

Morphology of red blood cells

Red blood cells are the major cellular component of blood. Mature red blood cells are biconcave discs that lack nucleus and most cell organelles such as lysosomes, endoplasmic reticulum and mitochondria.

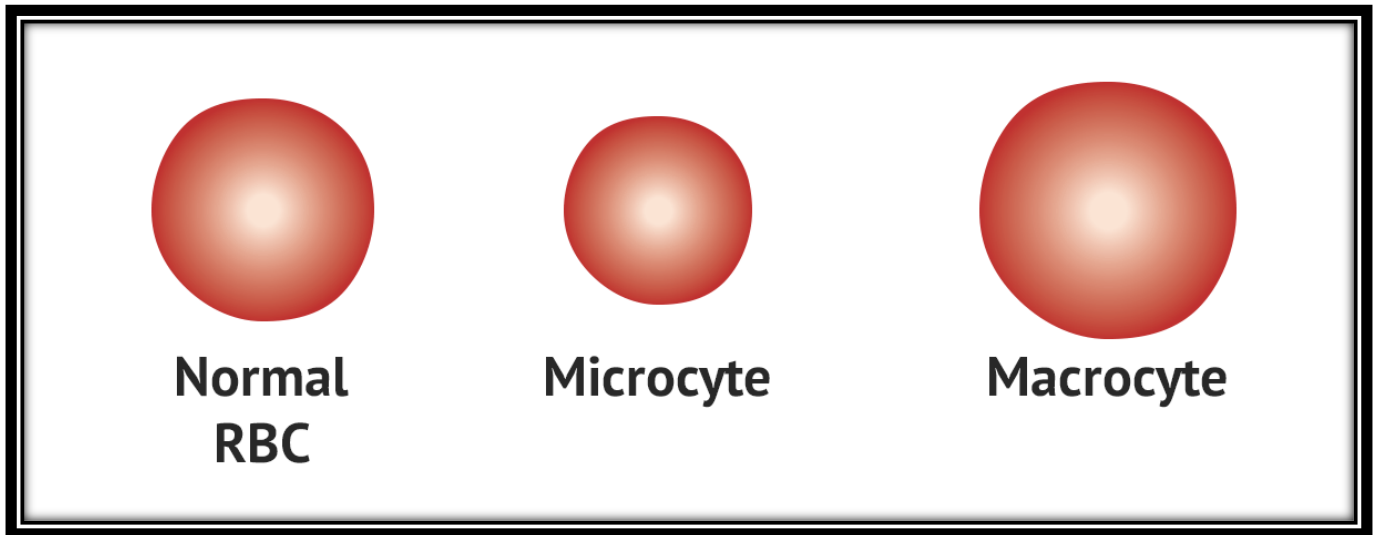


However, variable abnormal erythrocyte morphology is found in various pathological conditions:

- Anisocytosis: Variation in size
- Poikilocytosis: Variation in shape
- Variation in color
- Presence of inclusion bodies.

▪ **Anisocytosis : Variation in size**

Variation of size of RBC is called anisocytosis. The normal size of RBC is 7.5 ± 0.2 micrometer in diameter. Nucleus of small lymphocyte is useful guide to the size of RBC. Anisocytosis is divided into Macrocytosis and Microcytosis.

