

Tutorial - Blood Cell Morphology

A Clinical Pathology 201 Study Module

by

Carolyn Sue Walters, MHS, MT(ASCP)

Department of Pathology

School of Medicine

Louisiana State University Health Sciences Center

New Orleans, Louisiana

© 2002 Do not reproduce this tutorial.

[click here to continue](#)

C. Sue Walters, MHS, MT(ASCP)



**Associate Professor
Department of Pathology
LSU Health Sciences Center
New Orleans, LA**

**It is illegal to reproduce the
text and images in this
computer exercise without
written permission by Ms.
Walters.**

[click here to continue](#)

Special Acknowledgment

A special thanks and acknowledgment for the generosity of Mrs. Angela Foley, MS, MT(ASCP), Department of Clinical Laboratory Science, School of Allied Health, LSU Health Sciences Center New Orleans for the use of many of the blood cell images used in this presentation.

[click here to continue](#)

Feedback

Feedback as to the quality and usefulness of this exercise is solicited and suggestions for improvement are welcomed. Please forward your remarks by E-mail cwalte@lsuhsc.edu

or via US MAIL:

C. Sue Walters, MHS, MT(ASCP)
LSU Health Sciences Center
Department of Pathology
1901 Perdido Street
New Orleans, LA 70112

[click here to continue](#)

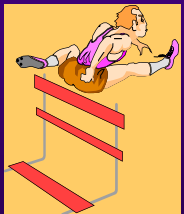
Directions

The directions for navigating through the exercise are given on the next 2 pages. They are the same as those routinely used in Clinical Pathology 202 study modules. Please click on:



to visit the directions before continuing with the exercise.

or



to go directly to the first page of the exercise.

Directions, continued

The following directional icons are provided throughout the exercise for your convenience. You can click on:

in the upper left hand corner of every page to return to the previous page

menu

in the upper right corner of the page to return to the Main Menu selection.



in the lower right corner of the page to continue.



in the lower right corner of the Main Menu page to Quit (i.e., end the exercise).



Directions, continued

“Hot points” (symbols, words, phrases) have been inserted on the pages as navigational tools and can be identified by their “gold” color. If it’s “gold”, click on it to move to the next text/data entry. Also, sounds have been added in a few places for emphasis.

Caution, failure to follow the structured order of the “hot points” may result in confusion. If you use the mouse without placing the cursor directly on the “hot point” , you may skip over vital information.

Remember, if it’s **gold**, click on it. Try it!

Special Comments

This exercise has numerous **images**. You may note that, when a page contains images, there may be a rather long delay before you regain control of the cursor. Please be patient. I think you will find the images are worth the wait.

NOTE:

Some animation and/or interactive **affects** may be lost if you attempt to replay a page by returning to the previous page and then advancing to that page again.

Now, click on the **gold** to begin.

Hematologic Cells Found in Peripheral Blood and Bone Marrow



MAIN MENU

Introduction

Leukocytes

Erythrocytes

Abnormal erythrocytes - terminology

Platelets

Disorders – characteristic morphology

quit

Introduction



What is the purpose of this study module?

This study module is designed for LSUHSC L2 students enrolled in Clinical Pathology 201. It is intended as a reference for blood cell and bone marrow morphology.

The presentation of illustrative cells in this module is by no means a comprehensive study of blood cells. It is limited to the material covered in the lectures and laboratory sessions.

Unfortunately, a few cell illustrations are not available at this time but will be added later.



Leukocytes



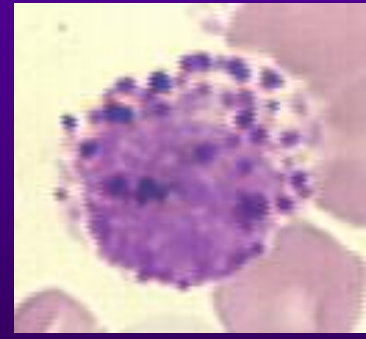
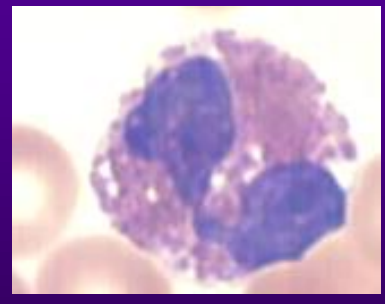
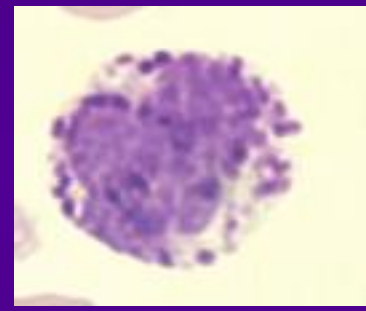
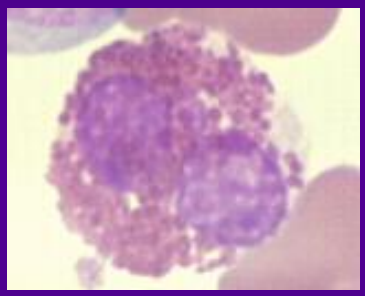
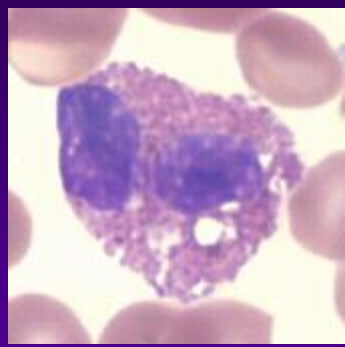
How are the WBC identified and classified?

Typical nuclear and cytoplasmic morphologic features provide a means by which WBC can be identified and classified as to **cell line** (i.e.):

- **granulocytes** [*neutrophils, eosinophils, or basophils*]
- **monocytes**
- **lymphocytes**



i.e., classified as granulocytes:



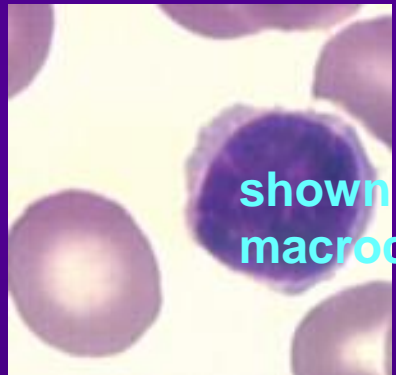
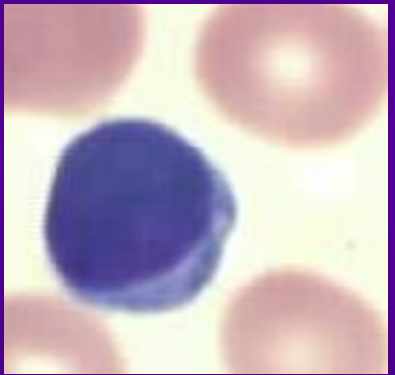
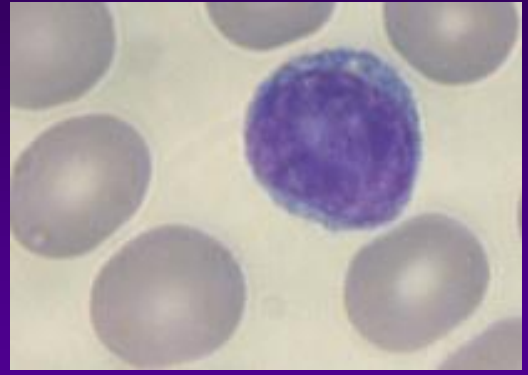
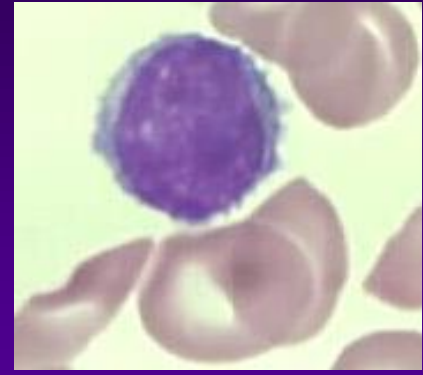
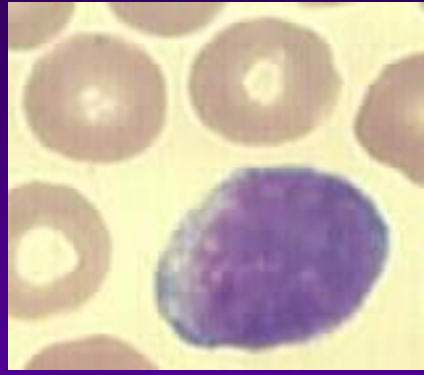
neutrophils

eosinophils

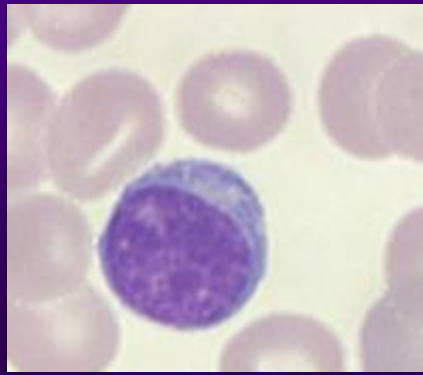
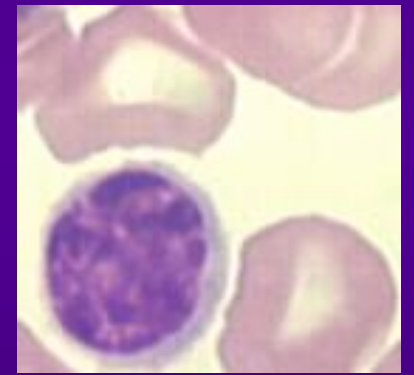
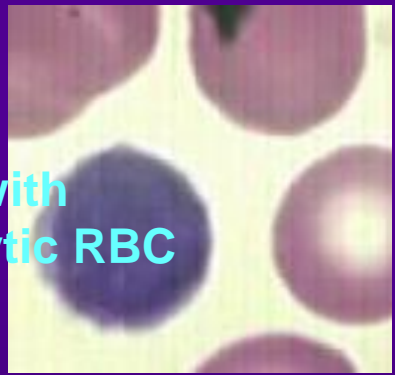
basophils



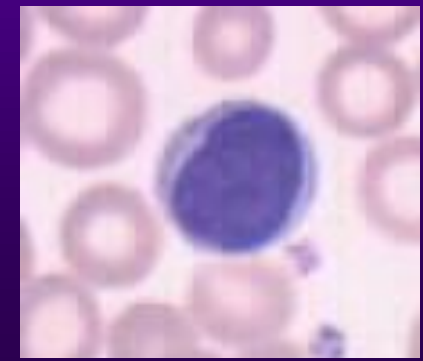
i.e., classified as lymphocytes:



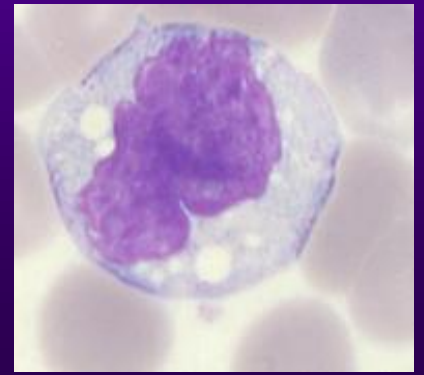
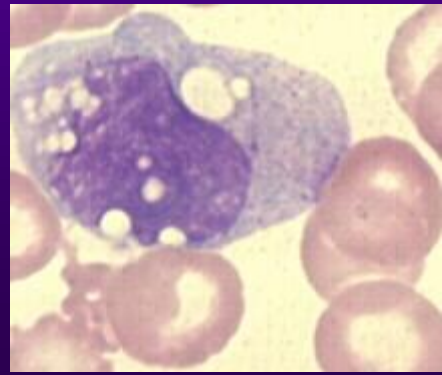
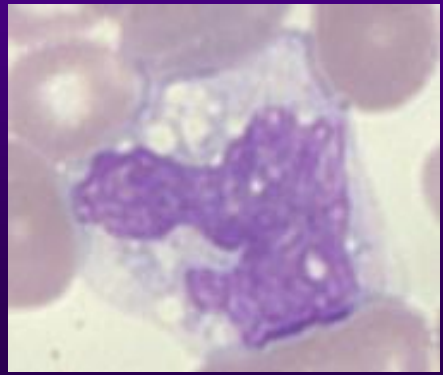
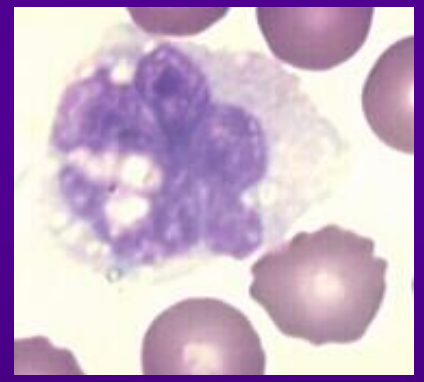
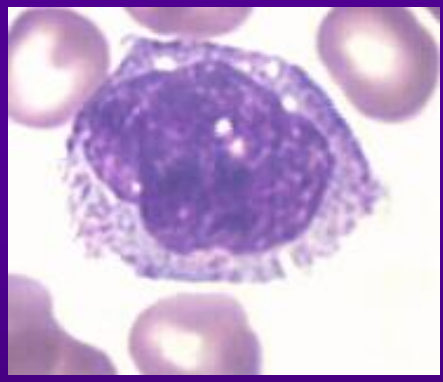
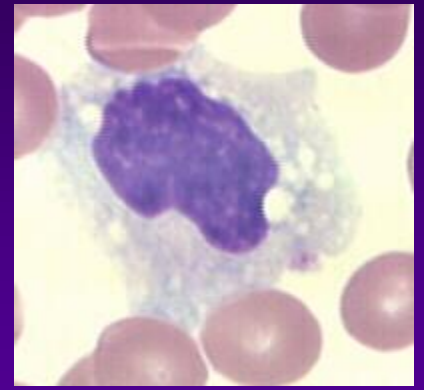
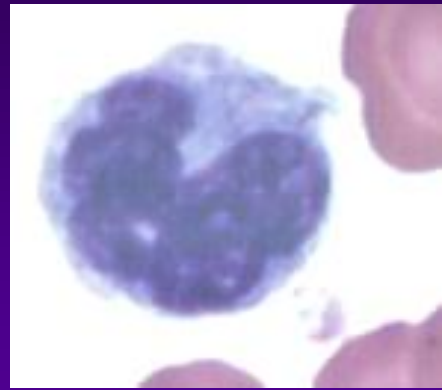
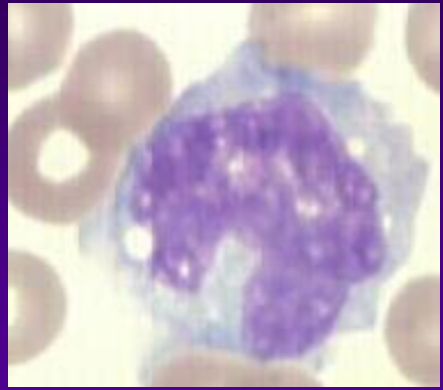
shown with
macrocytic RBC



shown with
microcytic RBC



i.e., classified as monocytes:



i.e., Identified as to cell lines

granulocytes



neutrophils



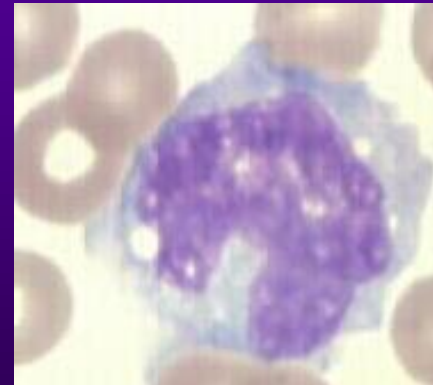
eosinophils



basophils



lymphocytes



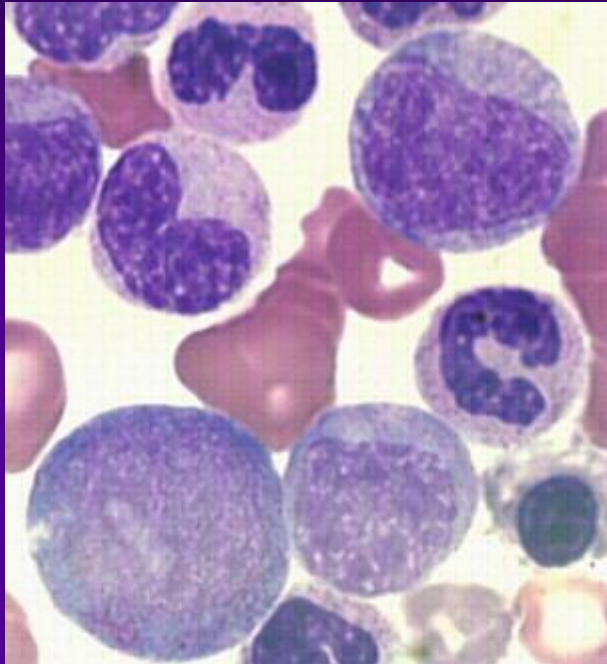
monocytes



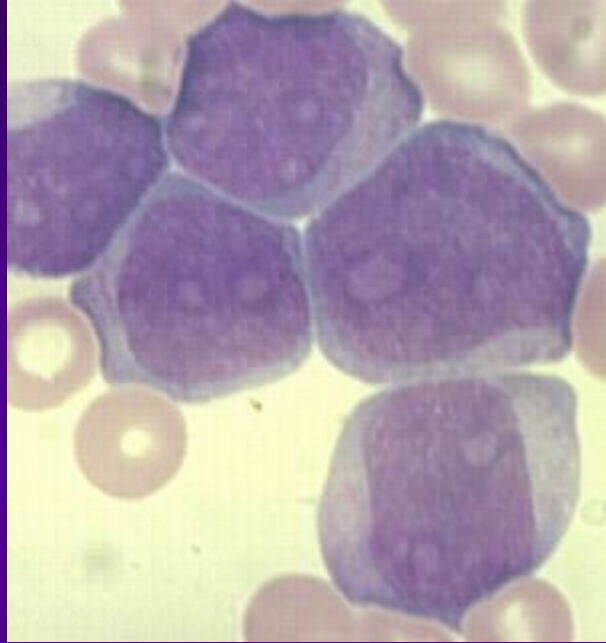
WBC can also be identified and classified as to...

- **maturity** (i.e., mature cell or immature stage of development).

Immature WBC, e.g.:



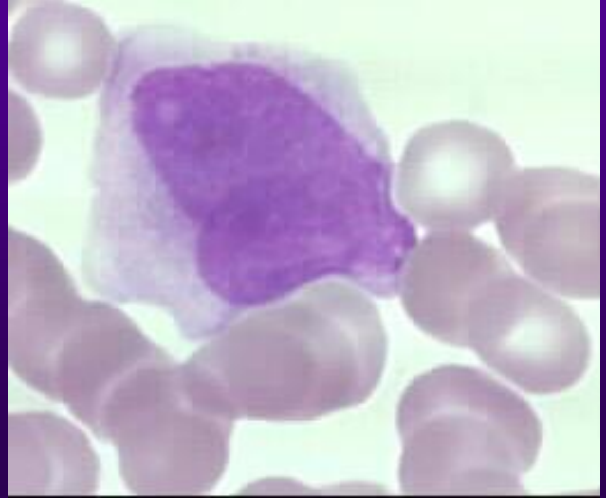
**granulocytes
(various stages)**



myeloblasts



lymphoblasts

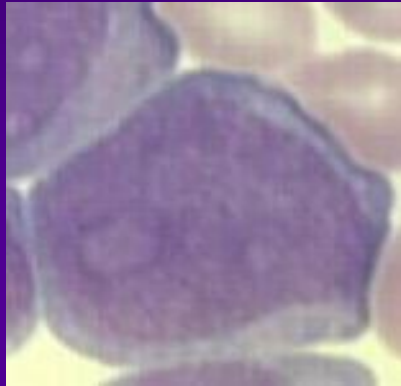


monoblasts

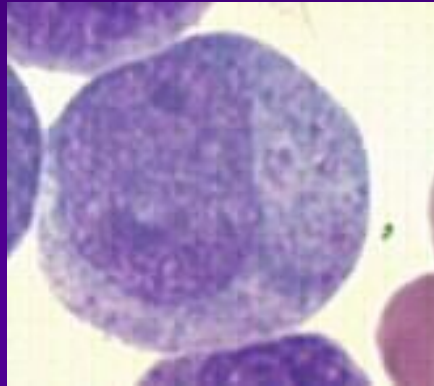


e.g., Neutrophils in various stages of maturation...

