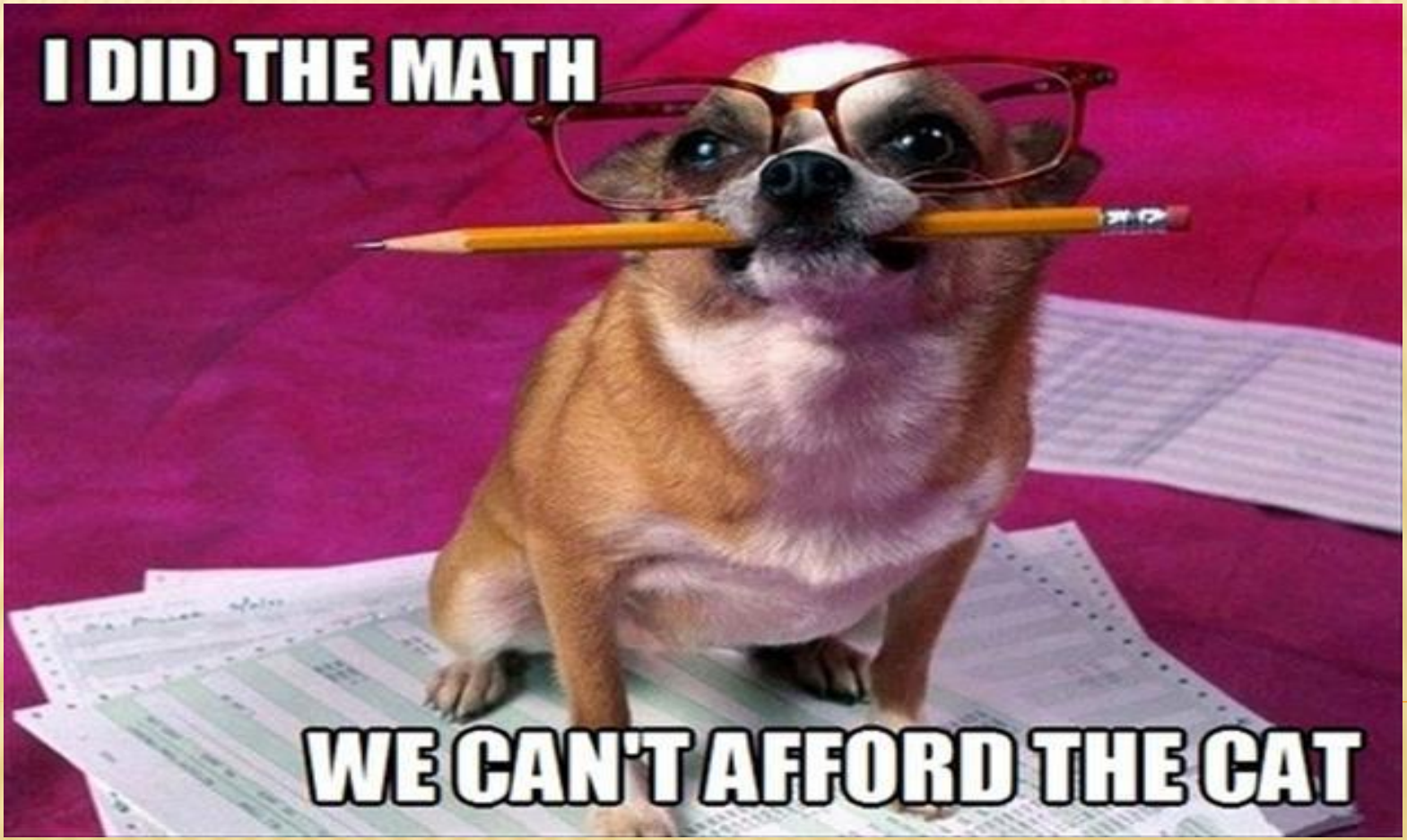
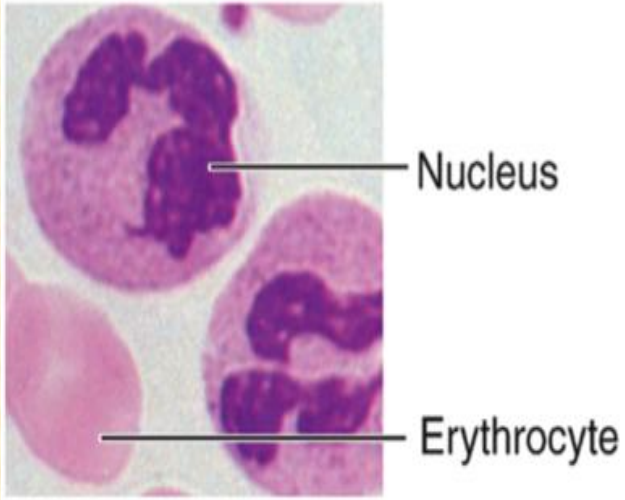

I DID THE MATH
WE CAN'T AFFORD THE CAT

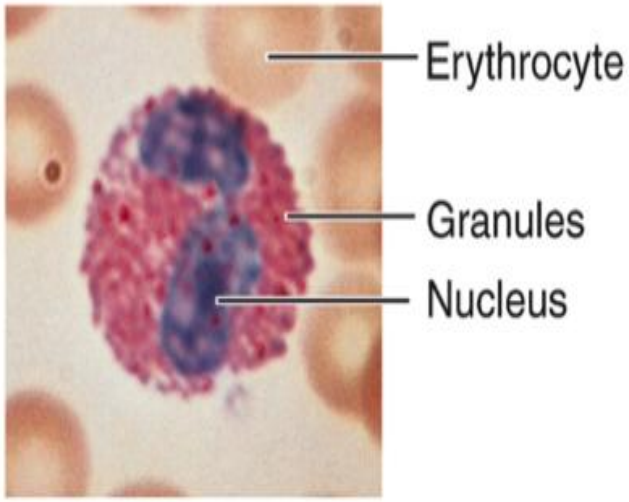
LEUKOCYTES (LEUKON)

- They are cells of the immune system, involved in defending the body against both infectious disease and foreign materials.

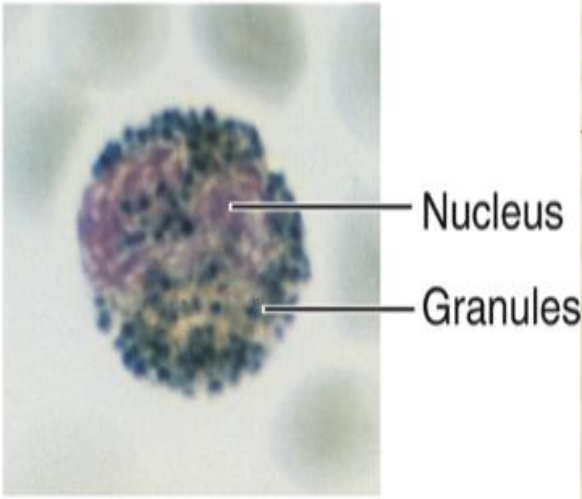
Granulocytes



A Neutrophil

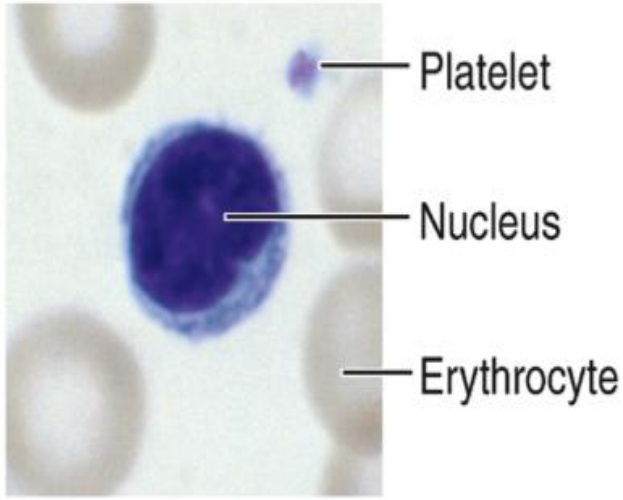


B Eosinophil

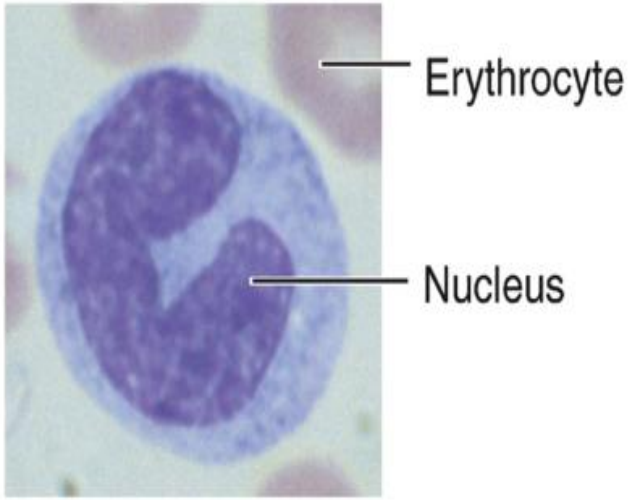


C Basophil

Agranulocytes



D Lymphocyte



E Monocyte

- White blood cells are put into two different groups based on microscopic appearance.

It includes:

a- Granulocytes(polymorphonuclear)
Neutrophils , eosinophils , and basophils.

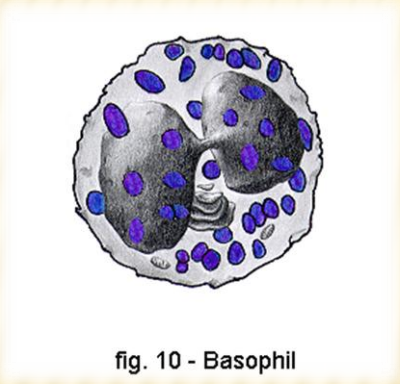


fig. 10 - Basophil

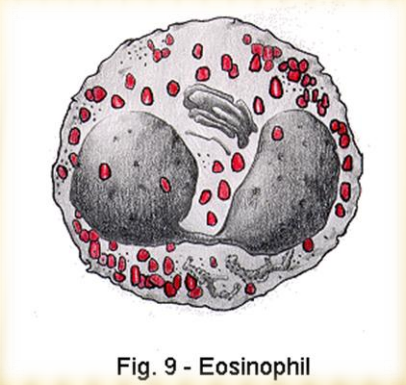


Fig. 9 - Eosinophil

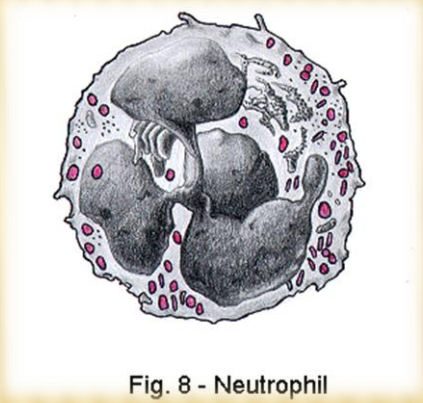
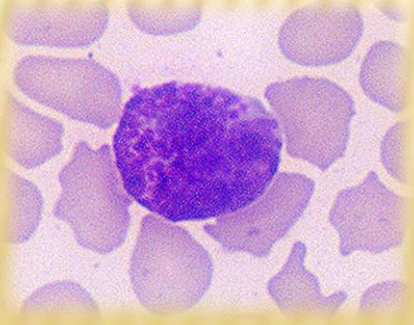
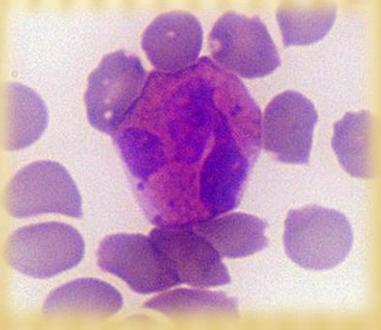
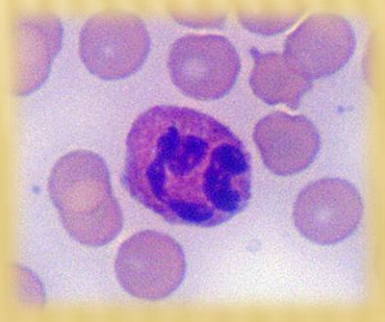


Fig. 8 - Neutrophil



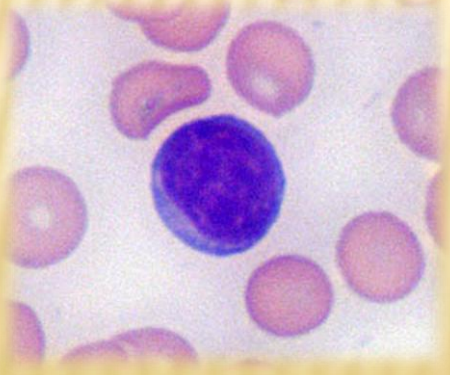




b-Agranulocytes (mononuclear cells) :

Monocytes and lymphocytes.