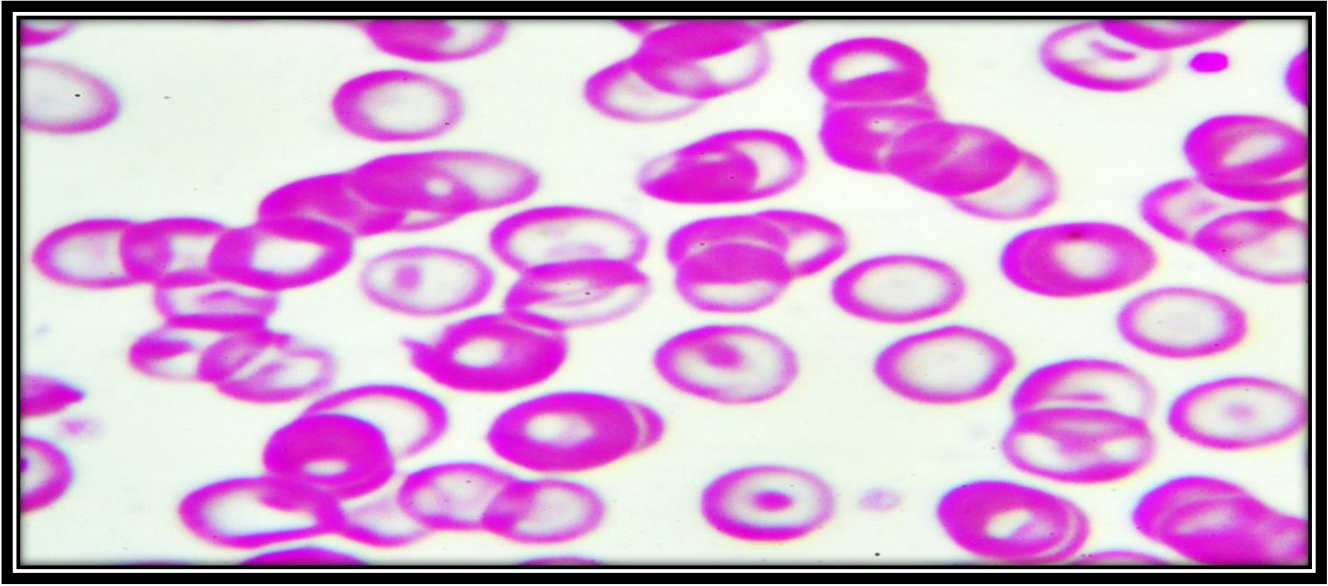


1. **Microcytosis:** RBCs smaller than the normal size are considered as microcytes. Microcytosis is seen in : Iron deficiency anemia, thalassemia, lead poisoning, sideroblastic anemia and anemia of chronic disorders.
2. **Macrocytosis:** RBCs larger than the normal size are considered as macrocytes. Macrocytosis is seen in : Liver diseases, hypothyroidism, megaloblastic anemia, chemotherapy, post splenectomy and some other causes of elevated erythropoiesis.

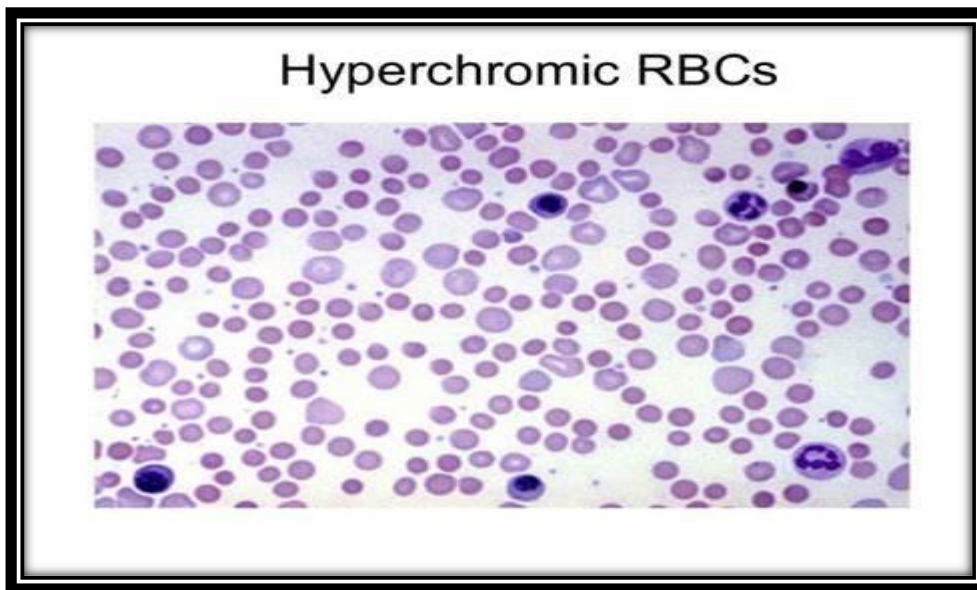
- **Variation in color**

RBCs that appear disc shaped and having an area of central pallor that occupies approximately one-third of the cell's diameter (containing normal amount of hemoglobin) are considered as normochromic RBCs.

1.Hypochromic : RBCs that have an area of pallor that is larger than the normal are called hypochromic(have decreased amounts of hemoglobin). This variation is seen in: Iron deficiency anemia, anemia of chronic diseases, thalassemia, some hemoglobinopathies, sideroblastic anemia and any of the conditions leading to microcytosis.