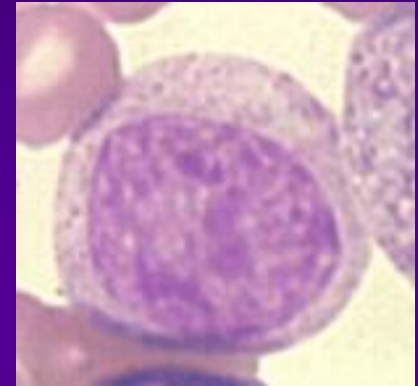
myeloblast



promyelocyte



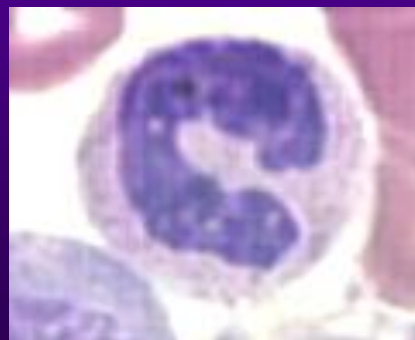
myelocyte



metamyelocyte



band

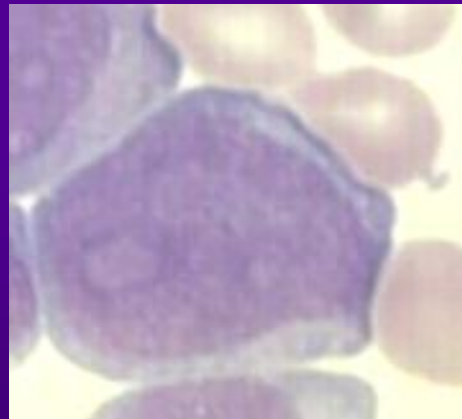


PMN (mature)



Neutrophilic Maturation

from immature blast to mature PMN

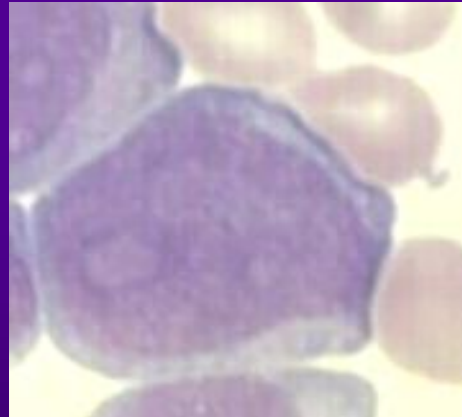


Neutrophilic blast "stab"
Mature neutrophil "PMN"

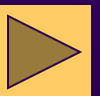


Neutrophilic Maturation

From mature PMN to myeloblast



Neutrophilic myeloblast “stab”
Mature neutrophil “PMN”

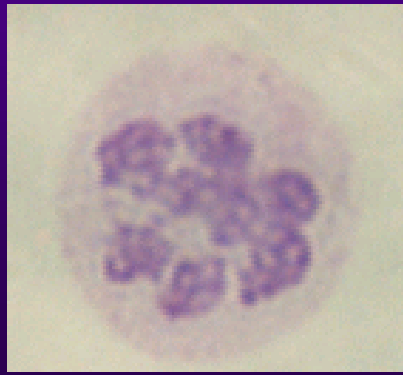
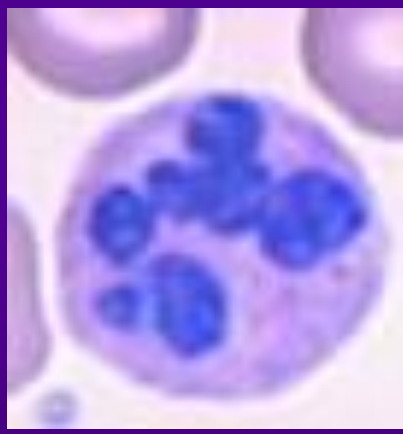


WBC can also be identified and classified as to...

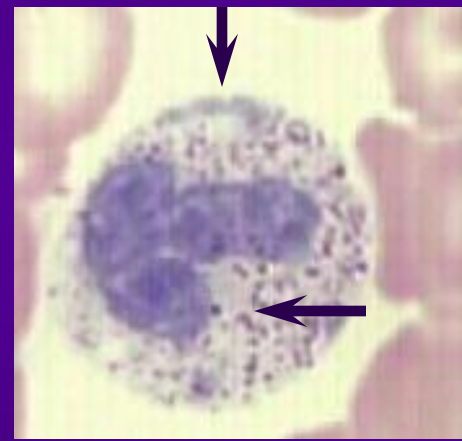
- **abnormal morphology** (i.e., nuclear or cytoplasmic alterations)

e.g., WBC with acquired non-neoplastic alterations...

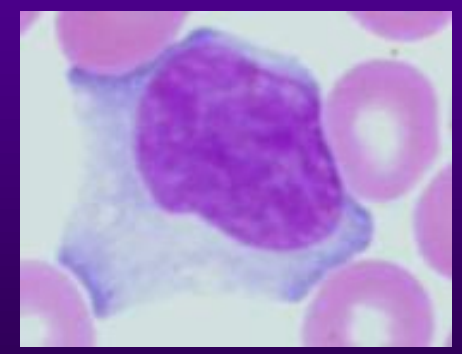
hypersegmented neutrophils in megaloblastic anemias



neutrophils
In bacterial infections



reactive/atypical lymphocytes (ATL)
In viral infections



&

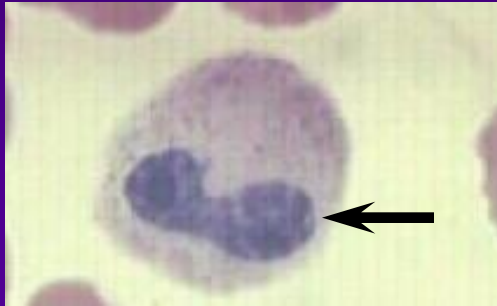
&

with Döhle bodies
and/or toxic granulation

inherited disorders

e.g., WBC with inherited non-neoplastic alterations...

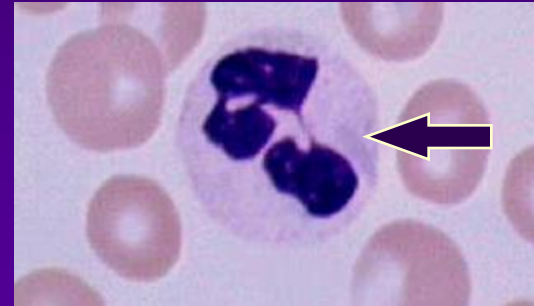
Pelger-Huet Anomaly



hyposegmented nuclei

&

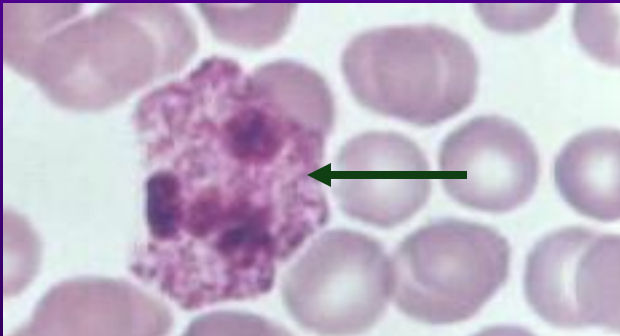
May-Hegglin Anomaly



cytoplasmic blue bodies

&

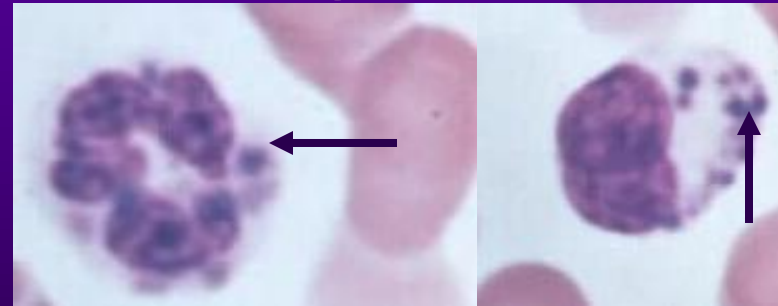
Alder-Reilly Anomaly



cytoplasmic
black granules

&

Chediak-Higashi Syndrome



cytoplasmic large
black granules



WBC with neoplastic alterations, e.g....

hairy cell lymphocytes



hairy cell leukemia

&

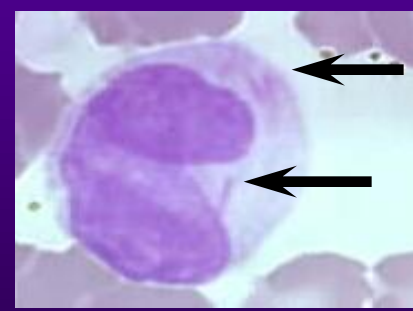
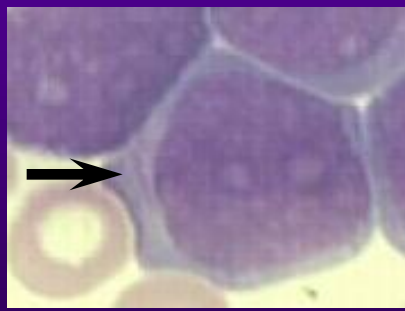
plasma cells



in multiple myeloma

myeloblasts w/ Auer rod(s)

&



in acute myelocytic leukemias



Leukocytic Maturation



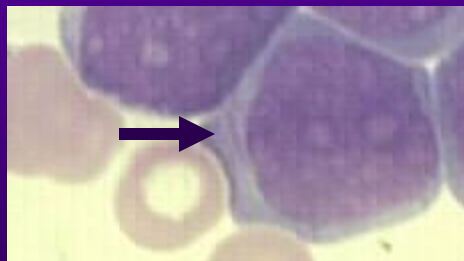
Blasts are the earliest leukocytic precursor that can be seen in peripheral blood.



myeloblast



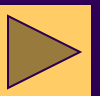
monoblast



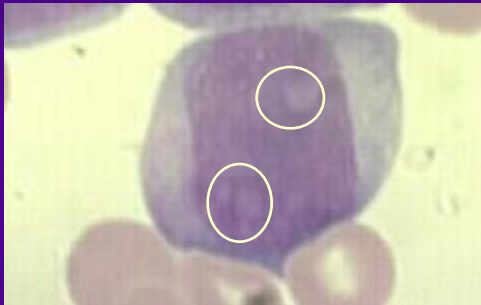
**myeloblast
w/ Auer rod**



lymphoblast



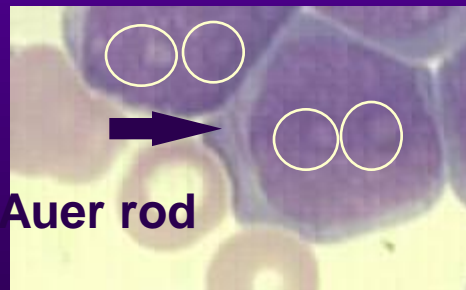
All blasts have **nucleoli**. and
Cell lines are difficult to differentiate on Wright's stain
without a distinguishing feature (eg, **Auer rod** in AML).



myeloblast



monoblast



myeloblast



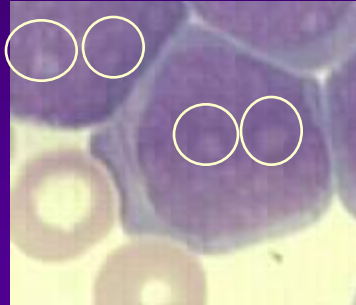
lymphoblast



While the presence of **nucleoli** differentiates blasts from more mature forms,



myeloblast



myeloblast



monoblast



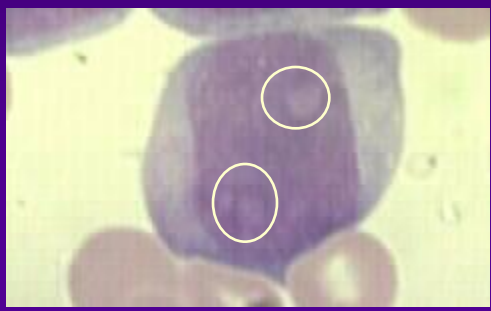
lymphoblast

special stains are usually needed for definitive identification of leukoblasts.

Leukoblasts must also be differentiated from **proerythroblasts**.

How do you differentiate leukoblasts (WBC) and proerythroblasts (RBC)?

Leukoblasts



myeloblast



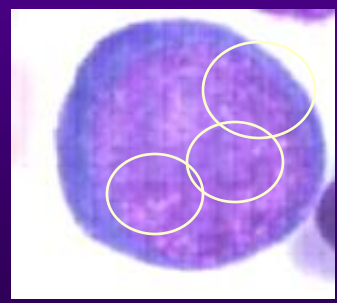
lymphoblast



monoblast

Proerythroblasts

&

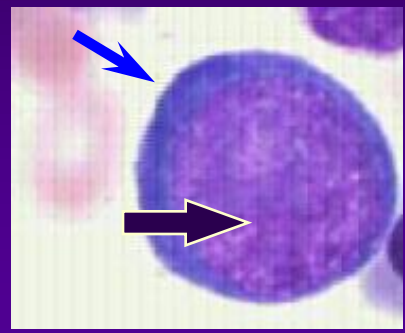


have nucleoli.



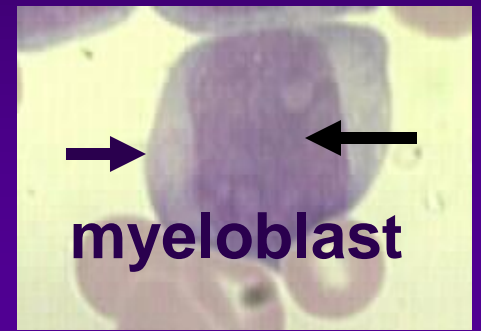
How do they differ morphologically?

In the **proerythroblast**,

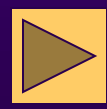
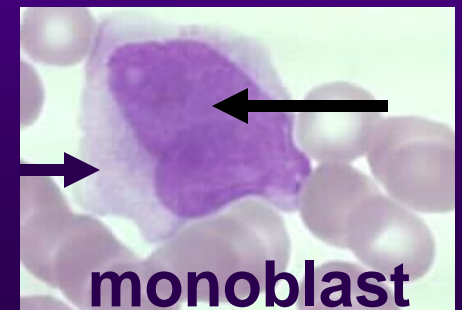
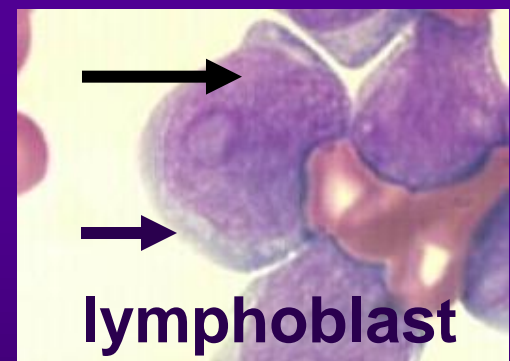


the cytoplasm is usually darker and bluer **and** the nuclear chromatin strands are linear and distinct

than the leukoblasts



compared to leukoblasts, which are more delicate and interlaced.



Myelocytic (or Granulocytic) Series

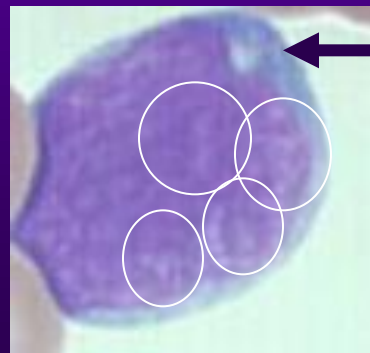


Myelocytic Maturation

There are **three types** of cells in the myelocytic (or granulocytic) series: neutrophils, eosinophils, and basophils.

Myeloblasts (ie, the earliest precursor) originate in the marrow from a stem cell common to erythroid, megakaryocytic, and granulocytic cells. Prominent nucleoli are seen in the nucleus and the cytoplasm is agranular. Morphologically, they are difficult to differentiate from lymphoblasts or monoblasts.

Examples of myeloblasts:



nucleoli
& agranular cytoplasm

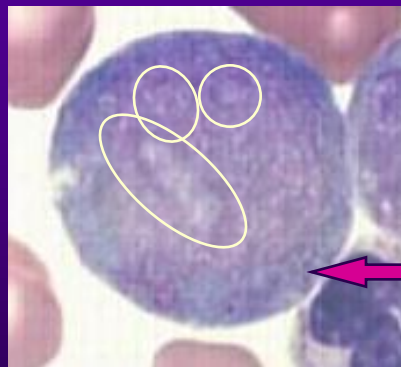


Myelocytic Maturation, continued

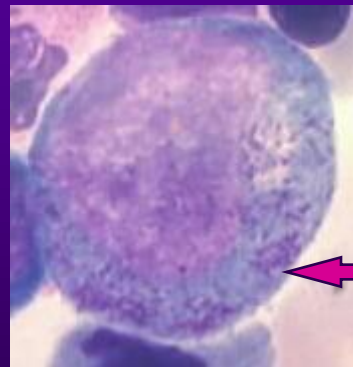
Nucleoli are also seen in the **promyelocyte** and the appearance of large azurophilic (nonspecific) cytoplasmic granules in the early stage of its transition is an indication that the cell is a granulocyte. However, morphologic determination as to neutrophilic, eosinophilic, or basophilic cannot yet be made.

Examples of promyelocytes:

prominent
nucleoli and
cytoplasmic
non-specific
granules begin
to be visible



early promyelocyte



late promyelocyte

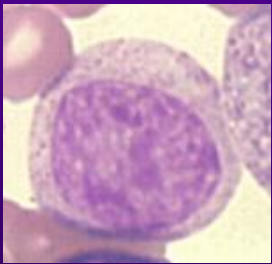
as the cell matures,
the nucleoli begin to
fade and the gran-
ules become more
numerous and
prominent



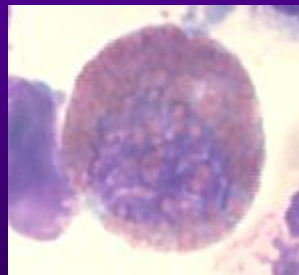
Myelocytic Maturation, continued

As the promyelocyte matures and reaches the myelocytic stage, it has definitely and visually differentiated into one of the three granulocytic types with characteristic cytoplasmic “**specific**” or **secondary granules**. Nucleoli are indistinct or not seen and this is the last mitotic stage.

Examples of myelocytes with specific granules:



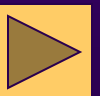
neutrophilic



eosinophilic

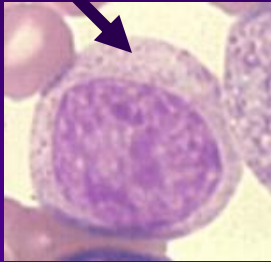


basophilic



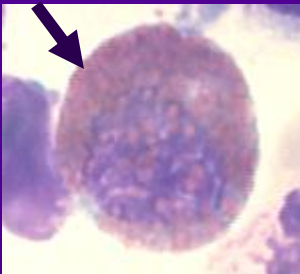
Myelocytic Maturation, continued

Specific cytoplasmic granules:



ill-defined reddish granules within the bluish cytoplasm resulting in a lilac or pinkish color

neutrophilic



relatively large, spherical, orange granules

eosinophilic



unevenly distributed large, blue-black granules, which are usually also visible on top of the nucleus

basophilic



Neutrophilic Maturation

From this stage on, as the cell matures, there is little change in the cytoplasm but the **nuclear chromatin becomes progressively more condensed** and the characteristic nuclear shapes of the metamyelocyte, band (stab form), and mature segmented cell are noted.

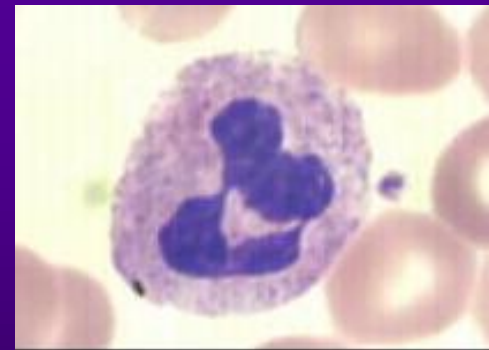
Illustrated below in the images of **neutrophilic cells**:



metamyelocyte



band (or "stab")



mature segmented
(or PMN)



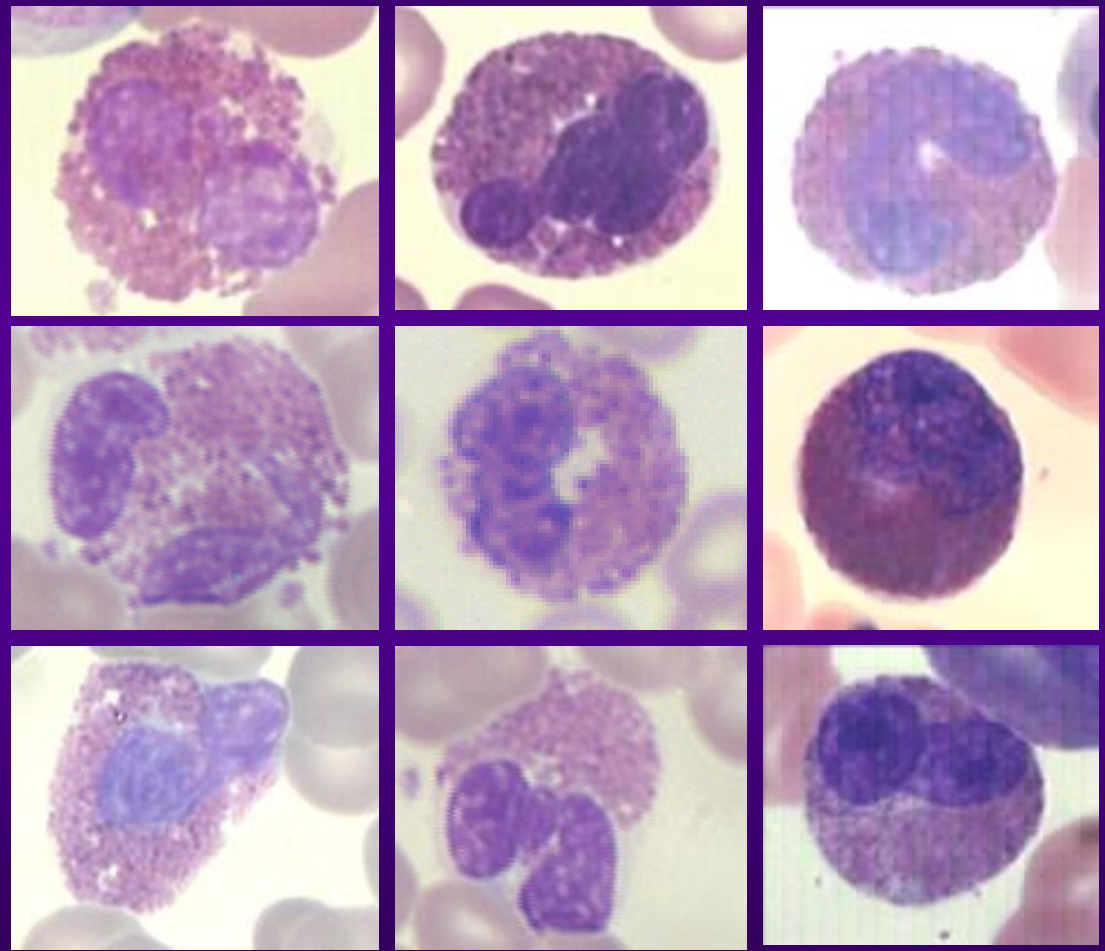
Eosinophilic and Basophilic Maturation

There is usually no differentiation made as to whether eosinophils and basophils are myelocytes, metamyelocytes, band, or mature cells. Regardless of the stage of maturation, they are still referred to only as eosinophils or basophils.

