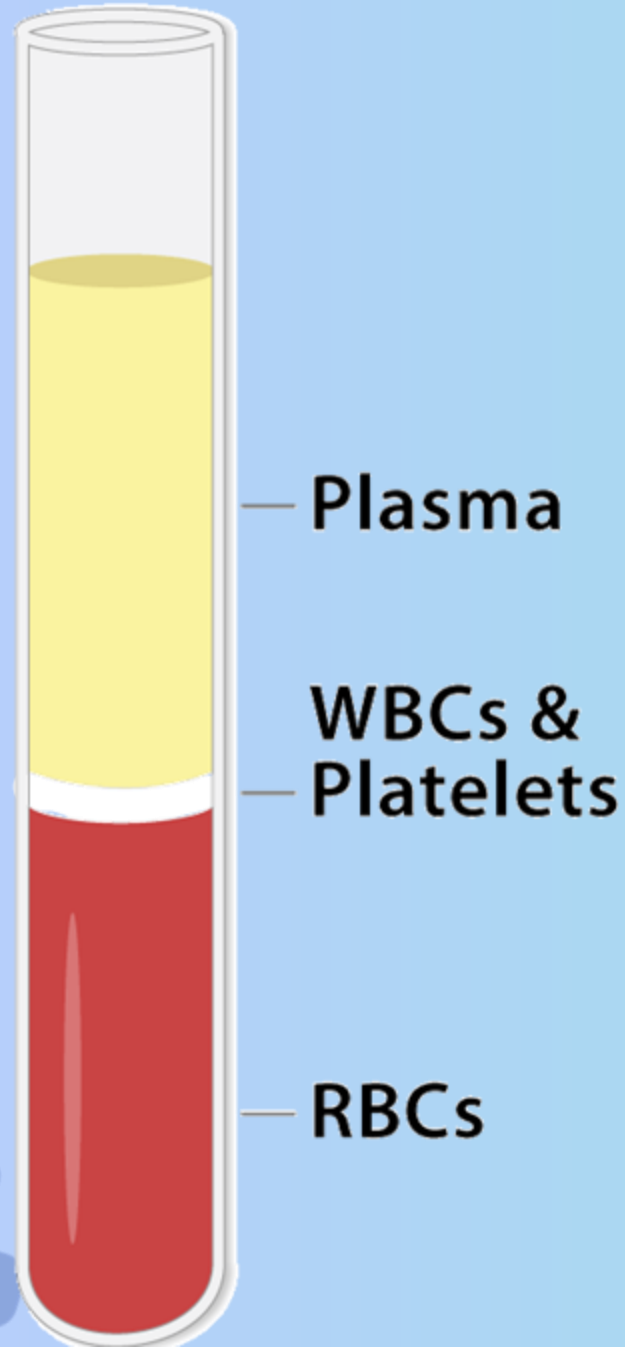

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Blood is a Tissue?

- Blood is a **fluid connective tissue** because:
  - It originates from **mesoderm**
  - It has **cells** suspended in an **extracellular matrix (plasma).**

- **Why is blood a special tissue?**
  - Unlike solid tissues, it **flows** yet retains the ability to **coagulate and solidify** when necessary (e.g., clotting).

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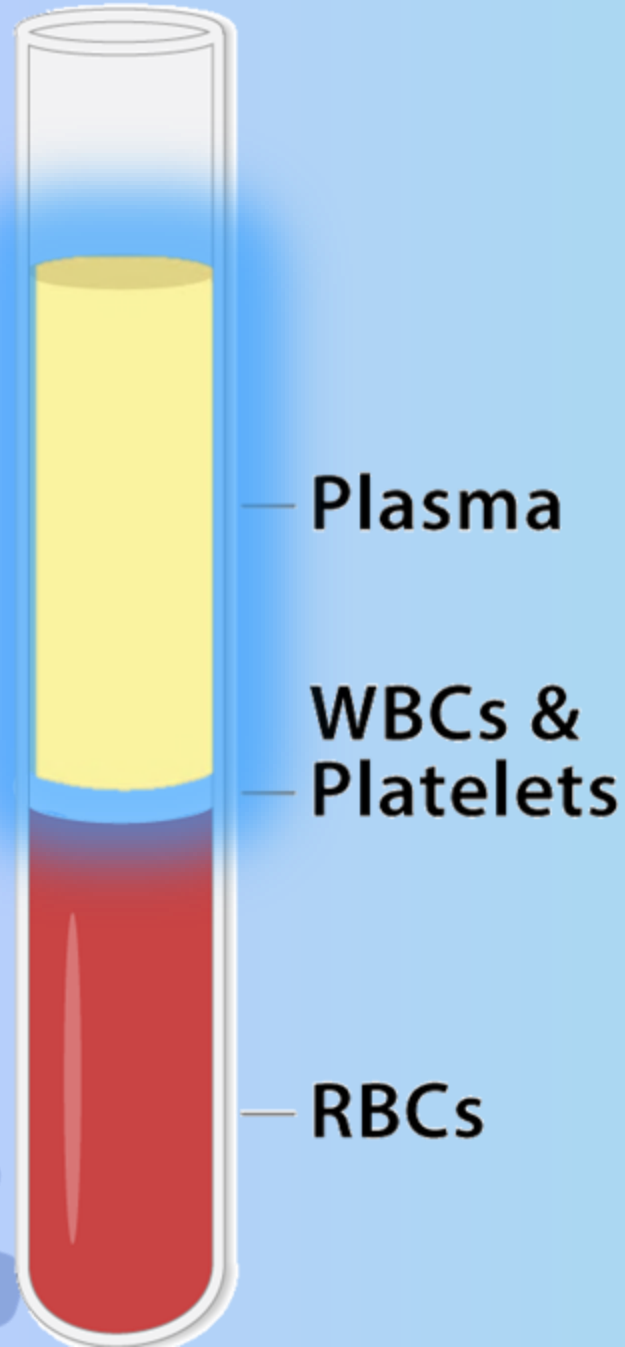

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Plasma (from Greek πλάσμα, plásma):

"something formed or molded."

Fluid, adaptable state of matter.

Plasma is a fluid **medium** that transports cells and nutrients.

Plasma Composition

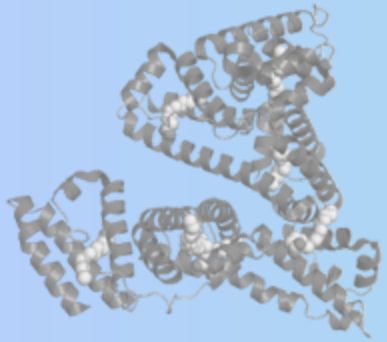
Main Components:

- **Water (90-92%)**
- **Proteins (7-8%)**

Lesser Components:

- Electrolytes
- Gases
- Hormones
- Nutrients

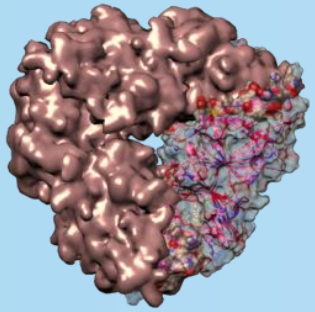
Proteins (7-8%)



Albumin:

(Latin albus = white)

keeps fluid in vessels (oncotic pressure)



Globulins:

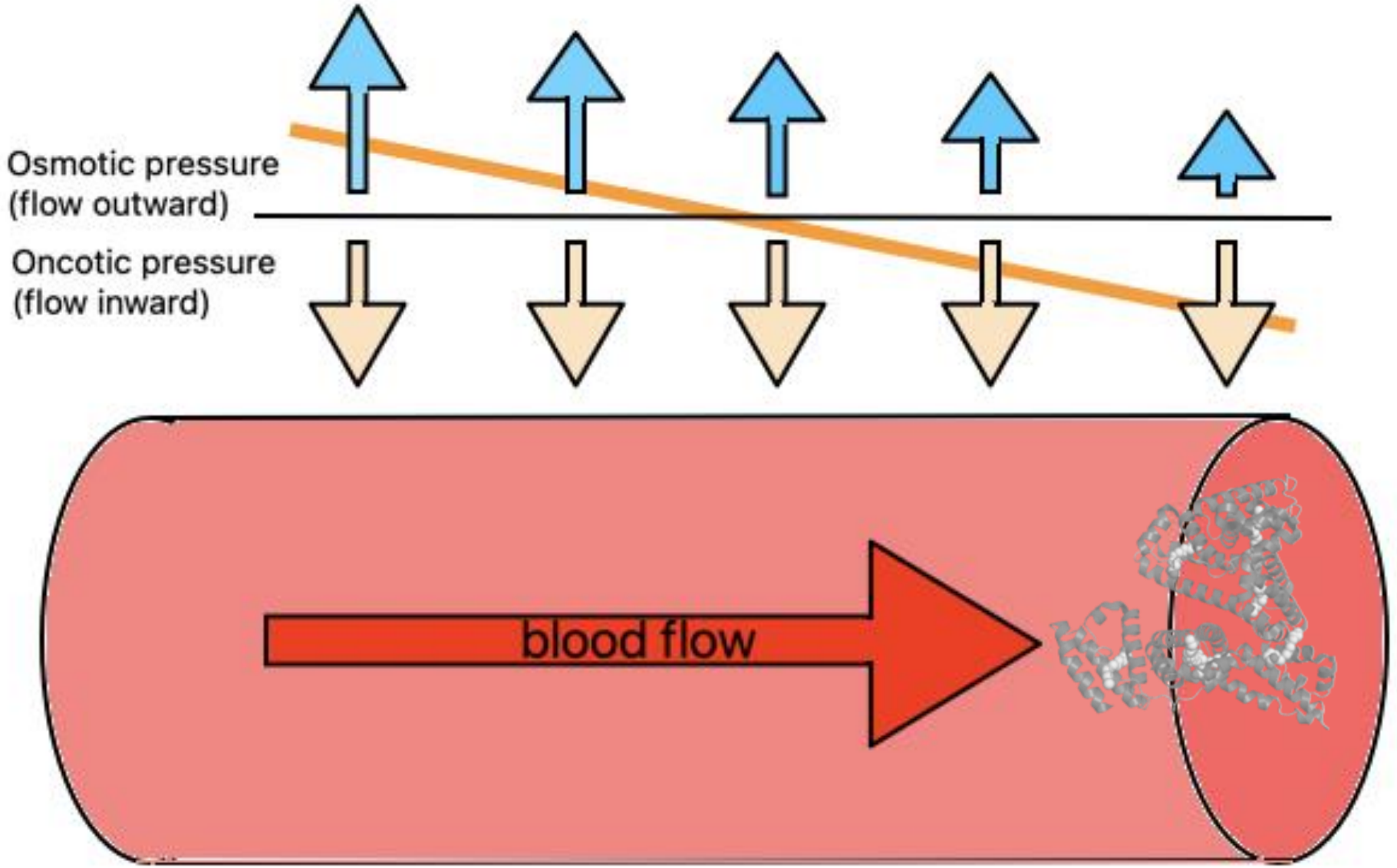
(Latin globus = sphere)

Some for immune defense - antibodies (immunoglobulins)

Fibrinogen:

(fibra = fiber, gen = to generate)

clotting protein


Osmotic pressure
(flow outward)
Oncotic pressure
(flow inward)
blood flow

Electrolytes

Sodium (Na^+):	Maintains fluid balance & nerve impulses
Potassium (K^+):	Muscle function & nerve signaling
Calcium (Ca^{2+}):	Bone health, blood clotting, muscle contraction
Magnesium (Mg^{2+}):	Enzyme activation, nerve & muscle function
Chloride (Cl^-):	Osmotic balance & acid-base regulation
Bicarbonate (HCO_3^-):	pH buffer for acid-base homeostasis

Hormones

Insulin (pancreas):	*Lowers blood glucose*
Glucagon (pancreas):	*Raises blood glucose*
Cortisol (adrenal gland):	*Stress response, metabolism*
Thyroxine (thyroid):	*Metabolism*
Epinephrine (adrenal gland):	*Sympathetic Response*

Nutrients

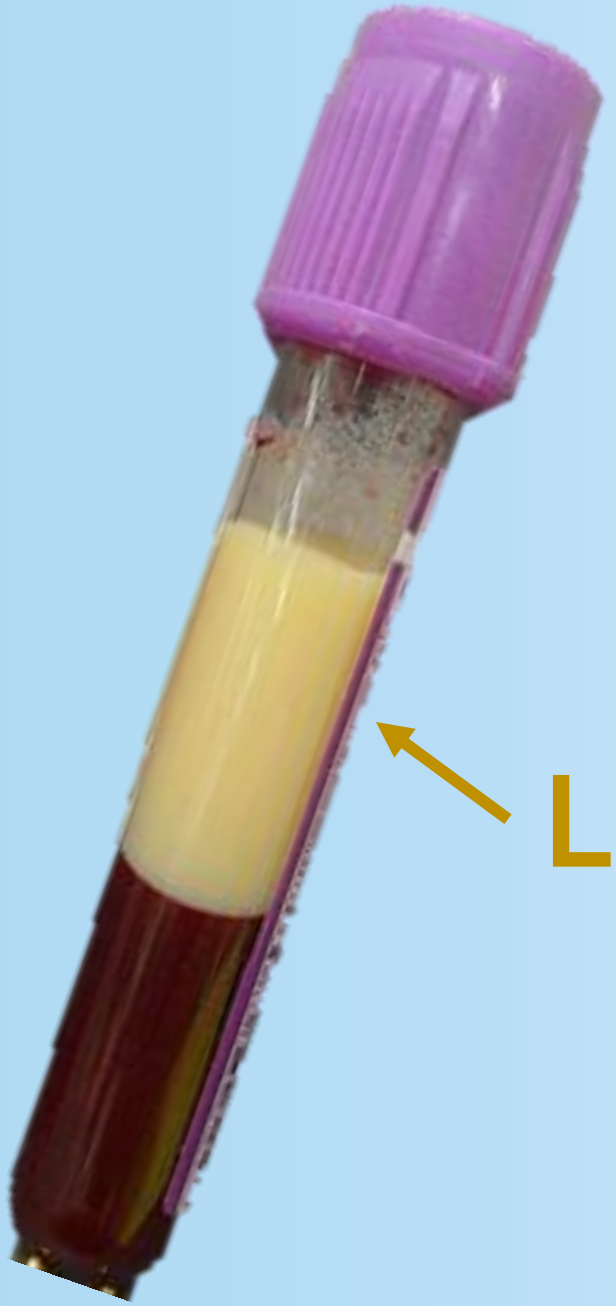
Glucose:	*Energy Source*
Amino Acids:	*Protein Synthesis*
Lipids:	*Fatty acids, Cholesterol, Triglycerides - energy storage and transport*
Vitamins/Minerals:	*Enzyme activity, metabolism, cellular function*

Gases

Oxygen (O_2):	~1.5% dissolved in plasma, most bound to hemoglobin - Essential for cellular respiration
Carbon Dioxide (CO_2):	Transported as **bicarbonate (HCO_3^-) (70%)**, bound to hemoglobin (20%), or dissolved (10%) - Regulates blood pH (via carbonic acid-bicarbonate buffer system)
Nitrogen (N_2):	Inert, minimal function in plasma

Lipids:

We can sometimes see ***hyperlipidemia*** *(high presence of lipids in the blood) in a blood sample!*



Lipid layer

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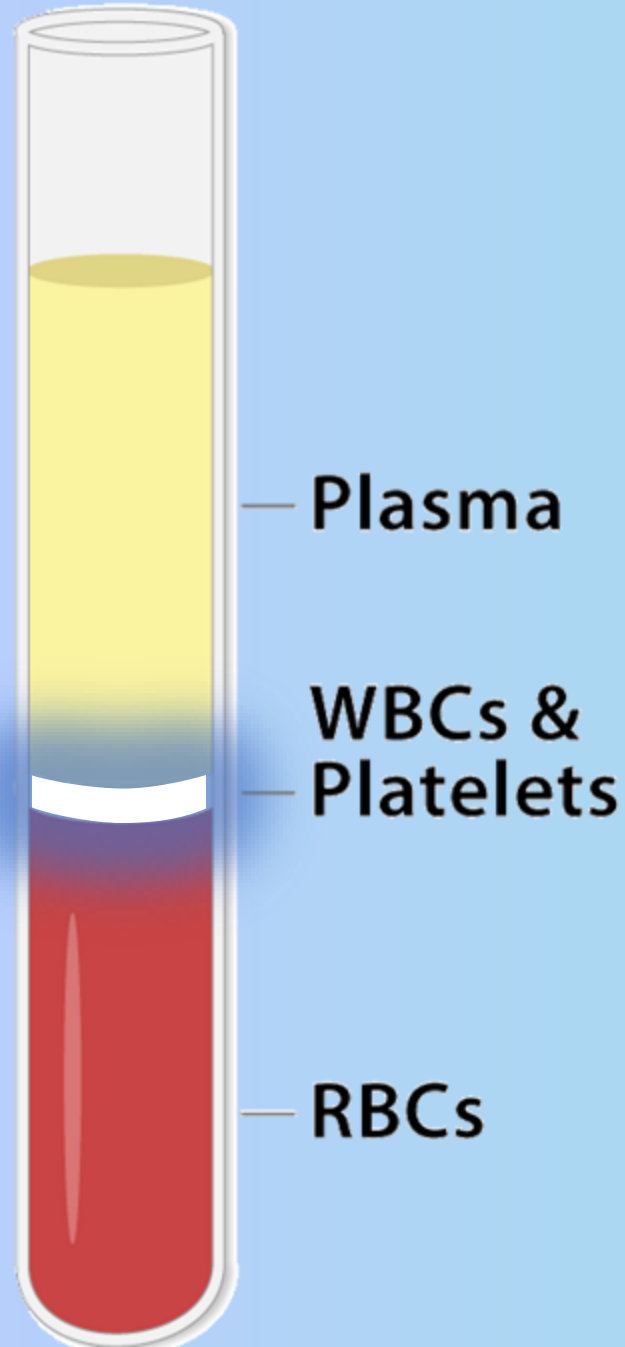

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White Blood Cells

Leuko (Greek λευκός, leukos) = “white”

Cyte = “cell”

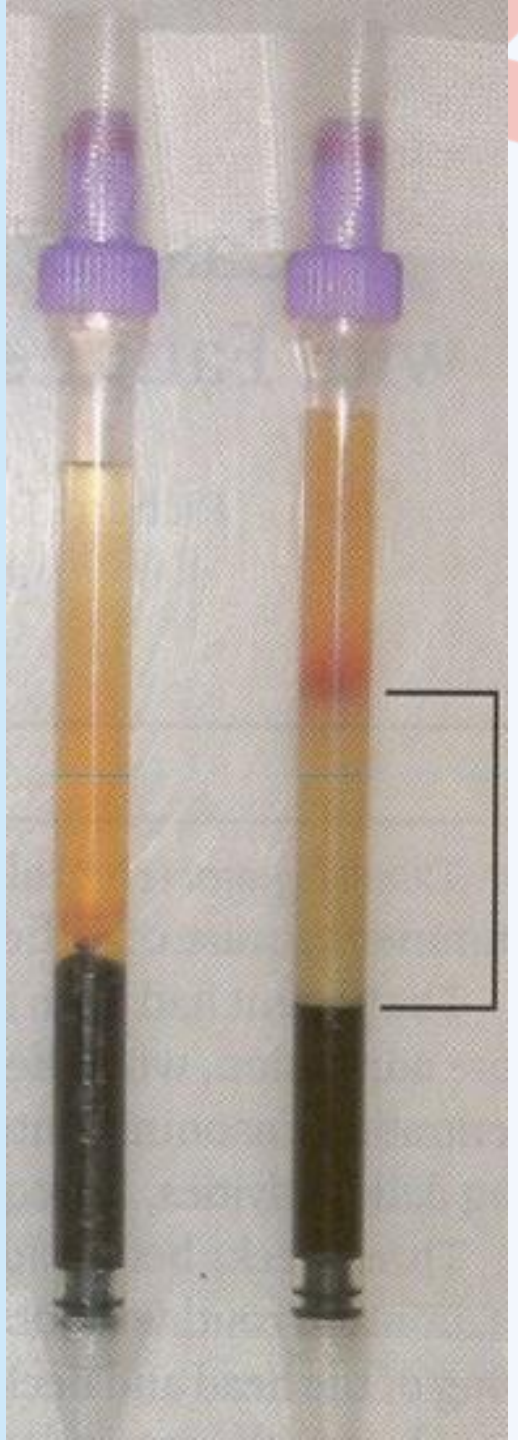
“White Cell”

Why is leukemia called "white blood"?

In leukemia, WBCs proliferate abnormally → **blood turns milky white** in advanced cases

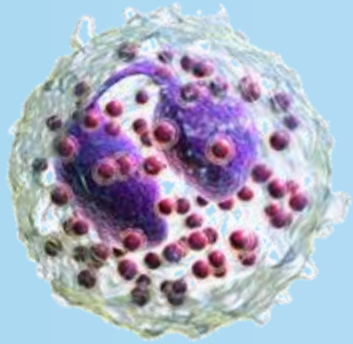
FUN FACT:

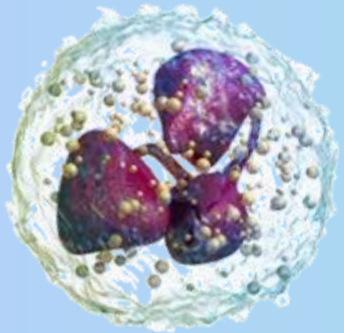
Leukemia = WHITE BLOOD?