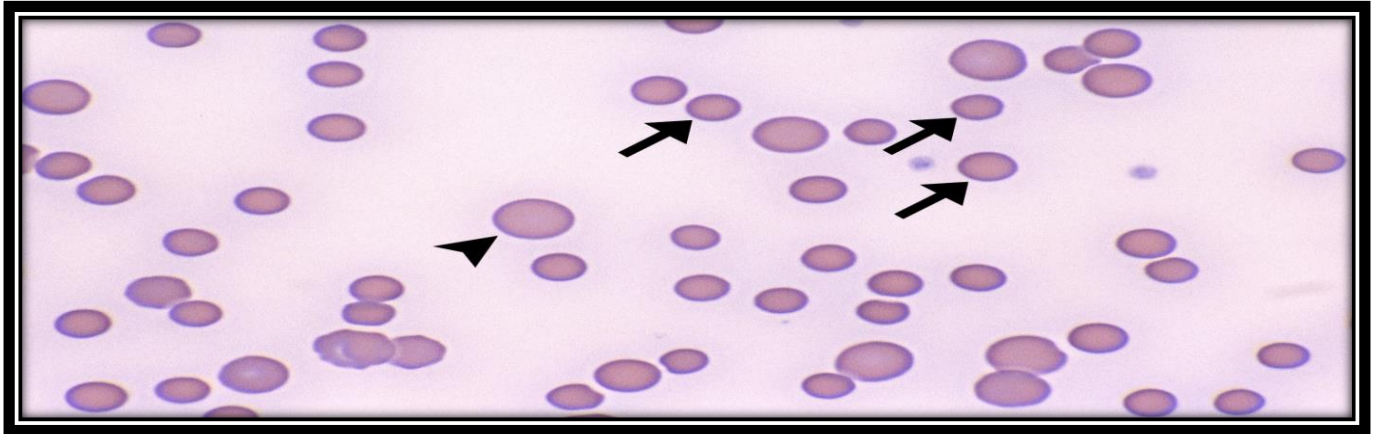
2.Hyperchromic an anemia with increase of hemoglobin in individual red blood cells and reduction in the number of red blood cells(means increase in color).



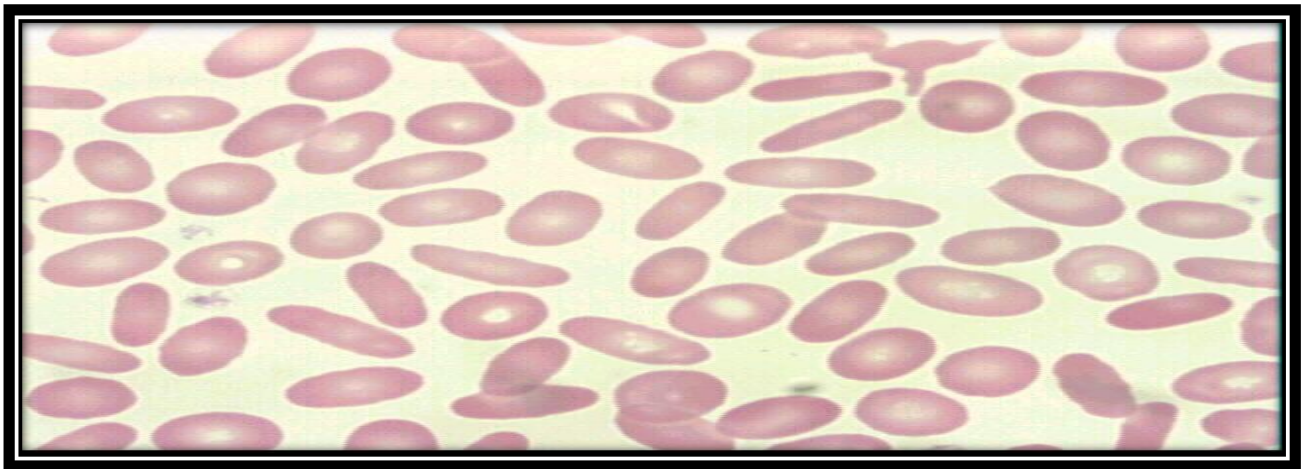
Poikilocytosis: Variation in shape

Variation in the shape of RBC is called poikilocytosis. RBCs exist as biconcave discs in large blood vessels but their shape changes to parachute like confirmation in capillaries. Following are some abnormal RBC shapes.

