HEMATOLOGY PART II

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White Blood Cells

Complete Blood Count:

	Patient Value	Normal Range 2 years – 6 years
WBC	8.4 x 10^9 / L	(5.0 – 17.0)
RBC	2.77 x 10^{12} / L	(3.90 – 5.30)
Hgb	7.5 g/dl	(11.5 – 13.5)
Hct	21.8 %	(34.0 – 40.0)
MCV	78.6 fl	(75.0 – 87.0)
MCH	26.9 pg	(25.0 – 31.0)
MCHC	34.2 gm/dl	(31.0 – 36.0)
RDW	17.3 %	(11.5 – 15.0)
PLT	192 x 10^9 / L	(150 – 450)

Differential:

	Absolute	Normal Range Number	2 years – 6 years
Neutrophils	43 %	(3.61)	(1.50 – 8.50)
Bands	6 %	(0.50)	(0.00 – 1.00)
Lymphocytes	41 %	(3.44)	(3.00 – 9.50)
Monocytes	4 %	(0.34)	(0.00 – 0.80)
Eosinophils	3 %	(0.25)	(0.02 – 0.65)

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Evaluation of the White blood cells (RBCs)
WBCs picture

Total WBCs count

Differential leucocytes count

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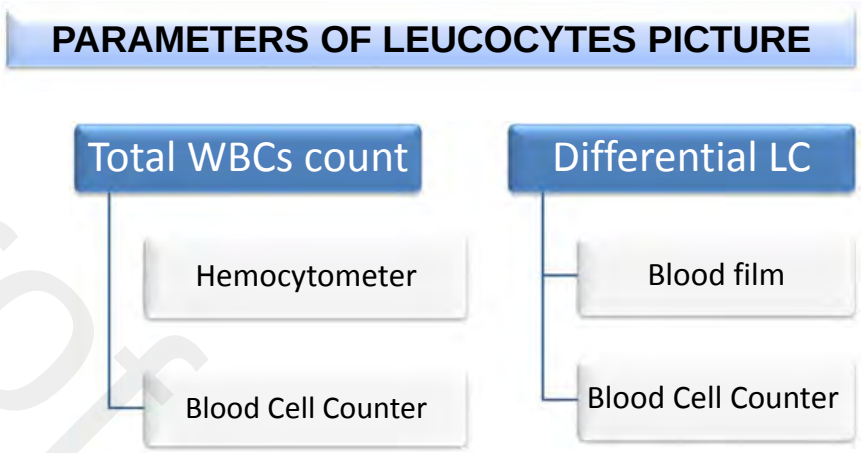

The significance of blood smear examination

1. Identification of different animal species.
2. Morphological examination of the erythrocytes and leucocytes.
3. Carrying out the Differential leucocyte count.
4. Diagnosis of leukemia.

The significance of blood smear examination

5. Diagnosis of blood parasites.
6. Diagnosis of bacterial diseases.
7. Prognosis of disease.
8. Diagnosis of toxicity with some heavy metals like lead.

The significance of blood smear examination

9. Estimation of the degree of anemia.
10. Diagnosis of some viral diseases (Canine Distemper)
11. Evaluation of the bone marrow.
12. Indirect method for counting of platelets.

Basics of the Hemogram Interpretation

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Basics of the Hemogram Interpretation

Interpretation of the erythrogram

Interpretation of the erythrogram is both qualitative and quantitative.

Interpretation of the erythrocytes count is either increase (Polycythaemia) or decrease (Anaemia).

I) Polycythaemia

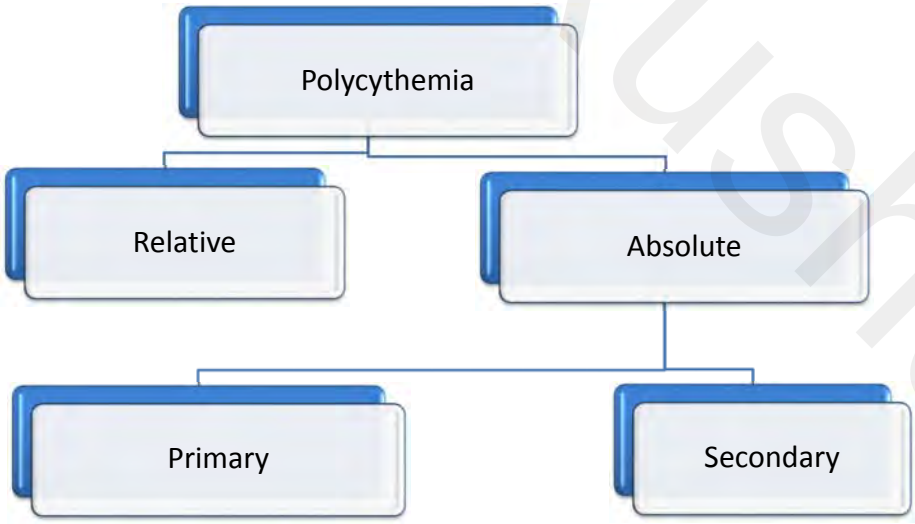
2) Anaemia

Polycythemia

Polycythemia

Definition

Polycythemia is the increase of RBCs count above the normal upper limit specific for each animal species. There are two types of polycythemia, which are relative and absolute polycythemia.



