

CLINICAL HEMATOLOGY ATLAS: A PICTORIAL GUIDE FOR THE HEMATOLOGY LABORATORY



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Clinical Hematology Atlas: A Pictorial Guide for
the Hematology Laboratory (Taylor and Doty)

Caroline Doty and Dawn Taylor

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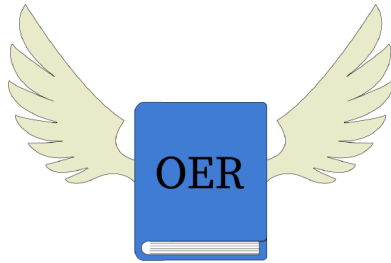
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Licensing

A detailed breakdown of this resource's licensing can be found in **Back Matter/Detailed Licensing**.

Introduction



About this Open Educational Resource (OER) Project

In Medical Laboratory Science (MLS) Hematology courses, students learn to evaluate normal and abnormal blood cell morphology through microscopic examination of blood smears. They learn to interpret results and correlate with other laboratory data to identify hematologic disorders. Access to quality atlases are a vital tool in the students' learning process. Because the cost of printing pictures is so great, the price of printed atlases is high. The number of images included is limited. And many excellent atlases are now out of print.

This project seeks to eliminate those challenges for students by giving access to an Open Educational Resource (OER) atlas for hematology. This format is easily accessed during students' time on campus and will continue into their careers as medical laboratory scientists. There are currently not many medical subject resources available as open resources. It is our hope that other healthcare professionals will find these resources beneficial. This project is unique in that students are the main contributors of the images used. While not entirely comprehensive at this point, the OER platform will allow for continual updating as new images and information become available.

Acknowledgements

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Reviewers

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Slide and Stain Quality

1. Ideal Reading Area
2. Too Thin of an Area on Peripheral Smear
3. Too Thick of an Area on Peripheral Smear
4. Water Artifact
5. Stain Precipitate
6. Fibrin Strand



The ability to perform a white blood cell differential, red blood cell morphology and platelet evaluation depends on the quality of the peripheral blood smear and staining process.

Ideal Reading Area

To find the ideal reading area of a peripheral blood smear for evaluation, you should navigate to the region of the slide that is just in from the feather edge, where the red blood cells are evenly distributed and not overlapping. This area will give the most even distribution of cells.

Ideal Reading Area

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Too Thin of an Area on Peripheral Smear

In the feather edge region of the smear, the red blood cells will be unevenly spaced and clumped together, leaving large clear spaces. Avoid this area.

Too Thin

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Too Thick of an Area on Peripheral Smear

Once you enter the thicker region of the smear (closer to the original drop of blood), the red blood cells begin to stack on top of each other and become distorted. Be careful, this area can begin to mimic rouleaux. The white blood cells are no longer spread out and the cytoplasm condenses around the nucleus, making identification difficult. Avoid this area.

Too Thick

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Water Artifact

Water artifact on the peripheral smear will most often appear as refractile objects on the red blood cells. This may be caused by staining a smear that is not completely dry, a humid environment or water contamination of the stain.

Water Artifact

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Stain Precipitate

Stain precipitate appears as aggregated material on the peripheral smear. It usually lacks a distinct morphology but be careful not to confuse it with bacteria.

Stain Precipitate

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Fibrin Strand

Fibrin strands are fairly colorless threadlike objects that indicate the initiation of coagulation. If you look closely, you can see it sitting on top of red cells. If detected, the specimen should be checked for clots. If a clot is found, the specimen should be rejected as all hematological tests may be affected. If only an occasional fibrin strand is found, the CBC results are usually acceptable.

Fibrin Strand

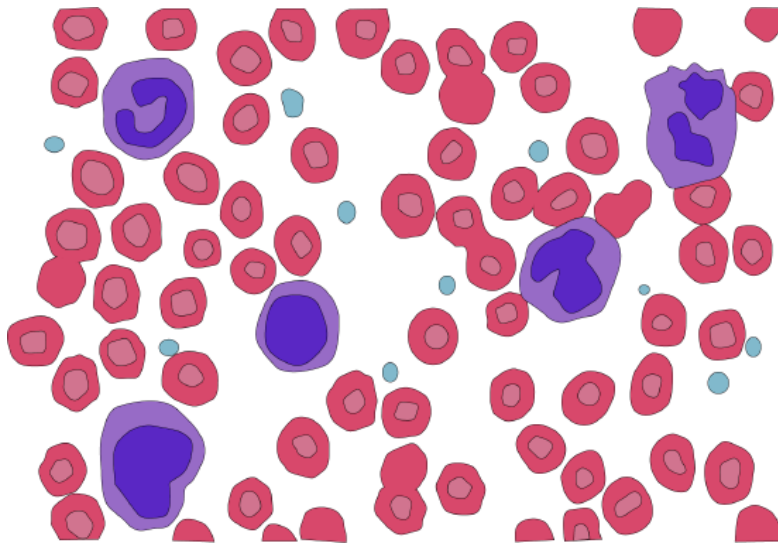
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Normal Blood Cells

1. Polymorphonuclear Segmented Neutrophil (PMN)
2. Band Neutrophil
3. Eosinophil
4. Basophil
5. Monocyte
6. Lymphocyte
7. Reactive Lymphocyte
8. Plasmacytoid Lymphocyte
9. Red Blood Cell
10. Platelet