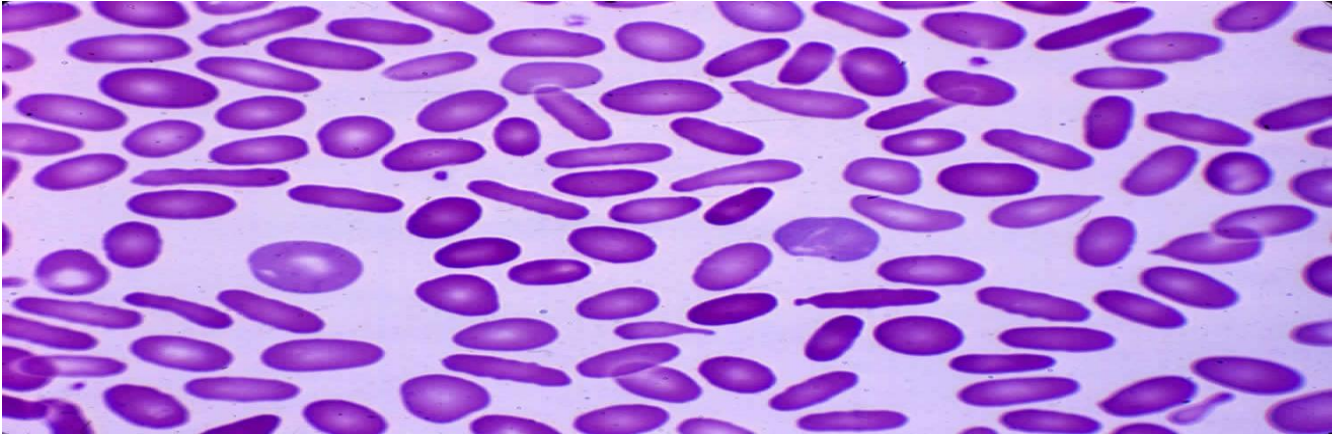
1. Spherocytes: RBCs lacks the biconcave shape and becomes more spherical; no central pallor is present with increased hemoglobin content. Spherocytes are found in: hereditary spherocytosis, hemolytic anemia and post transfusion reaction.



2. Ovalocytes: Oval shaped RBCs. Ovalocytes are found in: Thalassemia major, hereditary ovalocytosis, sickle cell anemia.

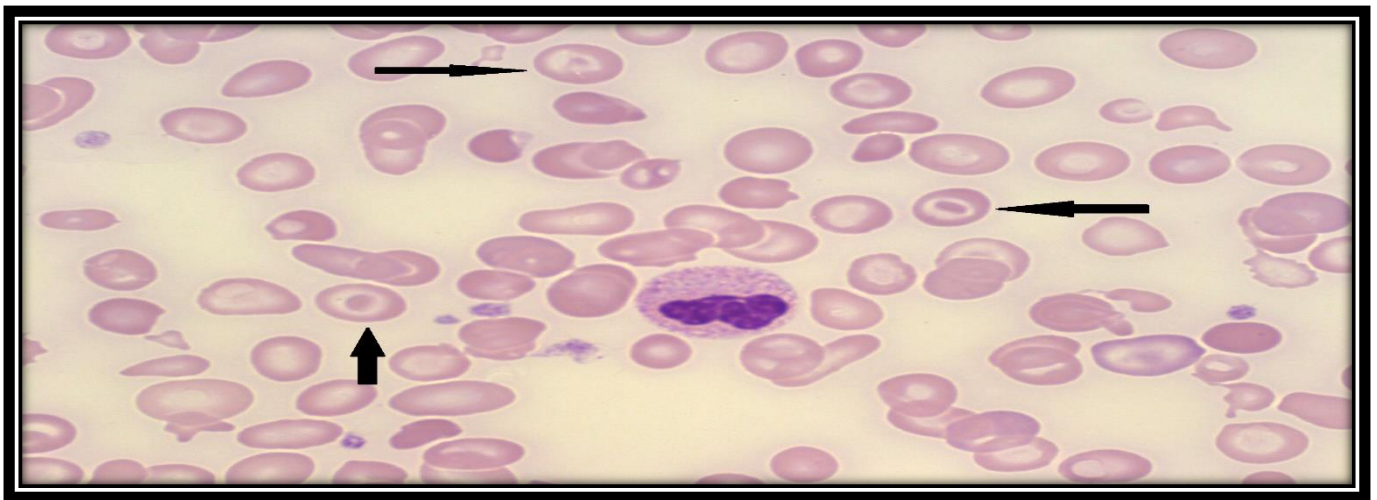


3. Elliptocytes: The RBCs are ovaal or elliptical in shape, long axis is twice the short axis. Elliptocytes are found in : hereditary elliptocytosis, megaloblastic anemia, IDA, thalassemia, myelofibrosis.