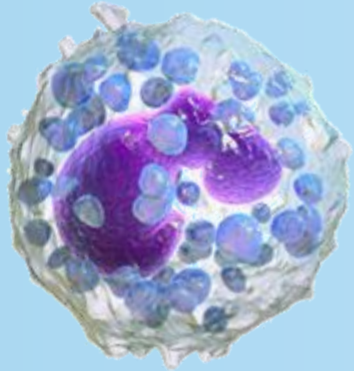


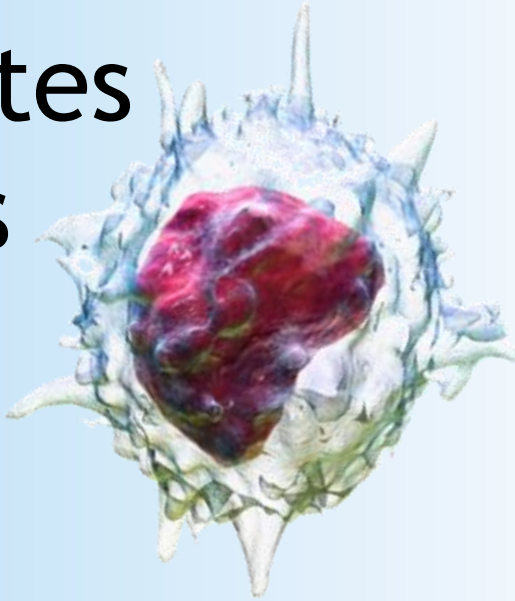
Types of WBCs

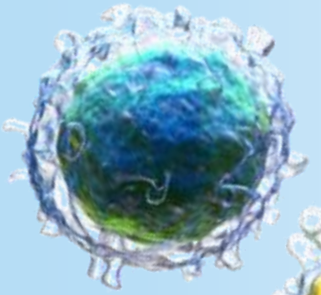
- **Granulocytes**
  - Neutrophils
  - Eosinophils
  - Basophils
- **Agranulocytes**
  - Lymphocytes
  - Monocytes

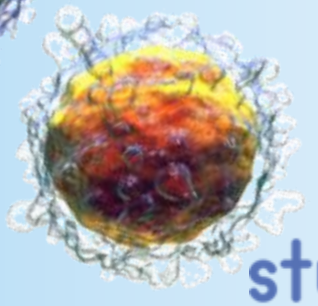












Types of WBCs

- **Granulocytes**
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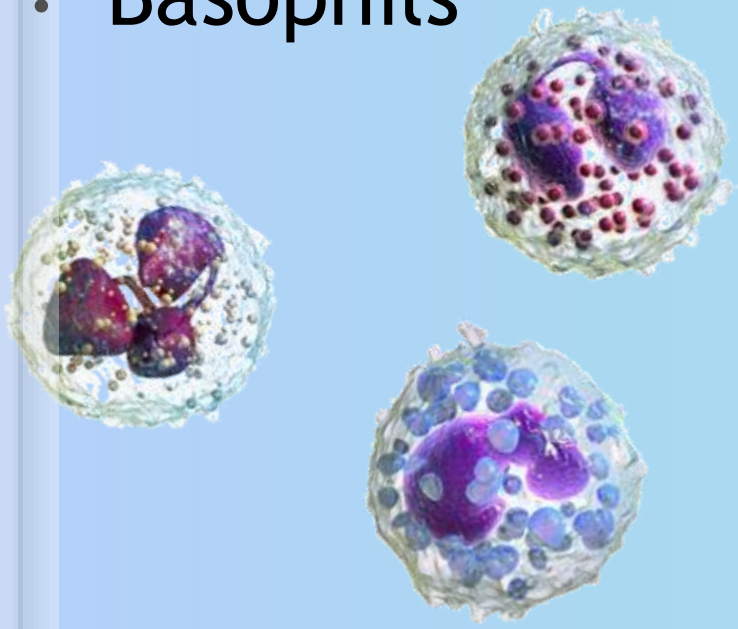
  - Basophils



- **Innate Immunity: Fast Responders!**
  - Release cytoplasmic granules
  - Also called “polymorphonuclear cells”

Neutrophils

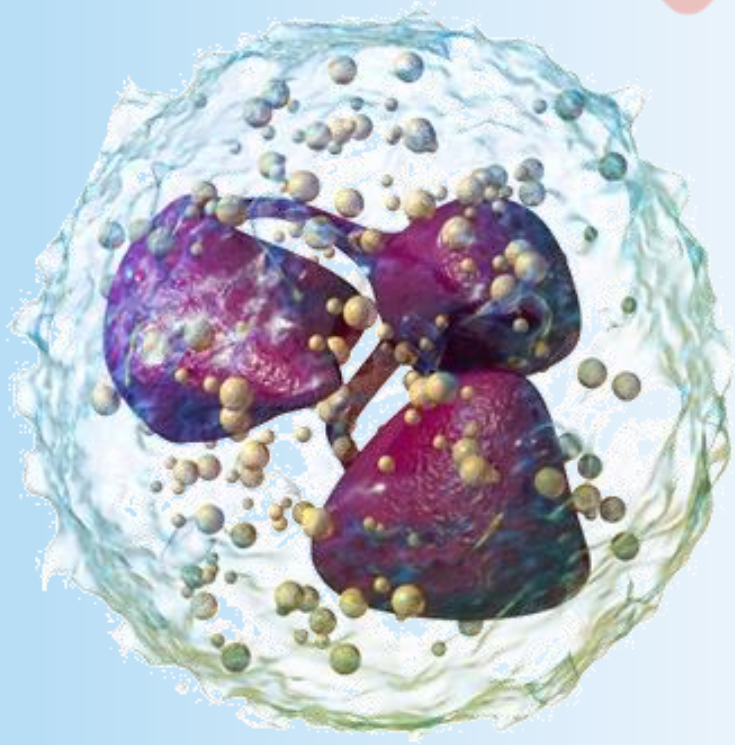
Why neutral?

Neutrophils contain **BOTH acidic and basic granules**, so they don't strongly attract either eosin (acidic) or methylene blue (basic).

Their granules contain **enzymes** which break down bacterial walls during **phagocytosis**

Function:

- **First responders to bacterial infections**
- **Phagocytosis** of microbes, debris, and dead cells



60-70%

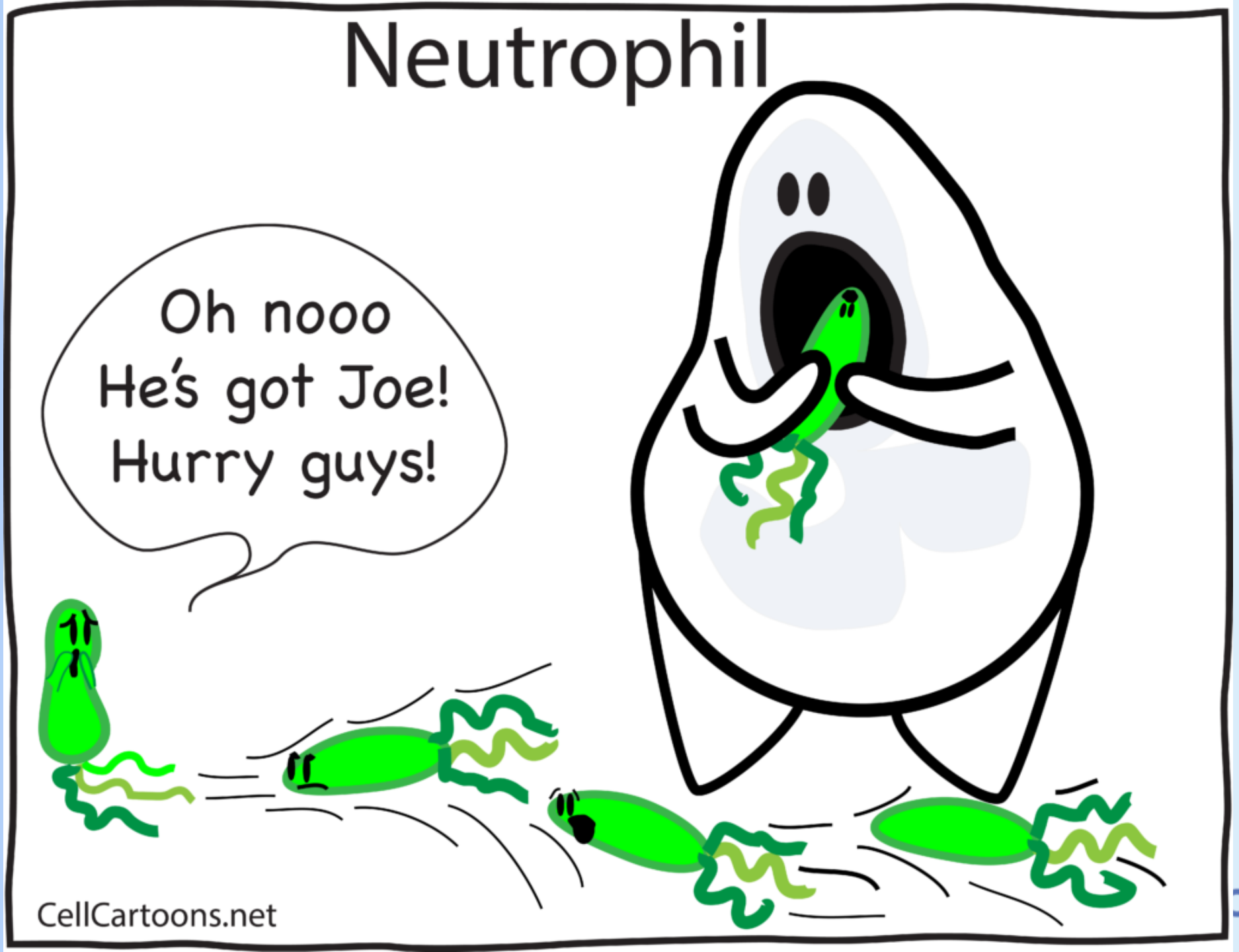
Staining Pattern: Neutral **(light pink/lavender)**

Neutrophils are **NEUTRAL.**

They don’t care what you are, but they mainly want to eat.

- **BACTERIAL DEBRIS**
- **CELLULAR WASTE**

Neutrophil



Eosinophils

Why eosin?

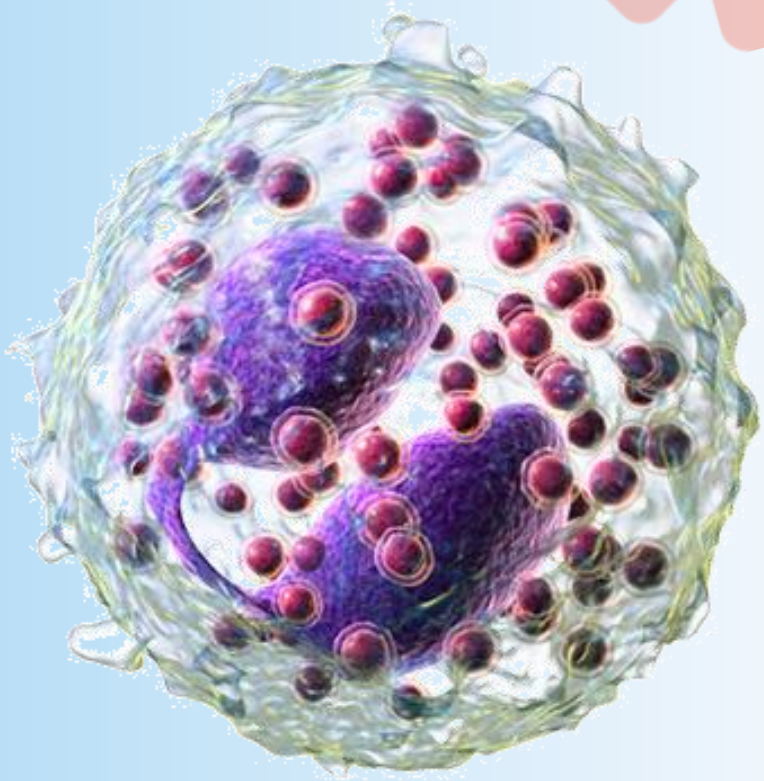
- **Highly basic (cationic, + charged)**, so they **attract acidic dye (eosin, - charged).**

These granules contain:

- **major basic protein (MBP)**
- **eosinophilic peroxidase**
- **cationic proteins**

Function:

- **Destroy parasites** by **oxidizing** their surface
- Allergies!!!