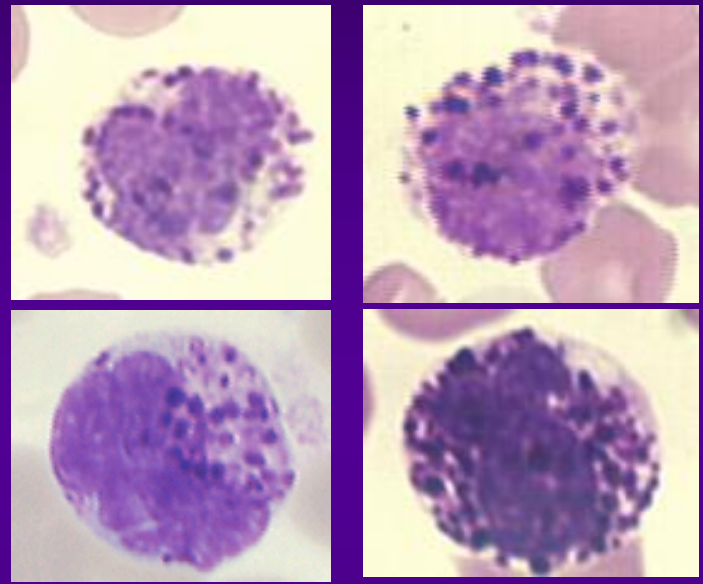
The granules observed in both cell lines are rather large, frequently dense and, in many cases, obscure the nucleus thus making it difficult to see the nuclear shape as illustrated in the images of **eosinophils and basophils**.

Various Stages Maturation

<-----Eosinophils----->



<----Basophils---->

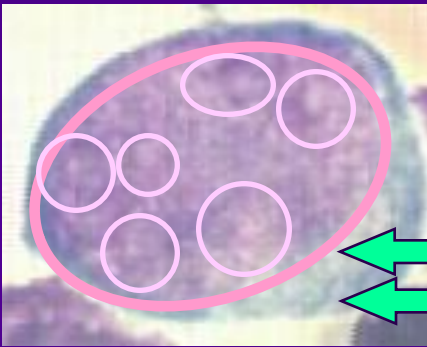


Morphologic Features of Granulocytes



Myeloblast

The **myeloblast** is morphologically undifferentiated as to granulocytic cell line (ie, neutrophilic, eosinophilic, or basophilic).



Size: variable, usually 15 to 20 μm diameter

Nucleus: relatively round and large; predominantly red-stained, delicate, interlaced, well defined and evenly stained chromatin

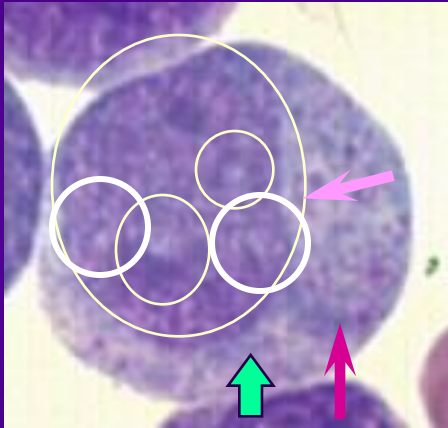
Nucleoli: large and usually 2 or more

Cytoplasm: agranular, bluish and stains unevenly usually lighter next to the nucleus than at the periphery and may have cytoplasmic tags)



Promyelocyte

The **promyelocyte** is still undifferentiated as to a specific granulocytic cell line (ie, neutrophilic, eosinophilic, or basophilic).



Size: usually larger than blasts but variable depending on the stage in the mitotic cycle

Nucleus: round and relatively large with predominantly red-stained chromatin

Nucleoli: usually demonstrable

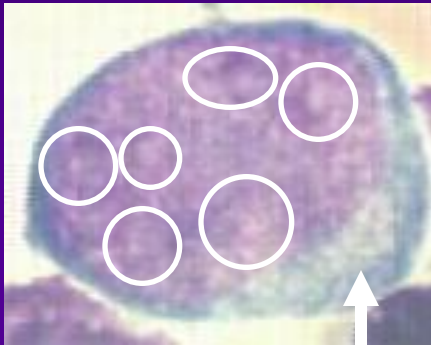
Cytoplasm:

- Stains **blue** with a **relatively light area** adjacent to the nucleus
- **Granules** - nonspecific (or primary) granules and absence of secondary granules (ie, neutrophilic, eosinophilic, or basophilic)



Myeloblast vs. Promyelocyte

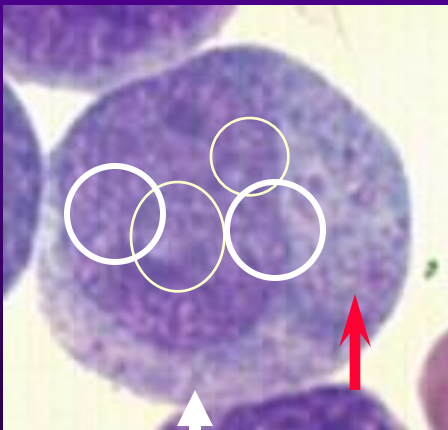
Myeloblast → Nucleoli: two or more, large, prominent



→ Cytoplasm: bluish, unevenly stained

→ Granules: none visible

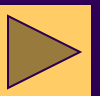
Promyelocyte



→ Nucleoli: usually demonstrable

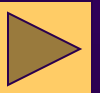
→ Cytoplasm: bluish, unevenly stained

→ Granules: distinct non-specific (or , primary), predominantly dark blue or reddish blue



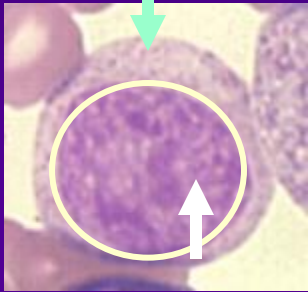
Granulocytes

Granulocytes are neutrophilic, eosinophilic, or basophilic. The cells cannot be morphologically differentiated on Wright's stain until they reach the myelocyte stage and develop specific granules.



Neutrophilic Myelocyte

This is the last stage in which nucleoli can be seen and mitosis can occur. However, if present, the nucleoli are usually indistinct. Cell line differentiation is seen.



Size: usually smaller than promyelocytes (10-18 μ m in diameter).

Nucleus: round, oval, or flattened on one side.

Chromatin: fine, dispersed pattern in early cells which becomes more condensed as the cell matures.

Nucleoli: usually not demonstrable

Cytoplasm: more than promyelocytes (N/C ratio about 2:1).

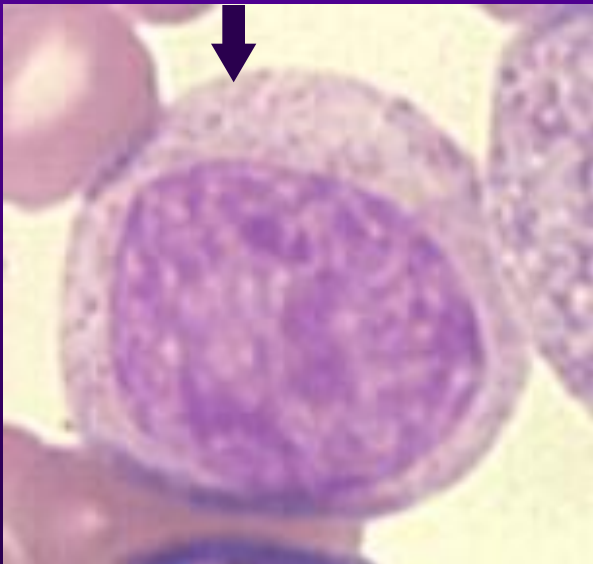
- Stains blue but becomes less basophilic as it matures.
- Granules - distinct specific (or secondary) granules that are neutrophilic, eosinophilic, or basophilic.



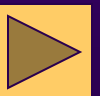
Myelocytes

The first morphologic evidence of specific or **secondary granules** that provide a means of identifying the cell as a neutrophil, eosinophil or basophil is seen in the myelocyte.

Neutrophils - neutrophilic granules give the cytoplasm a **lilac or pinkish** appearance



NOTE: an enlargement of the cell shown on the previous slide to better illustrate the granules.



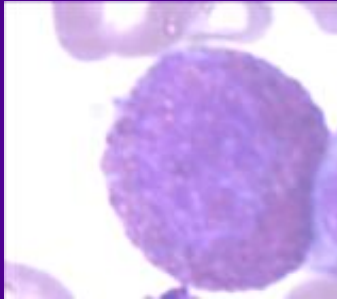
Myelocytes

The maturation sequence of the eosinophils and basophils is the same as the neutrophils. The nuclear features are identical but the color and/or size of the **cytoplasmic granules** differentiates these cells from the neutrophils.

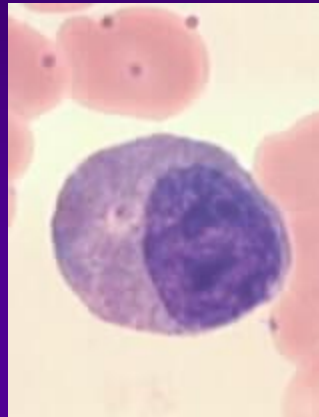
Eosinophils - relatively large and spherical purplish-red granules give the cytoplasm a **reddish-orange color**.

Basophils - **large dark blue to black** unevenly distributed granules may fill the cytoplasm and, when present in large numbers, may obscure the nucleus.

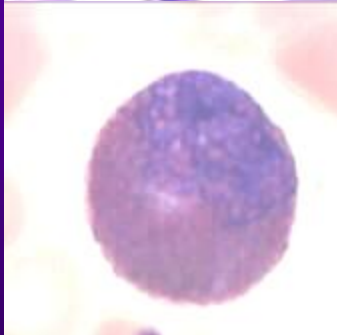
Neutrophilic, Eosinophilic, & Basophilic Myelocytes



eosinophilic



neutrophilic

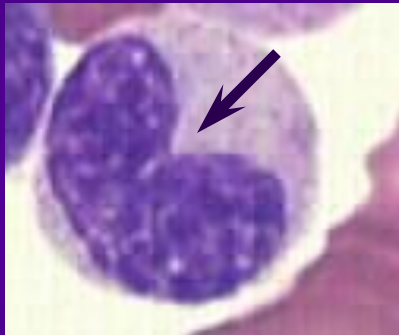


basophilic



Metamyelocyte (Neutrophilic)

As soon as the nucleus of the myelocyte (which may be neutrophilic, eosinophilic, or basophilic) becomes **indented**, the cell is classified as a metamyelocyte. The cell is no longer capable of mitosis.



Size: usually slightly smaller than myelocytes

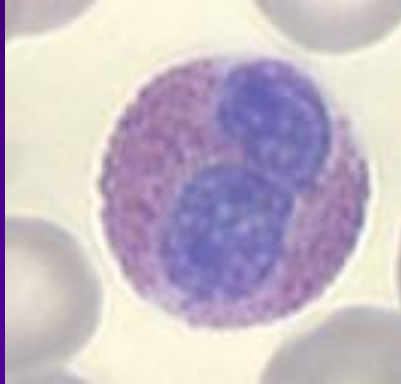
Nucleus: relatively smaller than myelocyte and, as the cell matures, indentation increases.

Chromatin: less well defined and becomes more condensed clumped, and darkly stained as the cell matures.

Nucleoli: not demonstrable

Cytoplasm: progressively less basophilic than myelocytes and distinct specific (or secondary) granules that are **neutrophilic, eosinophilic, or basophilic** predominate.

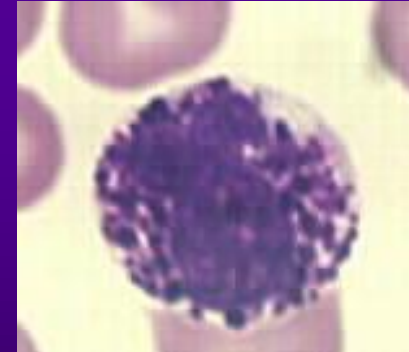
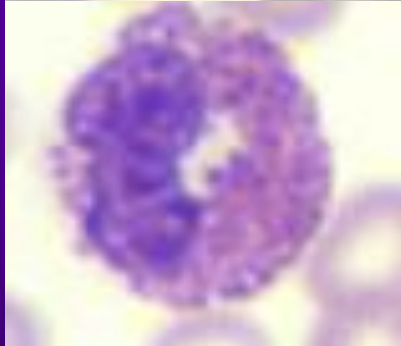
Metamyelocytes



**eosinophilic
specific granules**



**neutrophilic
specific granules**



**basophilic
specific granules**



Neutrophilic Band

As soon as the indentation in the nucleus of the metamyelocyte becomes **greater than 1/2 the diameter**, the cell is classified as a band (neutrophil, eosinophil, or basophil).



Size: slightly smaller than metamyelocytes

Nucleus: indented greater than 1/2 diameter and opposite edges of the nucleus become approximately parallel (horse-shoe shape).

Chromatin: dense and clumped, usually with a pyknotic mass at each pole where the lobe will be.

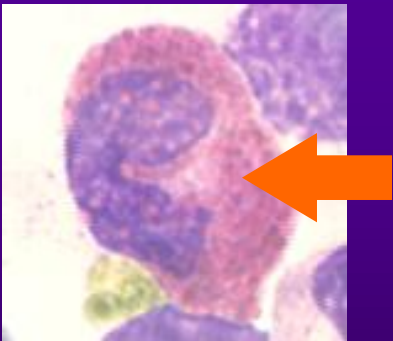
Nucleoli: none present

Cytoplasm: no basophilia & may be slightly eosinophilic; distinct specific (or secondary) granules that are **neutrophilic, eosinophilic, or basophilic** predominate.

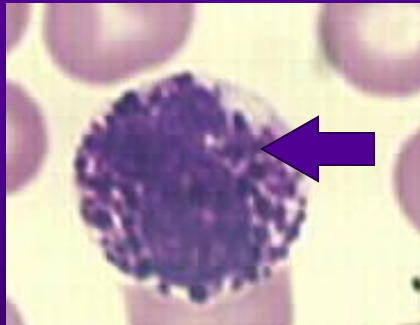
Bands



neutrophilic (lilac or pinkish) specific granules



eosinophilic (orange) specific granules

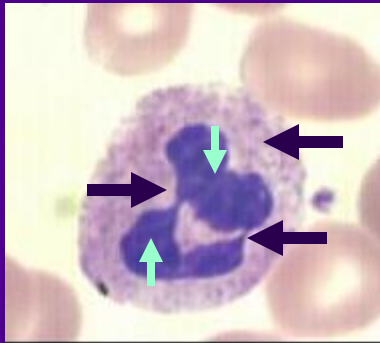


basophilic (blue-black) specific granules



MATURE SEGMENTED NEUTROPHIL (PMN)

Mature neutrophils have nuclei that are separated into definite lobes. They are frequently referred to as PMN (polymorphonuclear neutrophils).



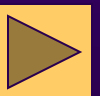
Size: 10-15 μm (about twice the size of RBC).

Nucleus: separated into definite lobes (usually 2 or 3 with occasional 4 or 5) which are connected by a very **narrow filament or strand**.

Chromatin: dense and clumped

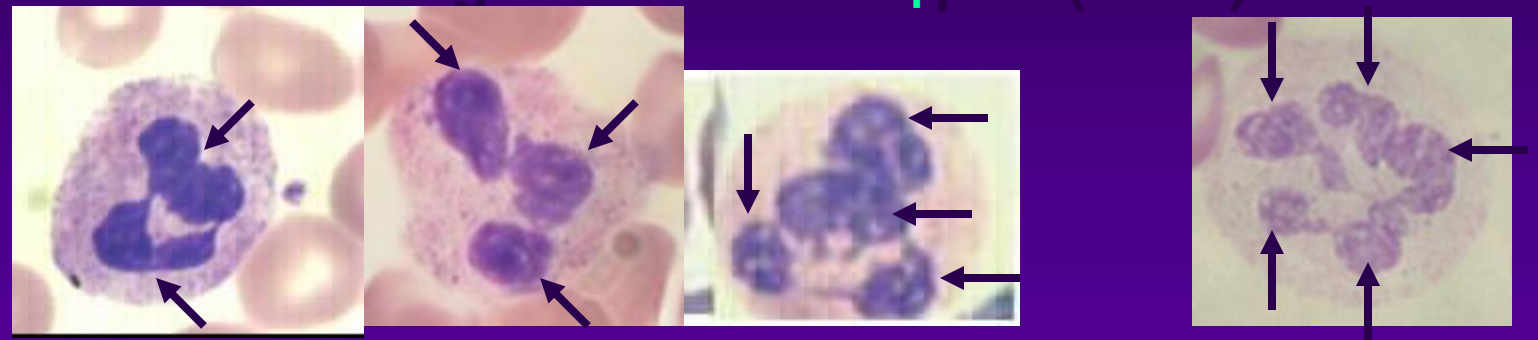
Nucleoli: not present

Cytoplasm: slightly eosinophilic or light pink with numerous pink to bluish-black evenly distributed small granules.