Polymorphonuclear Segmented Neutrophil (PMN)

- Cell size: 10-16 microns
- N/C ratio 1:1
- 2-5 distinct nuclear lobes (filament connecting lobes)
- Central or eccentric nucleus
- Deep blue-purple coarsely granular nuclear chromatin (distinct parachromatin)
- No nucleoli
- Abundant pink cytoplasm
- Fine violet-pink specific granules

PMN

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Band Neutrophil

- Cell size: 10-16 microns
- N/C ratio 1:1
- Elongated narrow band shape of uniform thickness, singular lobe
- Central or eccentric nucleus
- Deep blue-purple coarsely granular nuclear chromatin (distinct parachromatin)
- No nucleoli
- Abundant pink cytoplasm
- Fine violet-pink specific granules

Band

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Eosinophil

- Cell size: 10-16 microns
- N/C ratio 1:1
- 2 distinct nuclear lobes - rarely 3 or 4 (filament connecting)
- Central or eccentric nucleus
- Deep blue-purple coarsely granular nuclear chromatin
- No nucleoli
- Abundant pink cytoplasm
- Large red, uniform specific granules

Eosinophil

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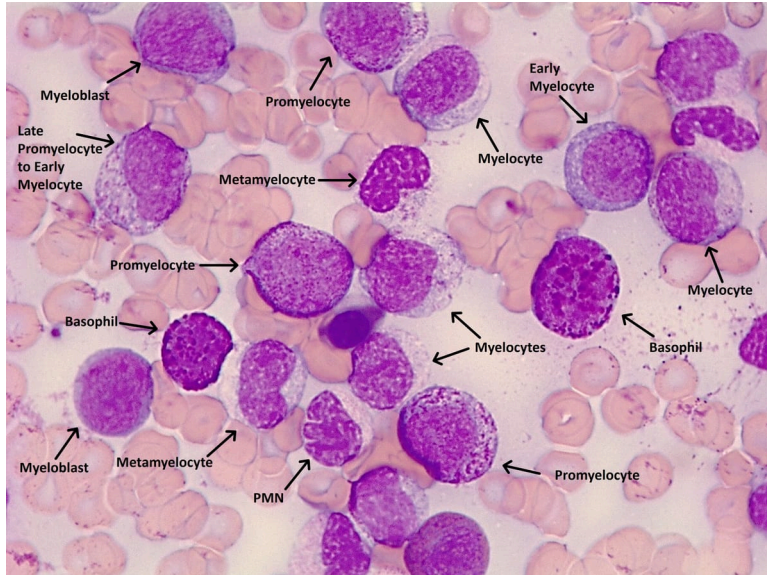
Basophil

- Cell size: 10-16 microns
- N/C ratio 1:1
- 2 distinct nuclear lobes - rarely 3 or 4 (filament connecting)
- Central or eccentric nucleus
- Deep blue-purple coarsely granular nuclear chromatin
- No nucleoli
- Abundant pale blue cytoplasm
- Coarse purple-black non-uniform specific granules (water soluble - may dissolve in staining)

Basophil

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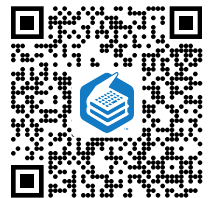
Monocyte

- Cell size: 12-20 microns
- N/C ratio 2:1 or 1:1
- Cerebriform or horseshoe shaped nucleus
- Central nucleus
- Blue-purple, fine reticular nuclear chromatin (less distinct parachromatin)
- 0-2 Nucleoli
- Abundant pale gray-blue cytoplasm. May see pseudopodia and vacuoles
- Numerous very fine (dust like) red granules evenly dispersed

Monocyte

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Interactive Content

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Lymphocyte

- Cell size: 7-18 microns (usually 9-12)
- N/C ratio 4:1 (occasionally 3:1)
- Round or indented nucleus
- Eccentric nucleus often with scanty cytoplasm
- Homogeneous, coarse blue-purple nuclear chromatin (smudged)
- Nucleoli often absent but may see in mature forms
- Light to dark blue cytoplasm, scanty to moderate
- Occasionally a few azurophilic granules seen

Small Lymph

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Average to Large Lymph

Interactive Content

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Reactive Lymphocyte

- Activated T-Lymph

- Wandering or Ballerina skirt cytoplasm often indented by adjacent red blood cells
- Bluer cytoplasm periphery especially where indented by red blood cells
- Nucleus also has wandering appearance
- Coarser nuclear chromatin

Reactive Lymph

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Plasmacytoid Lymphocyte

- Activated B- Lymph
- Generally considered a lymph transitioning to a plasma cell
- Slightly larger with darker royal blue cytoplasm and more heavily clumped chromatin
- May lack very eccentric nucleus and well developed golgi of plasma cell

Plasmacytoid Lymph

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Red Blood Cell

- Cell size: 6-8 microns
- Clear pink to red cytoplasm, central pallor 1/3 of cell diameter
- No cytoplasmic granules

RBC

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Platelet

- Cell size: 2-4 microns
- Light blue, fragment of megakaryocyte cytoplasm
- Evenly dispersed, fine red-purple granules