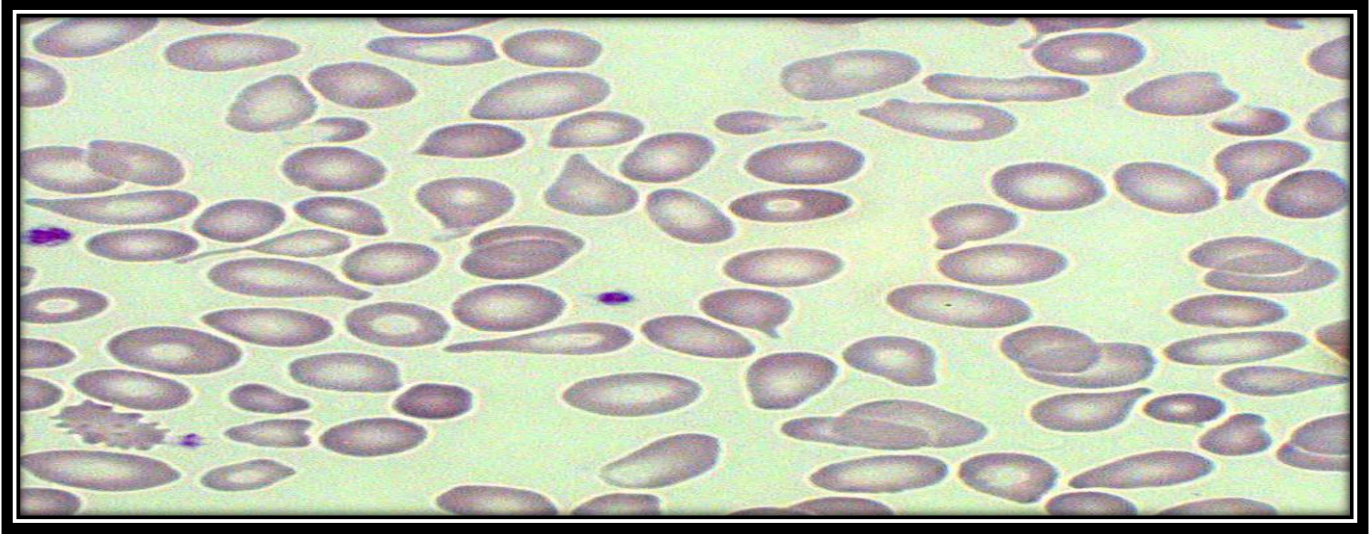
4.Target cells: Red cells have an area of increased staining which appears in the area of central pallor.

Target cells are found in : obstructive liver disease, severe IDA, thalassemia, Hemoglobinopathies, post splenectomy.



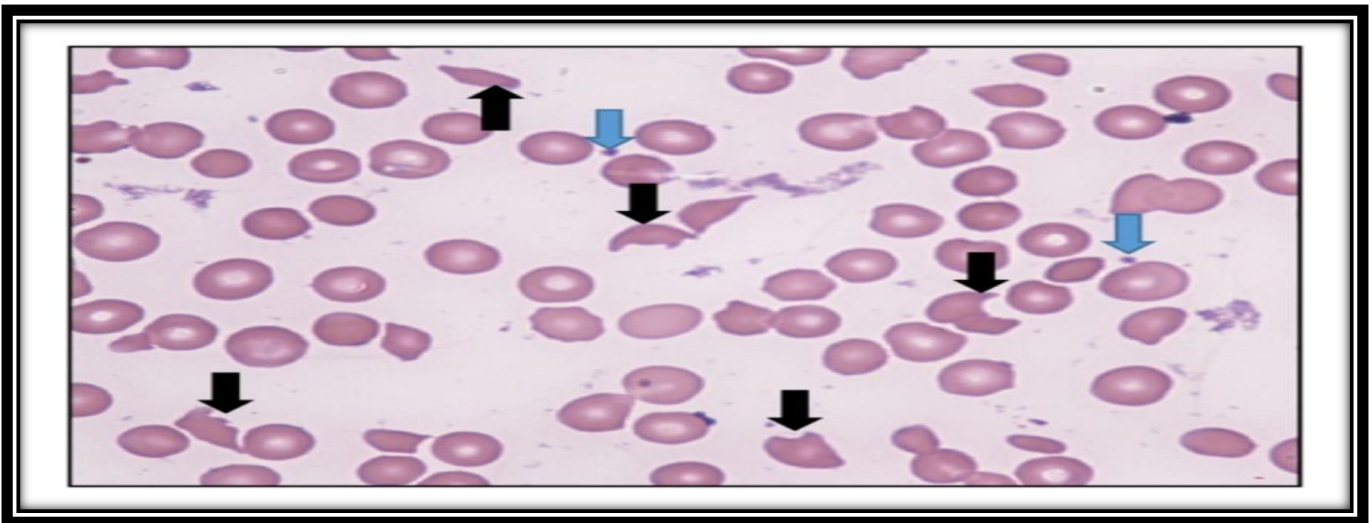
5.Teardrop cells: RBCs having the shape like teardrop or pear. These are usually microcytic and often hypochromic.