Fig. 11 - Lymphocyte



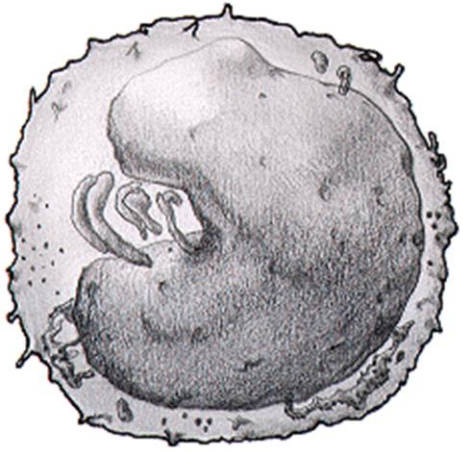
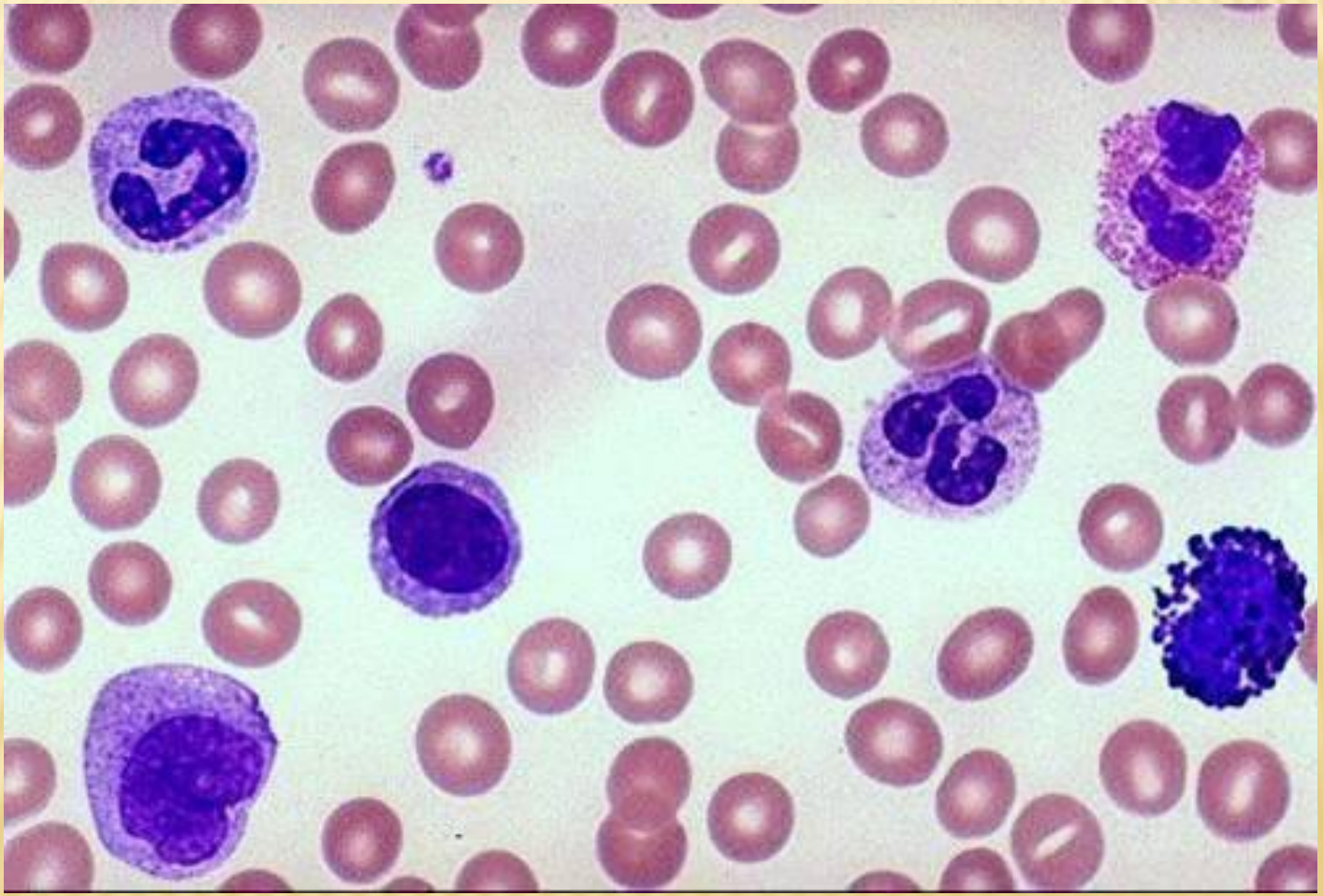


Fig. 12 - Monocyte



unlike RBCs leukocytes do not exhibit a life span in blood , they rather leave the blood randomly in response to chemotactic stimuli They utilize the blood stream as one uses a high way to travel from home (the bone marrow) to work (tissues)

Because their morphology and numbers are relatively stable in health and may dramatically change in disease , they can provide information's to help in diagnosis and prognosis.

EVALUATON OF LEUKOCYTES :

1-Total leukocyte count /µl of blood .

2-Differential leukocyte count , to detect the percentage of each kind of leukocyte in the blood.

3-Calculation of absolute number of each type of leukocytes / µl of blood.

4- Examination of a well- stained , well- prepared blood film to observe the morphology of leukocytes and identify abnormalities that may help in diagnosis and prognosis of the clinical condition.

REPORTING A DIFFERENTIAL COUNT

Ways to report the values

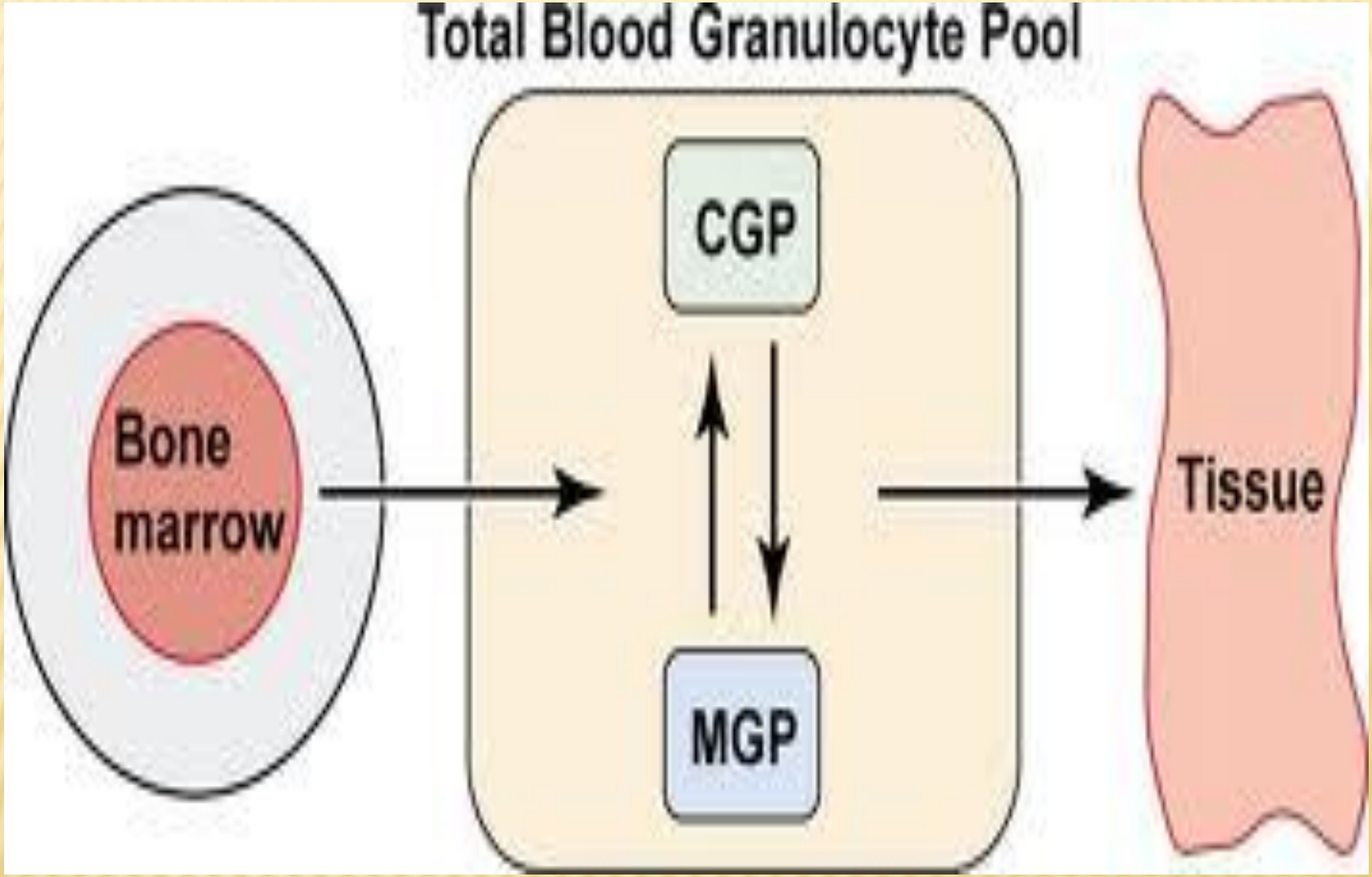
By relative **%** of each WBC type **(INCORRECT)**

By **absolute** number of each WBC type **(CORRECT)**
(%of each cell type x total WBC number)

INTERPRETING DIFFERENTIAL RESULTS

↑ in a particular leukocyte → *Neutrophilia*
Eosinophilia
Basophilia
Lymphocytosis
Monocytosis

↓ in a particular leukocyte → *Suffix "penia"*
(i.e. Lymphopenia)

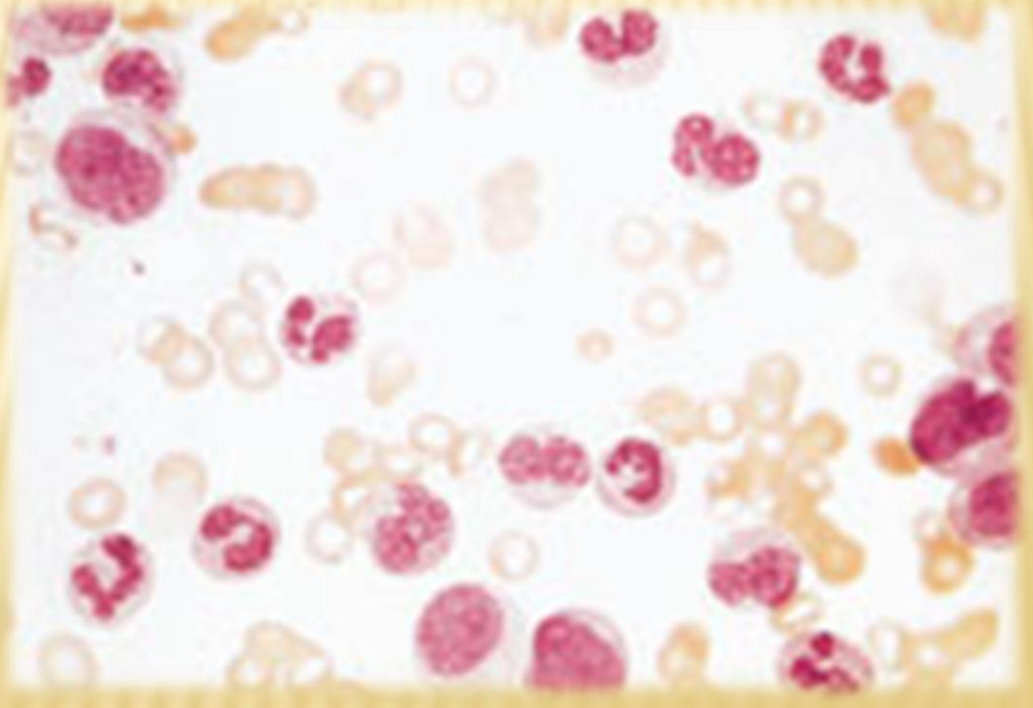

Total Blood Granulocyte Pool
Bone marrow
CGP
MGP
Tissue

Abnormalities of the leukogram include

- Quantitative or numerical abnormalities.
- Morphologic abnormalities.

Abnormalities in the number of leukocytes

Leukocytosis: Means increase in the number of circulating leukocytes, it can be mild, moderate or severe. If kind of cells responsible for that elevation is not mentioned it is usually neutrophilic leukocytosis.



Leukopenia : Decrease in the number of circulating WBCs.

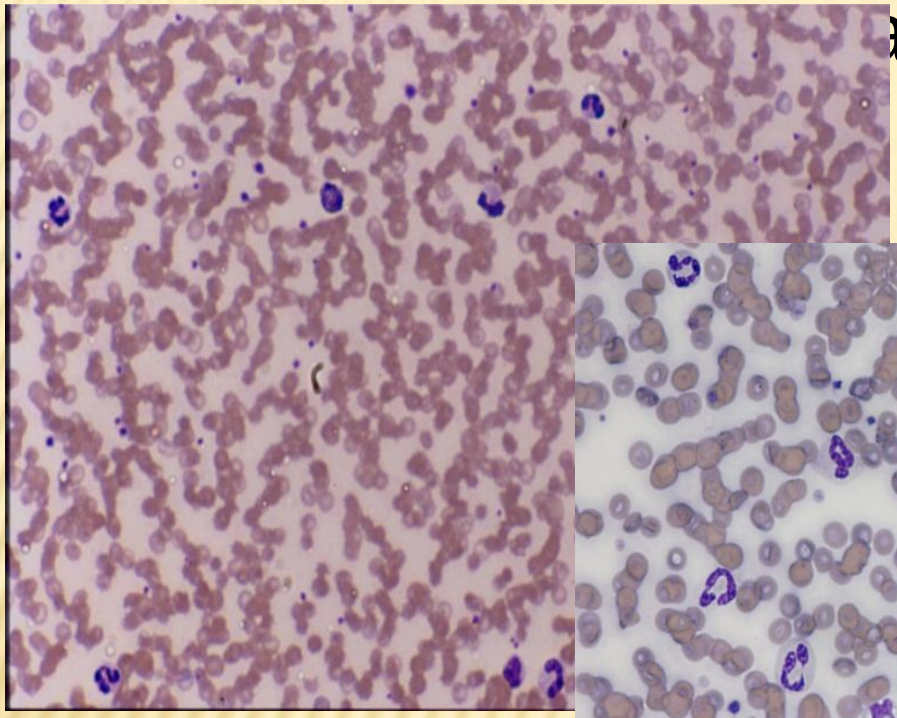
a- Due to decrease in neutrophil count.