Platelet

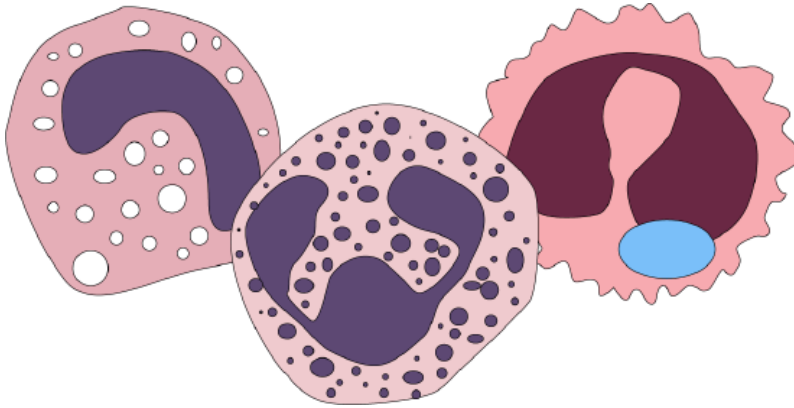
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White Blood Cell Variants

1. Barr Body
2. Dohle Body
3. Toxic Granulation
4. Toxic Vacuoles
5. Hypersegmented Neutrophil
6. Hyposegmented Neutrophil
7. Pyknotic Degeneration (Necrotic or Necrobiotic Cell)
8. Smudge Cell



Barr Body

- Represent an extra X-Chromosome unnecessary for normal nuclear function.
- Expressed as a miniature lobe or “drumstick” protruding from the nucleus of PMNs.
- Since females are XX it is normal for them to demonstrate one Barr body.
- Males that are XXY or XXXY can demonstrate Barr bodies.
- These are usually not reported.

Barr Body

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Dohle Body

- Pale blue translucent bodies in the cytoplasm of granulocytes and occasionally monocytes
- Remnant RNA
- Severe infections and tissue destruction
- Often seen with toxic granulation, toxic vacuoles, and a shift to the left

Dohle Body

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Toxic Granulation

- Dark purple-blue granules in PMNs and Bands
- Stimulation of granulocytic cells results in fewer mitotic divisions. Prevents normal dilution of nonspecific granules.
- Severe bacterial infection or toxicity
- Often seen with toxic vacuoles, Dohle bodies and a shift to the left.

Toxic Granulation

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Toxic Vacuoles

- Clear holes contained in the cytoplasm of phagocytic cells
- Toxic is increased vacuolization - more numerous or larger than normal
- Severe bacterial infection or toxic states
- Often seen with toxic granules, Dohle bodies and a shift to the left.

Toxic Vacuoles

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Hypersegmented Neutrophil

- Segmented neutrophils with six or more nuclear lobes
- Cells often larger than normal
- Congenital disorder or megaloblastic change

Hypersegmented PMN

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Hyopsegmented Neutrophil

- No granulocytes with > 2 nuclear lobes
 - Bilobed cell – Pince-nez or spectacle
 - Unilobed cell – Stodtmeister
- Benign congenital hyopsegmentation of PMNs is known as Pelger-Huet anomaly.
 - Greater than 68% of neutrophils are hyopsegmented.
 - It may also present with increased bands.
- Pseudo or Acquired Pelger-Huet will present with similar morphology but will have more normal PMNs present.
 - Pseudo PH cells may be seen in severe bacterial infections, HIV, tuberculosis and mycoplasma pneumonia.Various drugs can induce this abnormal morphology.

Hyopsegmented PMN

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Pyknotic Degeneration (Necrotic or Necrobiotic Cell)

- Degenerating neutrophils
- Cells are undergoing apoptosis
- Nuclear material loses chromatin pattern
 - One or several dense masses
- **Watch Out! These are not nucleated rbcs.**

Pyknotic PMN

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Smudge Cell

- Cells destroyed in the process of making the peripheral smear.
- Associated with increased cell fragility.

- Often seen in Chronic Lymphocytic Leukemia (CLL) and Acute Lymphoblastic Leukemia (ALL)
- Reporting varies from lab to lab.
- Can add albumin and remake slide to avoid creating this artifact.

Smudge Cell

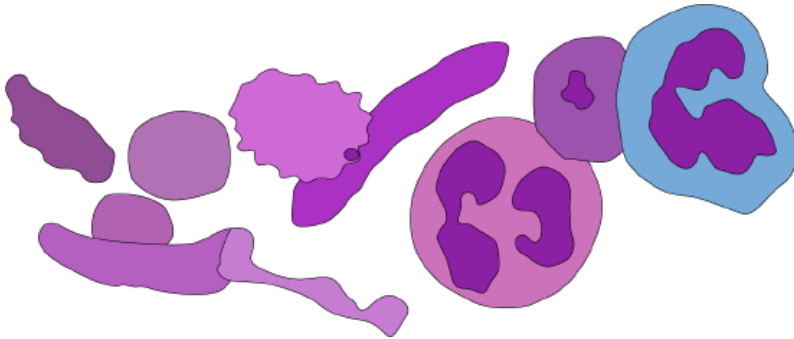
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Platelet Variants

1. Large Platelets
2. Abnormal Platelet Morphology
3. Agranular and Hypogranular Platelets
4. Platelet Clumps
5. Platelet Satellitosis
6. Platelet on Red Blood Cell



Large Platelets

Increased platelet size should be noted. Reporting will vary from lab to lab. Some labs differentiate Macro Platelets (slightly large to approaching the size of a RBC) versus Giant Platelets (size of a RBC and larger).