Teardrop cells are found in : myelofibrosis, megaloblastic anemia, IDA, thalassemia.



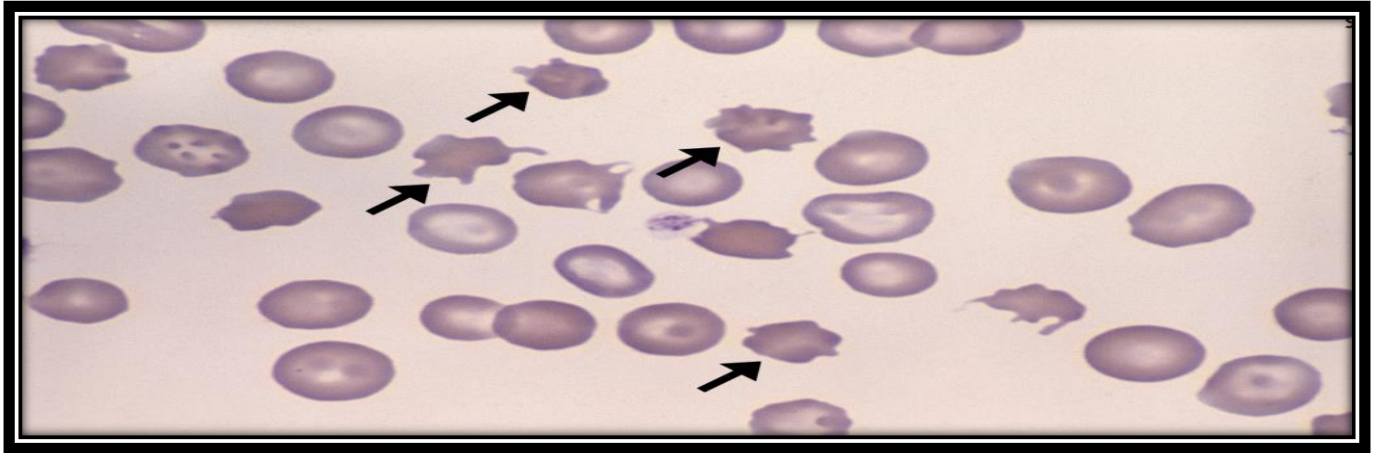
6.Schistocytes: These are helmet or triangular shaped, fragmented or greatly distorted RBCs smaller than normal size.

Schistocytes are seen in : Thalassemia, microangiopathic hemolytic anemia, mechanical hemolytic anemia, uremia, artificial heart valves.



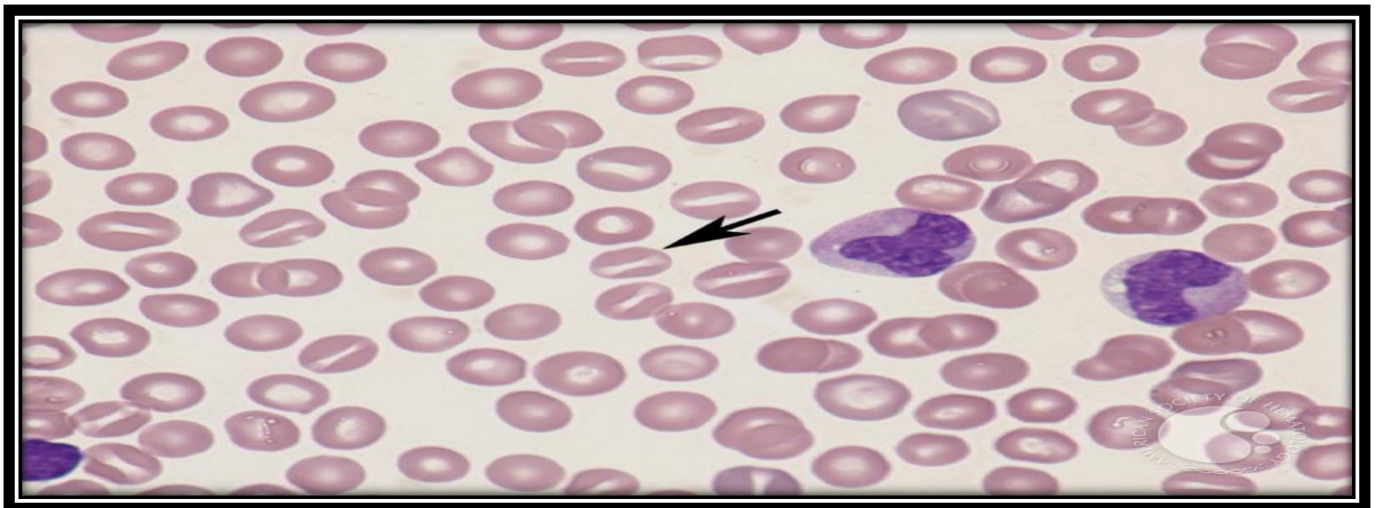
7.Acanthocytes: RBCs with irregularly spaced projections. Projections vary in width but usually contain a rounded end.