I- If it is associated with mature neutropenia and no immature new cells are produced, it is mostly due to

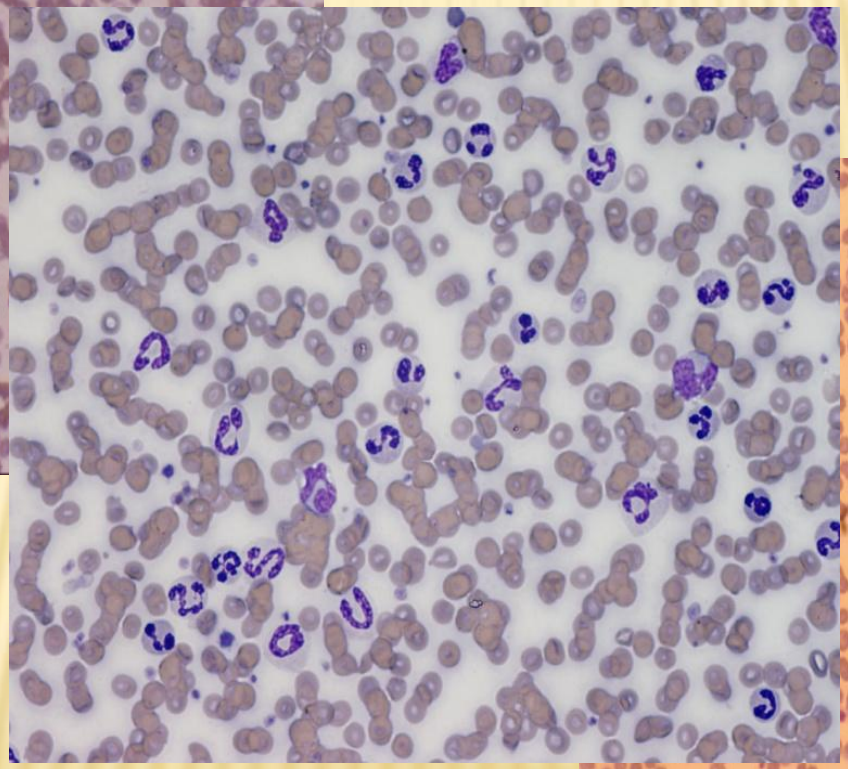
- --bone marrow hypoplasia or myelophthesis caused by:.
-

- --Increased margination caused by endotoxaemia or shock.
- -- Increased removal which is either immune-mediated or due to hypersplenism

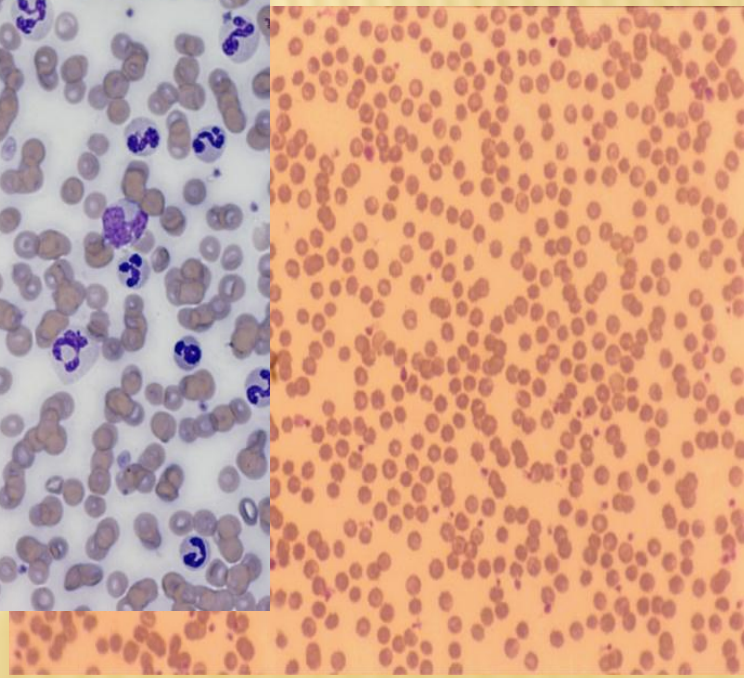
-Leukocyte estimation in a blood
ar (400x):



Normal number



Increased-nuetrophilic leukocytosis



Decreased- leukopenia

Meylophthesis =Is the replacement of hematopoietic tissue within the bone marrow by abnormal tissue.

- Usually replaced by fibrous tissue (= myelofibrosis) or malignant cells.
- May be reflected in the peripheral blood as pancytopenia

II. Predominantly immature neutrophils are found in the blood, it is mostly caused by acute overwhelming bacterial disease or viral diseases as FeLV and FID.

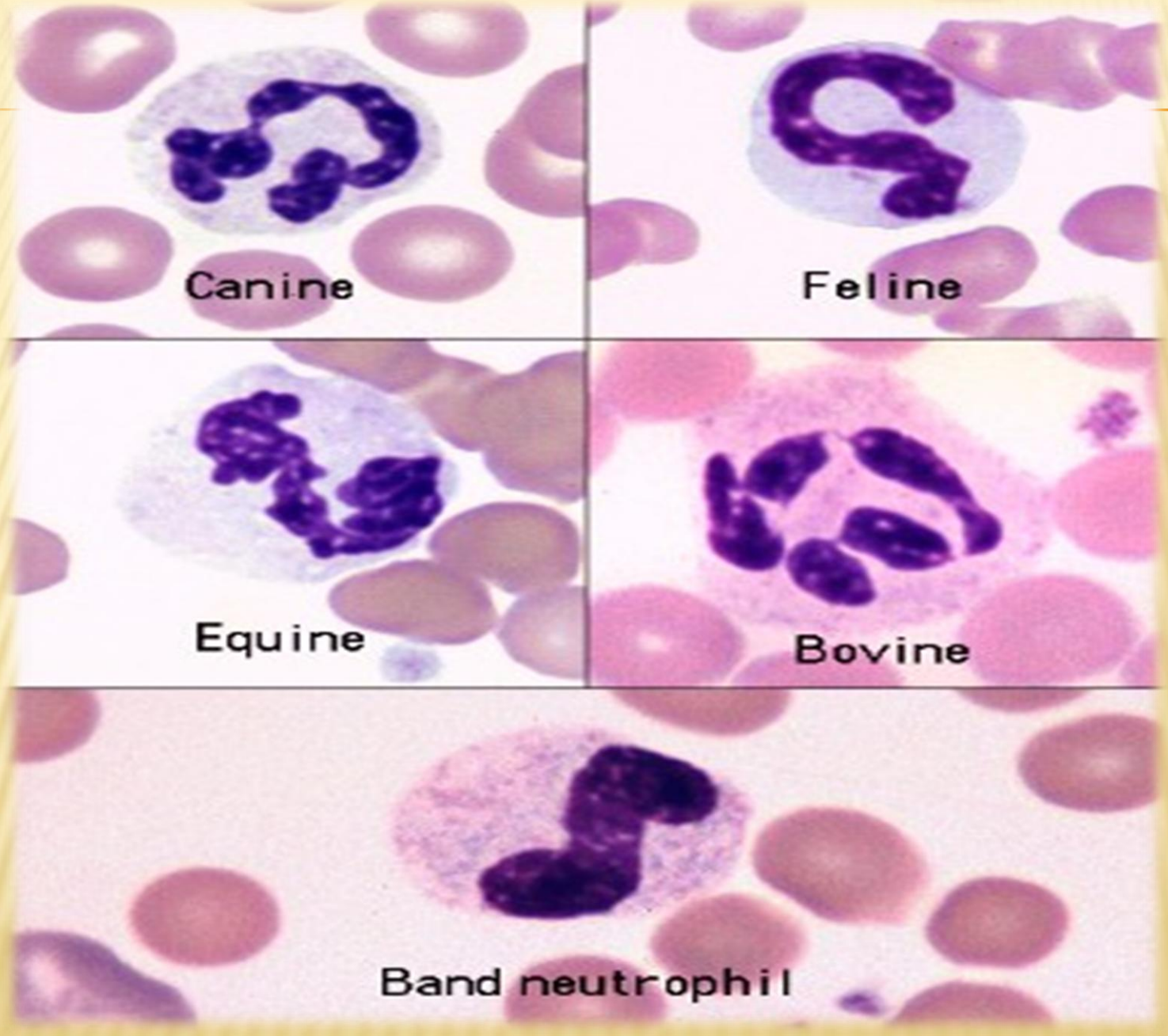
II. Absolute lymphopenia:

- Lymphopenia & Presence of immature neutrophils indicates acute inflammation.

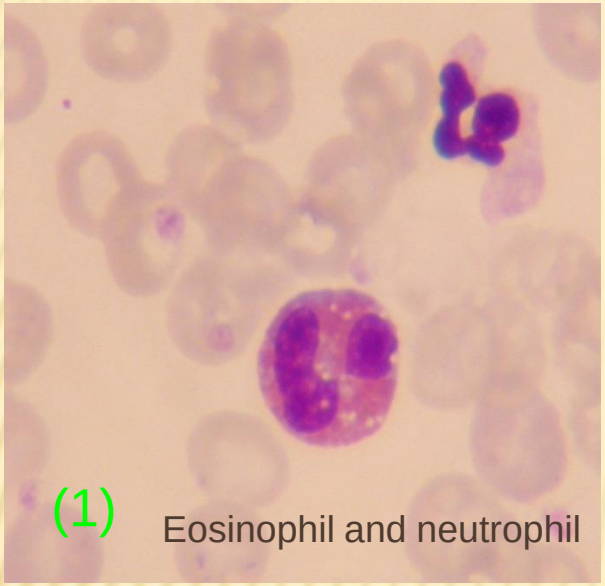
If lymphopenia is not associated with immature neutrophils, it could be due to loss of lymphocyte rich lymph, lymphoma, or hereditary T lymphocyte deficiency.

NEUTROPHILS:

Morphology: Mature neutrophil of mammals have multiple nuclear lobes , the cytoplasm of bovine neutrophil is pink with Romanowsky stains ,in other animals it is either coloureless or may contain very faint pink cytoplasmic granules .