Macro Platelet

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Giant Platelet

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Abnormal Platelet Morphology

Normal platelets are discoid in shape. More than an occasional abnormally shaped platelet should be noted. Abnormal platelet shapes may interfere with normal platelet function.

Abnormal Platelet Morph

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Agranular and Hypogranular Platelets

Normal platelets have fine granules dispersed throughout the cell. Occasionally they are more densely concentrated in one area. Platelets that have decreased or missing granules should be noted. Platelet granules are vital to normal platelet function.

Abnormal Platelet Granulation

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Platelet Clumps

Platelet clumping can be induced by EDTA anticoagulant. EDTA causes a conformational change in the platelets resulting in platelet agglutination. This may result in a falsely decreased platelet count and a falsely increased white blood cell count. It is also difficult to obtain an accurate platelet estimate.

To resolve this problem, the specimen can be redrawn in a sodium citrate tube. The sample is analyzed by the hematology instrument. The WBC and Platelet count must be corrected for the increased dilution in a sodium citrate tube by multiplying the counts by 1.1. All other CBC parameters should be reported from the EDTA tube.

Platelet clumps on the peripheral blood smear may also indicate that clotting has been initiated and the specimen should be checked for clots.

Platelet Clumping

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Platelet Satellitosis

Some samples experience an invitro phenomenon where EDTA causes the platelets to surround the neutrophils. The mechanism is not well understood, but there is some evidence an autoantibody is involved. EDTA may cause an alteration in platelet and neutrophil membranes that allow the antibody to form a bridge between the cells.

Platelet Satellites

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Platelet on Red Blood Cell

It is not uncommon to observe a platelet sitting on top of a red blood cell. There is no clinical significance and should not be noted. However, you must be careful not to confuse this with a red blood cell inclusion. If the platelet is on top of the red blood cell, there will usually be a clear area around it as the platelet pushes some of the hemoglobin aside. If the object is a true inclusion inside the red blood cell, there will be no clear area.

Platelet on RBC 1

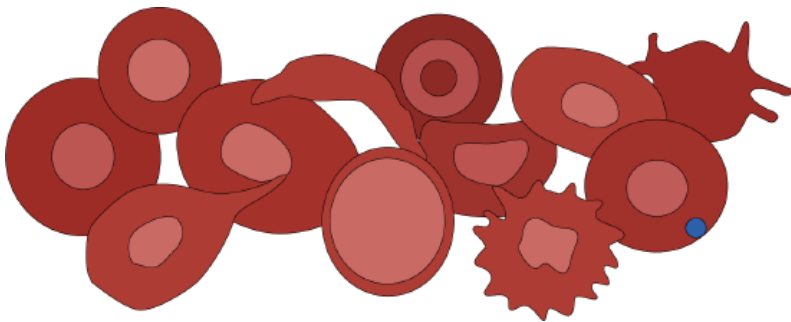
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Red Blood Cell Morphology

1. Size and Color
 1. Microcyte
 2. Macrocyte
 3. Hypochromasia
 4. Polychromasia
2. Shape
 1. Acanthocyte
 2. Agglutination
 3. Burr Cell
 4. Crystal Cell
 5. Ovalocytosis / Elliptocytosis
 6. Rouleaux
 7. Schistocyte
 8. Sickle Cell
 9. Spherocyte
 10. Stomatocyte
 11. Target Cell
 12. Tear Drop
3. Red Cell Inclusions
 1. Basophilic Stippling
 2. Cabot Ring
 3. Heinz Bodies (supravital stain)
 4. Hemoglobin H Inclusions (supravital stain)
 5. Howell-Jolly Body
 6. Malarial Parasites
 7. Pappenheimer Bodies



Red blood cell morphology is always done with the 100x oil objective. Make sure to perform the red cell morphology just in from the feather edge of the smear, where the red blood cells are evenly distributed and not overlapping. The manner in which red cell morphology is reported is laboratory dependent. Some labs use specific terminology to semi-quantitate the degree of abnormal morphology such as slight/ few, moderate or marked. Other labs use a scale from 1+ to 3 or 4+.

Size and Color

Abnormal amount of variation in red cell size is termed anisocytosis. The degree of size variation is indicated by the Red Cell Distribution Width (RDW) on the CBC.

The Mean Cell Volume (MCV) indicates the average size of red blood cells present in the specimen. An increased MCV indicates that there are a significant number of macrocytes present. A decreased MCV indicates that there are a significant number of microcytes present. Beware: a normal MCV may indicate normal sized red blood cells, but since it is a mean, small and large red blood cells may average out to a normal MCV.