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1. Relative (apparent) polycythemia

It is an apparent or relative increase of RBCs count due to loss of fluids from the body.

The increase of RBCs count in case of relative polycythemia is temporary, as the RBCs count is returned to normal after correcting the loss of body fluids.

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Causes of relative Polycythemia:

1. Hemoconcentration as in cases of diarrhea, diuresis, excessive vomiting or shock (shift of fluid form plasma to the interstitium).
2. Excitement, which results in release of epinephrine that stimulate contraction of the spleen.

Laboratory findings in relative Polycythemia:

1. Increase total RBCs count, hemoglobin concentration and PCV %.
2. Decrease plasma volume.
3. Increase plasma protein level.
4. Normal platelets and leucocytes counts.
5. Normal erythropoietin level.

II. Absolute (true) Polycythemia

It is a persistent increase in total RBCs count.

Absolute Polycythemia may be primary or secondary.

It may be either:

1- Primary Polycythemia.

2- Secondary Polycythemia.

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1- Primary Polycythemia

(Polycythemia Vera or erythremia)

Definition

Primary Polycythemia occurs due to hyperplasia of the bone marrow, or presence of tumor at the bone marrow, which results in increased synthesis of RBCs.

Causes

- Excessive erythroplastic activity of the bone marrow (hyperplasia of hemopoietic tissues of the bone marrow).
- Unknown causes.

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Secondary Polycythemia

- Secondary polycythemia occur in any case characterized by hypoxia or hinder the proper oxygenation of blood.
- Erythrocytosis should be regarded as a conservative vital reaction i.e. an effort on the part of the organism to compensate for some difficulty in the oxygenation of blood and tissues of the body.

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Secondary Polycythemia appears following hypoxic stimulation of the bone marrow under the following conditions:

- Exposure to high altitude.
- Any disease that interferes with the oxygenation of the erythrocytes as in obstructive lesion in air passage ways.
- Renal diseases that characterized by overproduction of Erythropoietin.
- Chronic diseases of the heart.

Laboratory findings in Absolute Polycythemia:

1. Increased total RBCs count, hemoglobin concentration and PCV %.
2. Normal blood total protein level and its fractions.
3. Normal blood urea nitrogen level.
4. High erythropoietin level.
5. Decrease Po_2 in case of hypoxia.

ANEMIA

Anaemia is a reduction below normal in the number of erythrocytes or hemoglobin concentration or both in the circulating blood per unit volume of blood.

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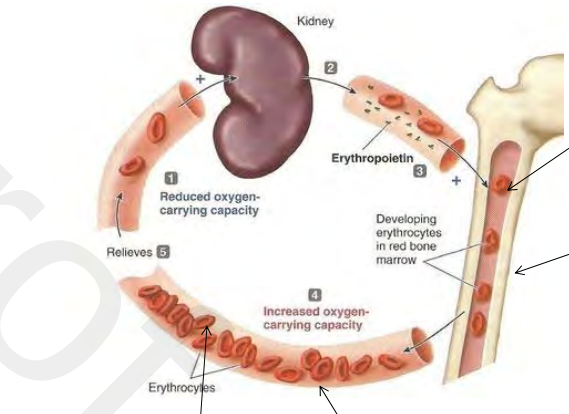
Diagnosis of anemia

- Red blood cells count.
- Hemoglobin concentration.
- Packed cell volume.
- Mean corpuscular values.
- Stained blood smear.