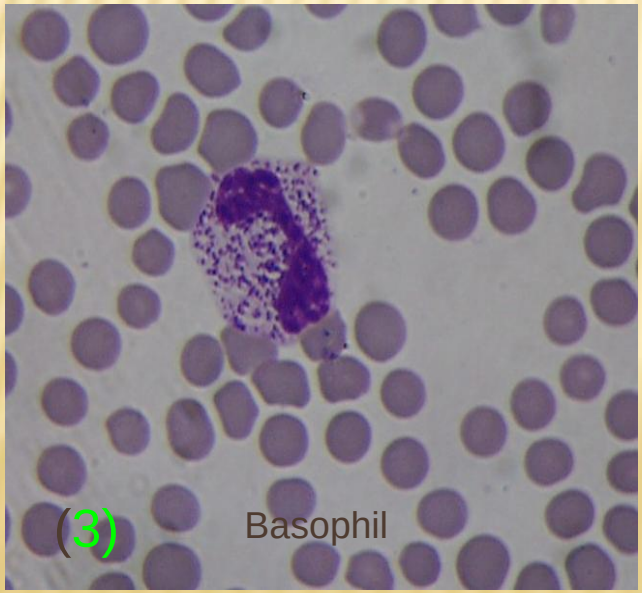

Canine
Feline
Equine
Bovine
Band neutrophil

Normal WBCs in different species, some examples

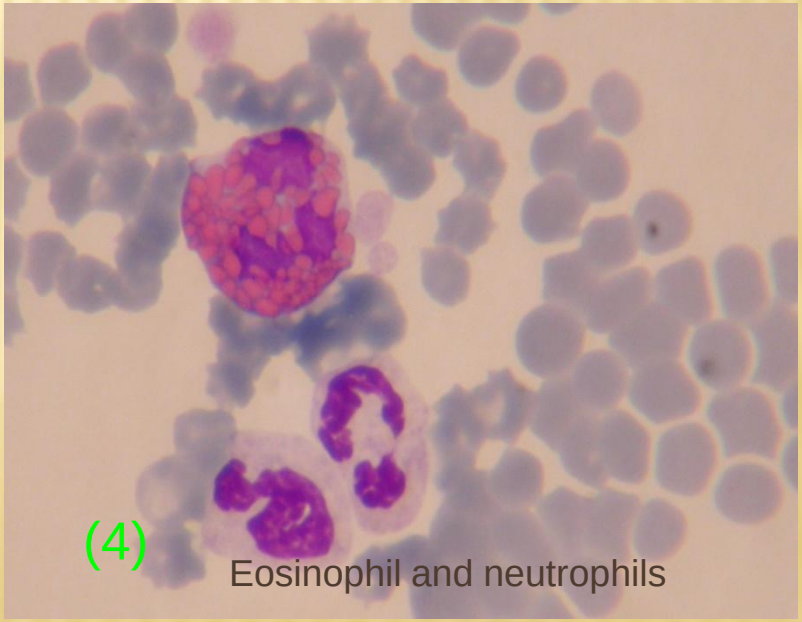


(1) Eosinophil and neutrophil

(2) Eosinophil

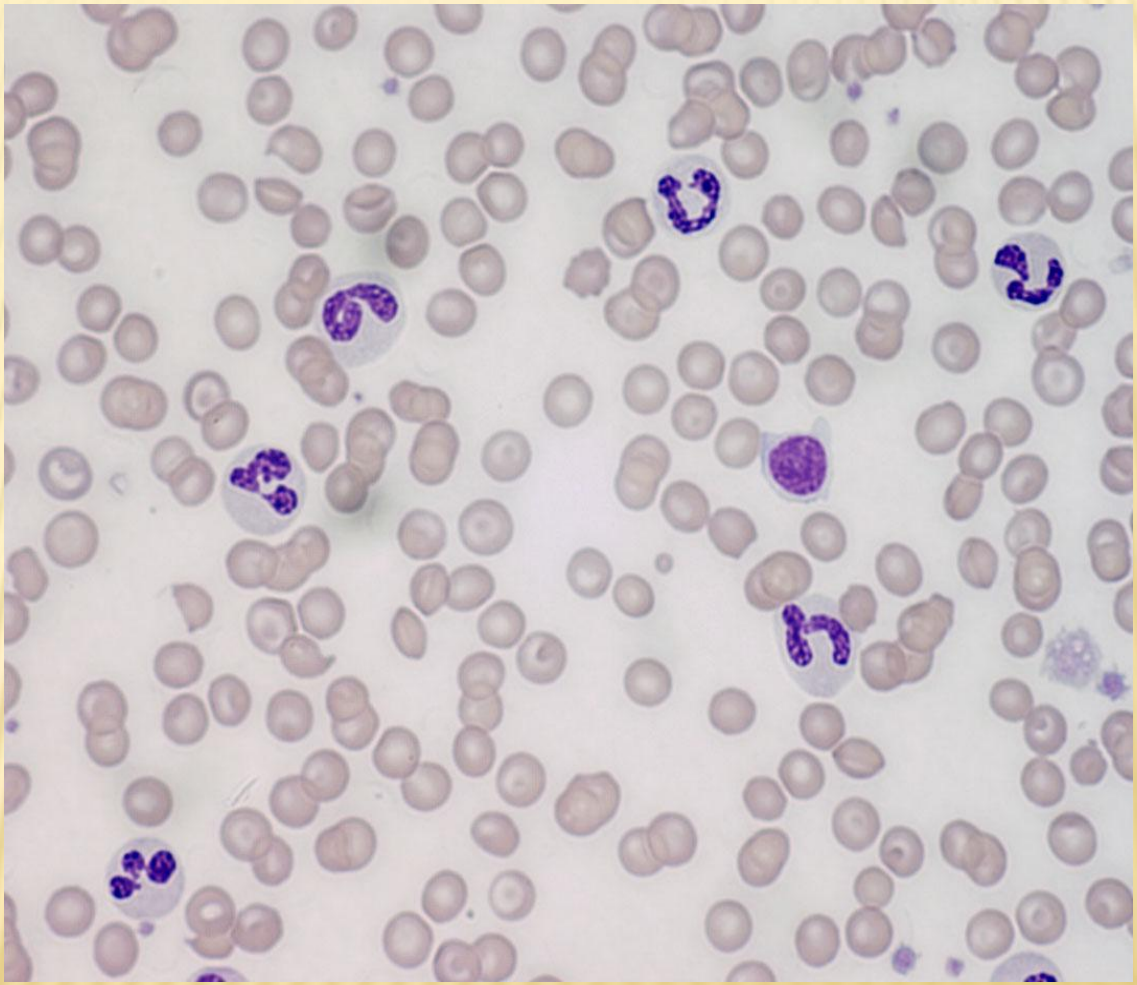


(3) Basophil



(4) Eosinophil and neutrophils

Normal neutrophils and a lymphocyte



Neutrophils are similar in most domestic species, characterised by pale cytoplasm and dark nucleus segmented into 2-5 lobes, although granules are more readily seen in ruminants.

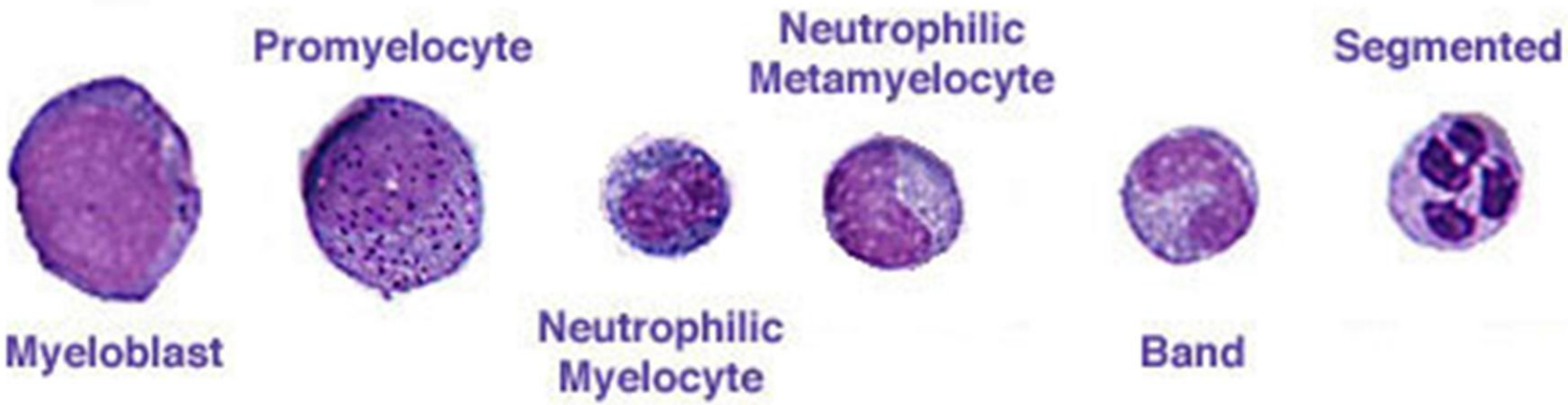
Neutrophils are the predominant WBC in the blood of man, dog, cat, young ruminants and camellidae ;

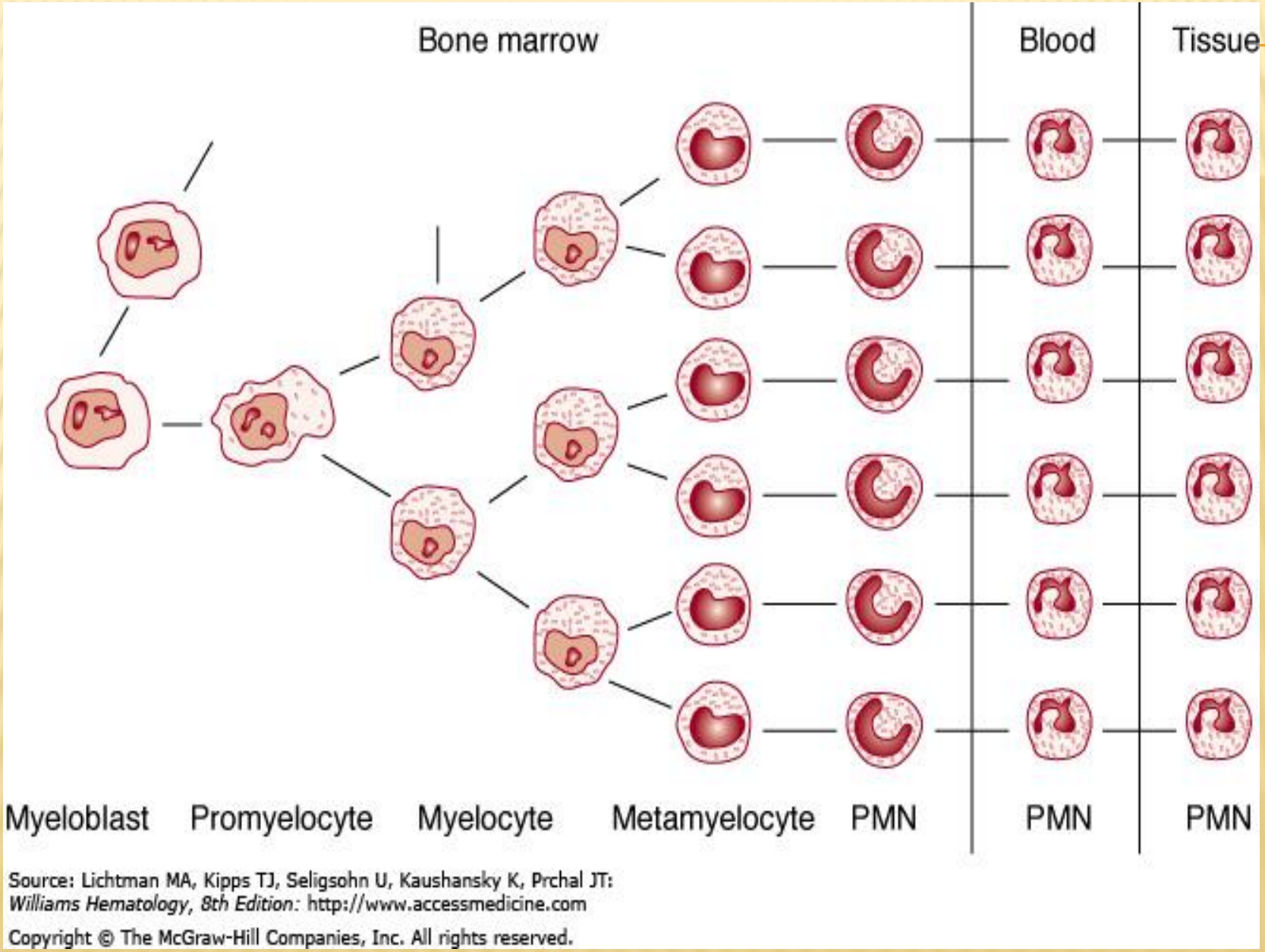
Adult ruminant lymphocytes are the predominant cells followed by neutrophils,

Horses number of neutrophils and lymphocytes are approximately equal.

Myeloid Series

KU MEDICAL CENTER
The University of Kansas





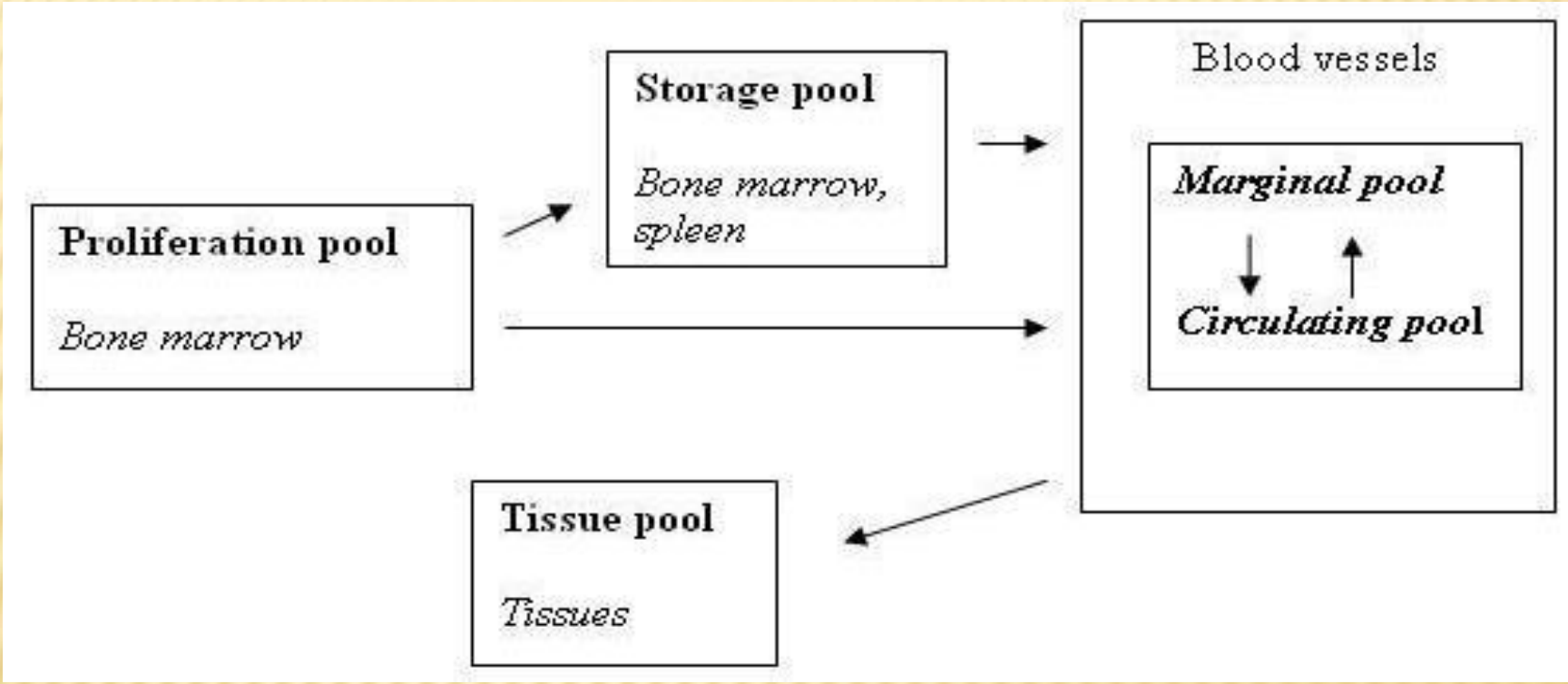
Source: Lichtman MA, Kipps TJ, Seligsohn U, Kaushansky K, Prchal JT: *Williams Hematology, 8th Edition:* http://www.accessmedicine.com

Total blood granulocyte pool(TBGP) :

1- Circulating granulocyte pool (CGP): It includes neutrophils in the flowing blood that can be counted in the leukogram.

2- Marginal granulocyte pool(MGP): They are closely associated with the endothelial cells of capillary and post- capillary venules, they are ready for migration from circulation to tissues, they are not represented in the leukogram.