Microcyte

- RBC <7 microns or MCV < 80 fL
- Often accompanied by hypochromasia
- Indicator of hemoglobin production problem
- Seen in:
 - Iron Deficiency
 - Thalassemias
 - Sideroblastic Anemias
 - Anemia of Chronic Inflammation
 - Some Hemoglobinopathies

Microcyte

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Macrocyte

- RBC >8 microns or MCV >100 fL
- Indicator of DNA synthesis defect
- Megaloblastic changes (asynchronism)
- Seen in:
 - Megaloblastic Anemias
 - Oval macrocytes
 - High reticulocyte count
 - Hemolytic anemia
 - Acute blood loss
 - Diphyllbothrium latum
 - Liver Disease
 - Tumors
 - Gastrectomy
 - Bowel diseases

Macrocyte

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Hypochromasia

- RBCs lack normal amount of hemoglobin
- Increased area of central pallor
- Often microcytic
- Often MCHC < 32 g/dL

- Seen in:
 - Iron Deficiency
 - Thalassemias
 - Sideroblastic Anemias
 - Anemia of Chronic Inflammation
 - Some Hemoglobinopathies

Hypochromasia

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Polychromasia

- Diffuse pale blue / gray or lavender cytoplasm
- Due to remnant RNA present in young RBCs (reticulocytes)
- Often macrocytic and lack central pallor
- Can be better visualized and counted with a supravital stain that precipitates the remnant RNA

Polychromasia

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Shape

Variation in red blood cell shape is termed poikilocytosis.

Acanthocyte

- Long, irregular, spiny uneven projections
- Caused by abnormal membrane lipids
- Seen in Liver disease and abetalipoproteinemia

Acanthocyte

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Agglutination

- Cluster of cells at all angles
- MCHC >36 g/dL
- Due to RBC antibody
 - Immune hemolytic anemias
 - Cold agglutinin
 - Pre-warm sample if IgM antibody

Agglutination

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Burr Cell

- Small blunt evenly spaced projections
- Usually due to change in tonicity of intravascular fluid
- Seen in:
 - Uremia
 - Liver disease
 - Anemias
 - Burns

Burr Cell

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Crystal Cell

- Condensation of abnormal Hgb C, often into a “Washington Monument” shaped crystal
- Hgb C disease (Hgb C-C)
- Hgb SC disease (Hgb SC)

Crystal Cell

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Ovalocytosis / Elliptocytosis

- Oval or elliptical shaped with rounded ends
- Many labs do not differentiate between the two shapes
 - Ovalocytes – egg shaped
 - Elliptocytes – cigar or hotdog shaped
- Physiological mechanism not well defined
- Seen in:
 - Hereditary Elliptocytosis
 - Spectrin defect
 - Iron deficiency
 - Megaloblastic anemias
 - Oval macrocytes
 - Thalassemias
 - Myelofibrosis
 - Myelodysplastic syndromes

Ovalocyte / Elliptocyte

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Rouleaux

- Stack of coins appearance, side to side
- Increased plasma proteins or immunoglobulins
 - Masks zeta potential
- Saline Replacement will dilute the proteins and disperse the rouleaux
- Seen in:
 - Multiple myeloma
 - Waldenstrom's macroglobulinemia
 - Infectious and Inflammatory conditions

Rouleaux

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Schistocyte

- Fragmented RBCs
- Seen in:
 - Hemolysis
 - Disseminated Intravascular Coagulation (DIC)
 - Thrombotic thrombocytopenic purpura (TTP)

- Hemolytic uremic syndrome (HUS)
- Acute promyelocytic leukemia

Schistocyte

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Sickle Cell

- Due to presence of abnormal Hgb S
- In decreased oxygen tension cells will take a crescent or sickle form.
- Cells do not always form the perfect sickle shape. These cells are called oat cells. They can be differentiated from elliptocytes and ovalocytes by their tapered ends. Ovalocytes/ elliptocytes have rounded ends.
- Seen in:
 - Sickle cell anemia
 - Hgb SC disease
 - Hgb S-Thalassemia

Sickle Cell

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Spherocyte

- Small, very dark, very round
- Lack area of central pallor
- Defect in or loss of cell membrane
- Usually microcytic
- MCHC may be > 36 g/dL
- Seen in:
 - Hereditary Spherocytosis
 - Spectrin defect
 - Hemolysis
 - Burns
 - Post transfusion
 - Newborns
 - Normal RBC aging

Spherocyte

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Stomatocyte

- Central pallor is slot or mouth shaped
- Usually an artifact
- Seen in:
 - Hereditary Stomatocytosis
 - Failure of Na⁺ and K⁺ pumps which increases cellular H₂O and cells swell
 - Liver Disease
 - Rh deficiency syndrome
 - Rare hereditary defect where Rh membrane proteins are absent (Rh null) or decreased (Rh-mod) resulting in mild to moderate hemolytic anemia

Stomatocyte

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Target Cell

- Bullseye appearance
- Increased membrane lipid resulting in increased surface area or decreased hemoglobin
- Seen in:
 - Liver disease
 - Hypochromic anemias
 - Any hemoglobin abnormality

Target Cell

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Tear Drop

- Tear or pear-shaped cells (one tapered end)

- Exact Physiological mechanism unknown
- Altered splenic or bone marrow structure
- Removal of inclusion from RBC
- May be an artifact, especially if all pointing in the same direction
- Seen in:
 - Myelofibrosis
 - Myelophthisic anemia
 - Megaloblastic anemia
 - Thalassemias

Tear Drop

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Red Cell Inclusions

Basophilic Stippling

- Fine to coarse blue dots evenly dispersed throughout cytoplasm
- Remnant precipitated RNA, reticulocyte
- Use Supravital stain to do reticulocyte count
- Coarse stippling associated with lead poisoning