Basics of Classification of Anemia



Hypoplastic anemia

- Iron
- Copper
- Vit. B12
- Folic acid
- Cobalt
- Protein

Nutritional deficiency anemia

Hemolytic anemia

Hemorrhagic anemia

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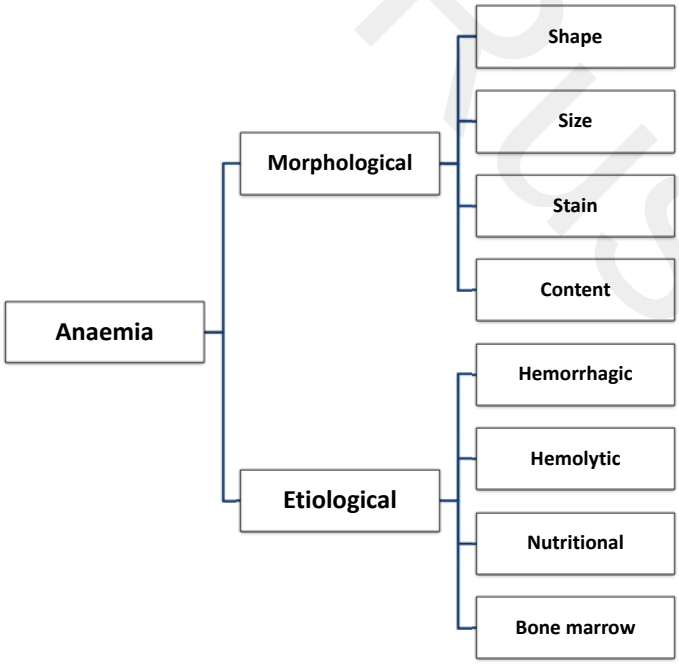

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Morphological classification of anemia

- Abnormalities in shape
- Abnormalities in size
- Abnormalities in stain
- Inclusion bodies of erythrocytes

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Abnormalities in shape of the erythrocytes (Poikilocytosis)

1. **Leptocytes**
2. **Spherocyes**
3. **Ovalocytes**
4. **Target cell**
5. **Nucleated**
6. **Tear Drop cell**
7. **Crenation**
8. **Eccentrocytes**

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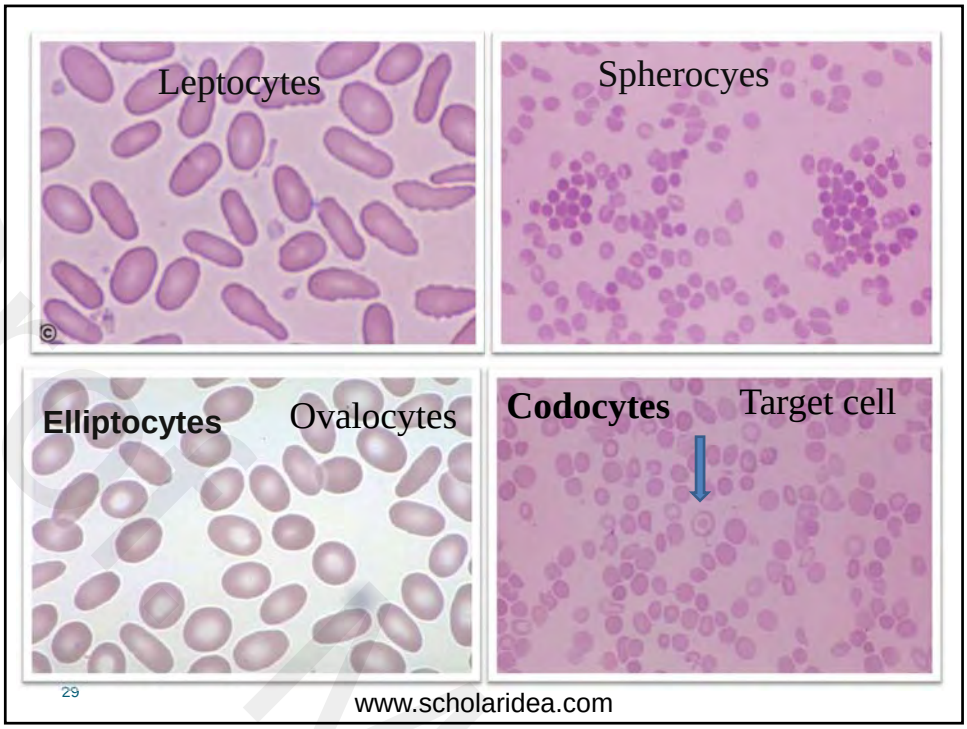
Leptocytes
Spherocyes
Elliptocytes
Ovalocytes
Codocytes
Target cell
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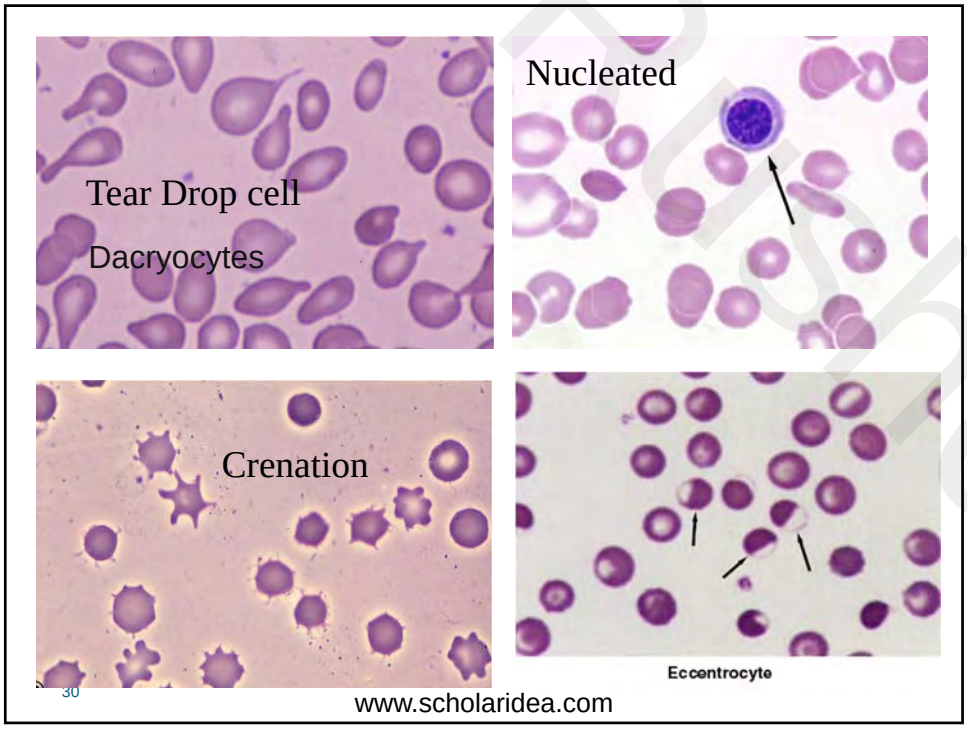
Tear Drop cell
Dacryocytes
Nucleated
Crenation
Eccentrocyte
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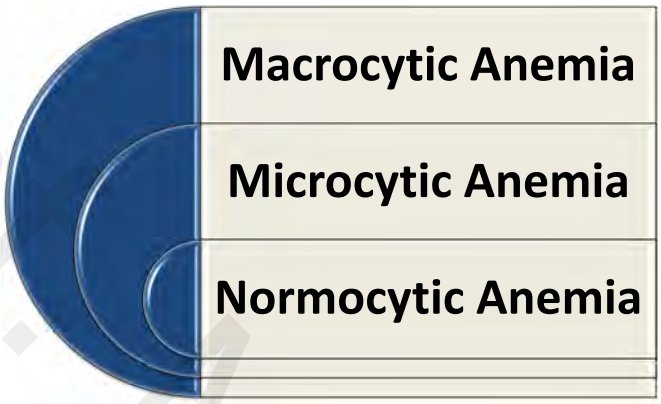
Abnormalities in size and stain