2-4%

Staining Pattern: Bright Red-Pink (eosinophilic)

As far as chemical burns go, **BASIC** chemicals are much worse than **ACIDIC** chemicals.

EOSINOPHILS use **BASIC GRANULES** to **CHEMICALLY BURN PARASITES.**

Basophils

Why base?

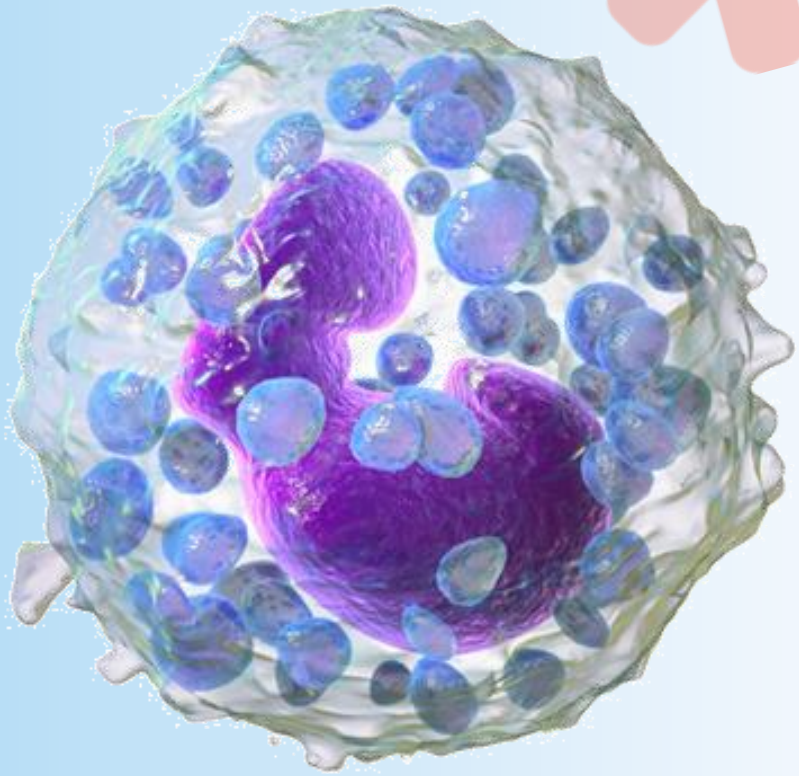
- Basophil granules are highly acidic, so they attract basic dye.

These granules contain:

- **Histamine**
- **Heparin - HIGHLY ACIDIC**
- **Inflammatory mediators**

Function:

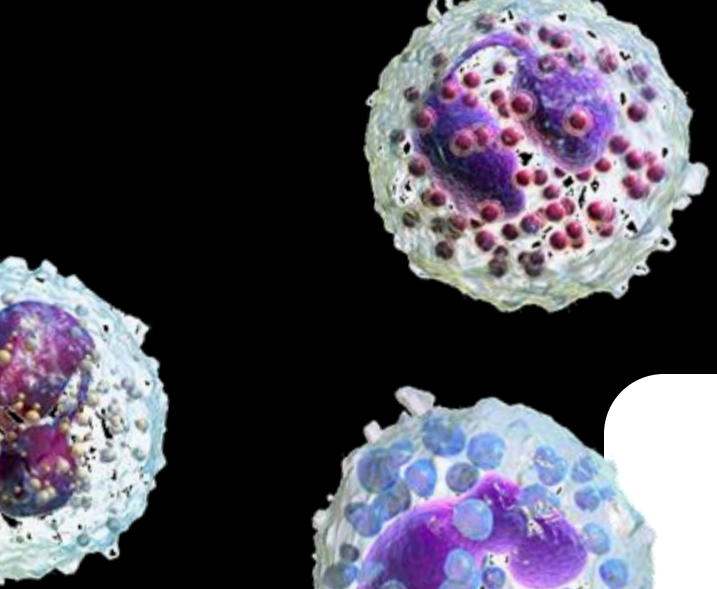
- **vasodilation and increased permeability** during allergic reactions.
- Trigger inflammation & allergic responses by releasing histamine.
- Mediate anaphylactic reactions



<1%

Staining Pattern: Dark Purple - BASOPHILIC

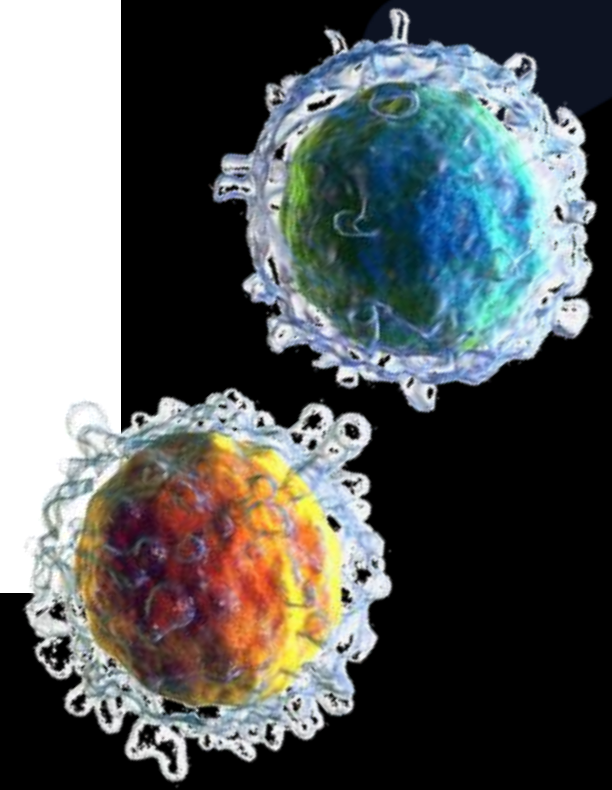

Spring is here!!
Inside the body
Guys, we have pollen
CellCartoons.net
Release the histamine
Arghhh Allergies!!
CellCartoons.net



FUN FACT:

Segmented nuclei (in granulocytes) reduce uncontrolled cell division.

That’s why leukemias primarily arise from **lymphocytes.**



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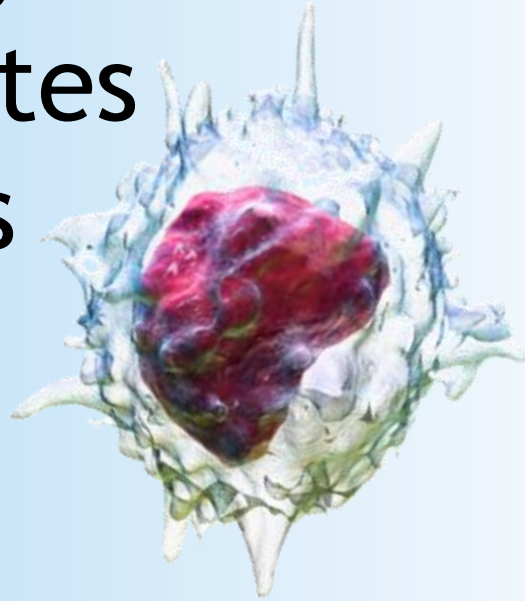
Types of WBCs

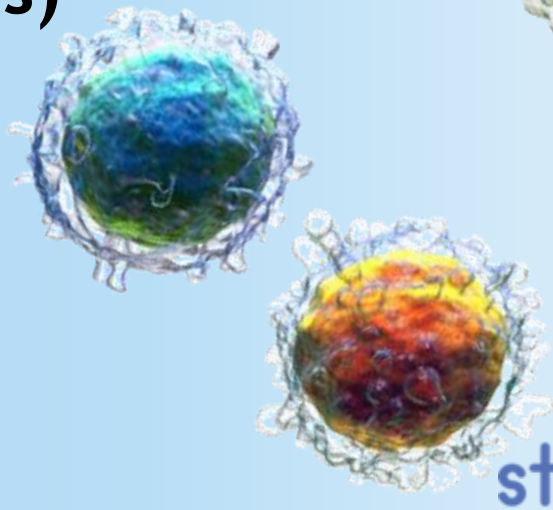
- **Agranulocytes**
  - Lymphocytes
  - Monocytes



Specialist Cells

(Adaptive Immunity & Phagocytosis)

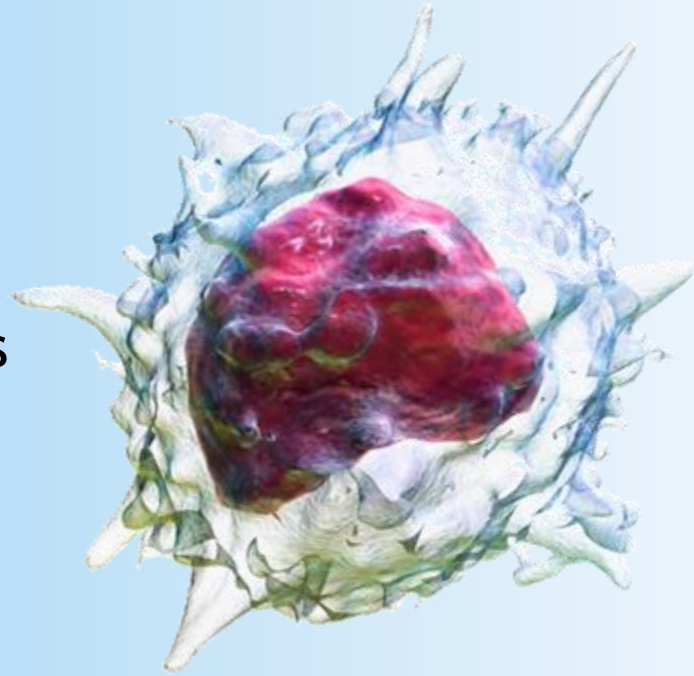
- Slow responders



Monocytes

Shape-shifting giant cells that love to EAT

Can become DENDRITIC CELLS or MACROPHAGES



2-8%

Function:

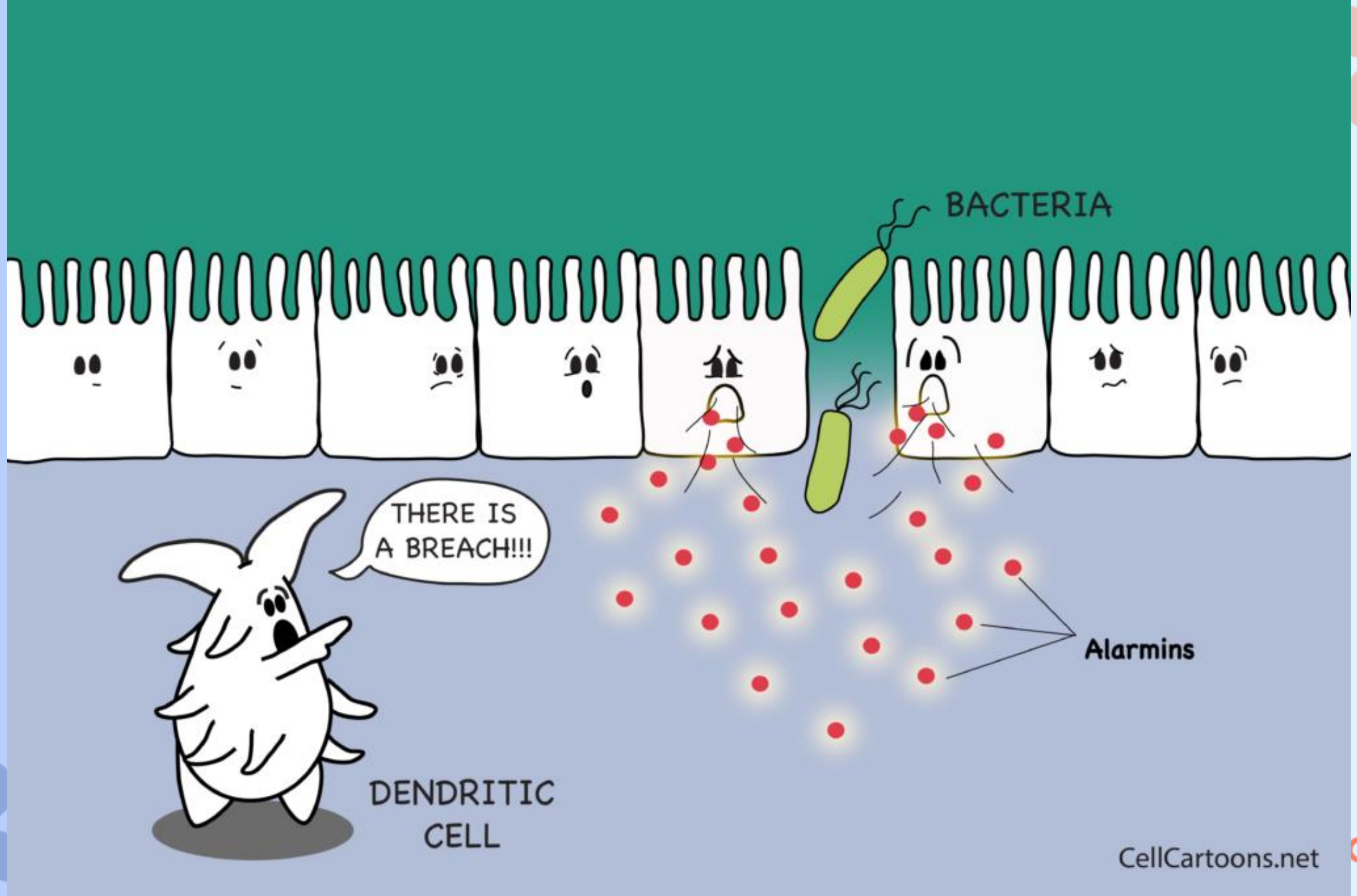
- Become **DENDRITIC CELLS** and hang out in tissues exposed to the environment (skin, lungs, gut)
- **Antigen presentation** → **DENDRITIC CELLS** help activate T- lymphocytes by presenting proteins they find on their trips out into the body.
- **Phagocytosis** → Monocytes migrate into tissues and become **macrophages**, eating up debris.

MACROPHAGES clean up the messes that neutrophils can’t.

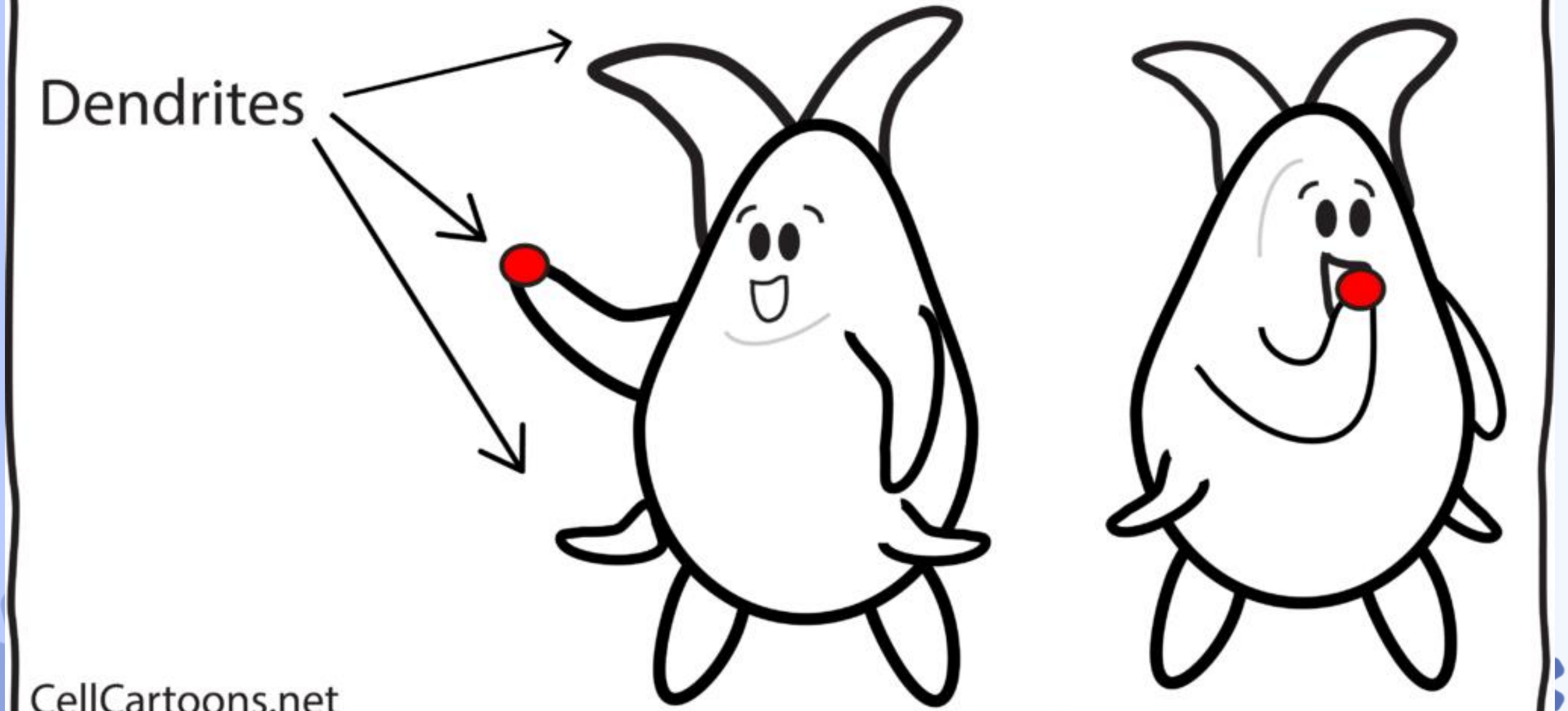
Lame neutrophil. **Vs.**

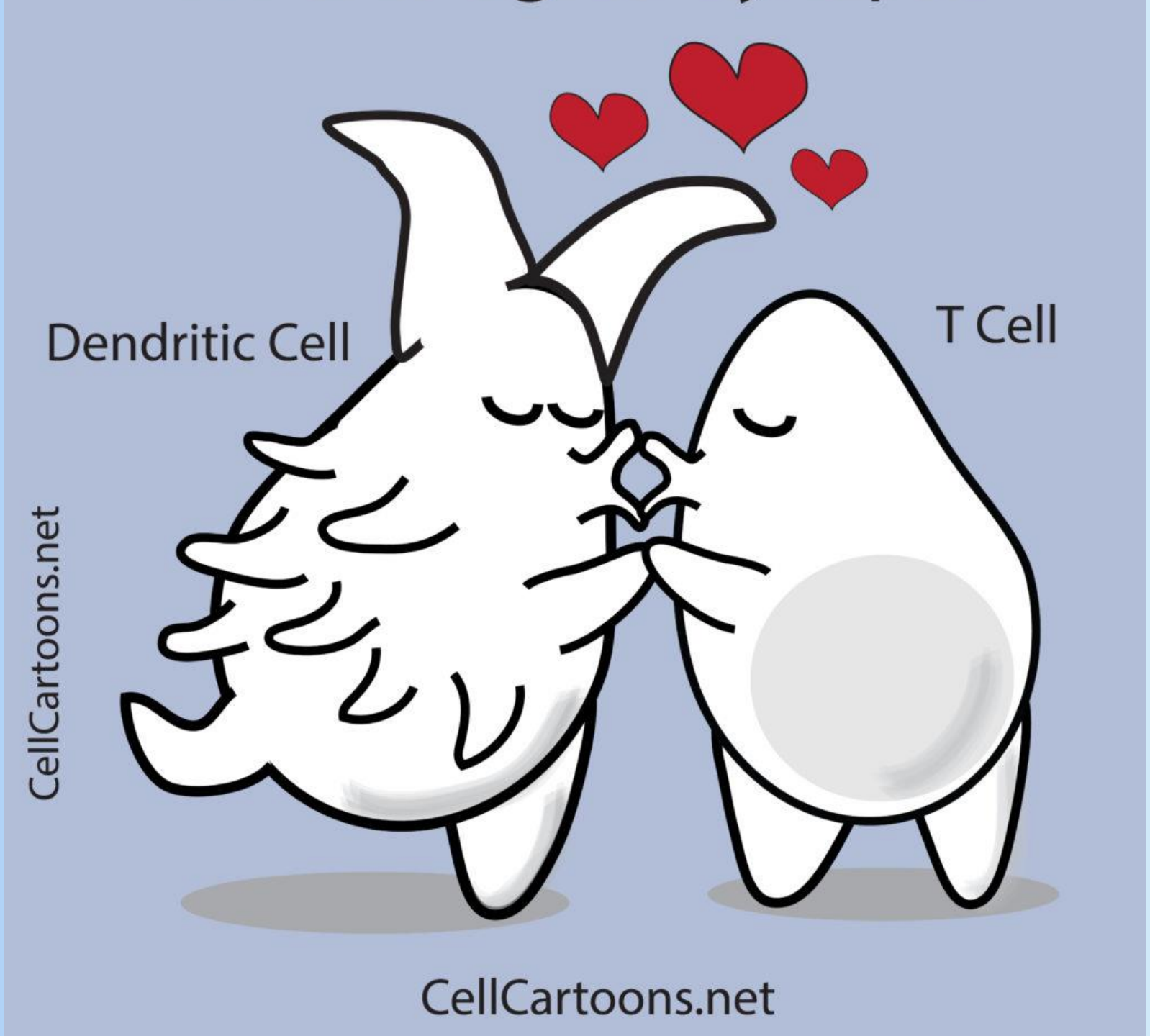
DENDRITIC CELLS EAT INVADERS and **PICK UP** their proteins.