Normal Mature Neutrophils, Eosinophils, and Basophils

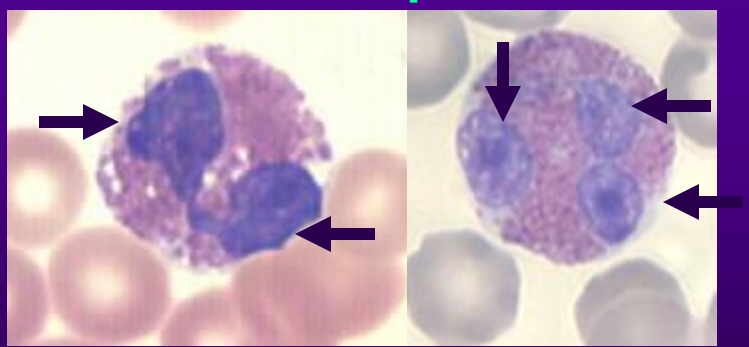
segmented neutrophils (PMN)



usually 2-4 lobed nucleus

but may have a few w/ 5 lobes

eosinophils



usually bilobed nucleus

but may have 3 or more lobes

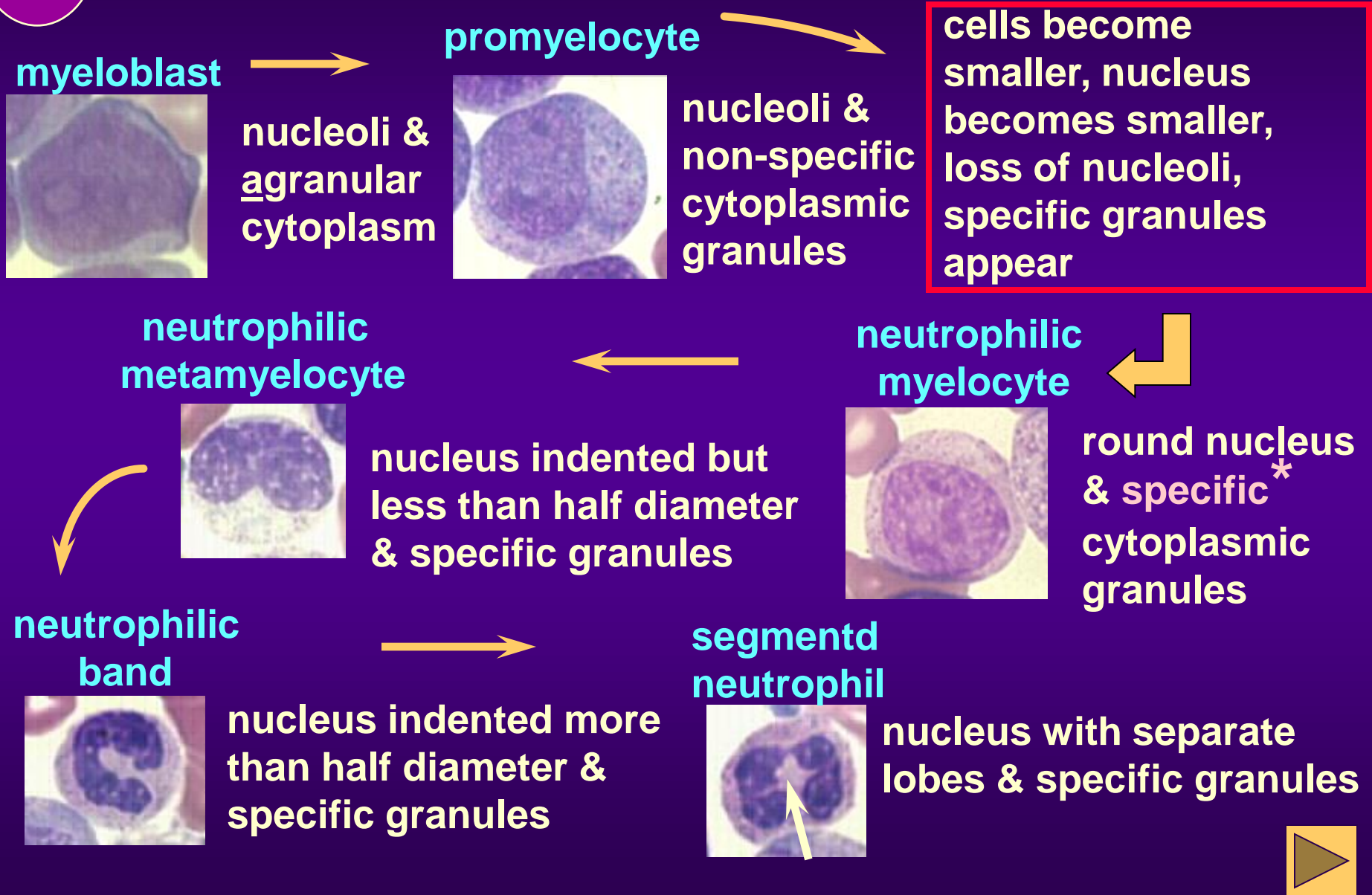
basophil



granules usually obscure nucleus

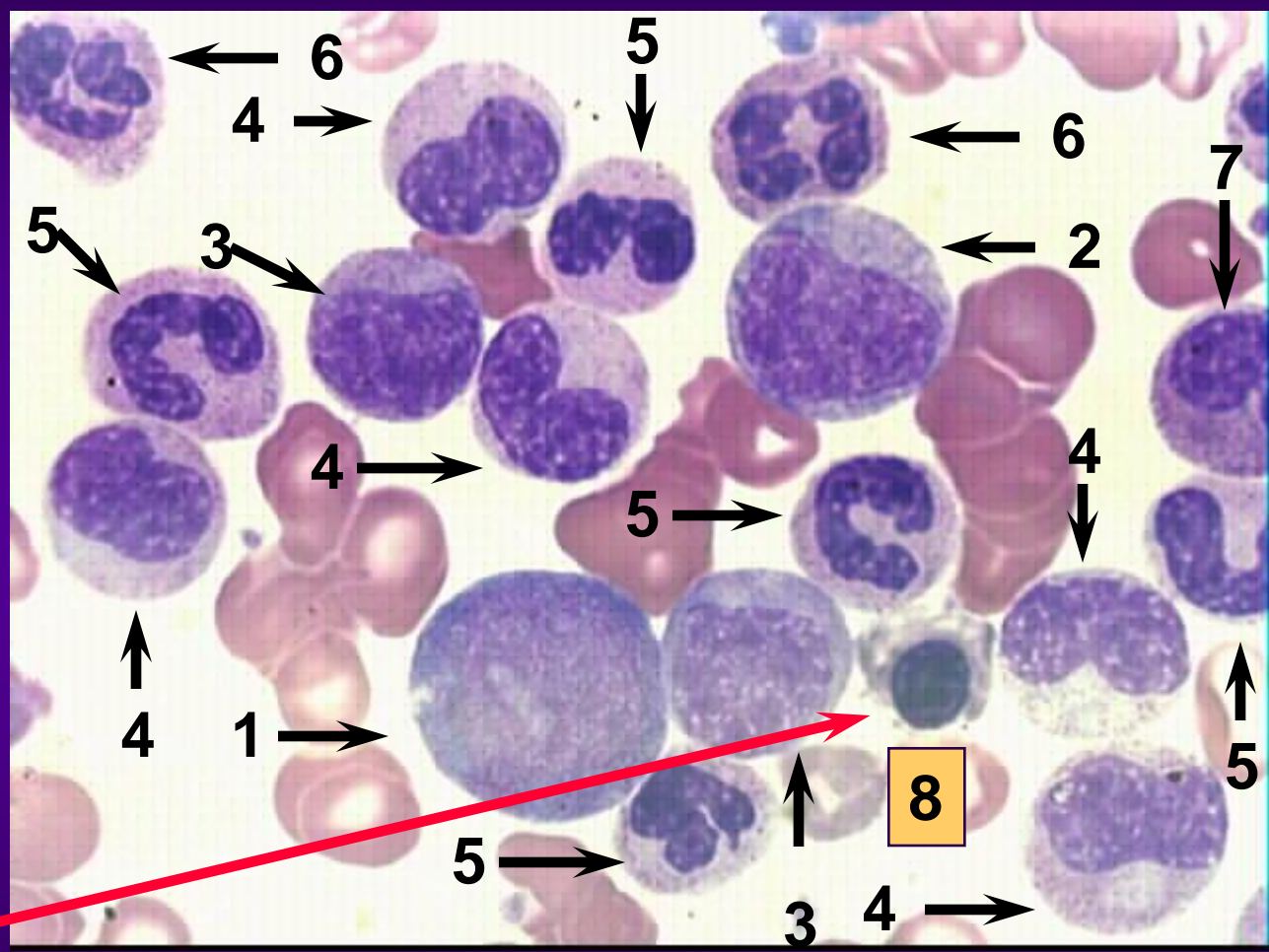


Review: Neutrophilic Maturation



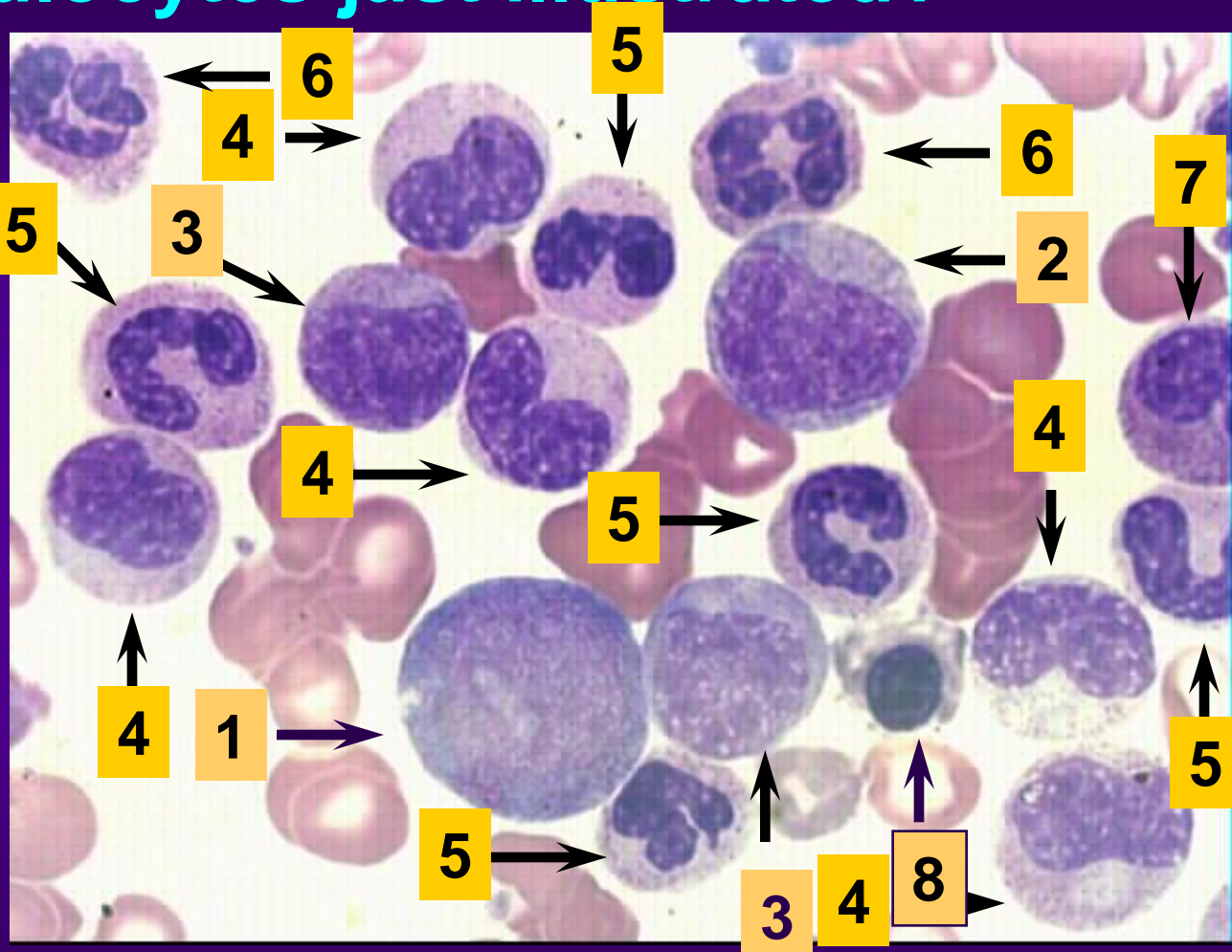
Examples of granulocytes in various stages of maturation:

- 1 early promyelocyte
- 2 late promyelocyte or early myelocyte
- 3 myelocyte
- 4 metamyelocyte
- 5 band neutrophil
- 6 mature segmented neutrophil (PMN)
- 7 eosinophil
- 8 **Whoa!** That's not a WBC. It's a nucleated RBC but will also be included in the total WBC count.



Now, Can you Identify the stages of granulocytes just illustrated?

- 1 early promyelocyte
- 2 late promyelocyte or early myelocyte
- 3 myelocyte
- 4 metamyelocyte
- 5 band neutrophil
- 6 mature segmented neutrophil (PMN)
- 7 eosinophil



8 Remember, it's a NRBC!



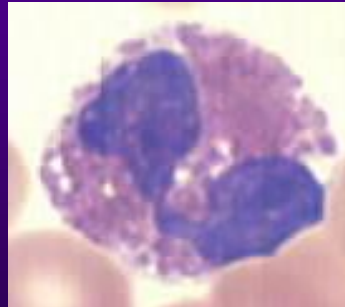
Review: Eosinophilic & Basophilic Maturation

The maturation sequence for eosinophils and basophils parallels that of neutrophils. Blast and promyelocyte stages are morphologically undifferentiated as to neutrophils, eosinophils, or basophils.

The cells can be differentiated in the myelocyte stage with the appearance of specific cytoplasmic granules (ie, neutrophilic pink, eosinophilic orange, or basophilic dark blue-black) that remain through **maturity**.



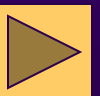
neutrophil



eosinophil



basophil



Lymphocytic Series



Lymphoblasts

Blasts are the earliest leukocytic precursor that can be seen in peripheral blood **and** have **nucleoli** which help to differentiate them from mature cells.



myeloblast



lymphoblast



monoblast

Special stains and/or flow cytometry are usually needed for **definitive** differentiation of the various leukoblast cell lines (i.e., myeloblasts, lymphoblasts, and monoblasts).

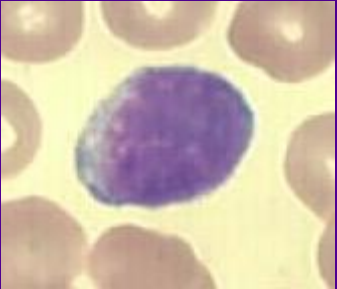
The least mature lymphoid cell seen in peripheral blood is the lymphoblast.



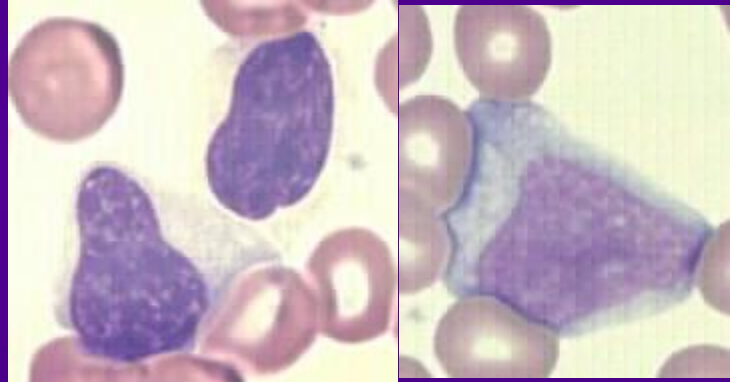
Lymphocytic Cells

For Clinical Pathology 201, you will be expected to be able to identify and differentiate:

mature lymphocytes



atypical (or reactive) lymphocytes



and

lymphoblasts

and



Monocytic Series



Blasts are the earliest leukocytic precursor that can be seen in peripheral blood **and** have **nucleoli** which help to differentiate them from mature cells.



myeloblast



lymphoblast



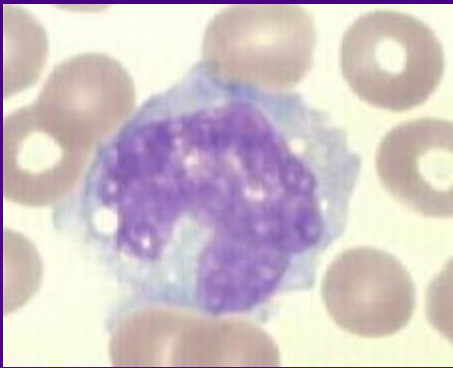
monoblast

The earliest monocytic cell seen in peripheral blood is the monoblast. Special stains are usually needed for **definitive** identification of blast cell lines. Refer to the Course Manual.



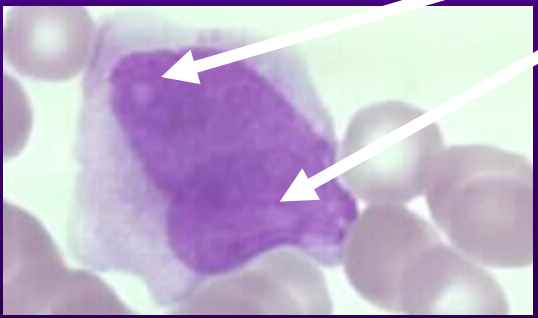
Monocytic Cells

For Clinical Pathology 201, you will be expected to be able to differentiate mature monocytes



i.e., recognize the mature cell and differentiate

from monoblasts



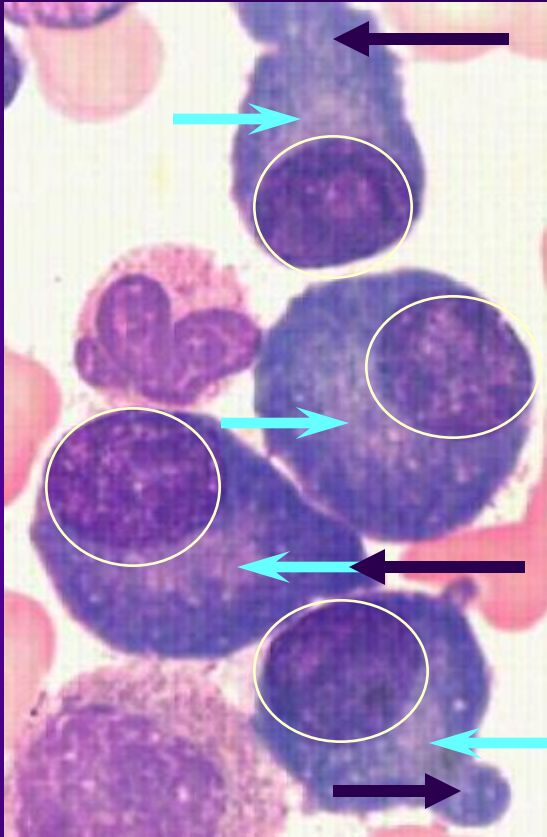
with nucleoli

Special stains and/or flow cytometry are usually needed for definitive identification of the blast cell line.



Plasma Cells





Size: mature cells vary greatly

Shape: usually oval shape with relatively smooth cytoplasmic margins, but, like the lymphocyte, the plasmocyte is easily traumatized and often has frayed or nebulous margins and pointed or filamentous cytoplasmic **projections**

Nucleus: relatively small and round and eccentrically located

Cytoplasm: abundant

The cytoplasm adjacent to the nucleus stains more lightly than the periphery of the cell which has a high saturation of red and blue dyes. The area is called a “**golgi**”.



Plasma cells are never present in normal peripheral blood. They constitute about 1% of the nucleated cells in normal bone marrow where they tend to be grouped in small islands around blood vessels. They may be present in small numbers in chronic infections, in granulomatous and allergic diseases and in plasma cell myeloma.

Plasmoblasts (not shown) are cells with relatively large nuclei, nucleoli and delicate chromatin which takes a predominantly red color. Plasmoblasts are not recognizable except in malignancies of the plasmocytoid type.



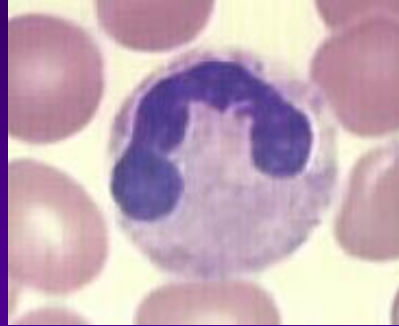
Leukocytes in Normal Peripheral Blood



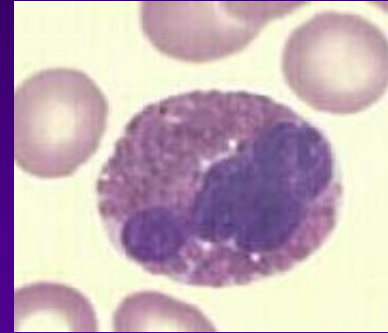
Review: WBC found in normal peripheral blood:



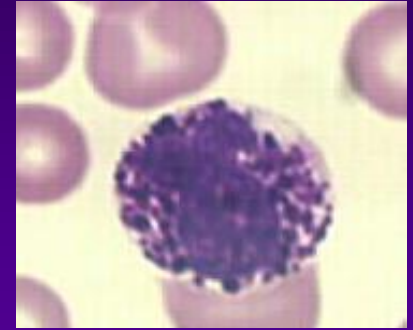
**mature
neutrophils**



**band
neutrophils**



eosinophils



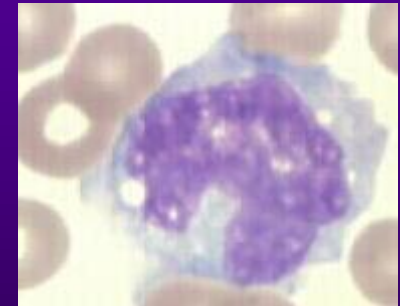
basophils



lymphocytes



**atypical lymphocytes
($<6\%$ of lymphocytes)**



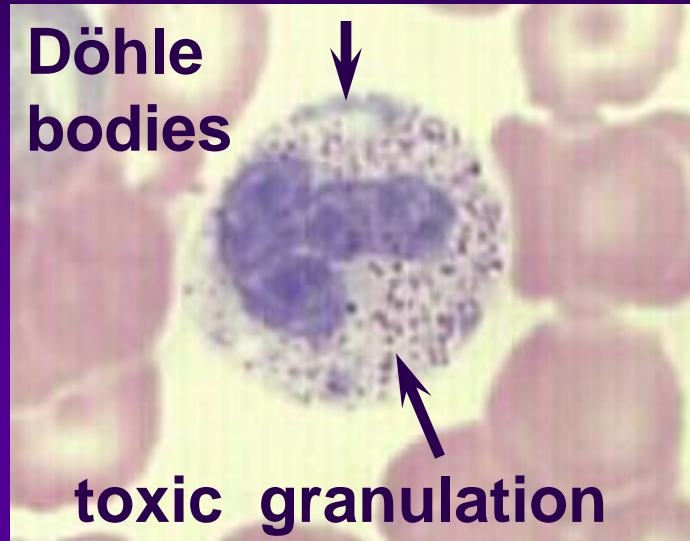
monocytes



Leukocytes with Acquired Non-neoplastic Alterations



Toxic Granulation & Dohle Bodies in Neutrophils



Toxic granulation - dark blue to purple cytoplasmic granules

and/or

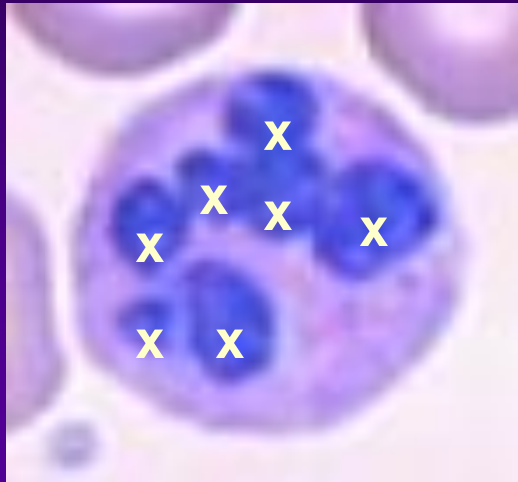
Döhle bodies - small blue cytoplasmic inclusions

Toxic granules may be seen in severe bacterial infections, burns, aplastic anemia, and following administration of toxic agents.

Frequently, **Döhle bodies** will also be seen concomitantly with toxic granulation.