Abnormalities in size (anisocytsis)

Mean Corpuscular Volume (MCV)



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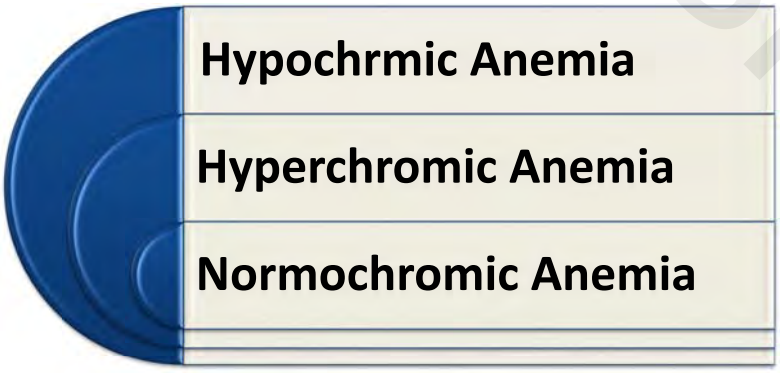
Abnormalities in stain

Mean Corpuscular Hemoglobin (MCH)

Mean Corpuscular Hemoglobin concentration (MCHC)



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Microcytic Hypochromic anemia

- **Deficiency of Iron.**
- **Deficiency of Copper.**
- **Molybdenum Poisoning.**
- **Chronic Blood Loss.**

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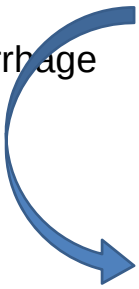
Macrocytic Hypochromic anemia

Acute Hemorrhage
Hemolysis



Normocytic normochromic anemia

Macrocytic hypochromic anemia

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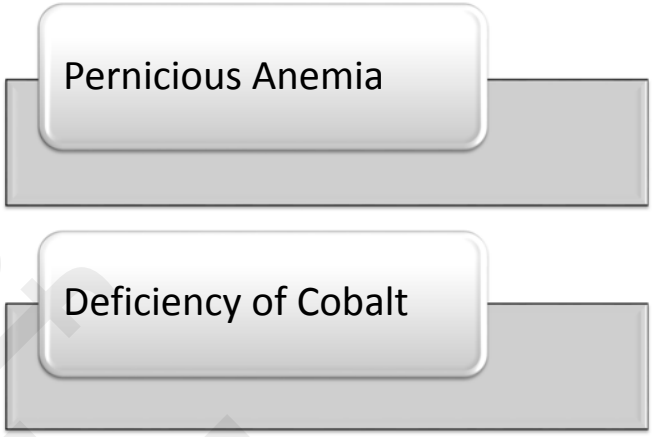
Macrocytic normochromic anemia



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Abnormalities in content of the red blood cell

Inclusion bodies of erythrocytes:

1. Reticulocytes.
2. Basophilic stippling.
3. Howell Jolly body.
4. Heinz bodies.
5. Distemper inclusion bodies.
6. Protozoal parasites.