They then come back to the **LYMPH**, and **SHARE** their findings to **T-LYMPHOCYTES.**


BACTERIA
THERE IS A BREACH!!!
Alarmins
DENDRITIC CELL
CellCartoons.net

Dendritic Cell




Dendritic Cell
T Cell
CellCartoons.net
CellCartoons.net

Lymphocytes

Lymphocytes - LYMPH cells - Cells which live in lymph

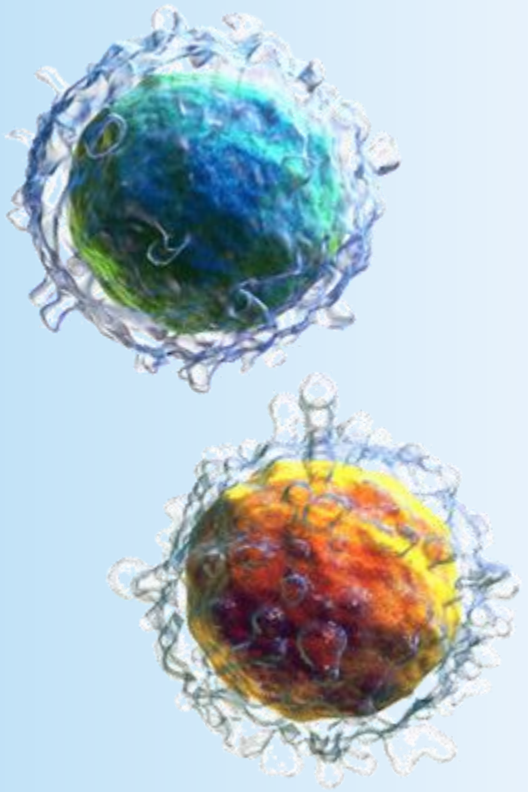
B-Cells = Lymph cells from BONE

T-Cells = Lymph cells from THYMUS

Natural Killer cells - "assassins" of diseased cells

Function:

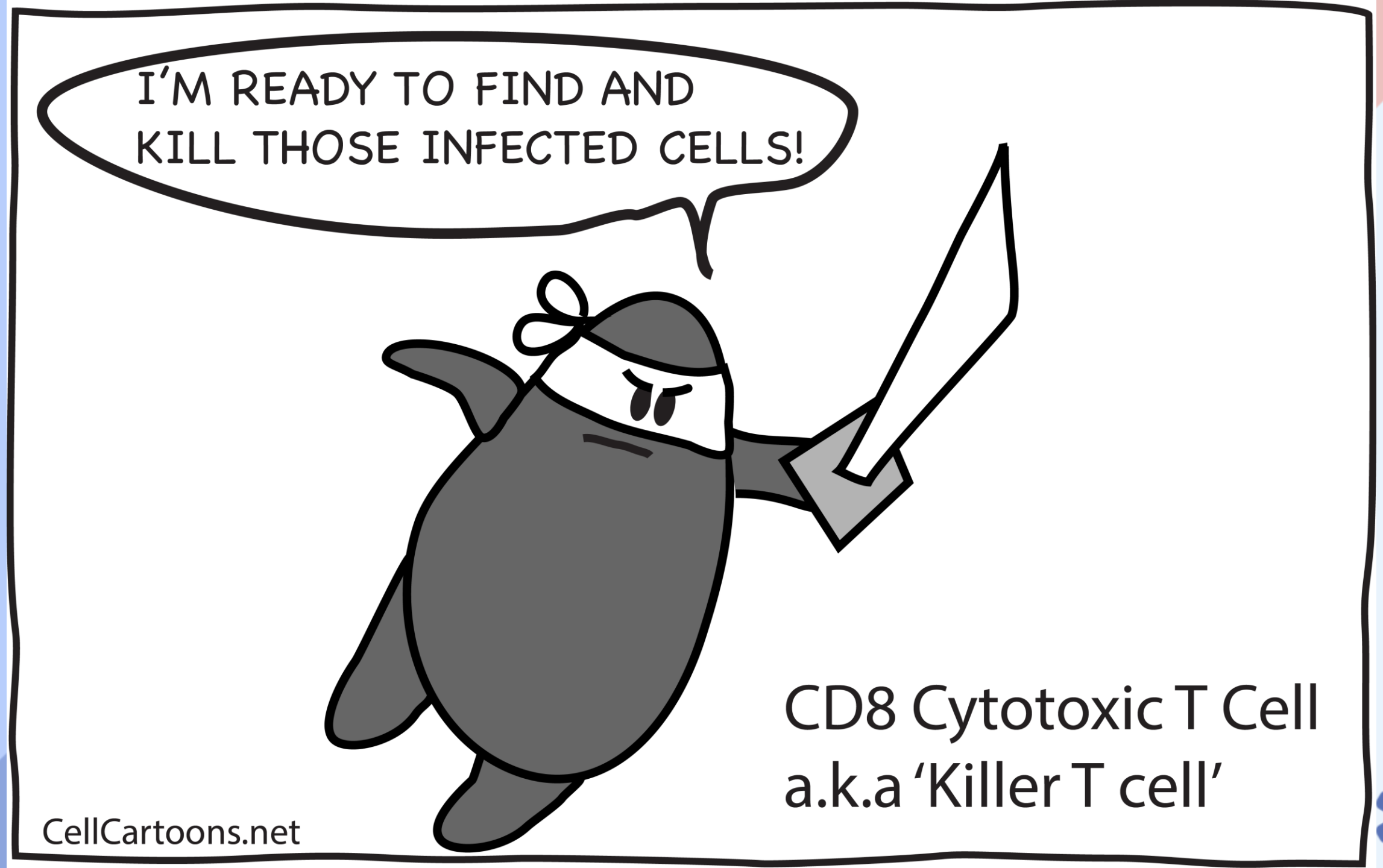
- **B-cells** → Produce antibodies (humoral immunity - AKA immunity from antibodies in the lymph).
- **T-cells** → Directly attack infected or abnormal cells (cell-mediated immunity).



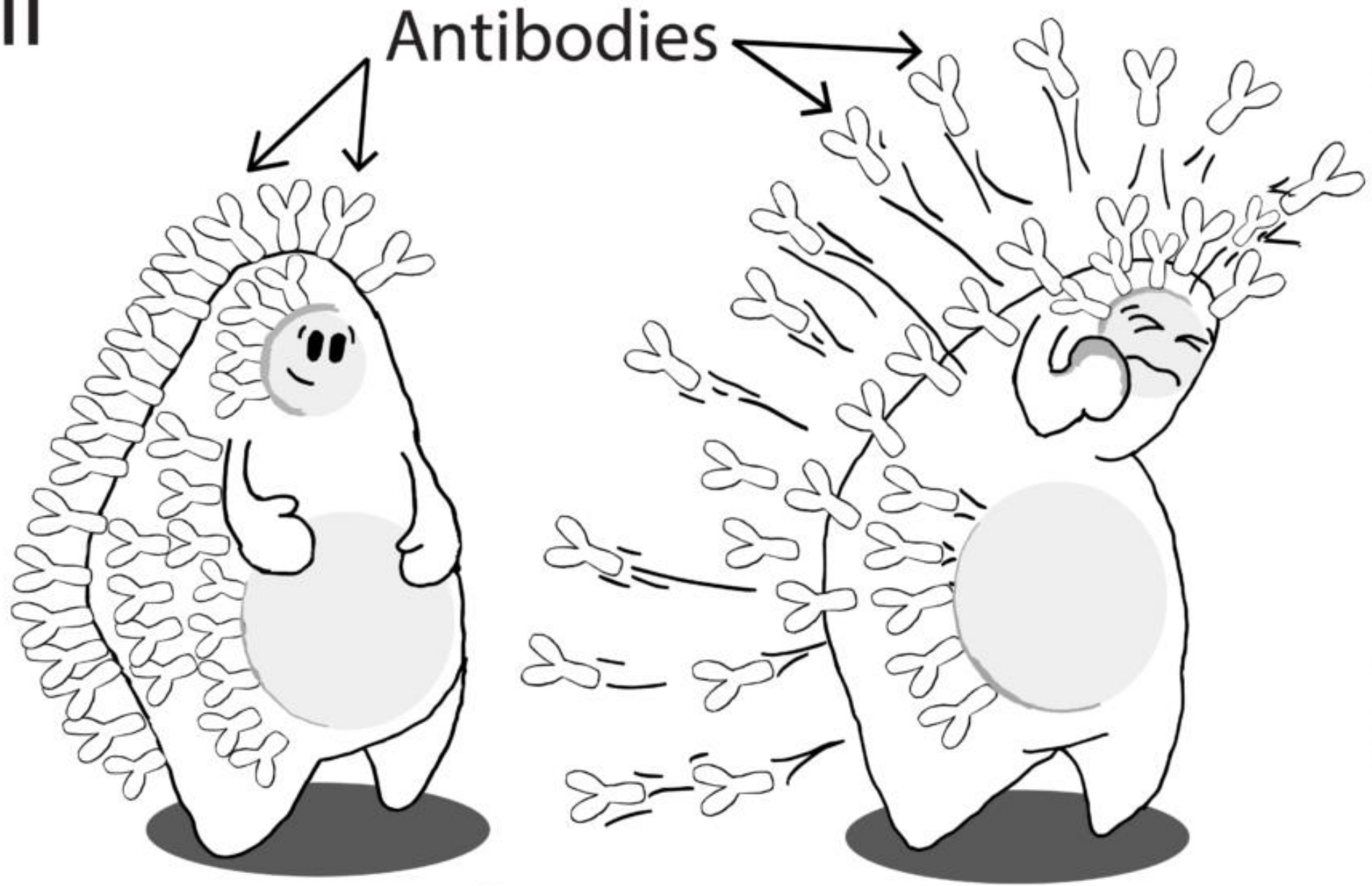
20%

B-Lymphocytes are **PREMADE** based on older immune responses and they shoot out **ANTIBODIES**

T-Lymphocytes are **TRAINED** in the **THYMUS SCHOOL** to fight **NEW INVADERS**


I'M READY TO FIND AND KILL THOSE INFECTED CELLS!
CD8 Cytotoxic T Cell
a.k.a 'Killer T cell'
CellCartoons.net