The two pools are in dynamic movement


Proliferation pool
Bone marrow
Storage pool
Bone marrow, spleen
Blood vessels
Marginal pool
Circulating pool
Tissue pool
Tissues

Function:

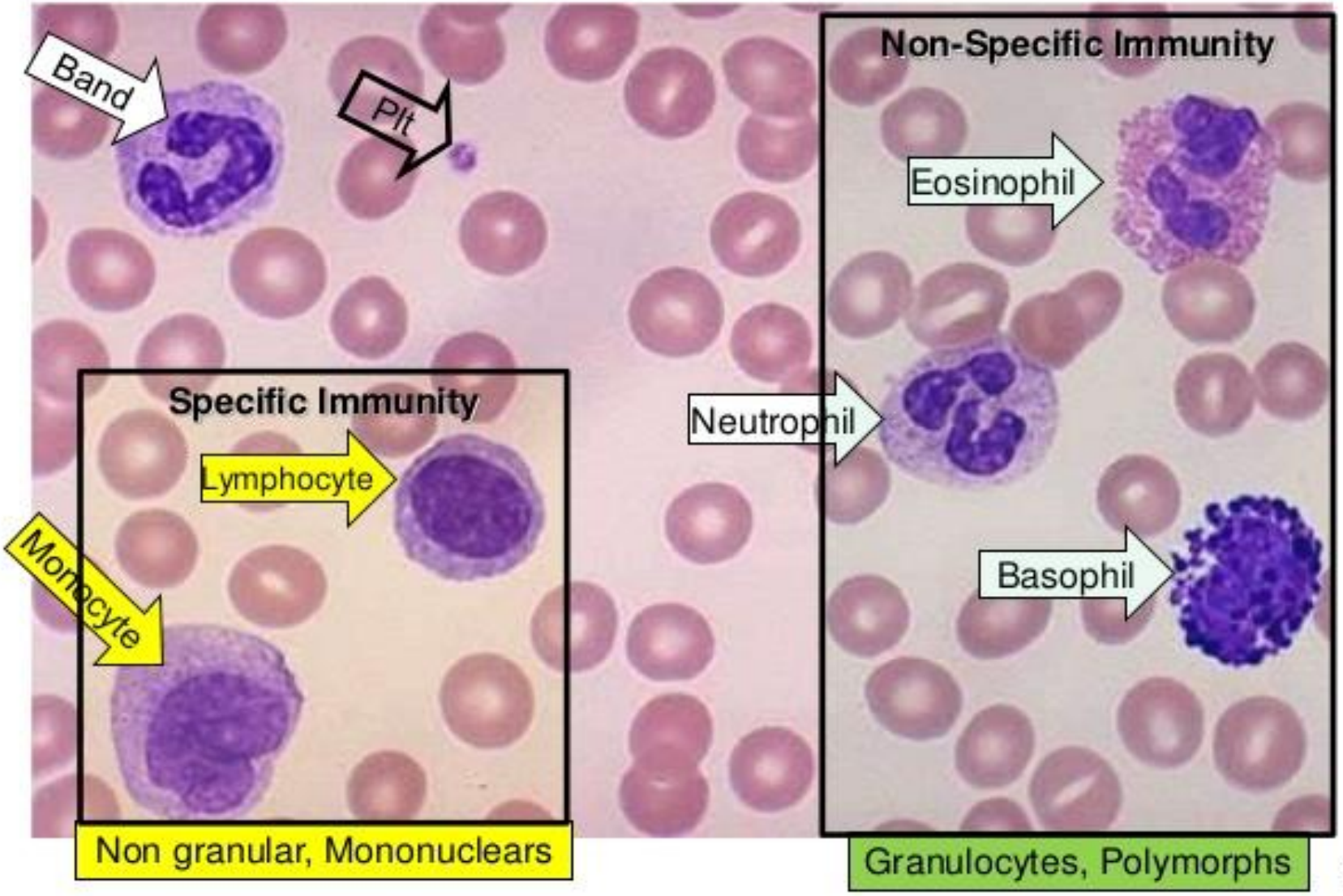
a- Phagocytosis and microbicidal action in the tissue and not in the blood.

- Neutrophils can kill and inactivate bacteria, some fungi, yeasts, parasites and viruses. Neutrophils can eliminate transformed cells.

ABNORMALITIES IN THE NUMBER OF NEUTROPHILS:

Neutrophilia: It means increase in the number of circulating neutrophils above the upper normal level for the particular species.

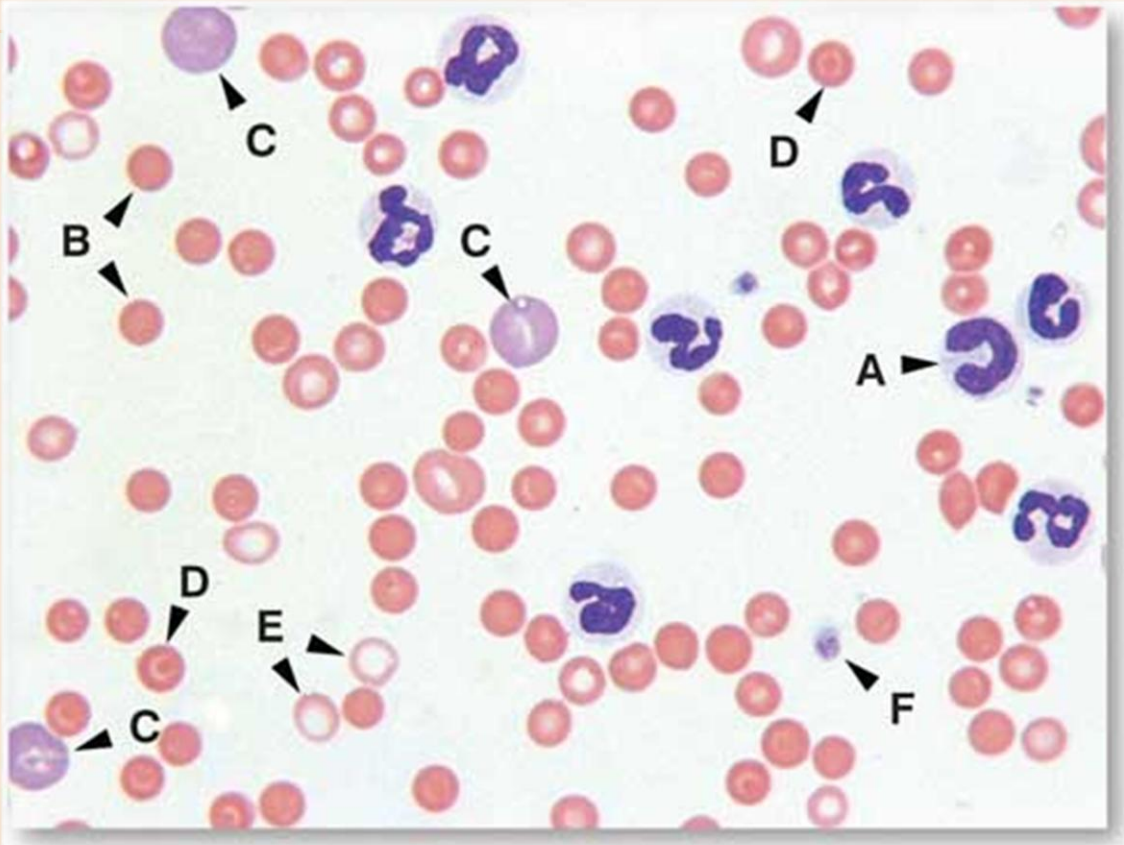
Normal Blood Cells:



a. physiological or pseudoneutrophilia (Pseudoleukocytosis):

The release of adrenaline and noradrenalin during fear, exercise pain or rough handling , it leads to movement of neutrophils from MGP to CGP, there is no bone marrow release and no immature neutrophils are observed in the circulation. It is transitory and observed in healthy animals only.

NEUTROPHILIC LEKOCYTOSIS WITH MILD LEFT SHIFT



A Decreased RBC density, supporting the degree of anemia present, as well as the presence of band neutrophils

B Numerous spherocytes

C Moderate polychromasia

D Moderate anisocytosis, mild target cell formation

E Presence of microcytic and hypochromic erythrocytes

F A relatively low number of platelets and the presence of few enlarged platelet forms

b. Stress- induced or corticosteroid- induced neutrophilia: Stress and endogenous cortisone release are consequences of pain, anesthesia , surgical manipulation , trauma , neoplasia or hyperadrenocortisism (Cushing,s disease) which is common in man and dog.

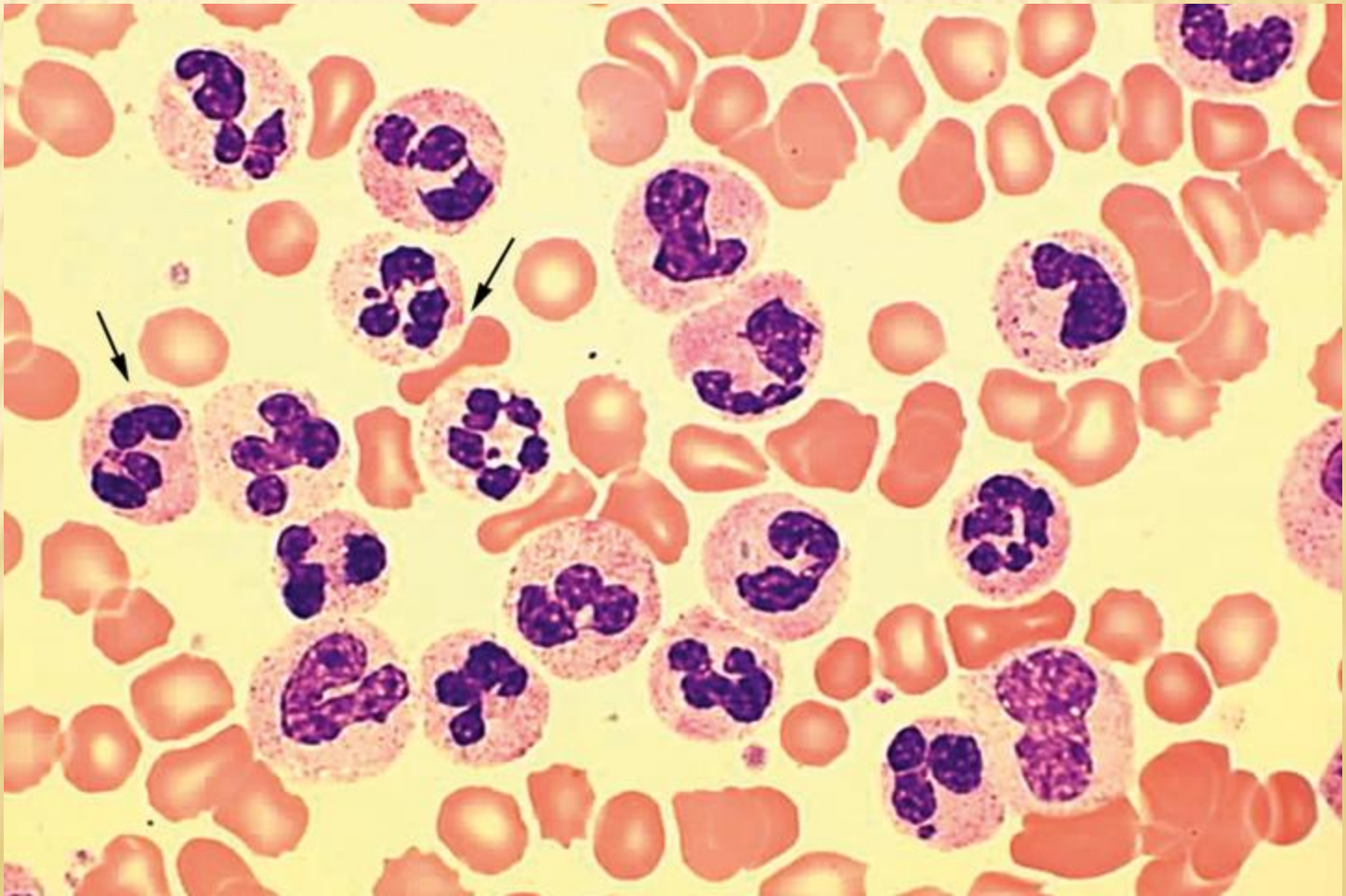
It is caused by the following mechanism:

1. Decrease in neutrophil migration to tissues.
2. Increase in bone marrow release of mature neutrophils, no increase in production, no immature neutrophils are detected.

C- Inflammatory

neutrophilia,Increase in tissue demand for neutrophils. May be due to bacterial, fungal, viral (pox), parasitic (like fasciola and toxoplasma) infection ; neolasia.

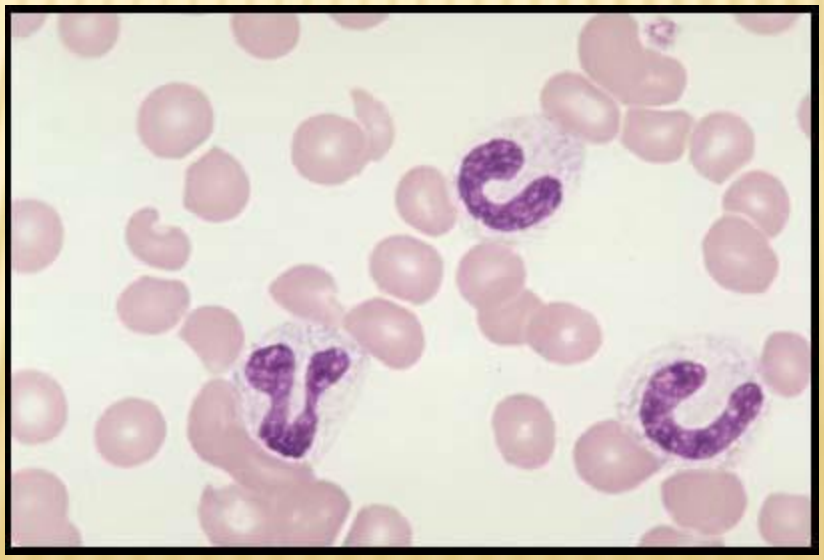
D. Chronic or acute neutrophilic leukemia



left shift : Is an increase in the number of immature, nonsegmented neutrophils, typically bands, but may also include metamyelocytes or even more immature forms.