Hypersegmented Neutrophils



Hypersegmented neutrophil - (ie, > 5 lobes) which are presumably the result of abnormal nuclear maturation. Five lobes in more than 5% of the neutrophils constitute hypersegmentation, as do any neutrophils with 6 or more lobes. In this case, **there are 7.**

Hypersegmented neutrophils are characteristic features of megaloblastic anemias that are due to **vitamin B₁₂ or folate deficiency.**

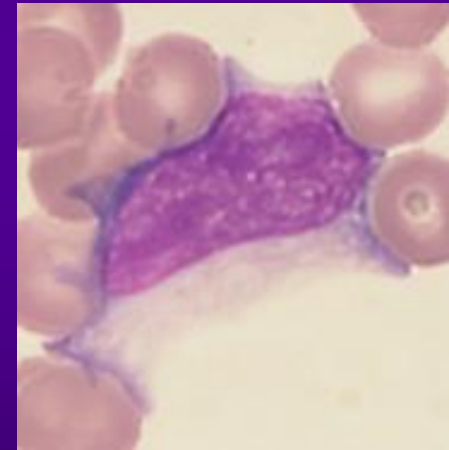
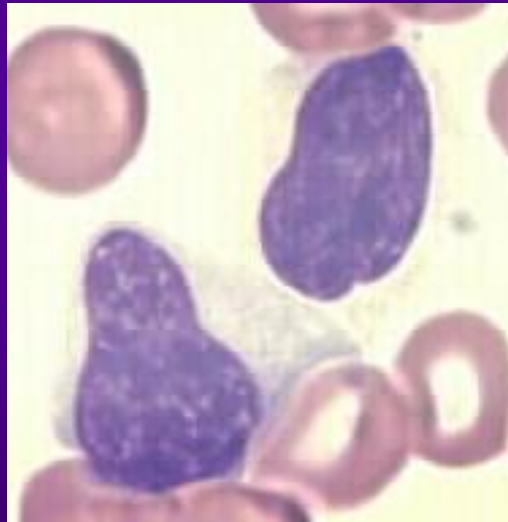
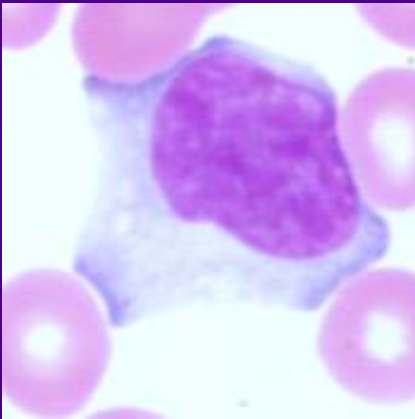
Refractory anemias that are megaloblastic usually **do not include** these granulocytic changes (ie, hypersegmentation).



Atypical/Reactive Lymphocytes

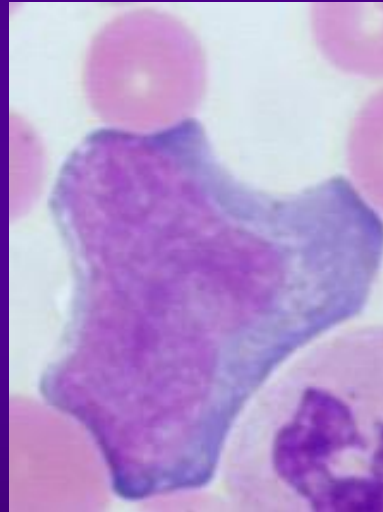
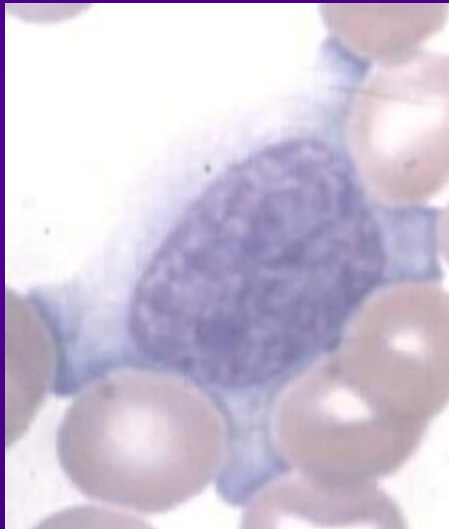
Atypical/reactive lymphocytes may be seen most typically in **viral** disorders.

Atypical lymphocytes may have abundant cytoplasm with scalloped or indented rims ...



Atypical/Reactive Lymphocytes

...or have darker cytoplasm and more monocytoid nuclear or plasmacytoid **features** ..



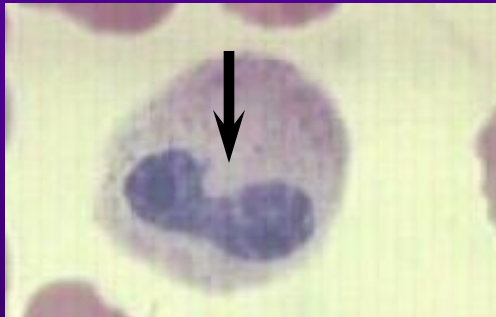
Leukocytes with Inherited Non-neoplastic Alterations



Pelger-Huet Anomaly

An inherited autosomal dominant condition in which there is a failure of normal segmentation of granulocytic nuclei (i.e., hyposegmented nuclei). The **nuclei** may be...

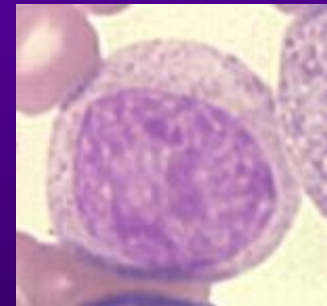
band shaped



bi-lobed or
“pince-nez”
shaped



or in very rare cases,
round shaped (like a
myelocyte).



Pelger-Huet Anomaly, continued

- **Absence of symptoms of infection or other cause of a “left shift”, history of persistent blood morphology, and/or similar blood morphology of other family members suggests the anomaly.**
- **The cell morphology persists through life and the cells are functional.**



Pseudo-Pelger-Huet Anomaly

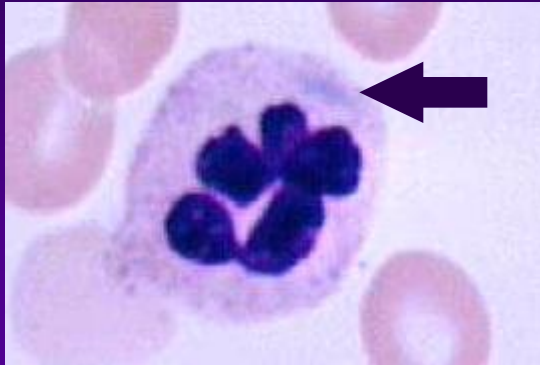
An **acquired disorder** similar in appearance to Pelger-Huet anomaly may occasionally be found in cases of granulocytic leukemia, myeloproliferative disorders, some infections, and after exposure to certain drugs.

Band forms, neutrophils with only two segments or “pince-nez” appearance (not shown), and/or neutrophils with **round non-segmented** nuclei are seen. Neutrophils with **> 2 segments (lobes)** will not be seen in this disorder.

There is asynchronism between the shape of the nucleus and the maturity of the nucleus and cytoplasm.



May-Hegglin Anomaly



Pale blue cytoplasmic inclusions that resemble Dohle bodies but are larger and more prominent. They may be found in neutrophils, eosinophils, basophils, and monocytes.

Bluish aggregations (RNA) particles can be seen in the cytoplasm of neutrophils. Giant platelets can also be seen.

This is a rare autosomal dominant condition.

The cells are functional and the cytoplasmic inclusions in **May-Hegglin persist through life**. Acquired Dohle bodies are transient.



Alder-Reilly Anomaly



This disorder is characterized by neutrophils with large azurophilic and basophilic **granules** in the cytoplasm that resemble toxic granulation.

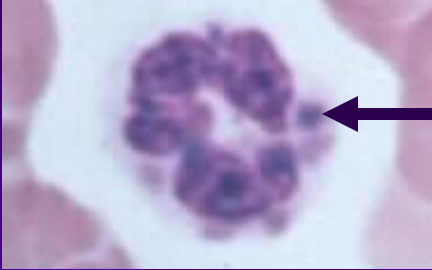
This is an autosomal recessive trait. There is no apparent interference with leukocyte function.

However, these granules may also be seen in association with some but not all patients with gargoylism (the Hurler syndrome), or more generally, the genetic mucopolysaccharidoses).

Alder-Reilly granules are persistent through life whereas acquired toxic granulation is transient.



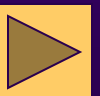
Chediak-Higashi Syndrome



Abnormally large **cytoplasmic black granules** which appear to be abnormal lysosomes may be seen in granulocytes, monocytes, and lymphocytes.

This is a rare autosomal recessive disorder characterized by paratial albinism, photophobia, and frequent pyogenic infections. An accelerated lymphoma-like phase occurs, with lymphadenopathy, hepatosplenomegaly, and pancytopenia. Lymphoid infiltrates are widespread and death ensues at an early age. Leukocyte functional abnormalities exist.

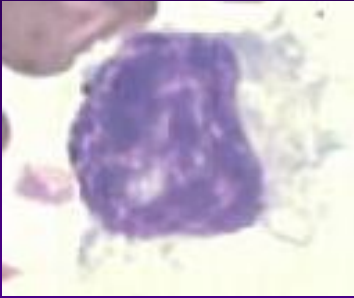
The abnormal morphologic features are persistent throughout life.



Leukocytes with Neoplastic Alterations



Hairy Cell Lymphocytes



The hallmark of hairy cell leukemia is the presence of lymphocytes with irregular long, delicate cytoplasmic projections which give them a hairy appearance.

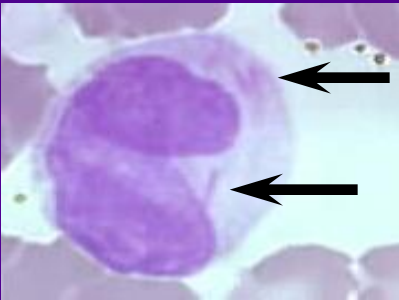
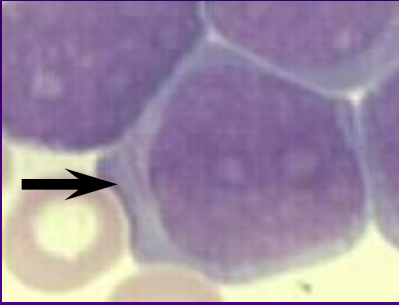
This is an uncommon chronic, low grade lymphoproliferative disease (or CLL) that occurs about 5 times more frequently in males than females.

Onset of disease is insidious; weakness and lethargy; or may be asymptomatic (10-15% of patients). May be bleeding and bruising.

Normocytic, normochromic anemia related to the neoplastic cell mass, marrow hypoplasia, and hypersplenism is also seen. Thrombocytopenia in about 75% of patients and Coomb's test may be positive.



Myeloblasts with Auer Rods



Auer rods in the cytoplasm of myeloblasts are associated with acute leukemias having a myeloid component. They appear as cytoplasmic reddish rods with Wright's or Wright's-Giemsa stains.

They may be seen in some, but not all, myeloblasts in some, but not all, of the **variants of acute myelocytic leukemia**. They are not seen in blasts in chronic myelocytic leukemia.

The **presence of Auer rods** in the cytoplasm of blasts effectively **rules out a lymphoid disorder**.



End of Leukocytes

This ends the section on leukocytes. Click on:

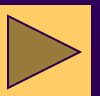
Erythrocytes to go to the next section of this study module as designed.

or

Menu to go back to the menu.

or

Quit to end the exercise.



Erythrocytes



How are the RBC identified?

Typical morphologic nuclear and/or cytoplasmic features provide a means by which RBC can be identified. For example:

- **Maturity**
- **Size**
- **Shape**
- **Color**
- **Hemoglobin content**
- **Inclusions (if any)**



How are RBC classified as to maturity?

Characteristic nuclear and/or cytoplasmic morphologic features allow red blood cells to be classified as:

- pronormoblast (or rubriblast), the earliest form seen in peripheral blood (ie, least mature)
- basophilic normoblast (or prorubricyte)
- polychromatophilic normoblast (or rubricyte)
- orthochromatic normoblast (or metarubricyte)
- polychromatophilic erythrocyte (or diffusely basophilic erythrocyte)
- mature erythrocytes



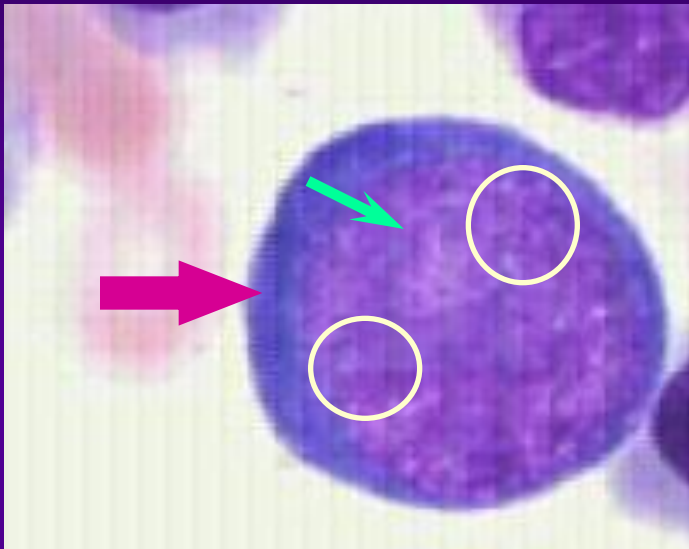
Summary of the key features of erythrocyte development:

Cell	Cytoplasm	Nucleus	Nucleoli	chromatin
Pronormoblast	Scanty, basophilic	Large	Prominent	Dispersed, finely granular
Basophilic normoblast	Increased, still basophilic	Moderate	Indistinct	Dispersed but more condensed
Polychromatophilic normoblast	Mixed basophilic & eosinophilic	Smaller	None	Chromatin & parachromatin
Orthochromatic normoblast	More eosinophilic	Pyknotic	None	Condensed chromatin, no parachromatin
Polychromatophilic erythrocyte*	Eosinophilic	None	None	None
erythrocyte	Eosinophilic	None	None	None

*called a reticulocyte after staining with a supravital stain



What are the characteristic features of pronormoblasts?



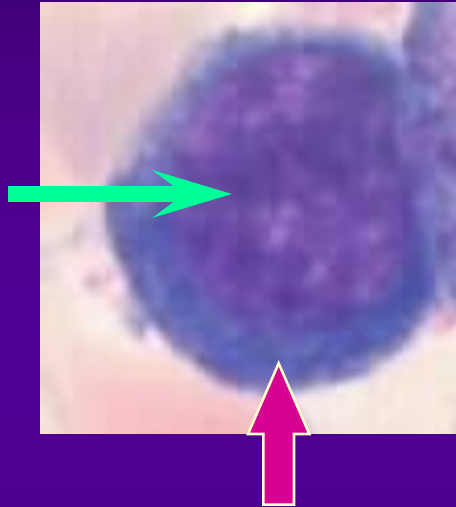
Nucleoli:
usually visible

Nuclear chromatin:
linear and distinct

Cytoplasm: in earliest form stains light blue; in later and more frequently occurring forms has a dark royal-blue color similar to that seen in some plasmacytes.



What are characteristic features of basophilic normoblasts (prorubricytes)?



Nucleoli:
ill-defined or absent

Nuclear chromatin:
coarsening of the
chromatin pattern

Cytoplasm: deeply basophilic due to the abundance of RNA with a reddish tinge produced by varying amounts of hemoglobin present

&

some cells may have a Golgi (clear) area adjacent to the nucleus (not visible in this cell).



What are characteristic features of polychromatophilic normoblasts (rubricytes)?



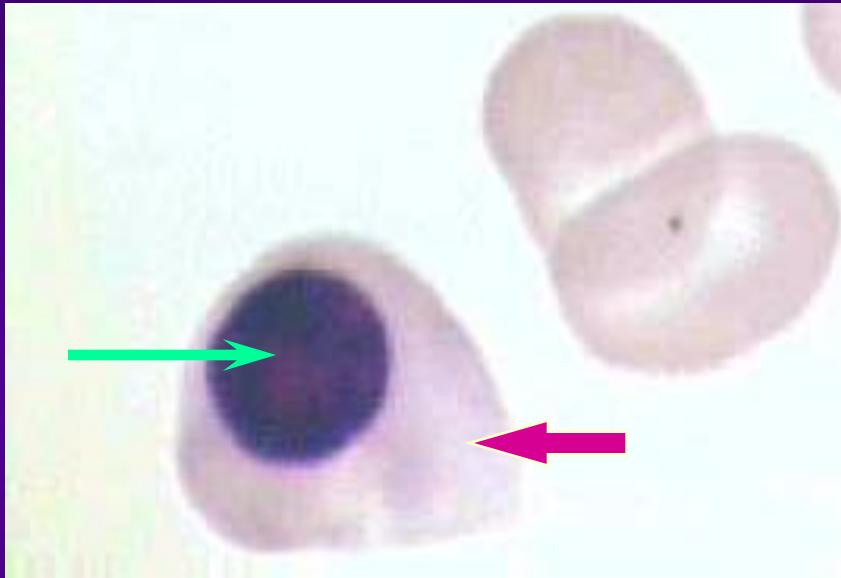
Nucleoli:
no longer visible

Nuclear chromatin:
thickened and
irregularly coarsened

Cytoplasm: relatively more cytoplasm than the basophilic normoblast and takes varying mixtures of red and blue stain



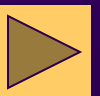
What are characteristic features of orthochromatic normoblasts (metarubricytes)?



Nucleoli: none

Nuclear chromatin: nonlinear clumped structure or, as shown in this field, a solid reddish-blue-black degenerated nucleus

Cytoplasm: predominantly red cytoplasm with minimal amounts of residual blue



What are characteristic features of **polychromatophilic erythrocytes** (diffusely basophilic erythrocytes)?



orthochromatic erythroblast
(erythroblasts have a nucleus)

As the cell matures, the nucleus is **extruded** and the cell becomes a

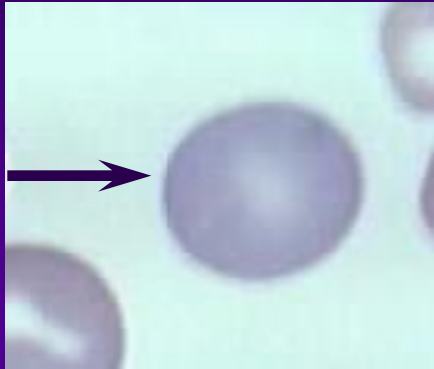


polychromatophilic erythrocyte
(erythrocytes do not have a nucleus)

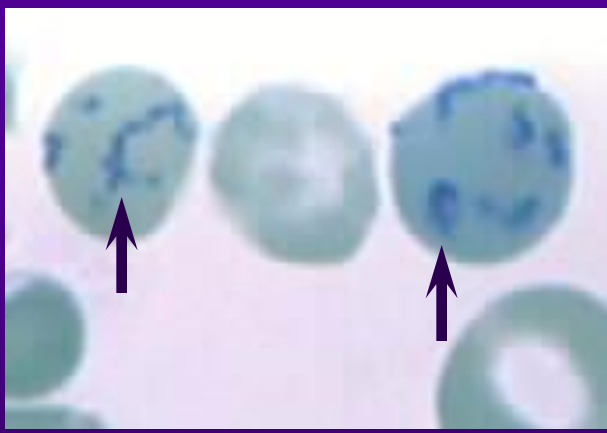
Cytoplasm: predominantly red but may have a bluish tinge due to the reticulum strands (RNA) still present.



What is the correct name for this cell on a Wright's stained blood smear?



On a **Wright's stained** blood smear, the cell is called a **polychromatophilic erythrocyte**.



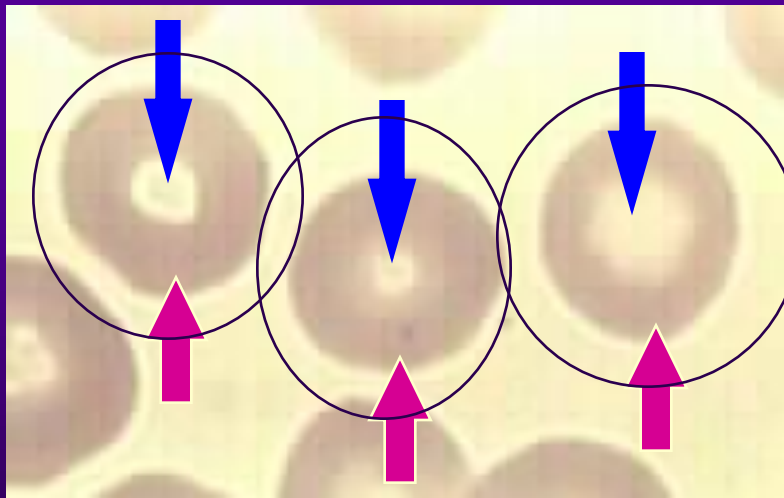
When these cells are stained with a **supravital stain** (e.g., new methylene blue), the **residual RNA strands** are precipitated,

and the cell is then called a **reticulocyte**.

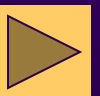


What are characteristic features of normal **mature** erythrocytes?

Normal mature erythrocytes are anucleated **biconcave discs** that stain a reddish buff color with Wright's (or Wright's-Giemsa) stain and have a small (about 1/3 of the cell) central pallor.