B Cell



CellCartoons.net

GRANULOCYTES

60 - 70% Neutrophil: eats bacteria and debris

2 - 4% Eosinophils: shoots alkaline granules at parasites

<1% Basophils: acidic granules, shoot histamine at allergens

AGRANULOCYTES

20% Lymphocytes

T-lymphocyte: ATTACK after kissing dendritic cell

B-lymphocyte: SNEEZE antibodies

2 - 8% Monocytes

Macrophage: BIG EATER, cleanup crew

Dendritic cell: picks up proteins and kisses T-cells

GRANULOCYTES

Neutrophil: Bacterial infections

Eosinophils: Parasitic infections, Allergy

Basophils: Allergy

AGRANULOCYTES

Lymphocytes: Viral infections

Monocytes: Nonspecific, allergens, immune reactions, infections

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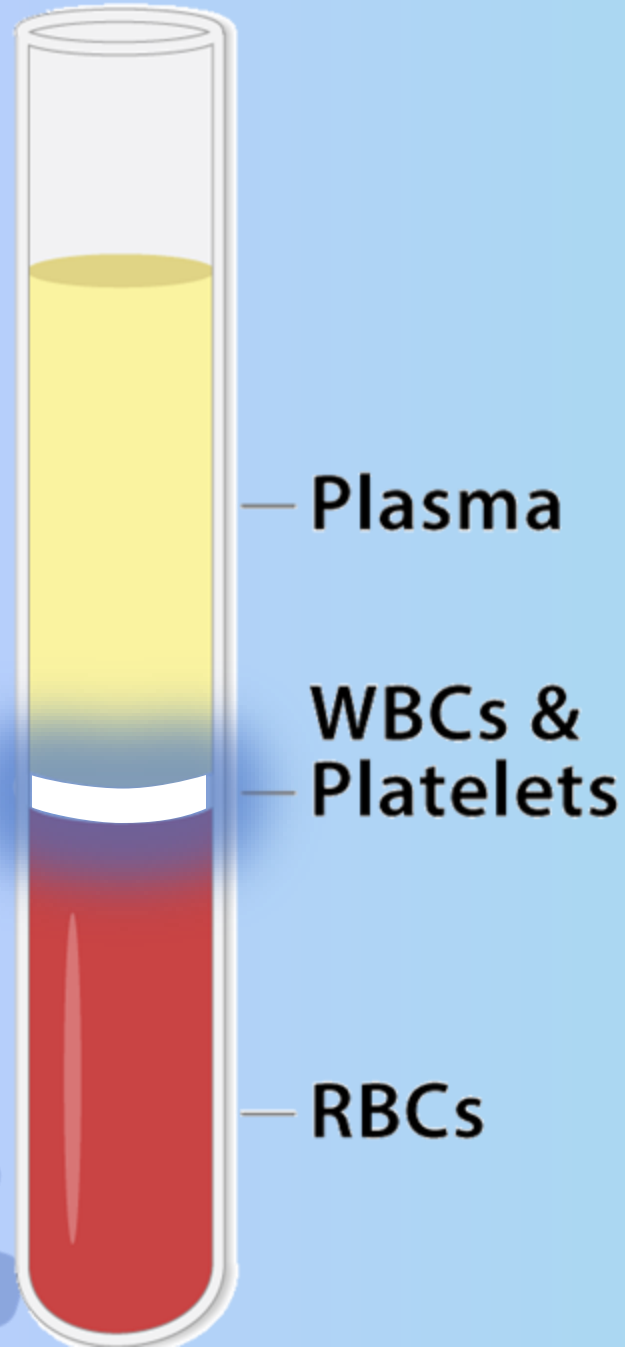
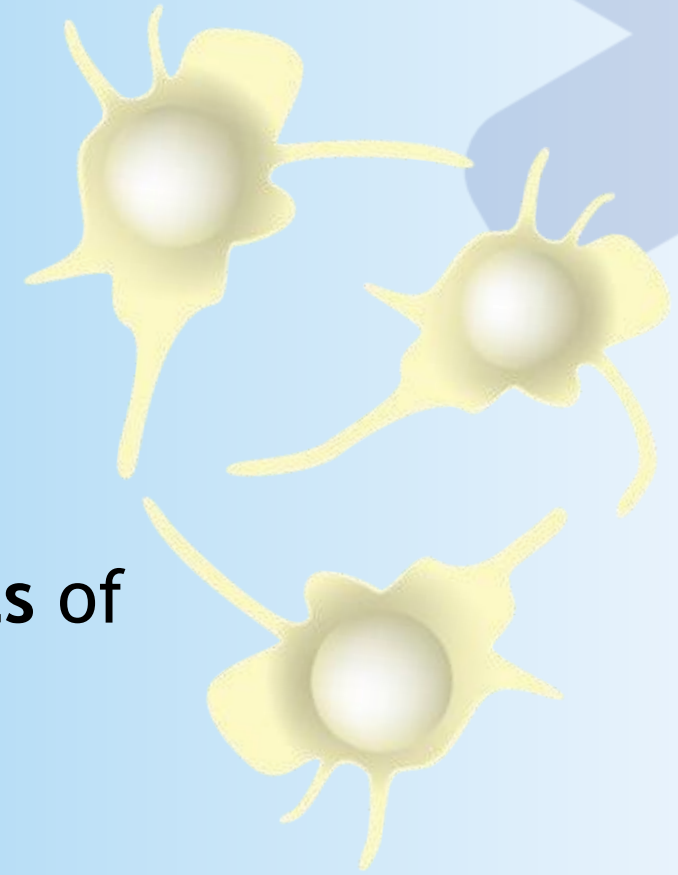


Thrombocytes (PLATELETS)

Thrombo- (Greek *θρόμβος, thrombos*) = **"clot"**

-cyte = **"cell"**



- Platelets **aren't full cells**—they are **fragments** of **megakaryocytes**.

Thrombocytes (PLATELETS)

Function: Hemostasis (clot formation)

Vascular spasm – Vasoconstriction

Platelet plug formation – Aggregation

Coagulation cascade – Fibrin clot

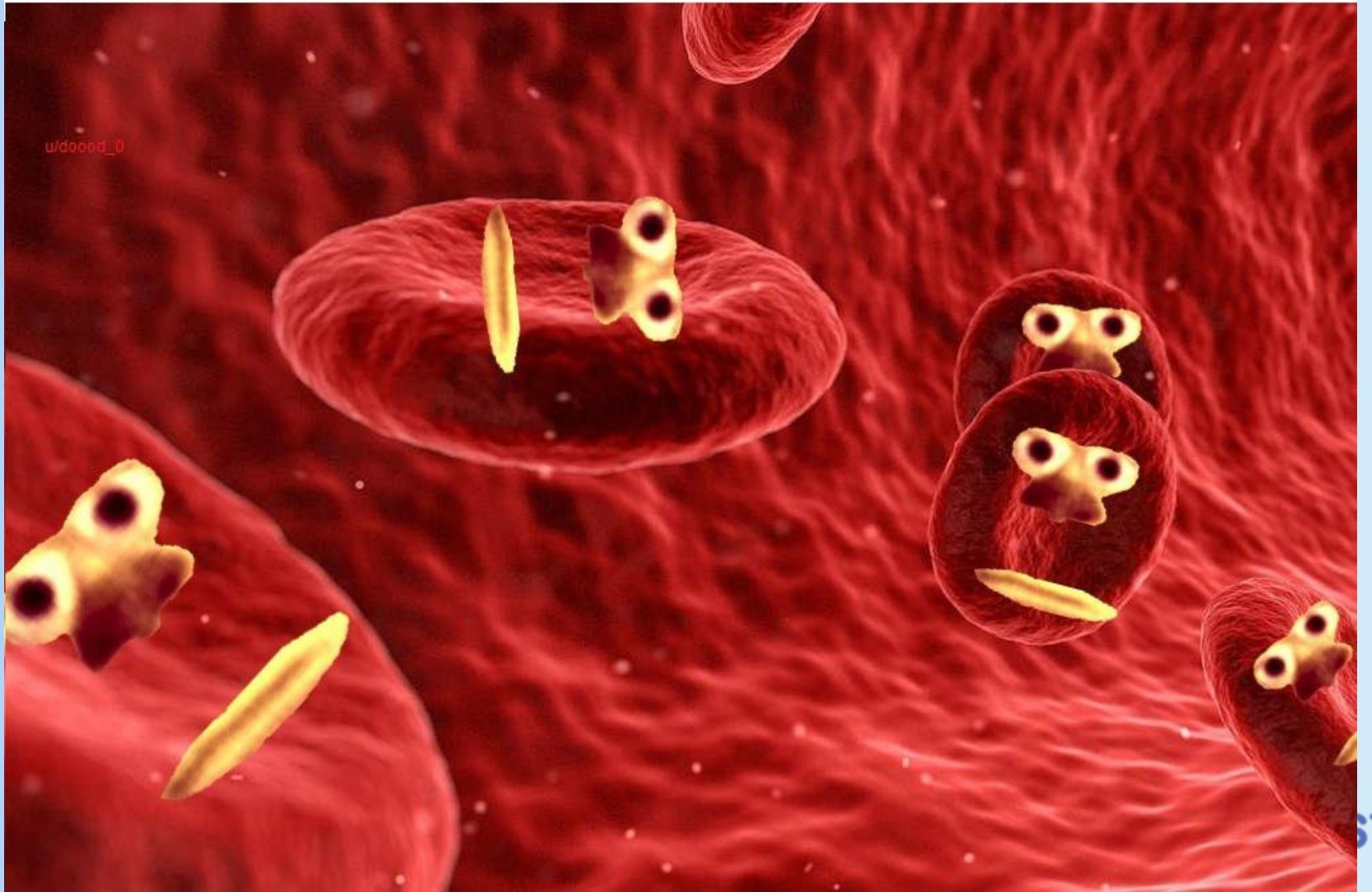
Clinical Significance:

- **Thrombocytopenia:** ↓ Platelets → bleeding risk
- **Thrombocytosis:** ↑ Platelets → thrombosis (stroke, DVT)

Platelets: *spends hours to clot my injury*

8 y/o me: *scratches the clot because its itchy*

Platelets:



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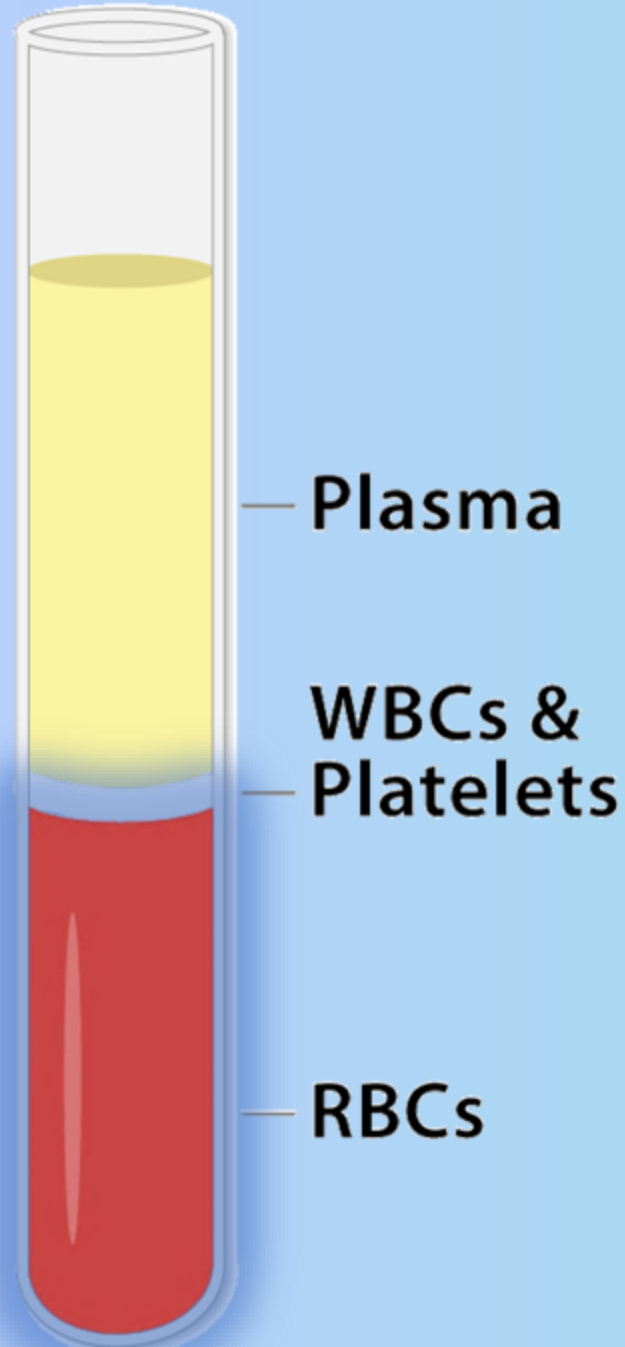


Erythrocytes

Erythro- (Greek *ἐρυθρός, erythros*) = **"red"**

-cyte (*κύτος, kytos*) = **"cell"**

- RBCs are literally **"red cells"** that give blood its color.