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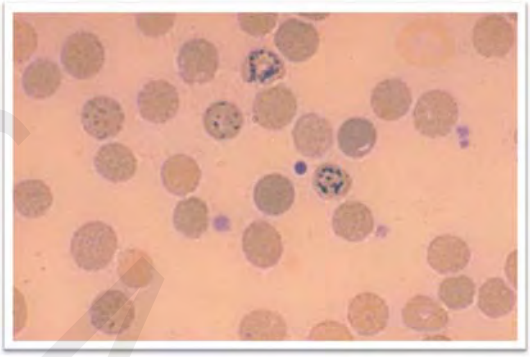
1. Reticulocytes

Reticulocyte is a non-nucleated cell of the erythrocytic series, which when stained with brilliant cresyl blue, present one or more granules or diffuse network of fibrils.



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The reticulocytes differ from erythrocytes in:

A. Larger in size
B. More resistant to crenation.
C. Has a lower specific gravity.
D. More resistant to hypotonic saline solution.
E. Reticulocytes don't participate in Rouleux formation.

Reticulocytosis: Occur in cases of acute hemorrhage or hemolytic anaemia.

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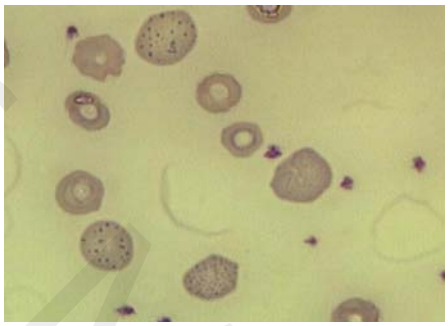
2. Basophilic stippling

A condition of the erythrocyte in which blue staining basophilic granules are scattered over the cell.

- Punctuate basophilic granules.
- Diffuse basophilic granules



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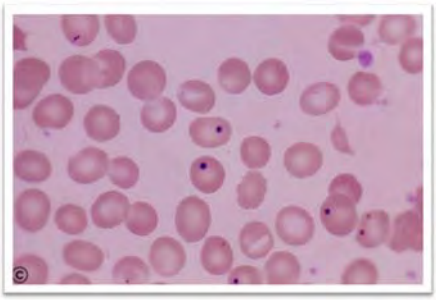
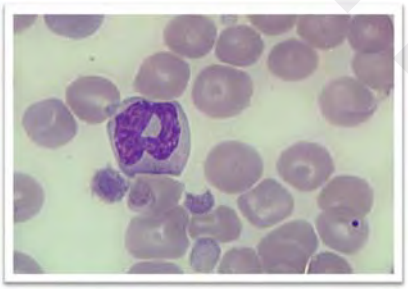
3. Howell Jolly body

This is a nuclear remnant of 1-2 microns in diameter.

In Giemsa stained smear, Howell jolly bodies appear as single and at times double spherical bluish bodies within red blood cells.





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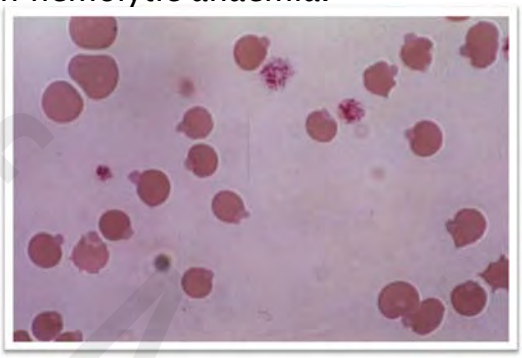
4. Heinz bodies

Heinz bodies are small, round to irregularly shaped inclusion bodies.

They formed within the RBCs of man and animals exposed to toxic drugs and chemicals and often resulting in hemolytic anaemia.



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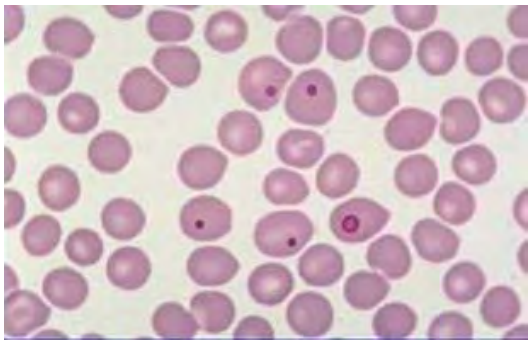
5. Distemper inclusion bodies

- In Giemsa or leishman stained blood film, the inclusion bodies take a pale blue stain and it is larger than Howell jolly bodies.