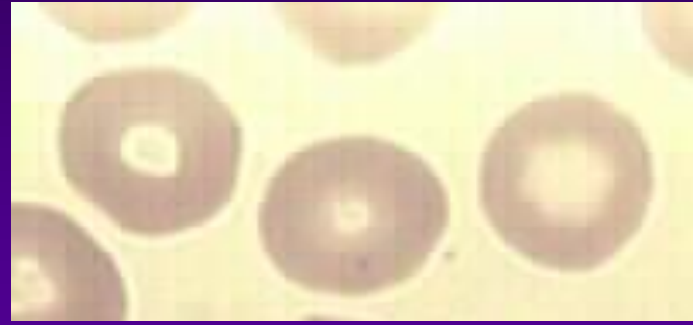


The intensity of the stain in the center of the cell (i.e., the **thin** portion) is less than at the outer rim of the cell (i.e., the **thicker** portion).



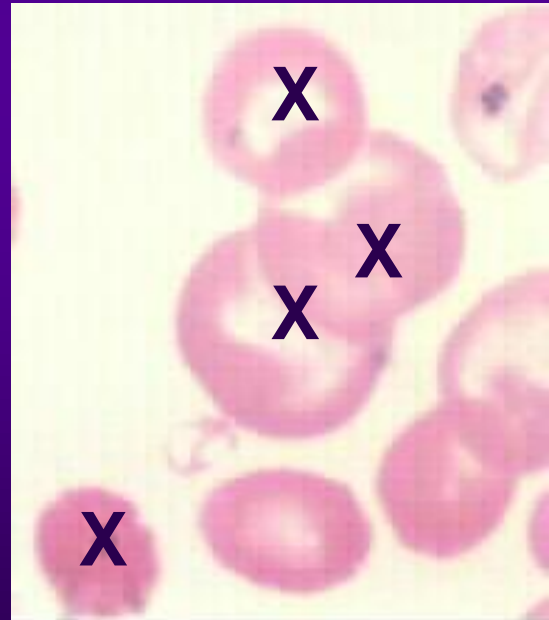
How are RBC classified as to size?

➤ **Normocytic** is the term used to indicate RBC that are **normal size** (6-8 μ in diameter) and normal shape.



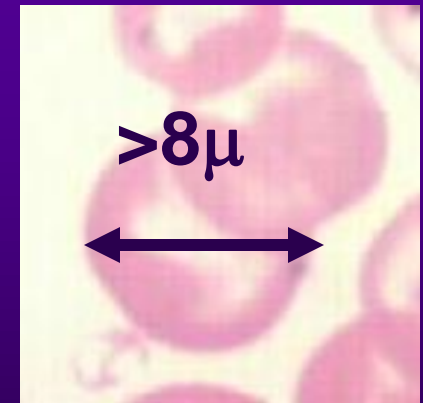
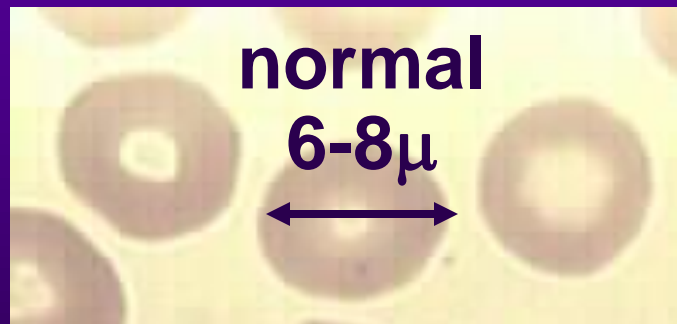
➤ **Anisocytosis** is a “generic” term used to indicate a variation in cell size, eg.,

normocytic microcytic macrocytic



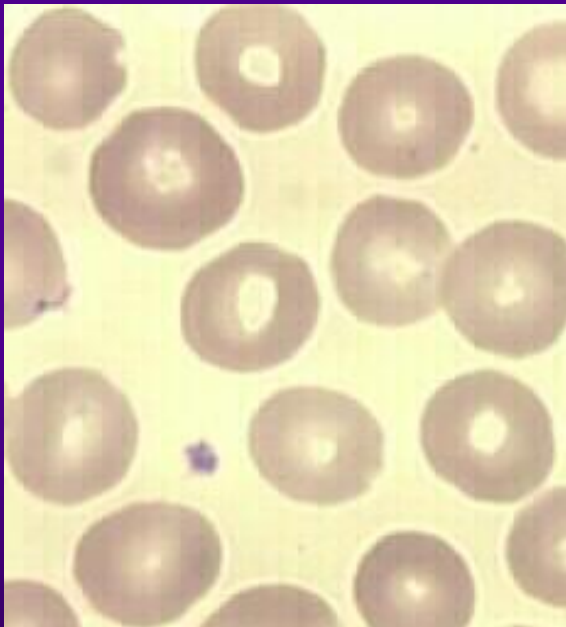
Individual red cells can be classified as...

- **Normocytic** (RBC 6-8 μ in diameter).
- **Microcytic** (RBC < 6 μ in diameter).
- **Macrocytic** (RBC > 8 μ in diameter).

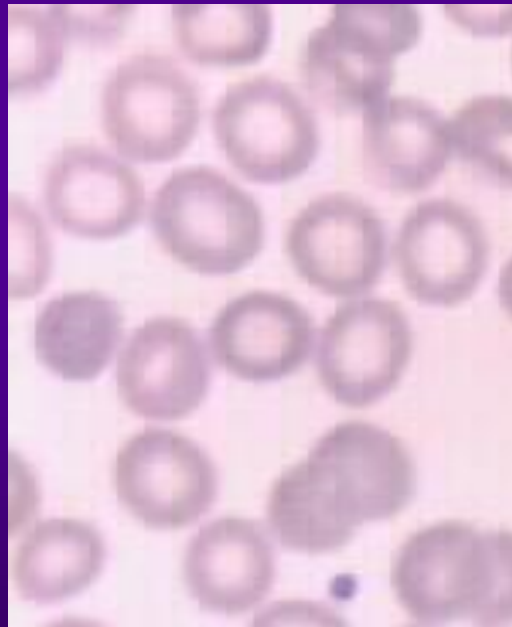


Depending upon the predominant cell size, an RBC population can be classified as...

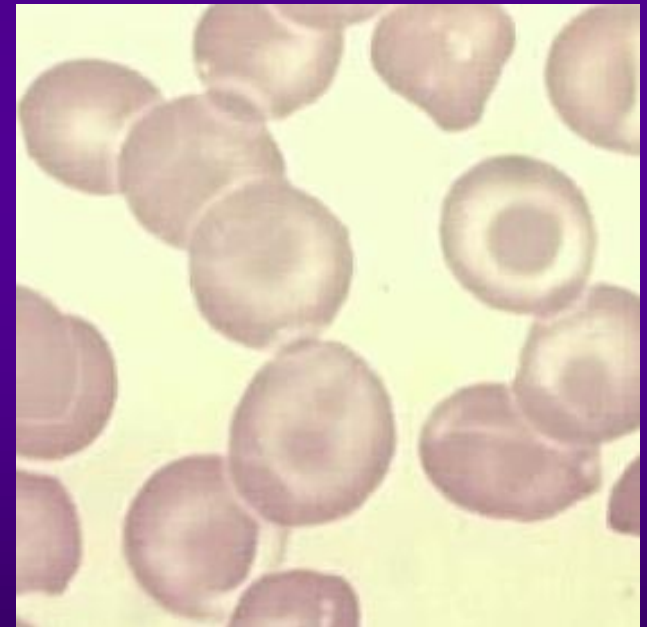
Normocytic



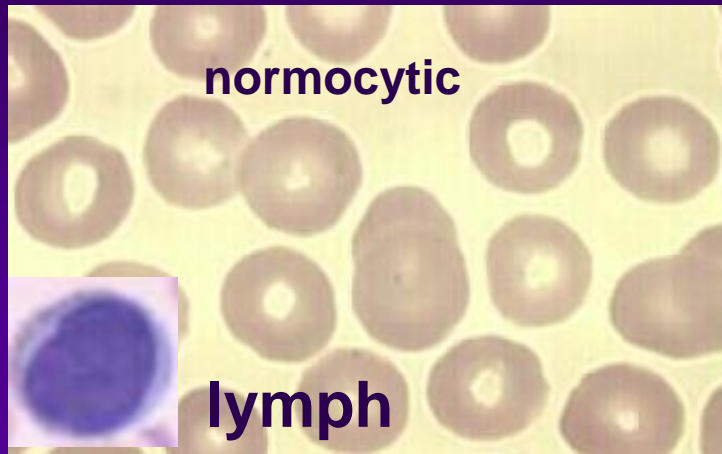
Microcytic



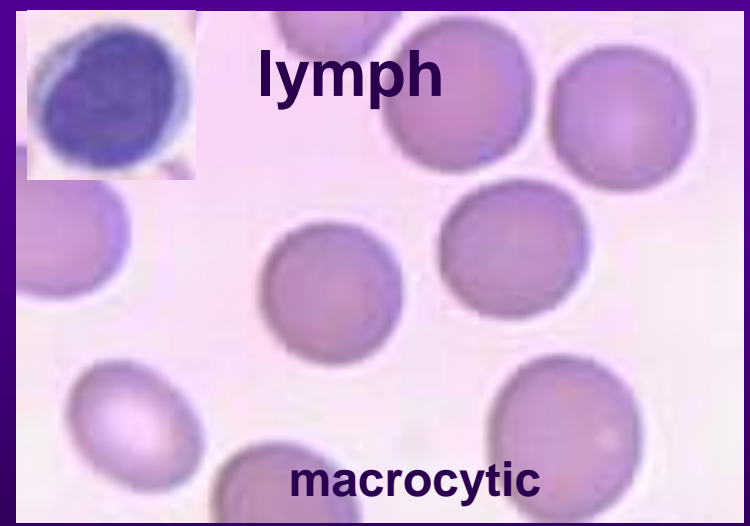
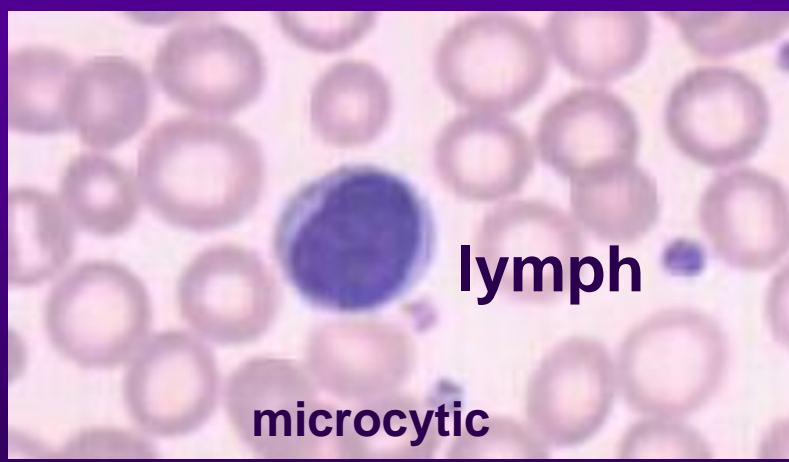
Macrocytic



Illustrative Mature Erythrocytes

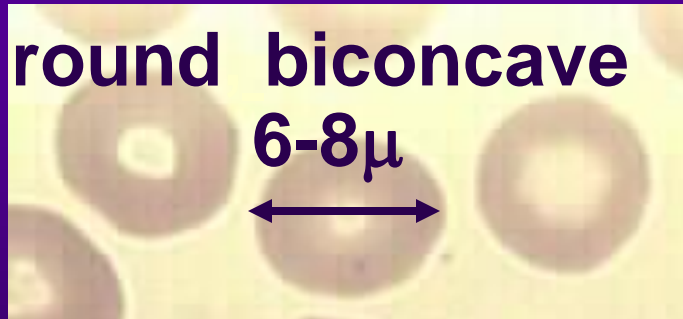


Comparison of erythrocytes with the normal small mature lymphocyte (which is about 6-10 μ in diameter) is helpful in determining whether cells are normocytic, microcytic, or macrocytic.



How are RBC classified as to shape?

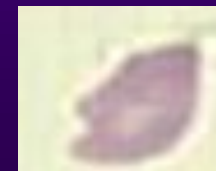
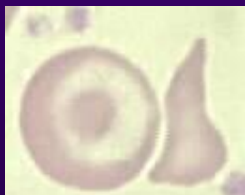
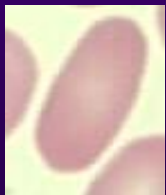
Normocytic is the term used to indicate RBC that are normal size (6-8 μ in diameter) and **normal shape** (i.e., round, biconcave).



Poikilocytosis is the “generic” term used to indicate variation in shape.



Individual red cells can have numerous abnormal shapes, eg:



What are some of the RBC shape classifications?

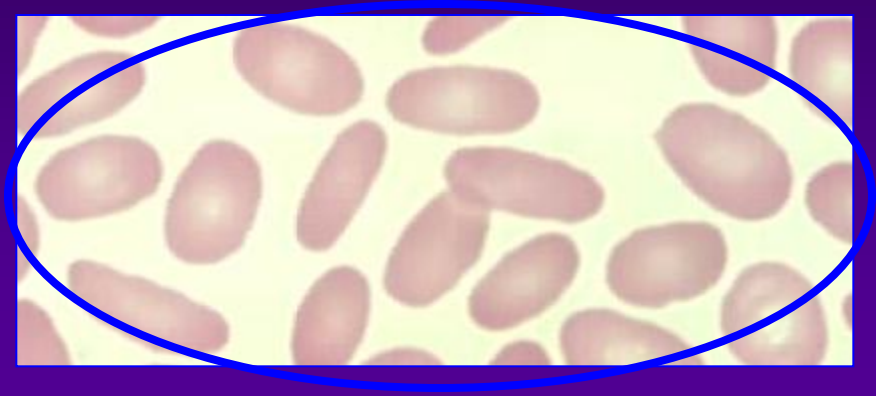
Individual red cells can be classified as:

- ovalocytes (elliptocytes)
- spherocytes
- target cells (leptocytes)
- schistocytes (RBC fragments)

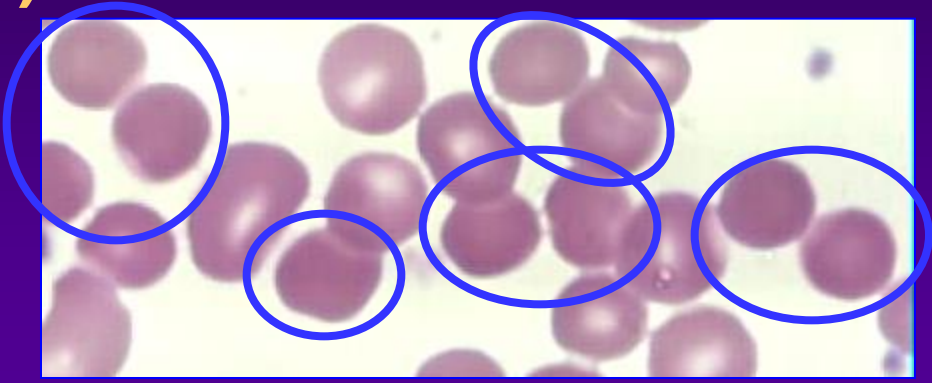


Illustrative RBC Shapes

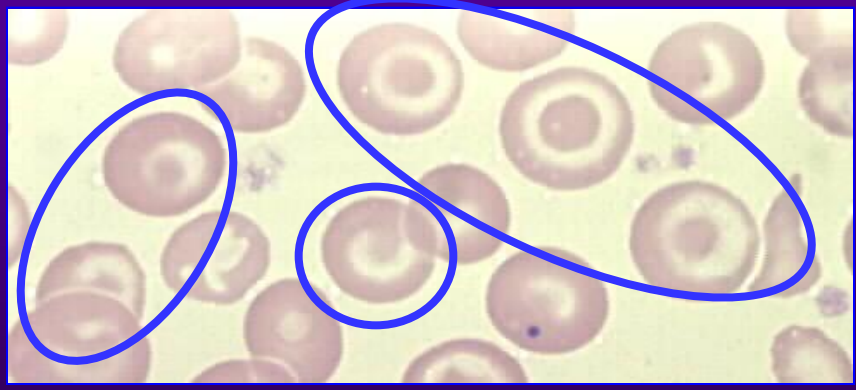
ovalocytes (elliptocytes)



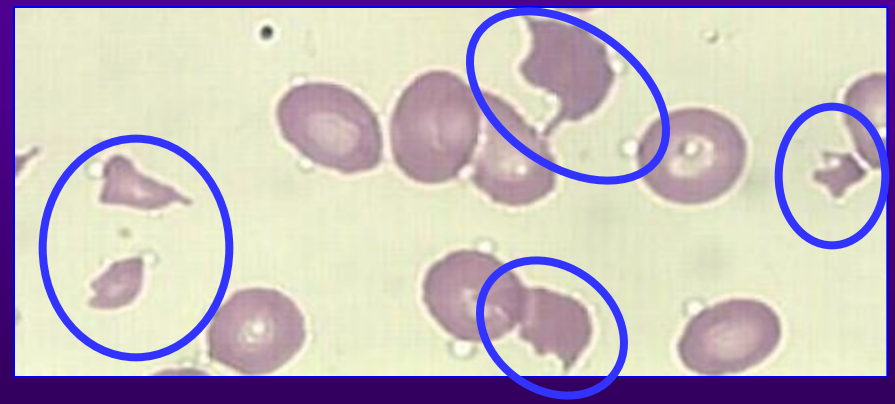
spherocytes



target cells

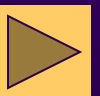
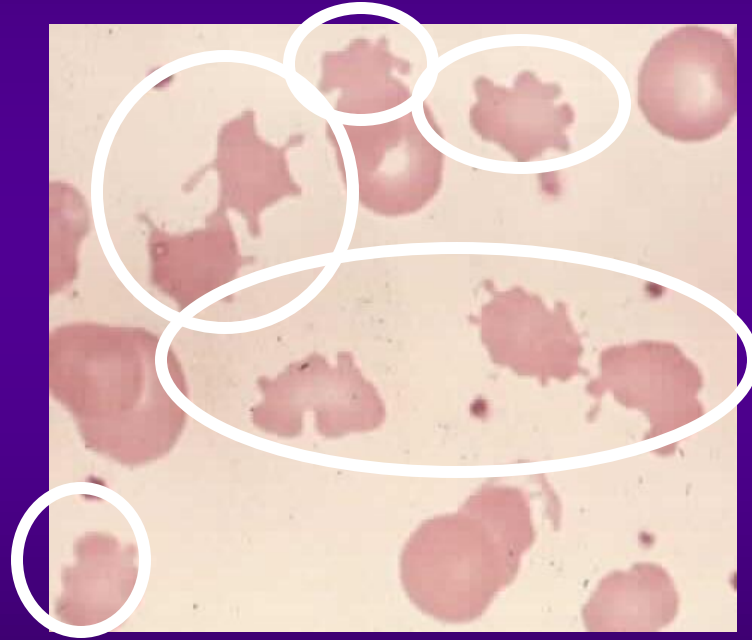
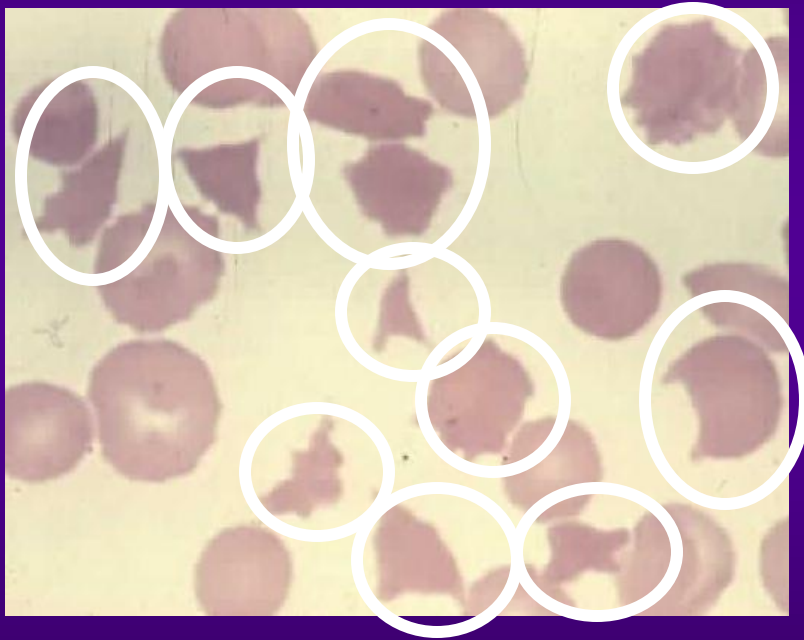


schistocytes



Schistocytes

Schistocytes are RBC fragments and may have a variety of shapes.



What **other** erythroid shapes can be seen?