Basophilic Stippling

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Cabot Ring

- Very fine single or double thread loops, may be seen in ring or figure 8
- Thought to be nuclear membrane remnant
- Seen in:
 - Megaloblastic anemias
 - Thalassemias

Cabot Ring

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Heinz Bodies (supravital stain)

- NOT visible on Wright's stain
- Requires a Supravital Stain
- Precipitated, denatured hemoglobin due to oxidative injury
- Seen in:
 - G6PD deficiency
 - Unstable hemoglobins

Heinz Bodies

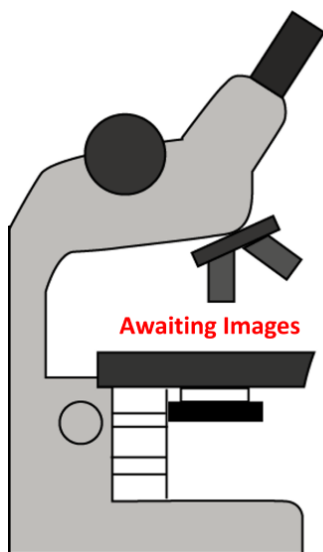
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Hemoglobin H Inclusions (supravital stain)

- Many purple blue inclusions resembling a golf ball
- Composed of precipitated chains of beta-hemoglobin (beta 4 tetramers)
- Seen in Alpha Thalassemia



Howell-Jolly Body

- Small, dense, round nuclear remnant occurring usually singly on periphery of cell
- Busy bone marrow
- Seen in:
 - Hemolytic anemias
 - Megaloblastic anemias
 - Thalassemias
 - Splenectomy

Howell-Jolly Body

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Malarial Parasites

Malaria may be present at any stage inside the RBC

Malaria

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Pappenheimer Bodies

- Small, irregular, blue granules clustered near cell periphery
- Granules of Iron
- ineffective utilization or excess
- Use Prussian Blue stain to confirm
- Seen in:
 - Sideroblastic anemias
 - Hemochromatosis
 - Hemoglobinopathies
 - Thalassemias

Pappenheimer Bodies

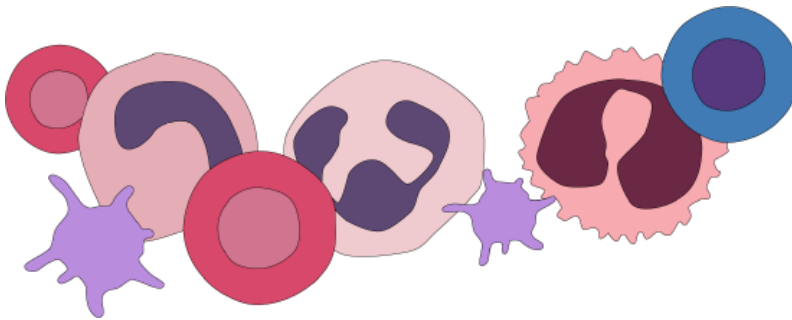
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Cells Series

1. Erythrocytic (RBC) Series
 1. Rubriblast (Pronormoblast)
 2. Prorubricyte (Basophilic Normoblast)
 3. Rubricyte (Polychromatophilic Normoblast)
 4. Metarubricyte (Orthochromatic Normoblast)
 5. Reticulocyte (Polychromatophilic Erythrocyte)
 6. Mature Erythrocyte
2. Myelocytic Series
 1. Myeloblast
 2. Promyelocyte
 3. Myelocyte
 4. Metamyelocyte
 5. Band Neutrophil
 6. Segmented Neutrophil (PMN)
3. Monocytic Series
 1. Monoblast
 2. Promonocyte
 3. Monocyte
4. Lymphocytic Series
 1. Lymphoblast
 2. Prolymphocyte
 3. Lymphocyte
 4. Plasmacytoid Lymphocyte
 5. Plasma Cell
5. Thrombocytic (Platelet) Series
 1. Megakaryoblast
 2. Promegakaryocyte
 3. Megakaryocyte
6. Platelet



Erythrocytic (RBC) Series

Rubriblast (Pronormoblast)

- Cell size 14-19 microns
- N/C ratio 4:1
- Round central nucleus
- Red-purple finely stippled, granular chromatin, fine lace-like
- 0-2 nucleoli
- Very basophilic cytoplasm
- No cytoplasmic granules

Rubriblast

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Prorubricyte (Basophilic Normoblast)

- Cell size 12 - 15 microns
- N/C ratio 3:1
- Round central nucleus
- Increased granularity of nuclear chromatin (more distinct parachromatin)
- Usually no nucleoli
- Basophilic cytoplasm
- No cytoplasmic granules

Prorubricyte

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Rubricyte (Polychromatophilic Normoblast)

- Cell size 10 - 15 microns
- N/C ratio 2:1
- Round central nucleus
- Smaller nucleus with increased condensation of chromatin, very coarse chromatin pattern (distinct parachromatin)
- No nucleoli
- Moderate polychromatophilic cytoplasm - may contain areas of pink hemoglobin near nucleus
- No cytoplasmic granules

Rubricyte

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Metarubricyte (Orthochromatic Normoblast)

- Cell size 8 - 12 microns
- N/C ratio 1:1

- Round central nucleus
- Smaller nucleus with pyknotic degeneration, condensed chromatin, no discernible parachromatin (nucleus is solid)
- No nucleoli
- Moderate cytoplasm, lavender - pink due to hemoglobin
- No cytoplasmic granules