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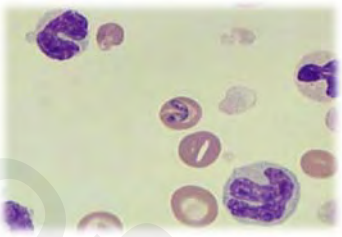
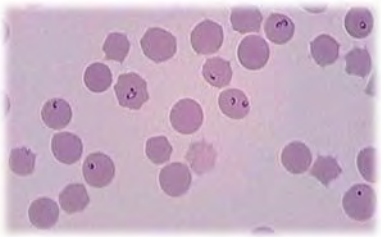
6. Protozoal parasites

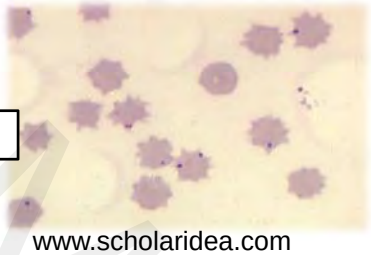
Babasia Sp.



Theileria Sp.



Anaplasma Sp.



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Regenerative and none Regenerative anemia

Regenerative anemia is characterized by the presence of immature RBCs (reticulocytes) in the peripheral blood. Regenerative anemia is usually associate hemorrhagic (Blood loss) and hemolytic anemia.

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Non-regenerative anemia is characterized by absence of immature RBCs from the peripheral blood.

- **Conditions characterized by non-regenerative anemia include:**
  - Anemia of inflammation, which is mild to moderate anemia.
  - Renal disease, due to the lack of erythropoietin and consequently decrease erythrocyte synthesis by the bone marrow.
  - Iron deficiency anemia, which characterized by microcytic hypochromic anemia.

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Infectious and inflammatory diseases:

- As part of the immune response that occurs with infection and noninfectious inflammatory diseases, cells of the immune system release proteins called cytokines. These proteins help heal and defend the body against infection. But they can also affect normal body functions. Cytokines interfere with the body's ability to absorb and use iron. Cytokines may also interfere with the production and normal activity of erythropoietin (EPO), a hormone made by the kidneys that stimulates bone marrow to produce RBCs.

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Interpretation of the leukogram

- **When interpreting the leucocytes data, the following should be taken in consideration:**
- Evidence of inflammation.
- Glucocorticoid response (Stress).
- Epinephrine response (Excitement).
- Systemic hypersensitivity reaction.
- Evidence of tissue necrosis.

INTERPRETATION OF LEUCOCYTES PICTURE

1. Leucocytosis.	2. Leucopenia.
3. Neutrophilia.	4. Neutropenia.
5. Lymphocytosis.	6. Lymphopenia
7. Eosinophilia	8. Eosinopenia
9. Basophilia.	10. Basopenia
11. Monocytosis	12. Monocytopenia

1. Leucocytosis

Means increase the total leucocytic count above the normal upper limit specific for each animal species / unit volume of blood. It is either **physiological or pathological.**

a. Physiological leucocytosis

Causes:

Age of the animal

Breed or species of the animal

a. Physiological leucocytosis

Muscular exercise and apprehension

Stage of pregnancy

Estrus

Stage of digestion

b. Pathological leucocytosis

Causes:

- Generalized infection such as (Pasteurellosis, leptospirosis and salmonellosis).
- Localized infection caused by bacteria such as *Staphylococcus*, *Streptococcus* and *Corynbacteria Spp*.

Pathological leucocytosis

- Rapidly growing neoplasm.
- Acute hemorrhage particularly into one of the body cavities.
- Sudden haemolysis of the erythrocytes.
- Leukaemia and trauma.

2. Leucopenia

Decrease the total leucocytic count below the minimum normal limit specific for each animal species.

2. Leucopenia

Causes:

A. Degeneration, depression, depletion and destruction of the bone marrow

B. Viral infection: Such as canine distemper, infectious canine hepatitis and swine influenza.

C. Bacterial endotoxins: Endotoxins of gram-negative bacteria are located at or in the cell wall and are released on autolysis of the bacteria as *Escherichia coli* endotoxins. Endotoxins resulted in a decrease in lymphocytes and neutrophils

2. Leucopenia

D. Overwhelming bacterial infection: Bacterial toxaemia and septicaemia.

E. Cachetic and debilitated states.

F. Physical agents such as x rays

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G. Chemical agents:

- Antibiotics as chroramphenicol, penicillin and streptomycin.
- Analgesics
- Inorganic chemicals: Lead, benzene, bismuth, mercury.