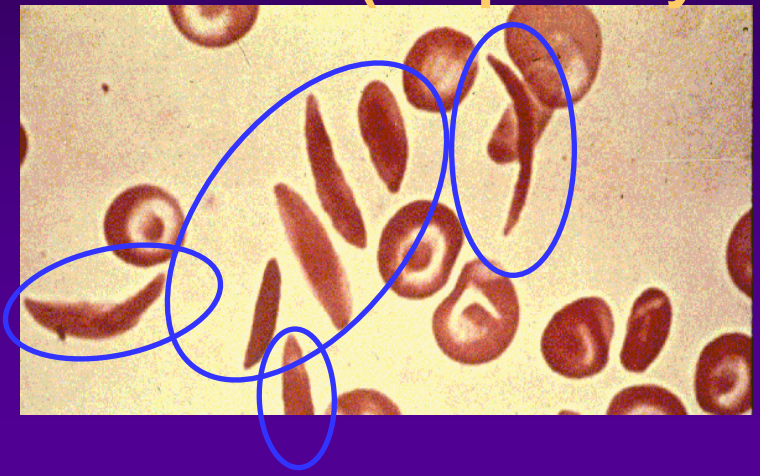
Individual red cells can also be classified as:

- sickle cells (trepanocytes or meniscocytes)
- bitocytes (keratocytes)
- echinocytes or crenated
- acanthocytes

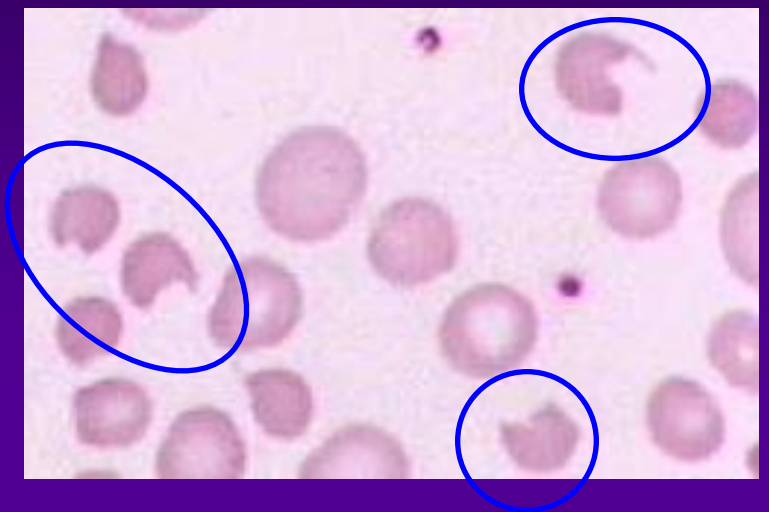


Illustrative RBC Shapes

sickle cells (drepanocytes)



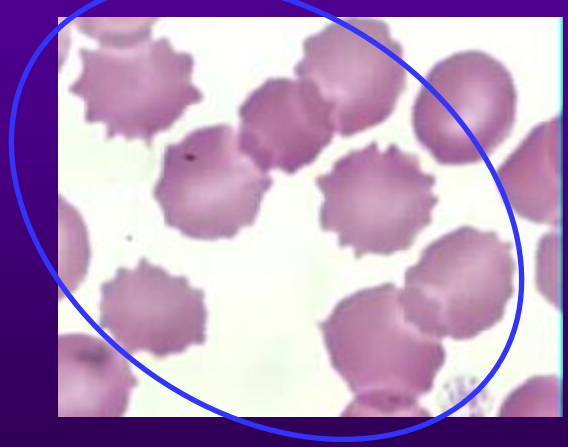
bitocytes (keratocytes)



spiculated (acanthocytes)



crenated (echinocytes)



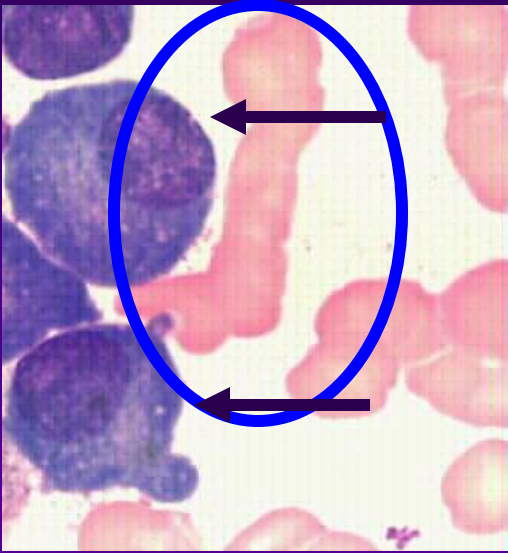
What about **groups** of RBC?

Groups or clumps of red cells can also be classified as:

- **rouleaux**
- **agglutination**



Illustrative rouleau RBC formation:

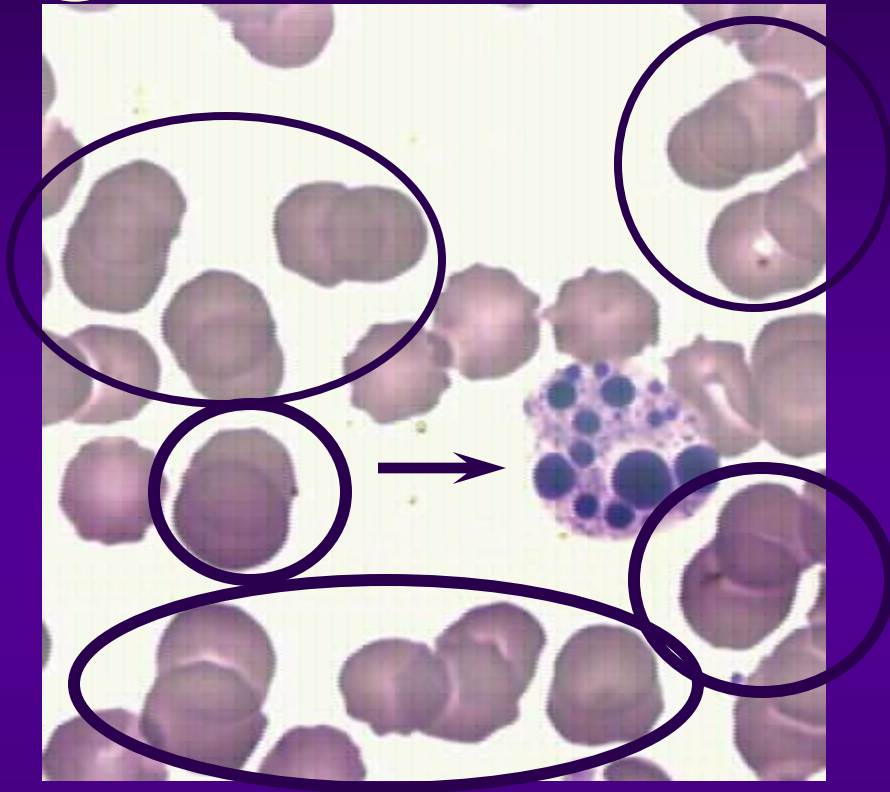


Rouleau is an aggreation of RBC that is aligned one upon the other resembling stacks of coins and is caused by elevated plasma fibrinogen or globulins.

This phenomenon causes an increased erythrocyte sedimentation rate (ESR) and interferes with the hemogram parameters. Rouleau is especially characteristic of paraproteinemia (monoclonal gammopathy), in which case **plasma cells** may also be seen.

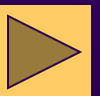


Illustrative agglutinated RBC:



Agglutination of red cells, caused by cold agglutinins, resembles rouleau but is more irregular and may appear in round clumps rather than linear rouleau.

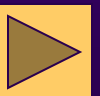
The large cell in the field is a **degenerated** neutrophil with pyknotic nuclei and nuclear fragments.



How are mature RBC classified as to hemoglobin content?

Depending upon the hemoglobin content, mature RBC may be classified as :

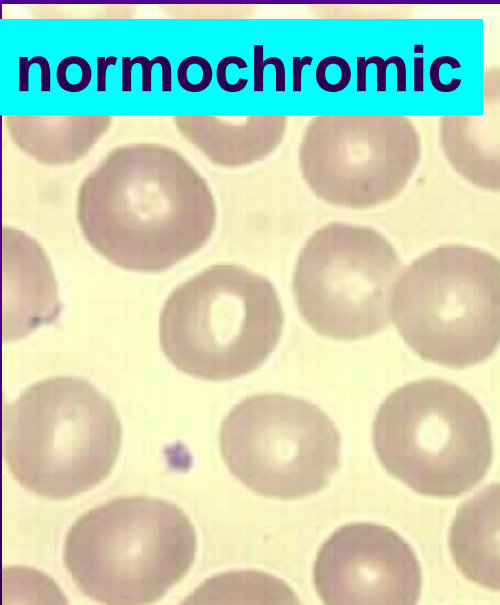
anucleated, pinkish cytoplasm with a small central pallor (about 1/3 of the cell diameter).



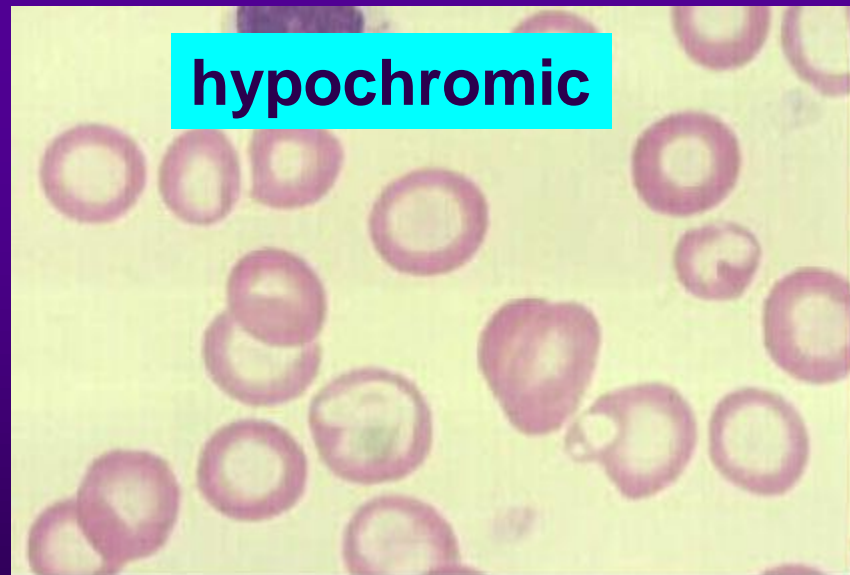
or hypochromic...

Anucleated, pinkish cytoplasm with a more pronounced central pallor (i.e., greater than 1/3 the diameter of the cell).

normochromic



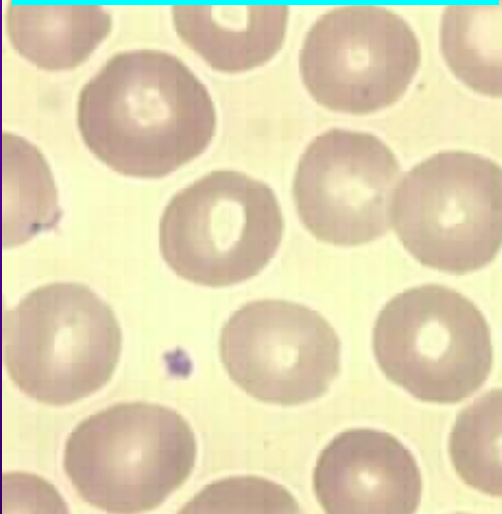
hypochromic



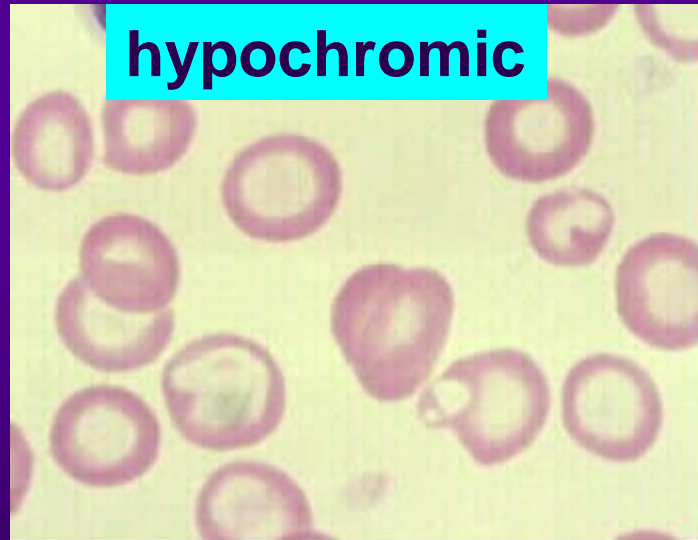
or hyperchromic...

Anucleated, pinkish cytoplasm without central pallor (generally associated with megaloblastic anemias).

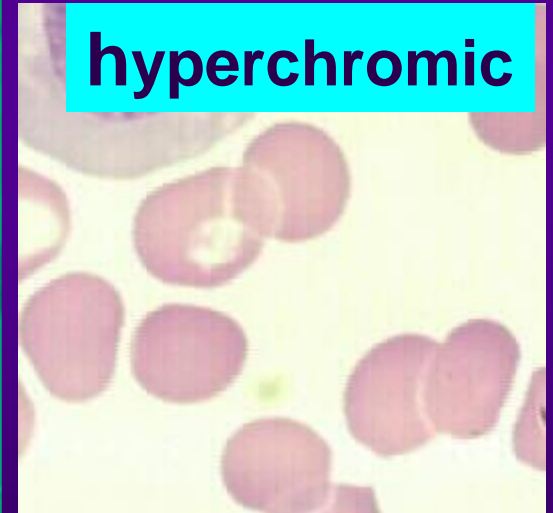
normochromic



hypochromic

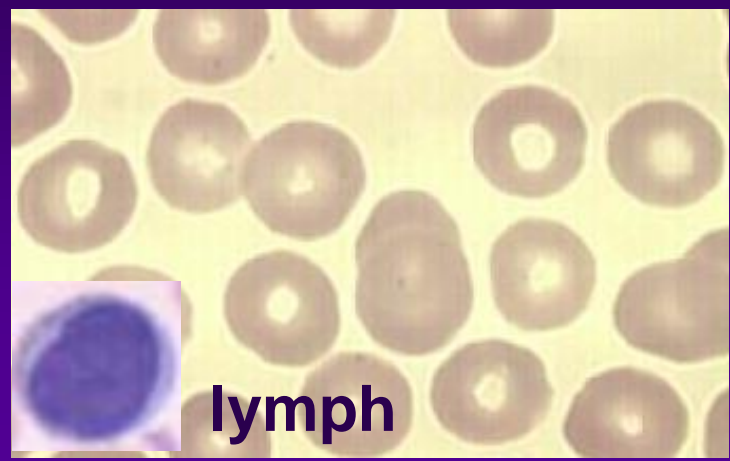


hyperchromic



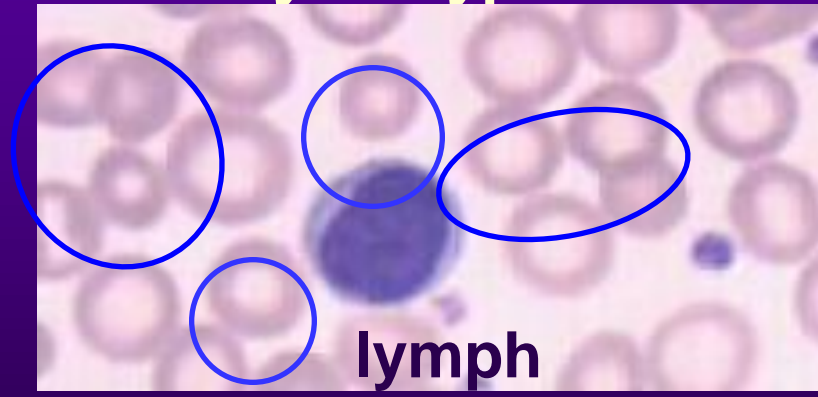
Illustrative Mature Erythrocytes

Normochromic (Normocyte)

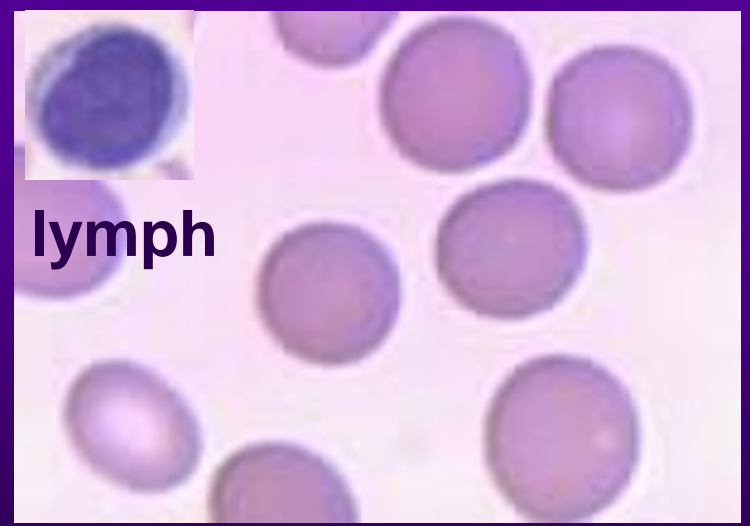


Remember, comparison of the RBC with normal small mature lymphocytes is helpful in classifying them as normocytic, microcytic, or macrocytic.

Microcytic Hypochromic



Macrocytic Hyperchromic



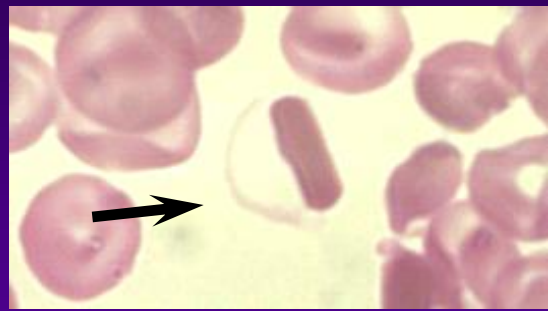
How are RBC inclusions classified?

Cellular inclusions that may be found in erythrocytes may include:

- Hemoglobin C crystals
- Basophilic stippling
- Howell-Jolly bodies
- Pappenheimer bodies
- Heinz bodies
- Cabot rings



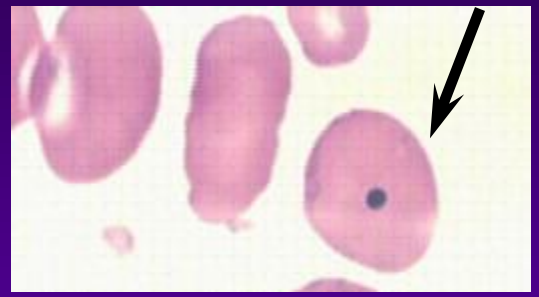
Illustrative RBC with inclusions:



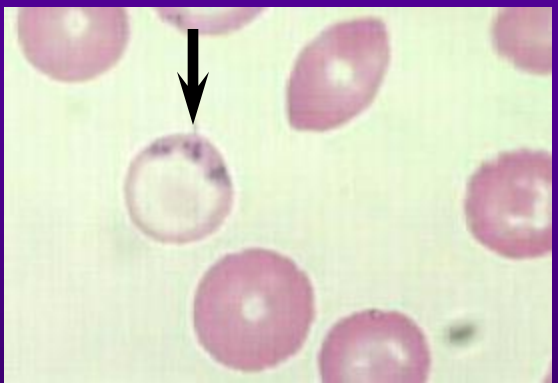
HbC crystals



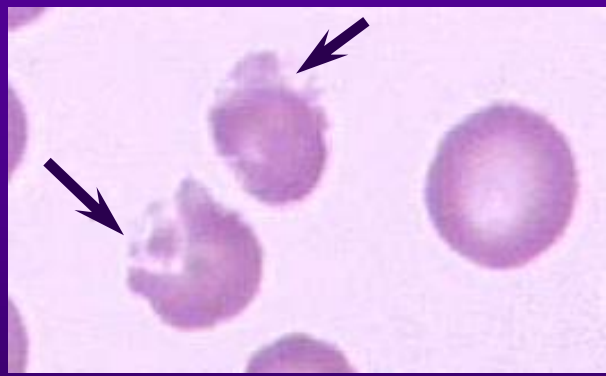
basophilic stippling



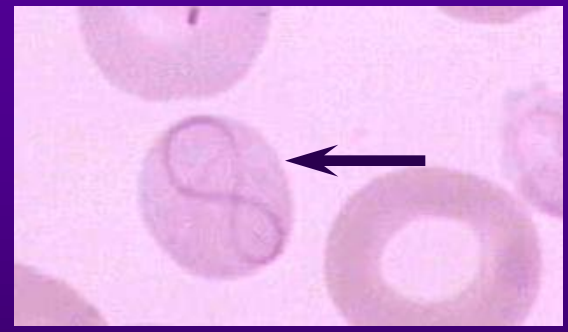
Howell-Jolly body



Pappenheimer bodies



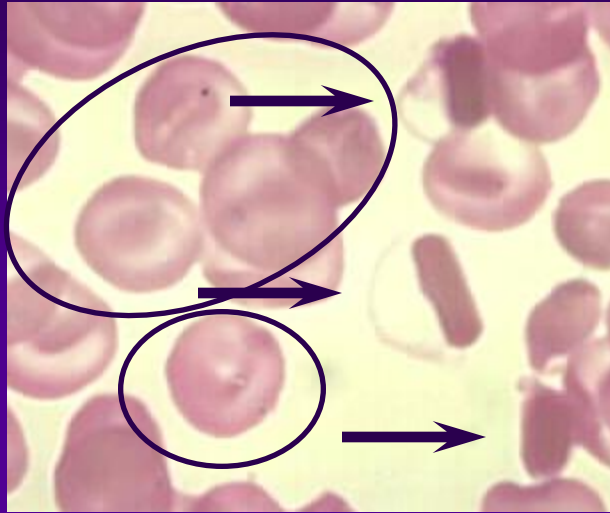
**(supravital stain)
Heinz bodies**



Cabot rings



Hemoglobin C Crystals



Target cells are characteristically seen in HbC disease and syndromes and may be the only abnormality in heterozygous HbC.