Metarubricyte

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Reticulocyte (Polychromatophilic Erythrocyte)

- Cell size 7 - 10 microns
- Nucleus absent
- Clear lavender - pink cytoplasm (polychromatophilic).
- Lacks central pallor
- No cytoplasmic granules

Reticulocyte

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Retic (Supravital Stain)

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Mature Erythrocyte

- Cell size 6-8 microns
- Clear pink cytoplasm
- Central pallor 1/3 of cell diameter
- No cytoplasmic granules

Mature RBC

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Myelocytic Series

Myeloblast

- Cell size: 12-20 microns
- N/C ratio 4:1
- Round-oval nucleus, “boxy rounded refrigerator corners”
- Central or eccentric nucleus
- Light red-purple fine meshwork chromatin with no aggregation of material
- 1-5 nucleoli
- Scanty basophilic cytoplasm
- No granules
- May contain Auer rods

Myeloblast

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Myeloblast with Auer Rod(s)

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Promyelocyte

- Cell size: 15-23 microns
- N/C ratio 3:1
- Round-oval nucleus,
- Central or eccentric nucleus
- Light red-purple fine meshwork chromatin, possibly slight aggregation at nuclear membrane
- 1-3 nucleoli
- Basophilic cytoplasm (may be slightly increased over blast)
- Coarse azurophilic nonspecific (primary) granules

- May contain Auer rods

Promyelocyte

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Myelocyte

- Cell size: 10-18 microns
- N/C ratio 2:1 or 1:1
- More round-oval nucleus
- Central or eccentric nucleus
- Red-purple fine chromatin with slightly aggregated pattern
- May or may not have nucleoli
- Moderate bluish - pink cytoplasm
- Nonspecific (primary) and specific (secondary) granules

Myelocyte

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Metamyelocyte

- Cell size: 10-18 microns
- N/C ratio 1:1
- Indented (kidney shaped) nucleus
- Central or eccentric nucleus
- Light blue-purple with chromatin clumps easily distinguishable
- No nucleoli
- Moderate bluish - pink cytoplasm (occasionally clear pink)
- Specific (secondary) granules, (few non-specific granules)

Metamyelocyte

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Band Neutrophil

- Cell size: 10-16 microns
- N/C ratio 1:1
- Elongated narrow band shape of uniform thickness, singular lobe
- Central or eccentric nucleus
- Deep blue-purple coarsely granular nuclear chromatin (distinct parachromatin)
- No nucleoli
- Abundant pink cytoplasm
- Fine violet-pink specific granules

Band

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Segmented Neutrophil (PMN)

- Cell size: 10-16 microns
- N/C ratio 1:1
- 2-5 distinct nuclear lobes (filament connecting lobes)
- Central or eccentric nucleus
- Deep blue-purple coarsely granular nuclear chromatin (distinct parachromatin)
- No nucleoli
- Abundant pink cytoplasm
- Fine violet-pink specific granules

PMN

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Monocytic Series

Monoblast

- Cell size: 12-20 microns
- N/C ratio 4:1
- Round-oval, or slightly folded nucleus
- Central or eccentric nucleus
- Pale red-purple, minimal, fine thready chromatin
- Usually 1-2 nucleoli
- Moderate basophilic cytoplasm, regular border
- No granules
- May contain Auer rods

Monoblast

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Promonocyte

- Cell size: 10-16 microns
- N/C ratio 3:1 or 2:1
- Round nucleus with chromatin creases or cerebriform folding more distinct
- Central or eccentric nucleus
- Pale red-purple, very fine pattern, (aerated network of threads)
- 0-2 nucleoli
- Paler opaque gray-blue cytoplasm, more abundant, may see pseudopodia and vacuoles
- Contains very fine red dust-like granules

Promonocyte

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Monocyte

- Cell size: 12-20 microns
- N/C ratio 2:1 or 1:1
- Cerebriform or horseshoe shaped nucleus
- Central nucleus
- Blue-purple, fine reticular nuclear chromatin (less distinct parachromatin)
- 0-2 Nucleoli
- Abundant pale gray-blue cytoplasm
- May see pseudopodia and vacuoles
- More numerous very fine (dust like) red granules evenly dispersed

Monocyte

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Lymphocytic Series

Lymphoblast

- Cell size: 10-20 microns
- N/C ratio 4:1
- Round or oval nucleus
- Central or eccentric nucleus
- Undifferentiated sparse red purple chromatin
- 1-2 indistinct nucleoli
- Scanty, often nearly absent, clear basophilic cytoplasm
- No granules

Lymphoblast

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Prolymphocyte

- Cell size: 9 - 18 microns
- N/C ratio 4:1 (occasionally 3:1)
- Round or oval and flat nucleus
- Central or eccentric nucleus
- Combination of condensed clumped blue-purple chromatin with red-purple parachromatin
- 0-1 very distinct nucleoli
- Often scanty, but visible clear basophilic cytoplasm
- No granules

Prolymphocyte

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Lymphocyte

- Cell size: 7-18 microns (usually 9-12)
- N/C ratio 4:1 (occasionally 3:1)
- Round or indented nucleus
- Eccentric nucleus often with scanty cytoplasm
- Homogeneous, coarse blue-purple nuclear chromatin (smudged)
- Nucleoli usually absent, rarely one seen in mature forms
- Light to dark blue cytoplasm, scanty to moderate
- Occasionally a few azurophilic granules seen