NEUTROPHILIA

Neutrophilia means increase the number of neutrophils in the circulation over about 10 x 10^9 / l in monogastric animals and about 4 x 10^9/l in ruminants**.**

Causes

As leucocytosis

NEUTROPENIA

Neutropenia means decrease the number of neutrophils in the circulation under about 4 x 10^9 / l in monogastric animals and about 1 x 10^9/l in ruminants.

Causes

As leucopenia except viral infection

LYMPHOCYTOSIS

Lymphocytosis means increase the number of lymphocytes in the circulation over about 6 x 10^9 / l in monogastric animals and about 9 x 10^9/l in ruminants.

Causes

1. Recovery from viral infection.
2. Following vaccination.
3. Hypoadrenocorticism.
4. Decrease level of ACTH.
5. Lymphoid leukaemia.

LYMPHOPENIA

Lymphopenia means decrease the number of lymphocytes in the circulation under about 1 x 10^9 / l in monogastric animals and about 3 x 10^9/l in ruminants.

Causes

- Hyperadrenocorticism in stress, steroid therapy.
- Acute viral infection as canine distemper, canine hepatitis and infectious feline enteritis.
- Ionizing radiation or immunosuppressive drugs.

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EOSINOPHILIA

Eosinophilia means increase the number of eosinophils in the circulation over about 1 x 10^9 / l.

Causes

- Allergy.
- Parasitic infection.
- Adrenocortical insufficiency.
- Granulocytic leukaemia.

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EOSINOPENIA

Eosinopenia means decrease the number of eosinophils in the circulation under about 0.1 x 10^9 / l.

Causes

- Stress.
- After administration of ACTH or corticoids as a therapeutic measure.
- Hyperactivity of adrenal gland.

BASOPHILIA

Basophilia means increase the number of basophils in the circulation over about 0.5 x 10^9 / l.

Causes

- Adrenocortical insufficiency.
- Basophilic granulocytic leukemia.
- Hypothyroidism.

BASOPENIA

Basopenia means decrease the number of circulating basophils. Since it is quite normal to fin no basophils at all in a blood film, the theoretical possibilities of Basopenia are not worth considering in clinical situation.

MONOCYTOSIS

Monocytosis refers to an increase the number of circulating monocytes above about 0.5 x 10^9/l.

Causes

- Chronic diseases.
- Monocytic leukaemia.
- Listeriosis in swines.
- Hyperadrenocorticism.
- ACTH and corticoid treatment in dog, cow and cat.

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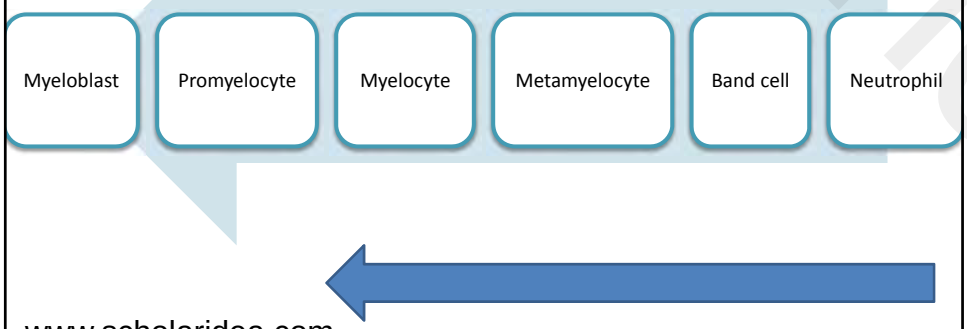
SCHILLING INDEX

It is an index used for classification of neutrophils depending on maturation of neutrophils.

Shift to the left



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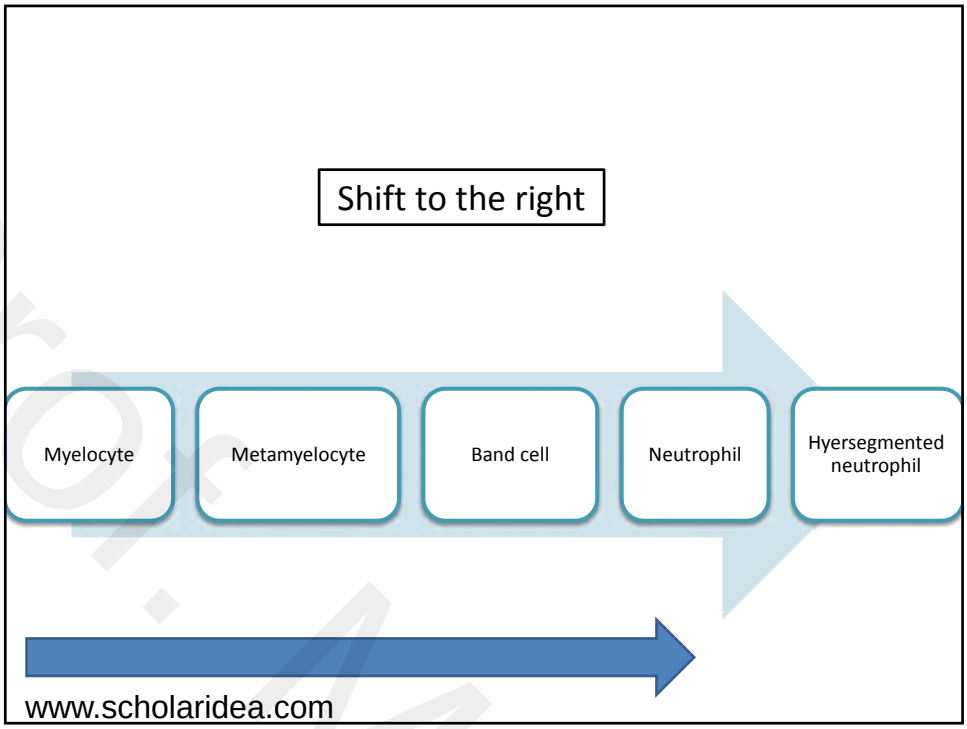