Acanthocytes are found in : liver diseases, post splenectomy, anorexia nervosa and starvation, alcoholism, vitamin C deficiency.

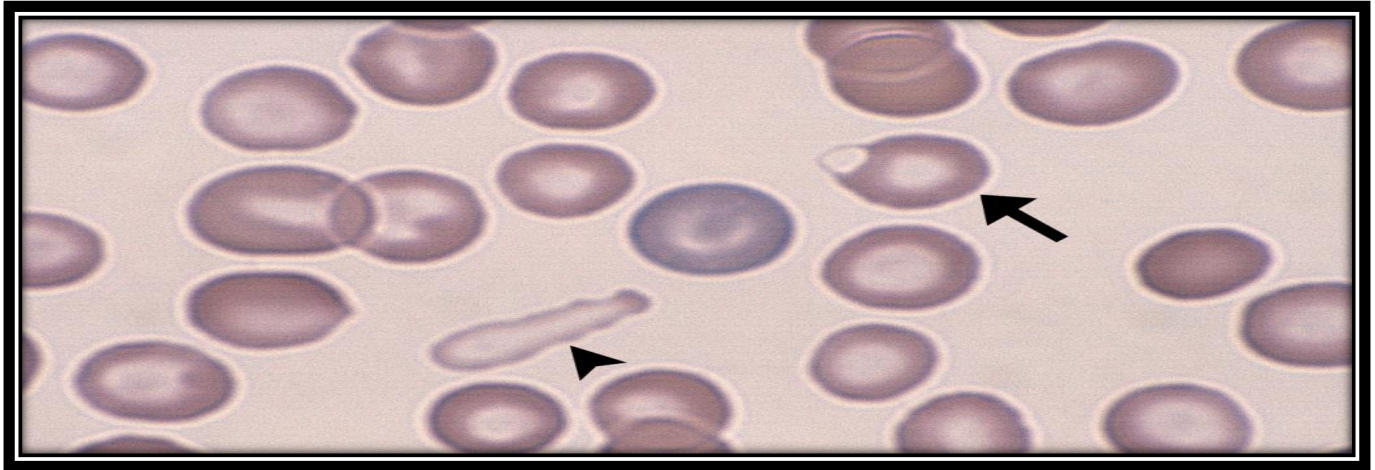


8.Stomatocytes: Red cells with a central linear slit or stoma. Seen as mouth shaped form in peripheral smear.

Stomatocytes are found in : excess alcoholism, alcoholic liver disease, heref=ditary stomatocytosis.

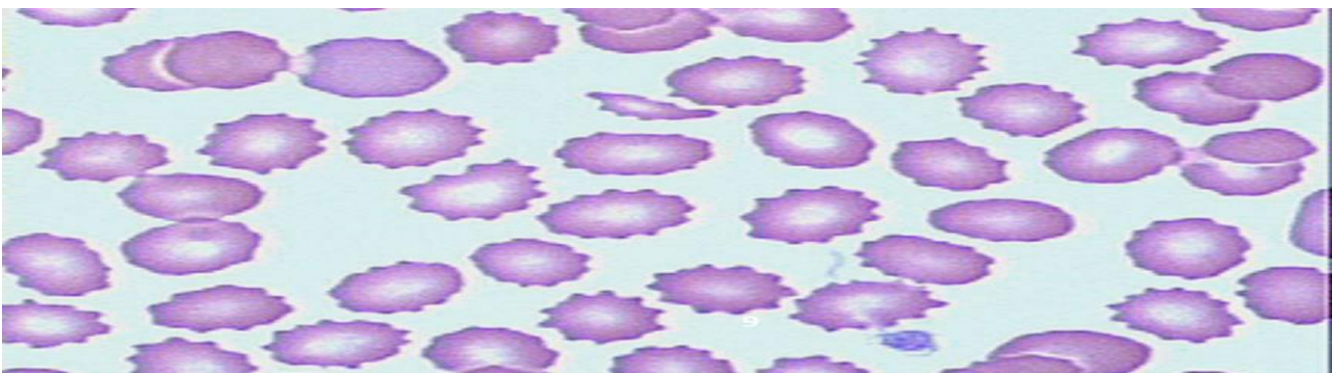


9.Keratocytes: These are half-moon shaped cells with two or more spicules. Keratocytosis is seen in G6PD deficiency, pulmonary embolism, disseminated intravascular coagulation.