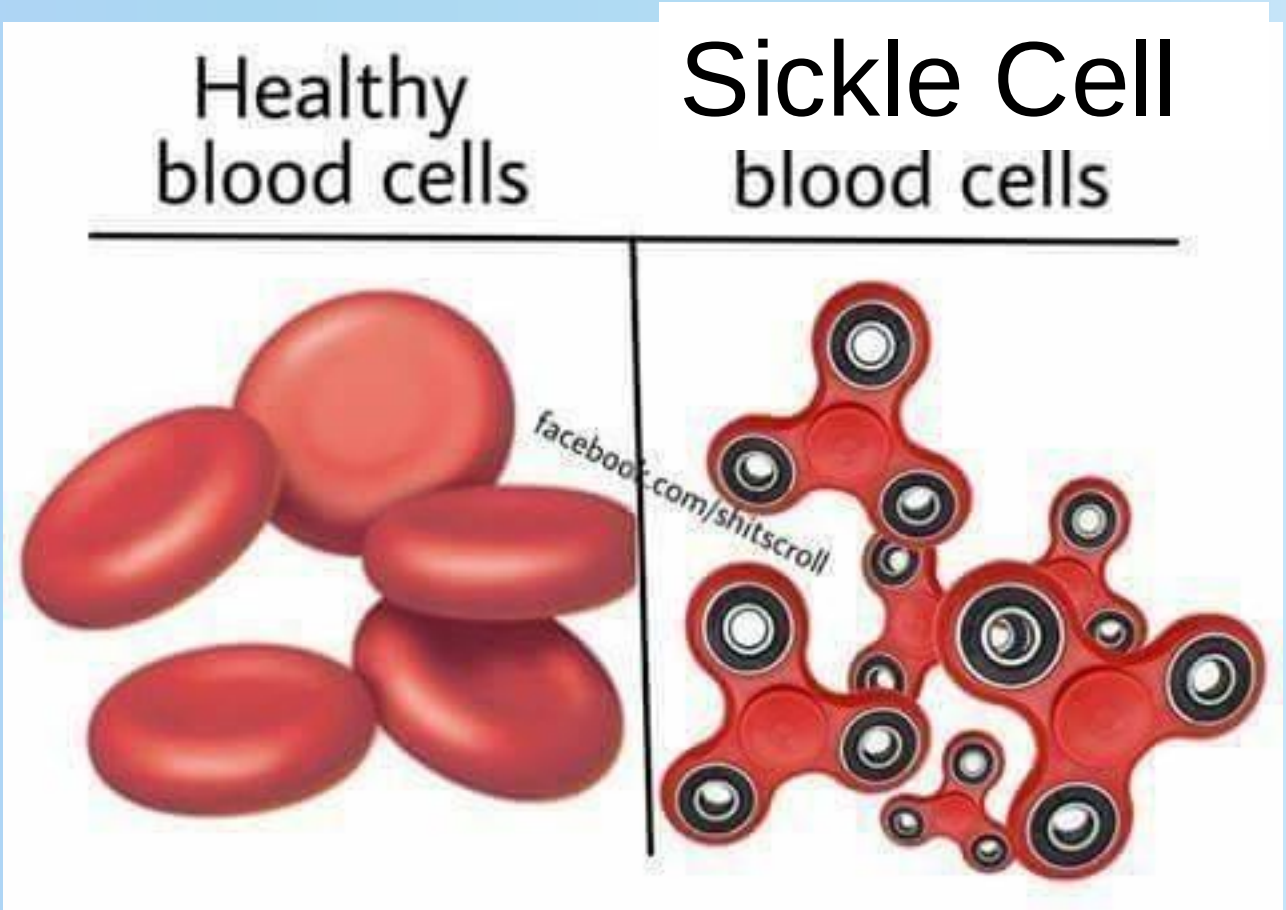
RBCs are **anucleate** (no nucleus), making them highly efficient for gas transport but unable to divide.

Erythrocytes

- **Structure & Function:**
  - **Biconcave shape** → increased surface area
  - **Flexible** → can squeeze through capillaries
  - **Hemoglobin (Hb)** binds **O_2 & CO_2**

- **Lifespan:** ~120 days → Phagocytosed in **spleen & liver**

- **Clinical Significance:**
  - **Anemia:** ↓ RBCs or hemoglobin
  - **Polycythemia:** ↑ RBCs → risk of thrombosis
  - **Sickle Cell Disease:** Abnormal Hb causes weird shape


Healthy
blood cells
Sickle Cell
blood cells
facebook.com/shitscroll

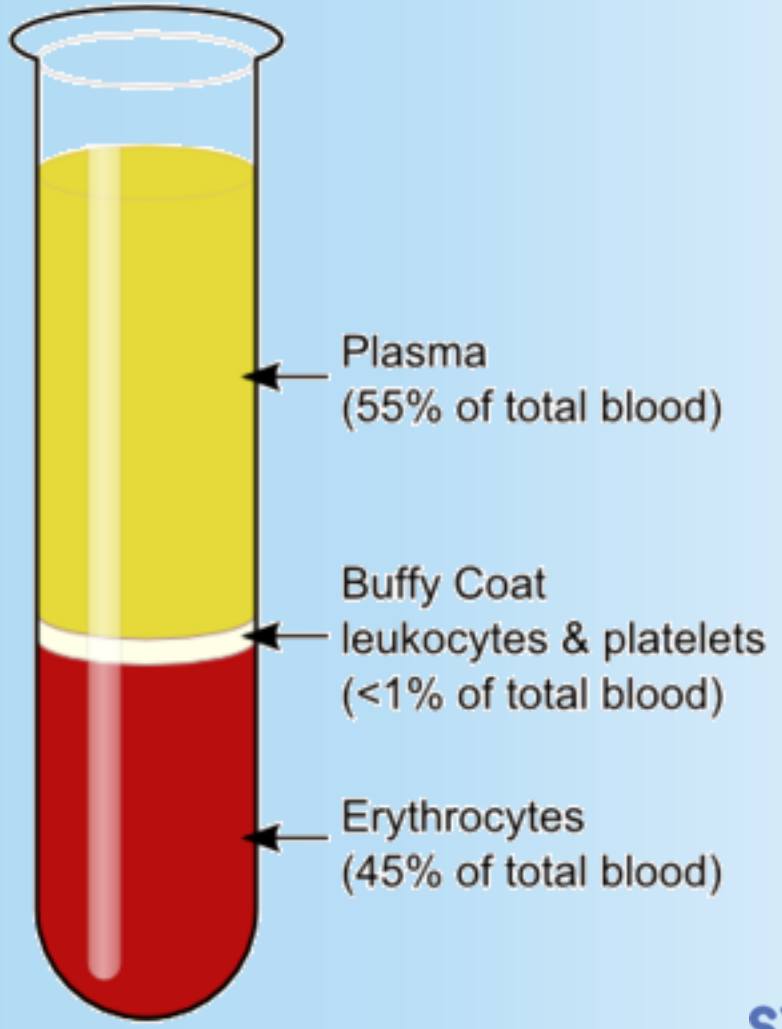
Putting it together: HEMATOCRIT

HEMATOCRIT

- Hematocrit (Hct) = **The percentage of blood volume occupied by red blood cells (RBCs).**

Ranges:

- **Men:** 40–54%
- **Women:** 36–48%
- **Children:** 35–44%



HEMATOCRIT

INCREASED HEMATOCRIT

- **Dehydration** (Less plasma, same RBCs = falsely high Hct)
- **Polycythemia Vera** (Bone marrow overproduces RBCs)
- **Chronic hypoxia** (e.g., COPD, high altitude) → EPO production in **kidney** → More RBCs for oxygen delivery
- **Erythropoietin (EPO) abuse** (Athletes using doping)

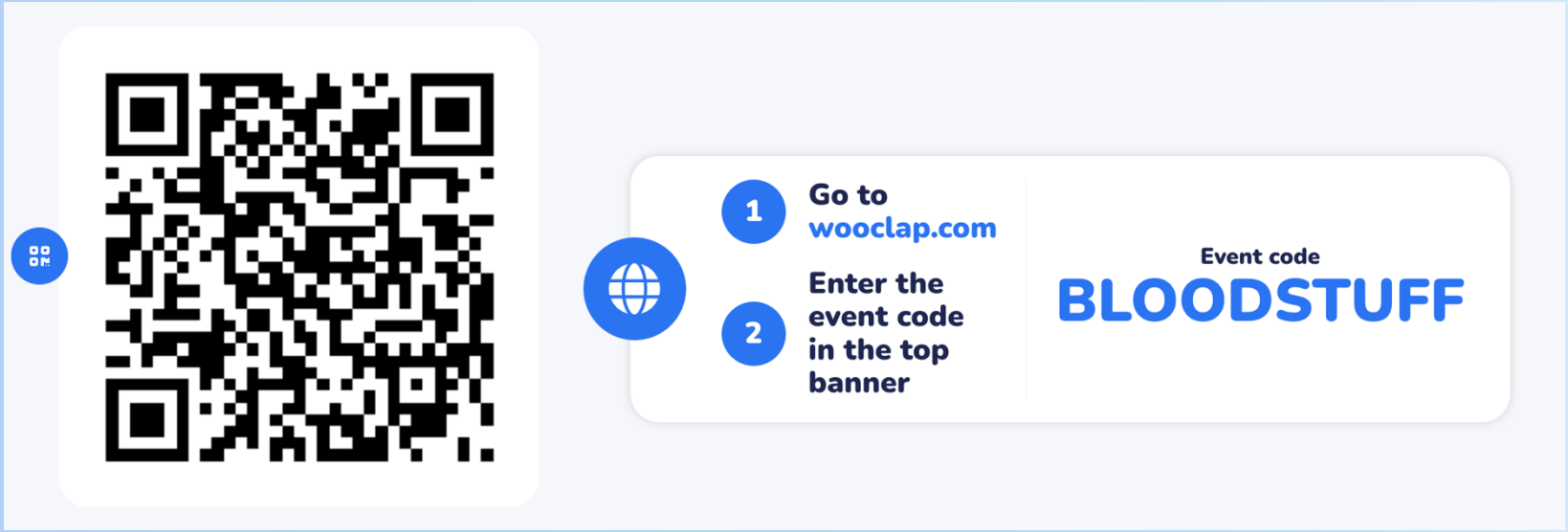
HEMATOCRIT

DECREASED HEMATOCRIT

- **Anemia (↓ RBCs or Hemoglobin)** → Iron deficiency, B12 deficiency, bone marrow failure
- **Hemorrhage** (Blood loss)
- **Overhydration** (More plasma dilutes RBCs)
- **Hemolysis** (RBC destruction in autoimmune diseases or sickle cell anemia)

QUESTIONS?

Thank you for your attention!



- WOOCLAP!