Shift to the left

Shift to the left is used to denote an increase in the umber of immature neutrophils in the peripheral circulation i.e. more than 7 % band cells.

a. Regenerative shift to the left: This shift is characterized by a leucocytosis, neutrophilia and with the appearance of immature neutrophilic granulocytes in peripheral blood, it is either:

1. A slight shift to the left: It is limited to the occurrence of band neutrophils.
2. A moderate shift to the left: It includes both band and metamyelocyte neutrophils.
3. A marked left shift: Would bring myelocytes and progranulocytes into peripheral blood

Prognosis: Good prognosis.

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b. Degenerative shift to the left

- There is normal, low total leucocytic count accompanied by moderate to marked shift to the left.
- This alteration is a result of inability of bone marrow to mature cells in response to infection and as a result increase the number of immature forms appear in the blood which show toxic changes.
- A degenerative left shift is common in septicemia.
- Toxic neutrophils are considered abnormal cells and are present in the blood as a reflection of toxic condition.

Toxic neutrophils appear as:

- Signs of toxaemia are seen in neutrophils in diseases accompanied by depression of granulopoiesis.
- Appear in acute inflammatory diseases as peritonitis, pericarditis, mastitis and metritis.
- The appearance of blue black granules.
- The presence of vacuoles located in the cytoplasm a long the periphery of the cell.
- Toxic granulation results from precipitation of the basophilic ground substance to form blue black granules.

LEUKAEMOID REACTION

- A blood picture exhibiting a marked leucocytosis with a considerable number of immature WBCs. It is similar to left shift of the regenerative type in which there is an extreme leucocytosis simulating that observed in leukemic leukaemia.
- Leukaemoid reaction indicates extreme Leucocytosis. With severe left shift to metamyelocyte and myelocytes but no signs of hemopoietic neoplasia and indicate severe inflammation.

Platelet count (Thrombocytes)

Interpretation of the Platelet count (Thrombocytes)

Platelets in mammals are fragments that contain small pink-red granules. Shed into the blood from megakaryocytes in bone marrow

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Platelet count (Thrombocytes)

Methods of counting

1. **Direct method**
   a. Haemocytometer.
   b. Automatic blood cell counter.
2. **Indirect method:** blood film.

The platelets per oil immersion field on a stained blood smear are counted and compared with the number of red or white cells. For example, the number of platelets per 100 white blood cells multiplied by the total white count is an estimate of the platelet count. Another method is to simply count the number of platelets per oil immersion field where one /oil is equivalent to 15,000/ul.

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Platelet count (Thrombocytes)

Abnormalities of blood platelets

a. Thrombocytopenia

b. Thrombocytosis

c. Thrombocythaemia

d. Thrombocytopathia

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a. Thrombocytopenia

- Aplasia of the bone marrow.
- Bacterial and viral infections (Bacteremia and hepatitis C)
- Abnormal loss of blood platelets in peripheral circulation (autoimmune disease, severe hemorrhage).
- Sequestration of platelets (Hepatomegaly and splenomegaly)

b. Thrombocytosis

Increase the number of circulating blood platelets, may be transient such as occurring after trauma or during disease process.

c. Thrombocythaemia

Means persistent increase in circulating blood platelets.

Causes:

- Megakaryoblastic tumors.
- Over production of thrombopoietin from the kidney.

d. Thrombocytopathia

Platelet normal in number but abnormal in function.

These platelets may have a normal or abnormal appearance, they may be:

- ❑Defective in adhesiveness.
- ❑Defective in aggregation.

Laboratory findings:

- ❑Hemorrhagic diathesis.
- ❑Normal levels of blood coagulation factors.
- ❑Normal platelet count.
- ❑Prolonged bleeding time.