10. Burr cells: Red cells with uniformly spaced pointed projections on their surface.

Burr cells are found in hemolytic anemia, uremia, megaloblastic anemia.



11. Sickle cells: These are sickle-shaped Red Blood Cells.
















Sickle cells are seen in Hb-S disease/ sickle cell anemia.

12. Red cell agglutinate: These are irregular clumps of RBCs.

These are found in cold agglutinations, warm autoimmune hemolysis.






13. Rouleaux Formation: Stacks of RBCs resembling a stack of coins.

These are found in hyperglobulinemia, hyperfibrinogenaemia..

Abnormal RBC Morphology	Cartoon Image	May be associated with
Microcytic RBC	 <p>6µm Normal</p>	Pyridoxine deficiency Thalassemia Iron deficiency anemia Chronic disease anemia (sometimes) Sideroblastic anemia (sometimes)
Macrocytic RBC	 <p>6µm Normal</p>	Vitamin B12 or Folate deficiency Liver Disease MDS Chemotherapy (e.g. methotrexate)
Spurr Cell RBC (Acanthocyte)		Abetalipoproteinemia Liver disease McLeod blood group phenotype Post-splenectomy Etc.
Burr Cell RBC (Echinocyte)		Artifact Uremia Liver disease Etc.
Schistocyte		Microangiopathic Hemolytic Anemia Mechanical valve induced Etc.
Bite Cell RBC		G6PD deficiency Unstable hemoglobin disorders Oxidative drugs
Elliptocyte		Hereditary elliptocytosis Severe iron deficiency anemia
Spherocyte		Hereditary spherocytosis Autoimmune hemolytic anemia
Stomatocyte		Hereditary stomatocytosis Liver disease
Target Cell RBC		Thalassemia Hemoglobinopathies Post-splenectomy Liver disease Artifact
Sickle Cell RBC		Hemoglobin SS disease Hemoglobin SC disease Hemoglobin SD disease S-beta thalassemia
Teardrop		Myelofibrosis Underlying marrow process/infiltrate Etc.
Hemoglobin C Crystals		Hemoglobin C disease Hemoglobin SC disease
Red Cell Agglutinate		Cold autoimmune hemolytic anemia Paroxysmal cold hemoglobinuria IgM associated lymphoma Multiple myeloma
Rouleaux		Chronic liver disease Malignant lymphoma Multiple myeloma Chronic inflammatory diseases

Present of Inclusion Bodies

Red blood cells have different morphological variations depending upon following type of inclusion bodies :

Common RBC Inclusions	Cartoon Image	Inclusion	May be associated with
Howell Jolly Bodies		DNA	Hyposplenism Asplenism Severe hemolytic anemia
Heinz Bodies		Hemoglobin	G6PD deficiency Oxidant drugs Unstable hemoglobin
Pappenheimer Bodies		Iron deposits	Thalassemia Sideroblastic anemia Hemolytic anemia Post-splenectomy
Hemoglobin H Inclusion		Hemoglobin	Hemoglobin H disease
Basophilic Stippling		Ribosomes	Lead poisoning Thalassemia Sickle cell anemia MDS

1. **Howell-Jolly bodies:** Small round cytoplasmic red cell inclusion with same staining characteristics as nuclei. These are fragments of DNA. Usually seen in Post splenectomy, MBA, hemolytic anemia.
2. **Heinz bodies:** These represent denatured hemoglobin (methemoglobin) within a cell. With a supravital stain like crystal violet, Heinz bodies appear as round blue precipitates. Seen in G6PD Deficiency, splenectomy.
3. **Pappenheimer bodies:** These represent iron deposits which as dense blue, irregular granules in wright stain. Pappenheimer bodies are found in RBCs with hemolytic anemia, splenectomy, sideroblastic anemia, thalassemia.

4. **Basophilic stippling:** These are considerable amount of small basophilic inclusions in red cells which represent precipitated RNA.
Seen in : thalassemia, MBA, hemolytic anemia, liver damage, heavy metal poisoning.
5. **Cabbot's ring:** Reddish, purple, thread-like rings in RBCs of severe anemias.
These are the remnants of nuclear membrane.
6. **Parasites of red cells:** Protozoan parasites like one of the four species of the malarial parasite may be seen in case of malarial infection.