- **A regenerative left shift** . it is a left shift accompanied with neutrophilic leukocytosis, the number of segmented mature neutrophils are greater than the less mature forms of neutrophils as bands. It indicates good bone marrow response.

- **A degenerative left shift** it is a left shift accompanied by normal to decreased total wbc count and the concentration of bands and less mature form equals or exceeds the number of segmented mature neutrophils

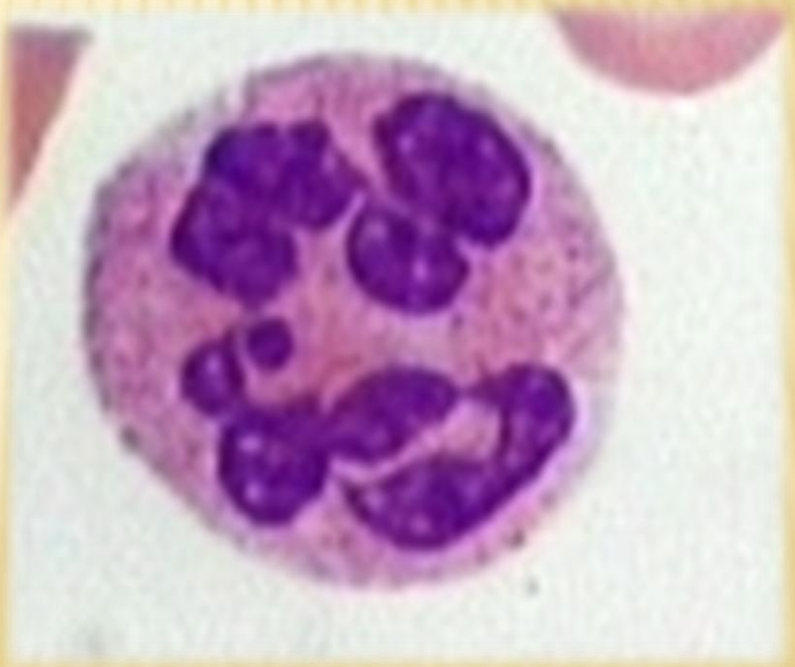


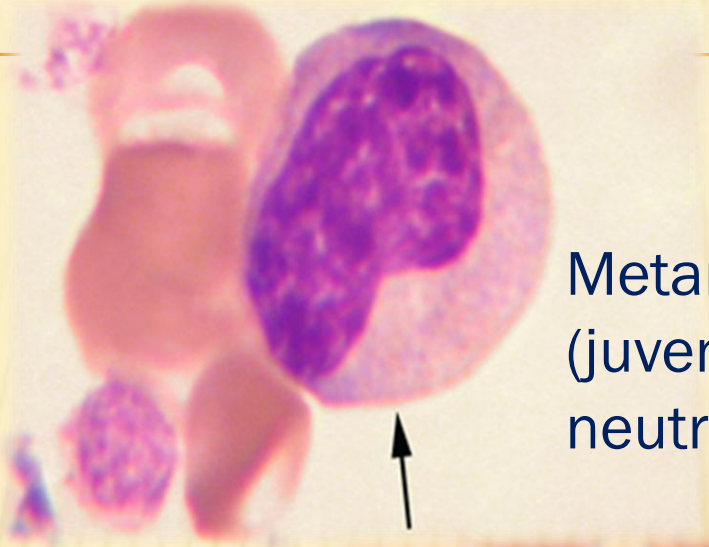
- . Left shift without neutrophilia or leukocytosis is an inappropriate response; it means that tissue utilization exceeds b. m. release and supply.

- Left shift without neutrophilia or leukocytosis

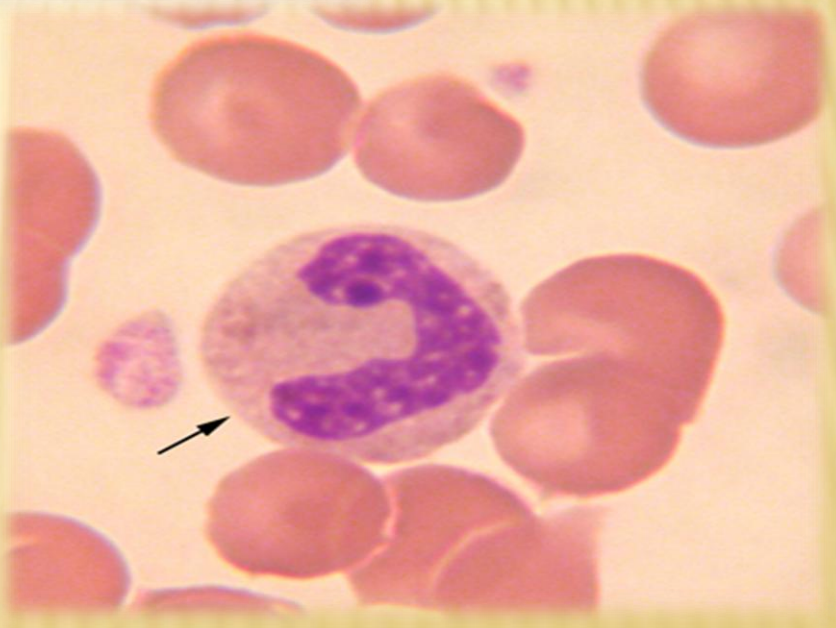
is an inappropriate response, it means that tissue utilization exceeds b. m. release and supply.

Right shift: it means hypersegmentation of the nucleus of the neutrophil, more than 5 lobes. It indicate long residency in the circulation.





Metamyelocyte (juvenile neutrophil



Band neutrophil(stab)

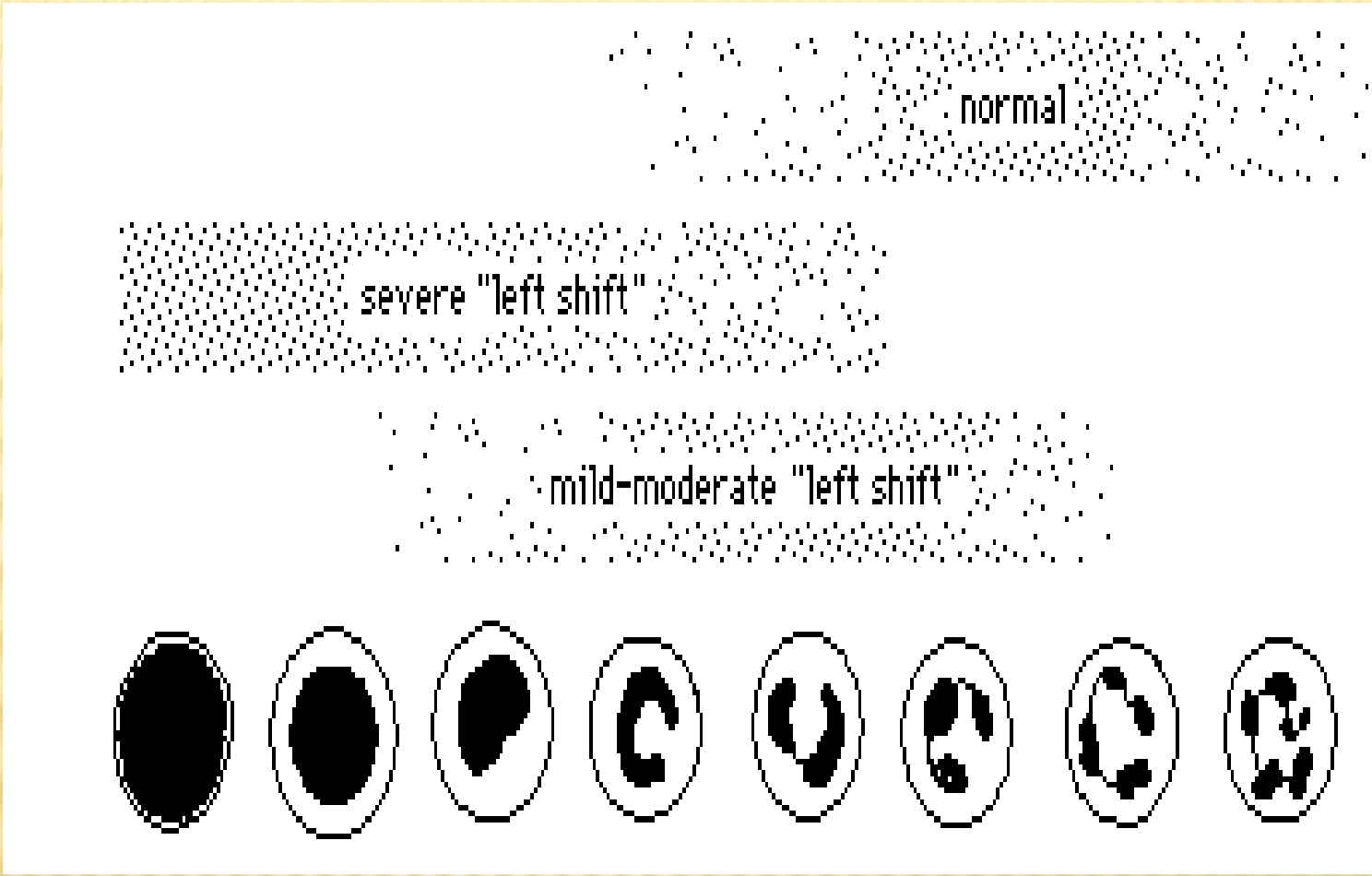
leukemoid reaction

Marked neutrophilia (30-50x103/µl) with severe left shift including band, metamyelocytes, myelocytes, it indicate serious inflammatory disease . It is known as leukemoid reaction because it resembles granulocytic leukemia.

.

A.

- leukemoid response are >70,000/µL for dogs, >50,000/µL for cats, >30,000/mL for horses, and >20,000/µL for ruminants.


normal
severe "left shift"
mild-moderate "left shift"

Neutropenia:

Reduction in the number of neutrophils below the lower normal range for the particular species(dog less than 3000, cow less than 1500, horse less than 2700).

Causes:

1. Excessive usage as in per-acute overwhelming bacterial infection e.g. peritonitis, aspiration pneumonia, metritis, equine salmonellosis, bovine mastitis.

Immune-mediated neutropenia, viral infection e.g. canine distemper and infectious hepatitis.

2.Reduced production(decrease in bone marrow granulopoiesis) caused by either

- *viral infections (feline infectious panleukopenia, feline leukemia virus, feline immunodeficiency virus infection),
- *protozoal infection (toxoplasmosis),
- *rickettsial infection (ehrlichiosis), be caused by
- *chemicals as estrogen toxicity in dogs and bracken fern poisoning in cattle(toxin in this plant destroyes the bone marrow cells) .
- *Genetic causes, e. g. canine cyclic neutropenia.
- *Myelophthesis.
- *irradiation.

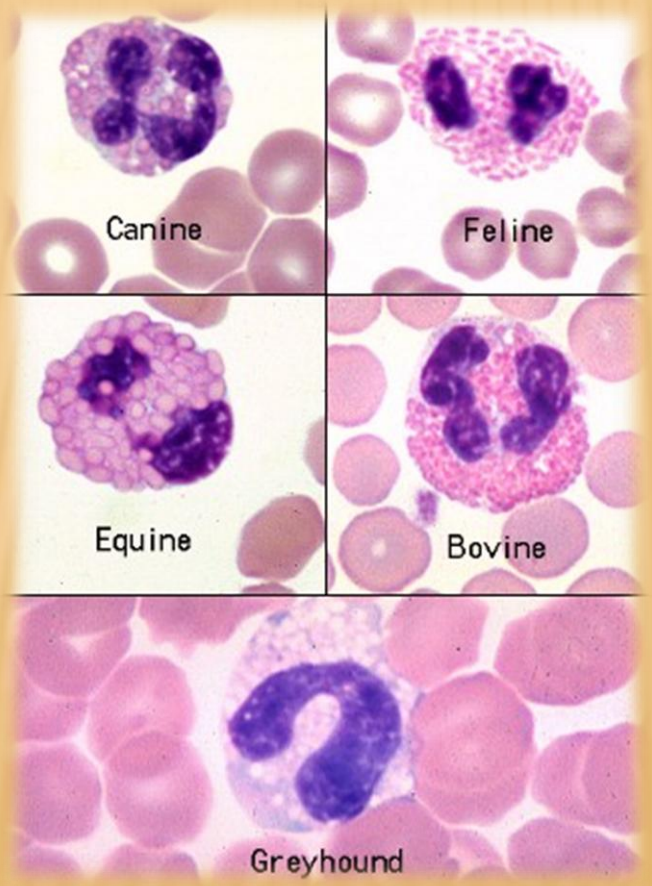
3. Endotoxine- induced neutropenia (pseudoneutropenia):