Lymphocyte

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Plasmacytoid Lymphocyte

- Activated B- Lymph
- Generally considered a lymph transitioning to a plasma cell
- Slightly larger with darker royal blue cytoplasm and more heavily clumped chromatin
- May lack very eccentric nucleus and well developed golgi of plasma cell

Plasmacytoid Lymph 1

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Plasma Cell

- Cell size: 8 - 20 microns
- N/C ratio 2:1 or 1:1
- Round or oval nucleus
- Usually eccentric nucleus
- Blue - purple, dense chromatin with large clumps near nuclear margin
- No nucleoli
- Moderate, basophilic cytoplasm
- perinuclear clear zone adjacent to nucleus
- May contain vacuoles
- No granules
- May see Russell Bodies

Plasma Cell

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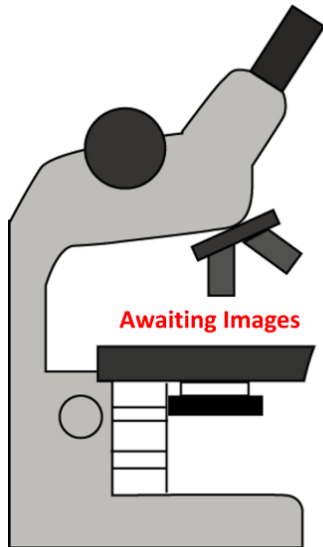
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Thrombocytic (Platelet) Series

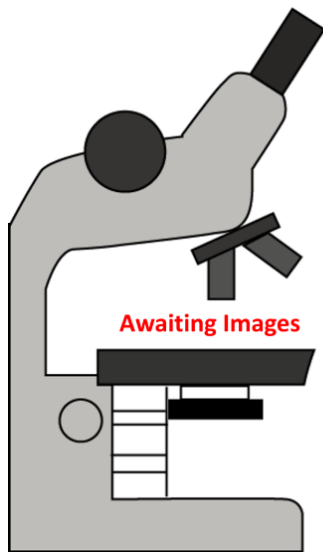
Megakaryoblast

- Cell size: 15 - 50 microns
- N/C ratio 4:1
- Usually single round, oval or kidney shaped nucleus (rarely multinucleated)
- Central or eccentric nucleus
- Red- purple, fine chromatin with distinct “smudged” clumps
- 1-5 nucleoli
- Varying shades of blue, amount varies from small to abundant with pseudopodia frequently
- Usually no granules



Promegakaryocyte

- Cell size: 20-80 microns
- N/C ratio 4:1 to 1:1
- Usually 2 - 4 or 8 nuclear lobes
- Central or eccentric nucleus
- Red- purple, increased granularity of nuclear chromatin
- Usually less nucleoli than blast
- Usually abundant cytoplasm with pseudopodia, usually basophilic, but paler as maturity approaches
- Fine azurophilic granules most adjacent to the nucleus



Megakaryocyte

- Cell size: 35 - 160 microns
- N/C ratio 1:2 to 1:3
- Usually 8 nuclear lobes (2 or more, but may have 16 or 32)
- Central or eccentric nucleus
- Blue - purple, granular chromatin
- No nucleoli
- Abundant pale blue (with pink cast)
- May exhibit pseudopodia and shedding platelets
- Numerous fine azurophilic granules, evenly distributed

Megakaryocyte 1

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Megakaryocyte 2

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Platelet

- Cell size: 2-4 um
- Light blue, fragment of megakaryocyte cytoplasm
- Evenly dispersed, fine red-purple granules

Platelet

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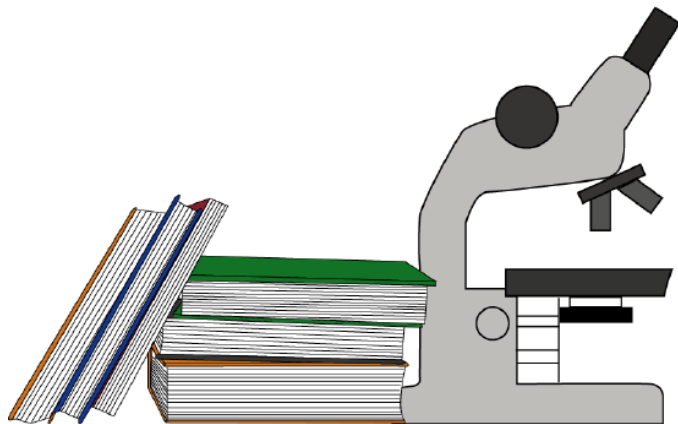
Lymphoproliferative Disorders

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Resources



Gulati, G., & Caro, J. (2019). *Blood cells: Morphology & clinical relevance*. ASCP Press.

Keohane, E. M., Otto, C. N., & Walenga, J. M. (2020). *Rodak's hematology: Clinical principles and applications*. St. Louis, Missouri.

O'Connor, B. H. (1994). *A color atlas and instruction manual of Peripheral Blood Cell Morphology*. Williams & Wilkins.

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H

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- [Clinical Hematology Atlas: A Pictorial Guide for the Hematology Laboratory \(Taylor and Doty\)](#)

GLOSSARY

S

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