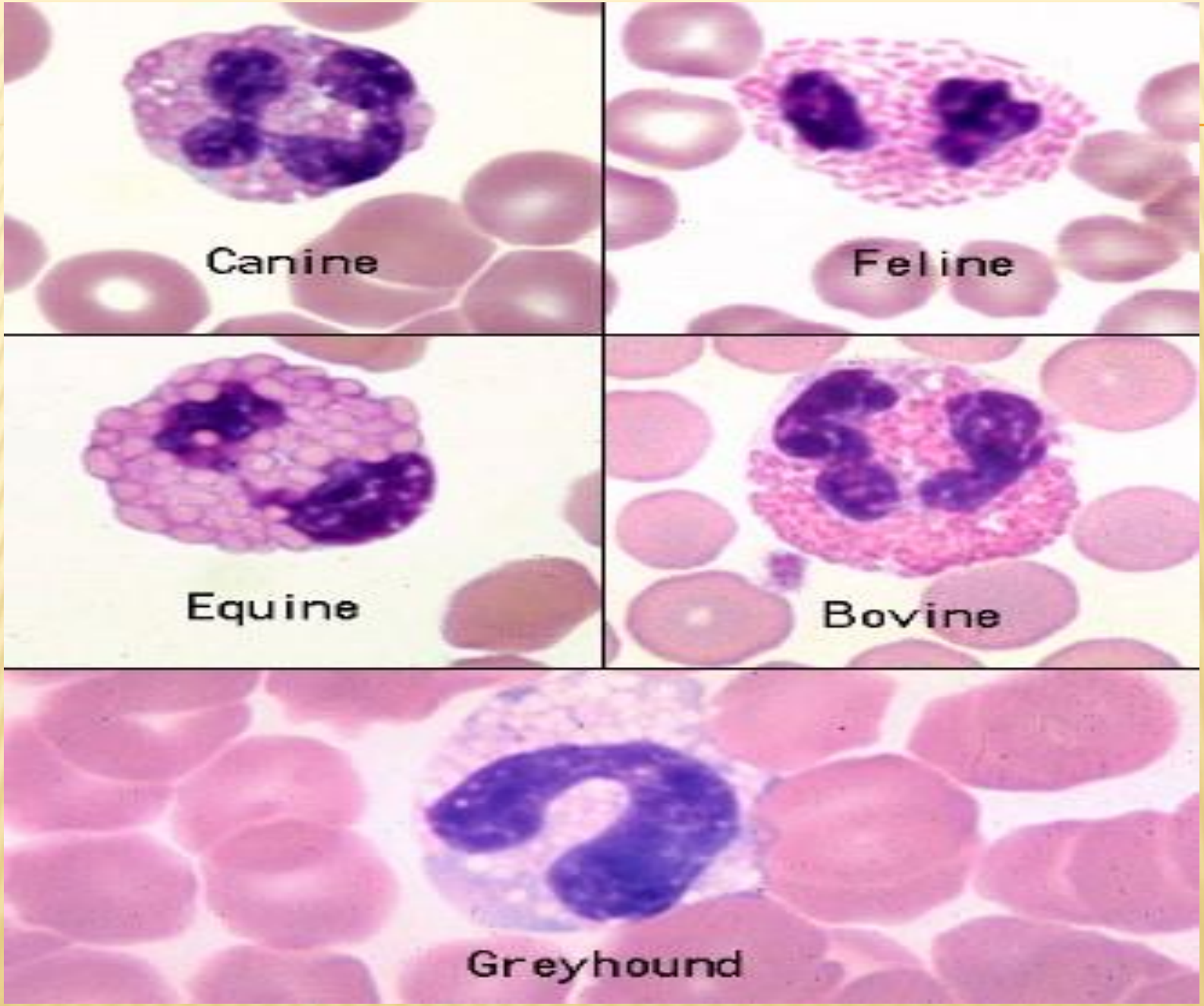
Caused by margination of neutrophils from circulatory granulocytic pool to marginal granulocytic pool caused by activation of adhesion molecules it is transient followed by neutrophilia, e.g salmonellosis in equine.

Abnormal morphology of Neutrophils: Practical lecture.

EOSINOPHILS:

They have limited phagocytic activity , poor defense against bacteria and viruses, active in killing metazoan parasites.




Canine
Feline
Equine
Bovine
Greyhound

EOSINOPHILIA:

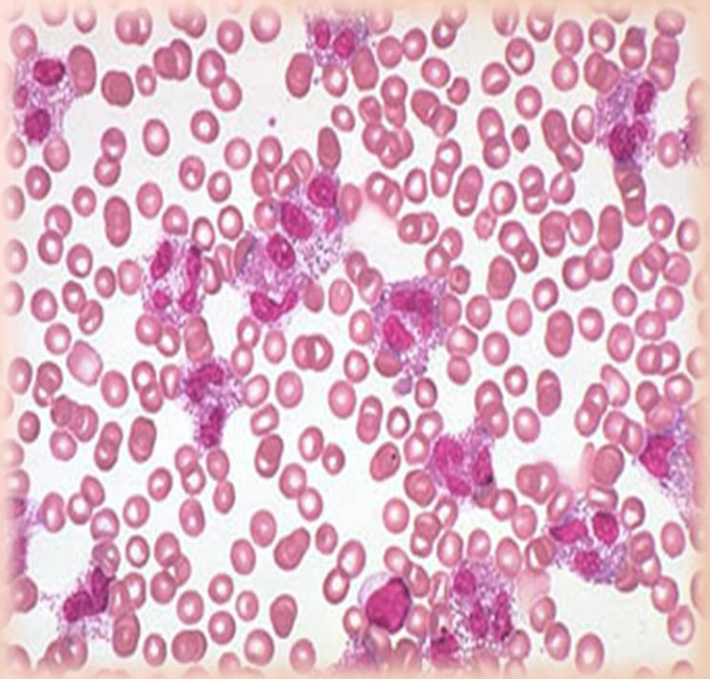
Increase in the number of eosinophils above the upper normal level for the particular sp., it may be caused by

* parasitic diseases.

*inflammatory conditions associated with certain organs like the skin, lung, intestine,uterus.

*IgE –mediated allergic hypersensitivity(flea bite and asthma).

*eosinophilic leukemia.



EOSINOPENIA:

Decrease or complete absence of eosinophils in the circulation,it can be caused by.

* increase release of endogenous cortisone due to stress or over-

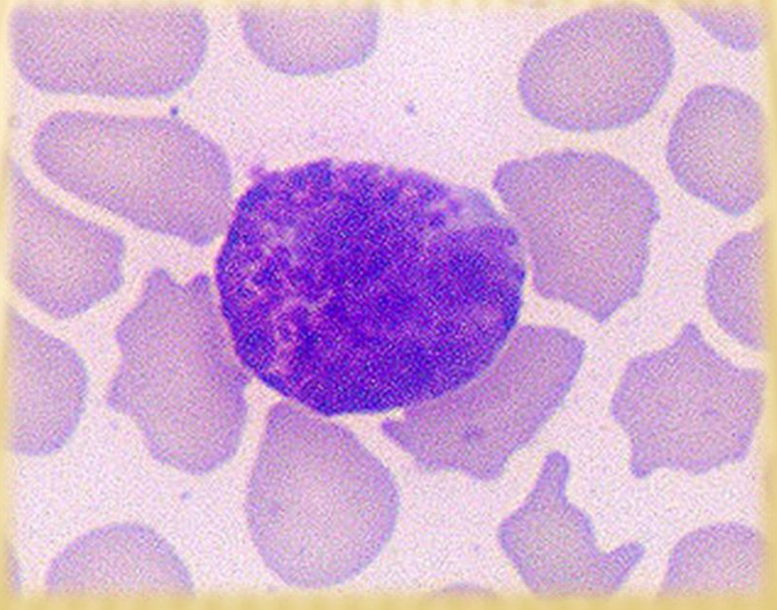
activity of adrenal cortex (hyperadrenocorticism or Cushing syndrome).

*treatment with cortisone.

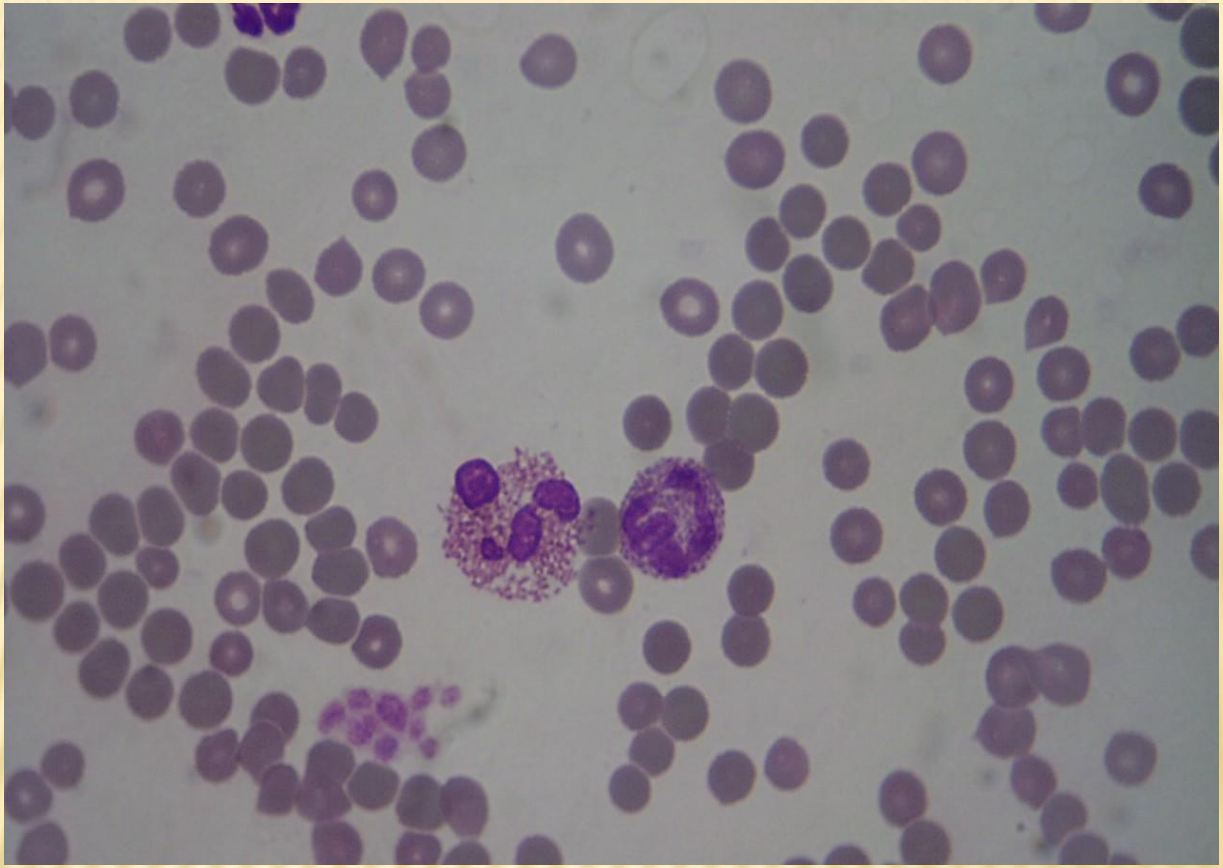
BASOPHILS:

Least numerous blood cell(0-0.5%),they participitate in delayed and immediate hypersensitivity through the release of mediators as histamine.Also it can reject parasites and may have tumour cytotoxicity.

Basophilia: Means persistent observation of more than 200 basophil/µl of blood.



Normal eosinophil and basophil



Morphology of eosinophils varies widely with species; granules are large in horses, small & numerous in ruminants, accompanied by vacuoles in dogs, and rod-shaped in cats.
Basophils have purple-black granules, are numerous in large animals and may be almost absent in healthy dogs and cats.

It is caused either by:

*hyper-sensitivity and / or inflammatory reactions.

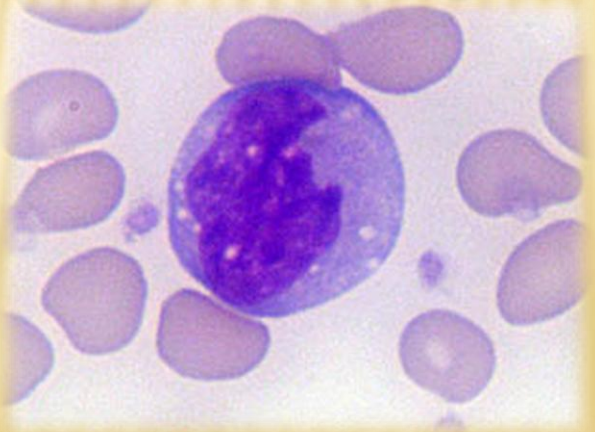
*parasitic diseases as ticks,fleas,vascular parasites as dirophilaria, GI parasites.

*drug administration as penicillin, heparin.

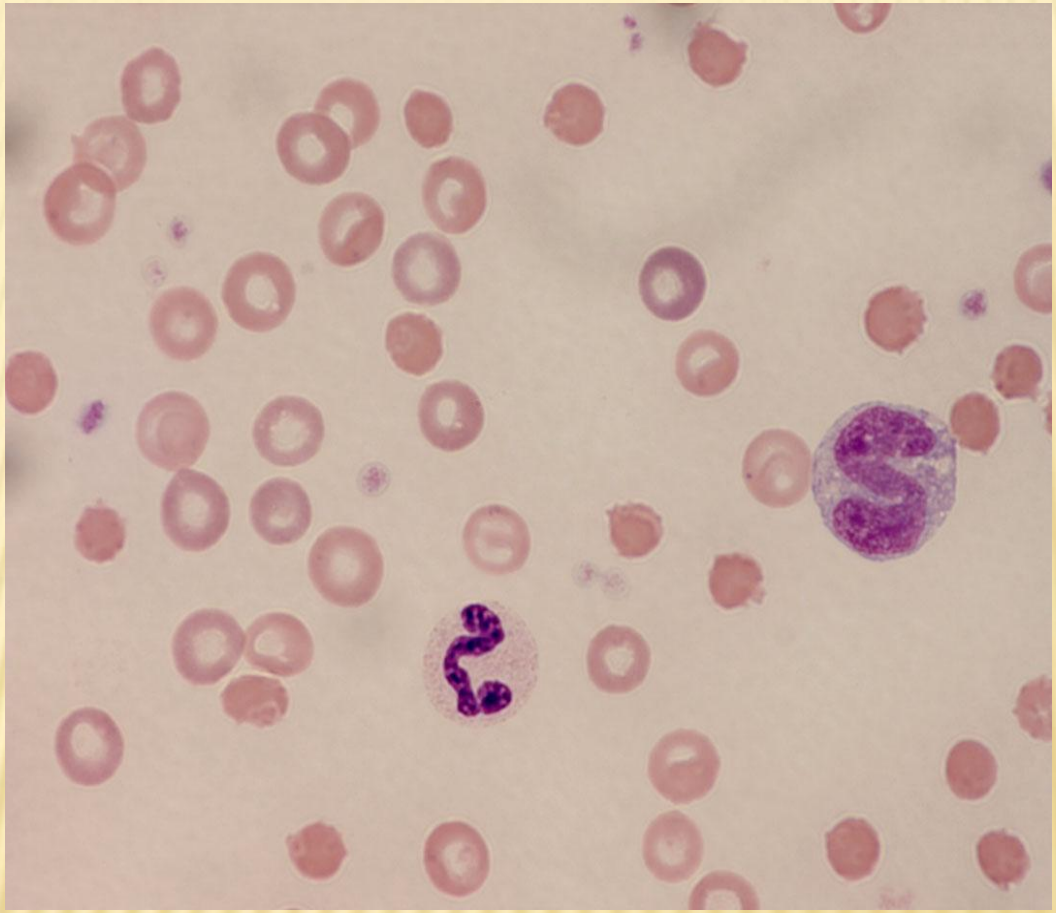
*mast cell and basophil leukemia.

MONOCYTES:

The largest circulating blood cell , derived from bone marrow , circulate in the blood then migrate to the tissues. It exerts defense mechanism against facultative intracellular bacteria like salmonella , listeria, mycobacterium, brucella , richettsia , fungi , protozoa like leishmania, toxoplasma, trypanosome in addition to viruses. Monocytes remove abnormal cells and debris, also it secretes different kind of monokines .



Normal neutrophil and monocyte



Monocytes are similar in most species; large cells with basophilic cytoplasm (often vacuolated or with tiny pink granules), and a pale irregularly clefted or folded nucleus with clumped chromatin.

Monocytosis :

*Chronic disease conditions mostly fungal and granulomatous infections.

*associated with neutrophilia.

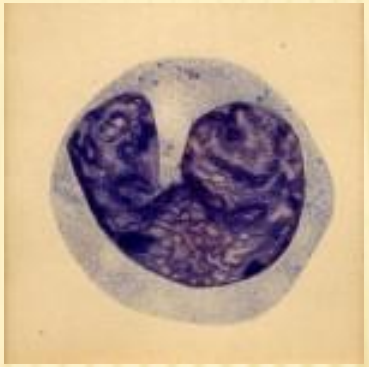
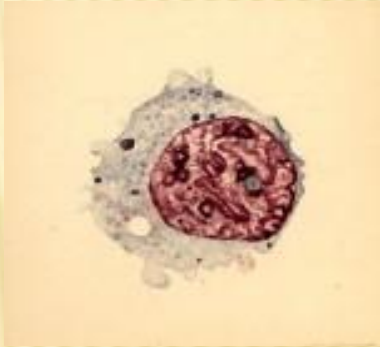
*monocytic or myelomonocytic leukemia

*stress monocytosis associated with neutrophilia+eosinopenia+lymphopenia due to endogenous cortisone release.

Monocytopenia: Normal animal may have few or no monocyte so this term is not used.

MONOCYTES WITH DIFFERENT- SHAPED NUCLEI

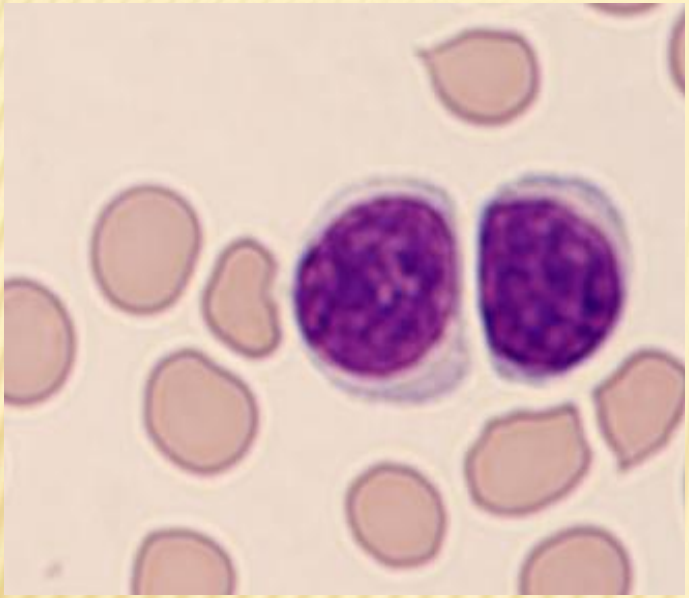


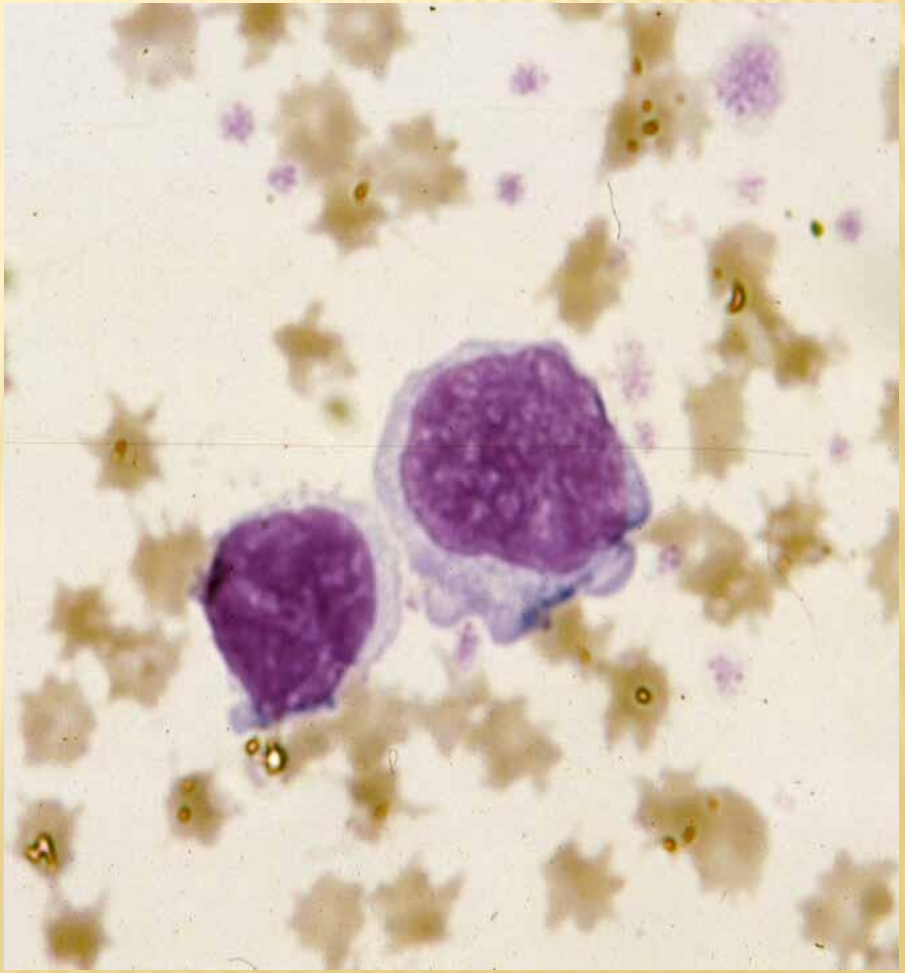
LYMPHOCYTES :

Only 10% of lymphocytes appear in the blood, they circulate in the blood then migrate to tissues, mostly lymph nodes then back to blood again, unlike other leukocytes which end their lives in the tissue and never return to the circulation. Lymphocytes end their life by division and transformation, they can live for years and take main part in cellular immunity,

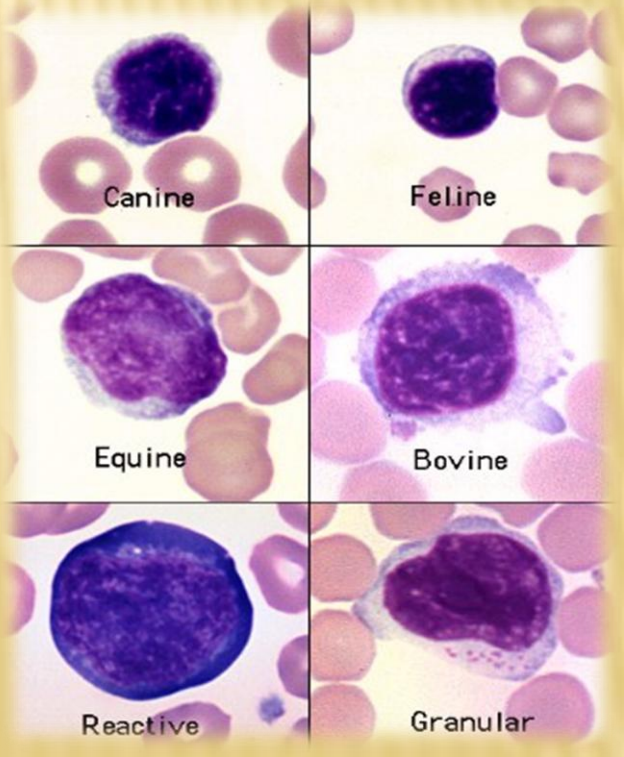
Small lymphocytes, dog



Small and medium lymphocyte, cow



B-lymphocytes survive for few days except memory B-lymphocytes, they take main part in humeral immunity and antibody production , 5-10% are natural killer(NK) cells which appear as large and small granular lymphocytes, they live from few days to several months.



Lymphocytosis: It indicate increase in the number of circulating lymphocytes above the upper normal level for the particular species, expected causes are:

1. Epinephrine release as a result of fear, excitement

in healthy cats and horses.

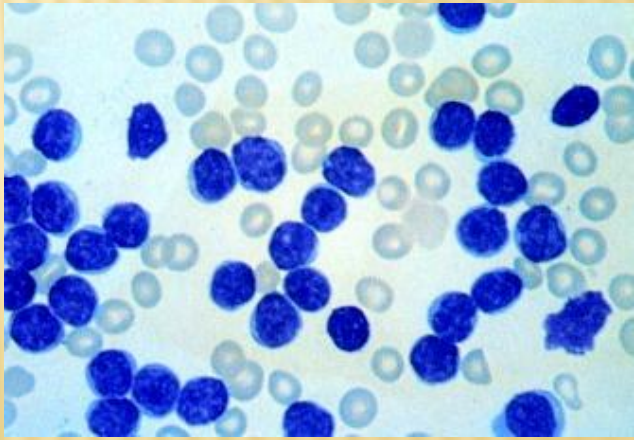
2. Chronic inflammations.

3.Viral infections(certain not all) .

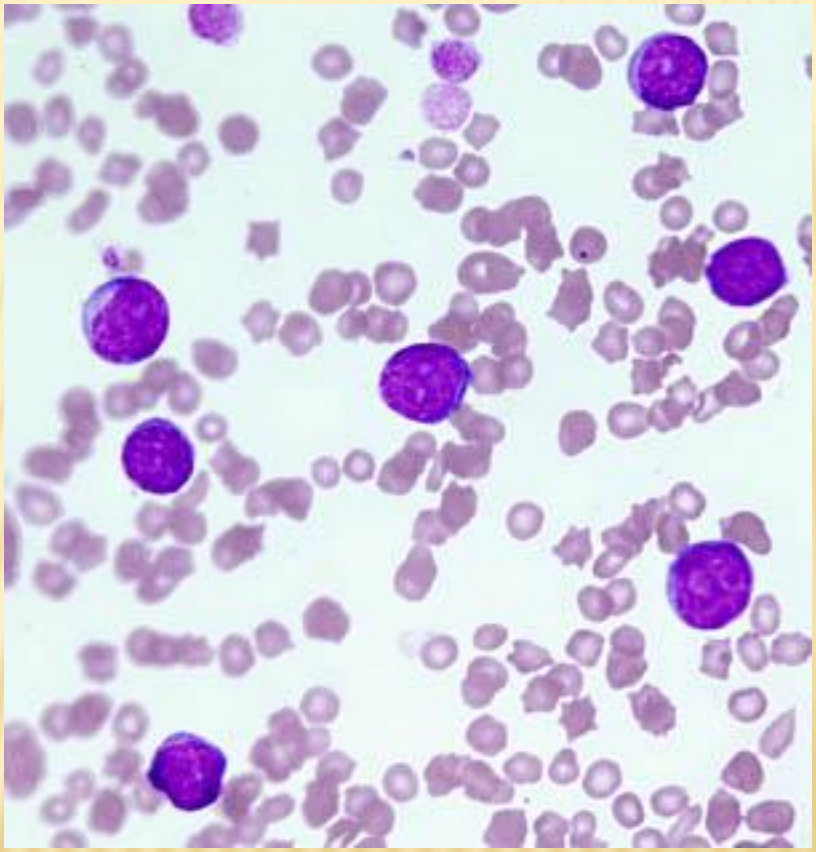
4. Bovine leukemia virus infection.

5. Acute and chronic lymphoma.

6. Hypoadrenocorticism (Addison's disease).



ACUTE LYMPHOCYTIC LEUKEMIA



Lymphopenia*:* Caused by:

1. Endogenous stress or hyperadrenocortisism (Cushing,s disease), accompany stress of severe acute inflammation, or exogenous treatment with corticosteroids as anti-inflammatory, cortisone induce lymphopenia by:

a- Sequestration of lymphocytes in lymph nodes and spleen.

b-Potentiate apoptosis of transformed lymphocytes.

c-Inhibit lymphocyte mitosis.

2. Diseases that result in disruption of lymph node architecture lymphoma and generalized granulomatous diseases.

3. Thoracic duct rupture, loss of lymph- rich lymph vessel.

4. Heriditory disease e. g. combined immunodeficiency of Arabian foals (CID) affecting both T and B lymphocytes.