Hexagonal shaped HbC crystals may be seen in homozygous HbC disease but are not seen in heterozygous HbC trait. The crystals may be **intracellular or extracellular.**



Hemoglobin C Crystals, cont'd

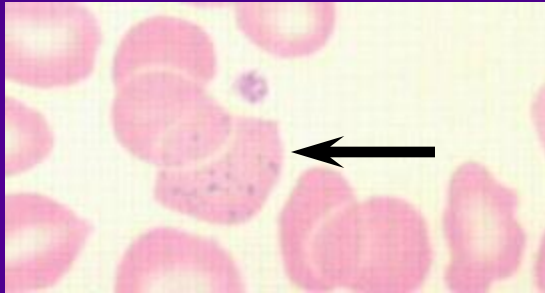


Other shaped forms of the crystals (e.g., **glove shaped**) are seen in HbSC disease.



Basophilic Stippling

Irregular basophilic granules, which may be coarse or fine, dispersed throughout an erythrocyte is called **basophilic stippling**. This finding is attributed to abnormal instability of the residual RNA in the cell.



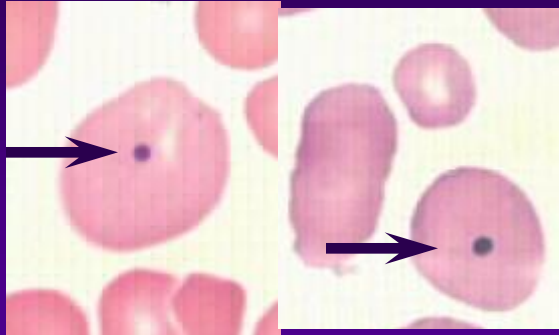
Fine stippling is commonly seen when there is increased polychromatophilia, and, therefore, with increased production of red cells.

Coarse stippling may be seen in;

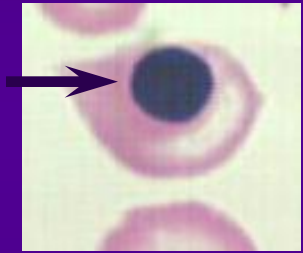
- lead poisoning or other diseases with impaired hemoglobin synthesis
- megaloblastic anemia
- other forms of severe anemia (eg, thalassemia major, sickle cell disease)



Howell-Jolly Bodies



Howell-Jolly bodies are smooth, round, intracellular remnants of nuclear chromatin (DNA) that may be found in erythrocytes.



Their color may vary with the stain but are usually the same color as the nuclei of polychromatophilic erythroblasts.

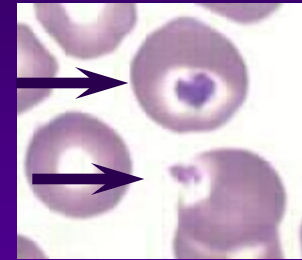
Single Howell-Jolly bodies may be seen in megaloblastic anemia, hemolytic anemia, hemoglobinopathies, thalassemia major, and after splenectomy.

Multiple Howell-Jolly bodies in a single cell is usually indicative of abnormal erythropoiesis (e.g., megaloblastic anemia).



Looks Like Howell-Jolly Bodies

Don't confuse Howell-Jolly bodies with platelets on top of a red cell.



Characteristically, platelets will appear to be surrounded by a clear “halo” where the hemoglobin has been displaced.

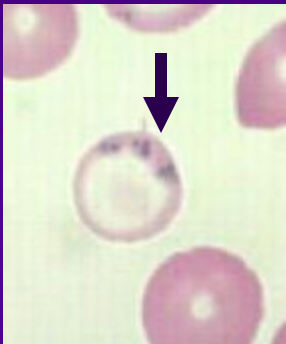


Howell-Jolly bodies usually have no halo.



Pappenheimer bodies:

Pappenheimer bodies appear as dark blue intracellular inorganic iron-containing granules when seen on Wright-Giemsa stained blood smears.



Pappenheimer bodies are few in a given red cell and are usually clustered at the edge of the cell membrane.

Wright-Giemsa stain

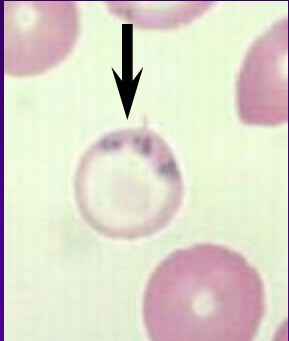
These cells are called siderocytes when observed after staining with an iron stain (e.g., Prussian blue).



Prussian Blue stain



Pappenheimer bodies, cont'd.

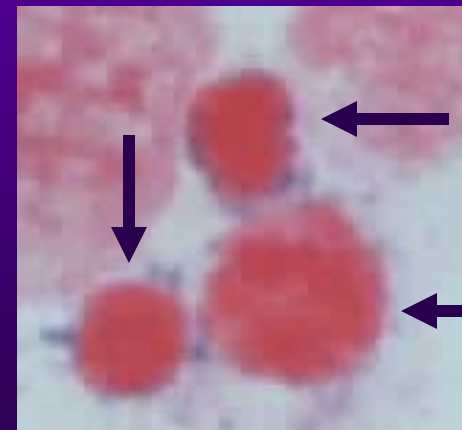


Pappenheimer bodies are associated with iron-loading disorders.

Wright-Giemsa stain

When Pappenheimer bodies are seen in peripheral blood, there may be a concomitant increase of siderocytes and sideroblasts in the bone marrow.

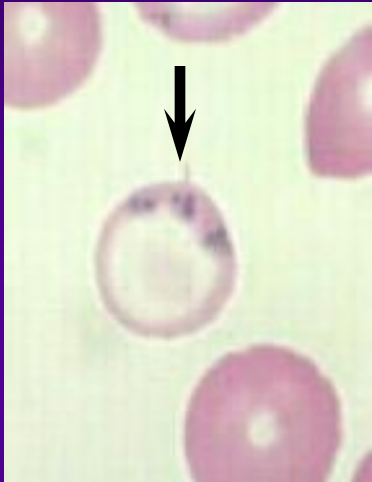
When the siderotic granules surround at least 2/3 of the circumference of the nucleus, the cell is called a “ringed sideroblast”.



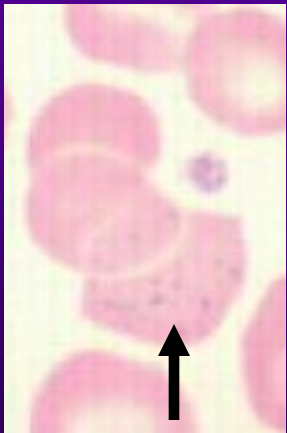
Prussian Blue stain



Don't confuse Pappenheimer bodies with basophilic stippling...



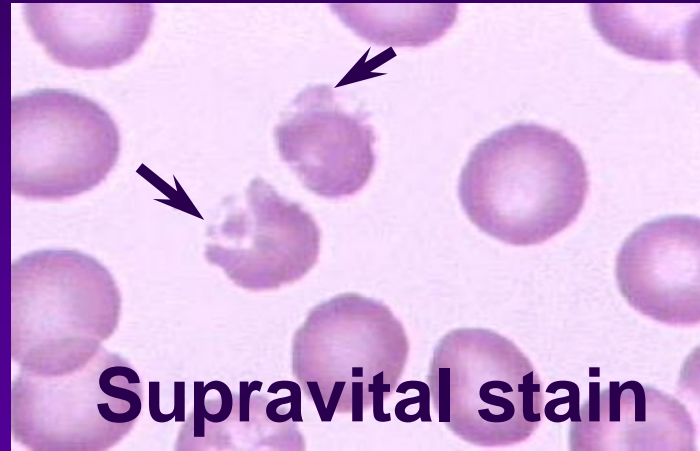
While Pappenheimer bodies usually appear as one or several small round particles clustered together (usually near the rim of the cell),



basophilic stippling particles are numerous and dispersed throughout the cell.



Heinz Bodies

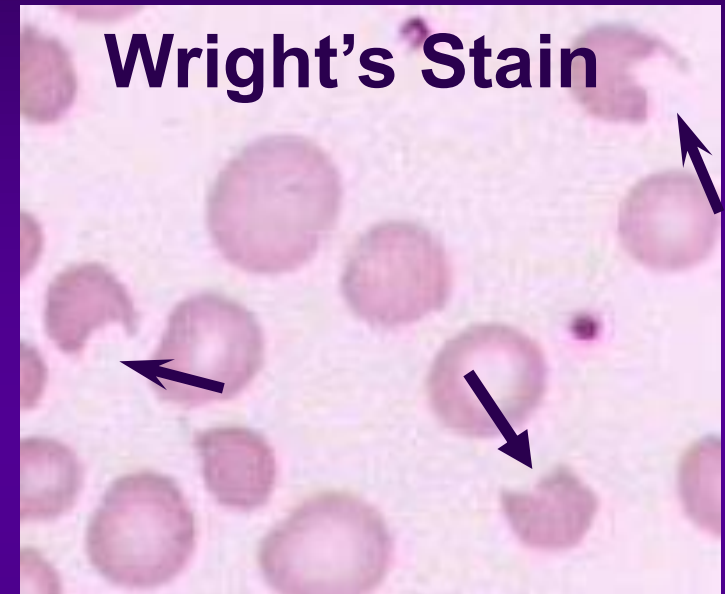


Heinz bodies are not visualized on Wright's stained blood smears but are seen only after staining with **supravital dyes**. Even with these stains, exposure to an oxidizing drug is often required before they are detected.

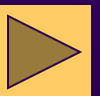


Heinz Bodies,cont'd

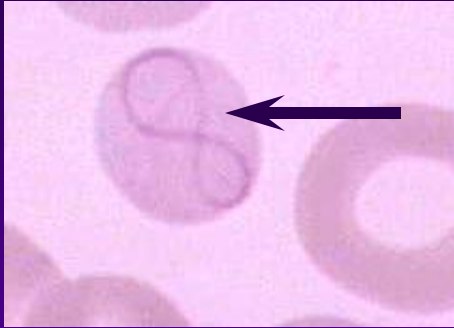
With removal of the Heinz body by the spleen, the cells observed on Wright-Giemsa stained blood smears appear to have had a bite taken out of the cell membrane and are called **keratocytes** (or “bitocytes”).



Heinz bodies are most frequently associated with G6PD and may be seen in hemolytic anemias and drugs such as phenacetin. They may also be associated with thalassemia major and hemoglobinopathies.



Cabot Rings



Cabot rings appear in erythrocytes as red or reddish purple intracellular structures. Their shape is usually in the form of a ring, figure-of-eight, or

loop with no internal structure. They are thought to be microtubules remaining from a mitotic spindle.

They are observed in erythrocytes **in rare cases** of pernicious anemia, lead poisoning, and certain other disorders of erythropoiesis. They are interpreted as evidence of abnormal erythropoiesis.

In this course, you will see them only in photos or computer images.



RBC Inclusions – Composition & Stains

Inclusions	Composition	Stain for ID
Basophilic Stippling	Unstable RNA	Wright-Giemsa
Cabot Rings	Mitotic remnant	Wright-Giemsa
Heinz Bodies	denatured hemoglobin	Supravital*
Hemoglobin C Crystals*	Hemoglobin C	Wright-Giemsa
Howell-Jolly Bodies*	DNA nuclear remnant	Wright-Giemsa
Normoblasts (NRBC)*	DNA	Wright-Giemsa
Pappenheimer Bodies	Iron particles	Wright-Giemsa
Reticulocytes	Precipitated RNA	Supravital*
Sideroblasts	Iron particles	Prussian Blue
Siderocytes	Iron particles	Prussian Blue

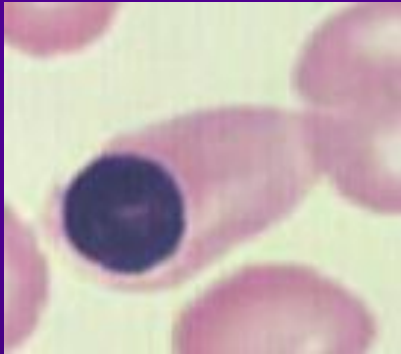
*may be observed with supravital but are identified with Wright-Giemsa

** e.g., new methylene blue, crystal violet

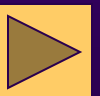


Nucleated Red Blood Cells (NRBC)

NRBC are not normally present in peripheral blood of adults. They may be seen normally in the peripheral blood of newborns and in some diseases in adults. The NRBC most commonly seen is the **orthochromatophilic erythroblast**.



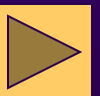
However, **less mature stages** may also be seen.



How are immature RBC classified?

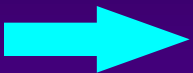
Immature RBC precursors are classified as:

- **Normocytic** - when they are of normal size.
- **Microcytic** - when they are smaller than normal.
- **Macrocytic Non-megaloblastic** - when they are larger than normal with synchronized nucleus and cytoplasm maturation (i.e., normoblastic bone marrow).
- **Megaloblastic** - when they are larger than normal (i.e., macrocytic) and have asynchronized nucleus and cytoplasm maturation (i.e., megaloblastic bone marrow).

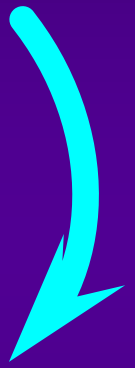


Characteristic nuclear/cytoplasmic features at various stages of RBC maturation.

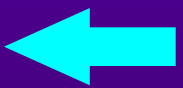
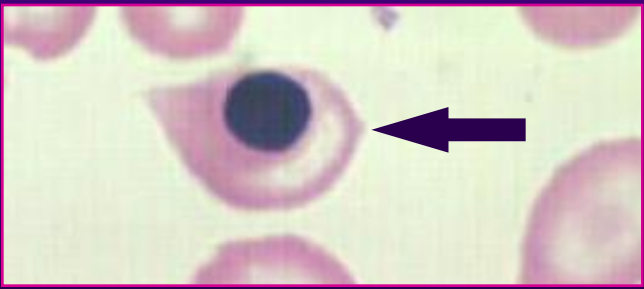
proerythroblast
(earliest form w/ nucleoli)



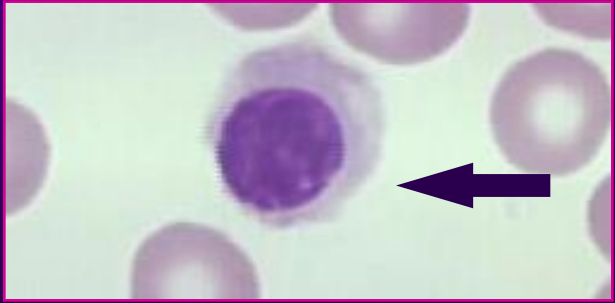
basophilic erythroblast
(ill-defined or absent nucleoli)



orthochromatophilic erythroblast
(last stage before extrusion of nucleus)



polychromatophilic erythroblast
(cytoplasmic evidence of HGB)



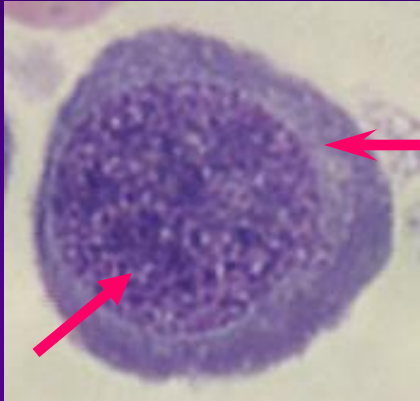
Characteristic nuclear/cytoplasmic features of megaloblastic RBC maturation.

The megaloblastic precursors are much larger than normal with asynchrony between the nucleus and cytoplasm maturation. The cytoplasm develops at the normal rate while the **nucleus lags behind**.

Therefore, it is difficult to assign a specific stage of development for an individual cell. For example, the nuclear features may be consistent with a basophilic megaloblast while the cytoplasm may be more mature and be consistent with a later stage.



Examples of nuclear/cytoplasmic asynchrony in megaloblastic precursors:



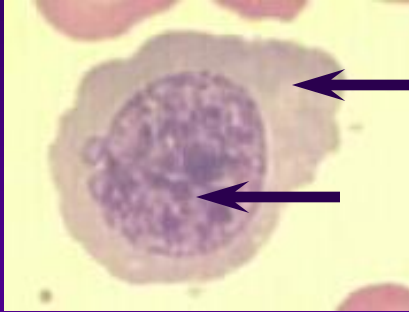
The very large early megaloblastic precursor has a **nucleus** consistent with a pronormoblast, but the **cytoplasm** is consistent with the more mature basophilic erythroblast with visible evidence of hemoglobin (i.e., pink tinges).



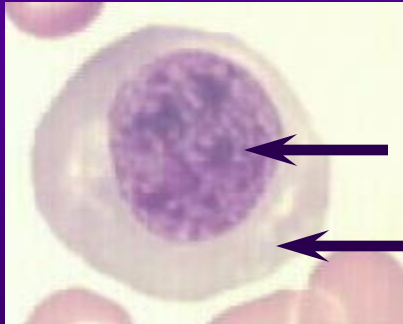
The **nucleus** of this megaloblast is consistent with a basophilic erythroblast but the **cytoplasm** is more consistent with a polychromatophilic erythroblast with varying mixtures of red and blood stain.



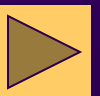
Other examples of megaloblastic precursors:



This **nucleus** is consistent with the thickened and irregularly coarsened chromatin of the polychromatophilic erythroblast ... while the **cytoplasm** is predominantly red with minimal amounts of residual blue that is more consistent with the orthochromatic erythroblast.



Another megaloblast in which the **nucleus** looks consistent with a polychromatophilic erythroblast while the **cytoplasm** is already as mature looking as the anucleated polychromatophilic erythrocyte.



More mature megaloblastic cells:

Polychromatophilic erythrocytes and mature RBC are **larger than normal** (i.e., macrocytic) and typically seen are:



macrocytes without central pallor



macroovalocytes



macro tear-drops



Abnormal Erythrocytes Terminology (Definitions)



Abnormal RBC are differentiated and identified as part of the “diff”.

Changes in size, shape, hemoglobin content, and/or appearance of cellular inclusions may occur as a result of a disease process. Such changes are noted as part of the “diff”.

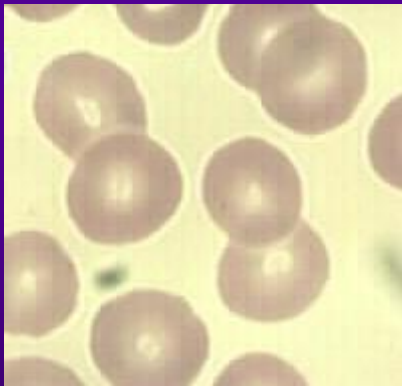
What **terminology** is used to indicate the presence of abnormal red cells?



Definitions:

Hypochromic

erythrocytes that demonstrate a central pale area that becomes larger and paler as the hemoglobin content diminishes (less than 1/3 of cell diameter).



normochromic



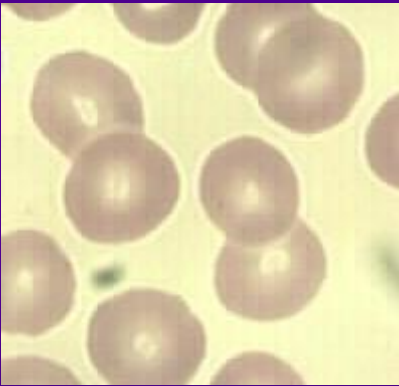
hypochromic



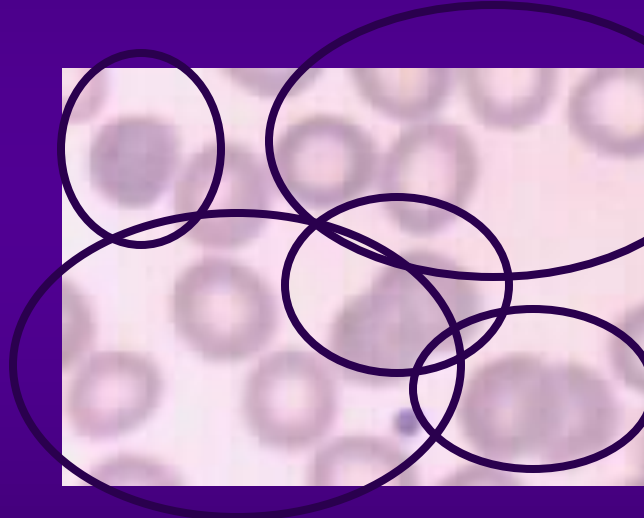
Definitions:

Anisochromic or dimorphic

indicates the presence of both normochromic and hypochromic cells in the same blood film.



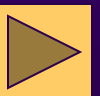
normochromic



anisochromic
or dimorphic

normochromic

hypochromic



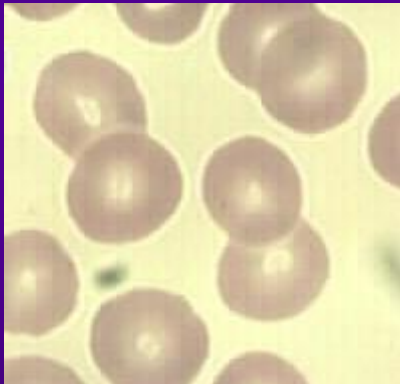
Definitions:

Polychromasia and polychromatophilia are interchangeable terms used to indicate the increased presence of non-nucleated immature erythrocytes (polychromatophilic erythrocytes) that contain residual RNA which gives a blue-gray tint to the red cells. These cells, which remain after ejection of the nucleus from the orthochromatic erythroblast, are slightly larger than mature erythrocytes. After exposure to a supravital stain, the cytoplasmic organelles of these cells clump into an easily recognized blue-staining reticulum and the cell is called a **reticulocyte**.

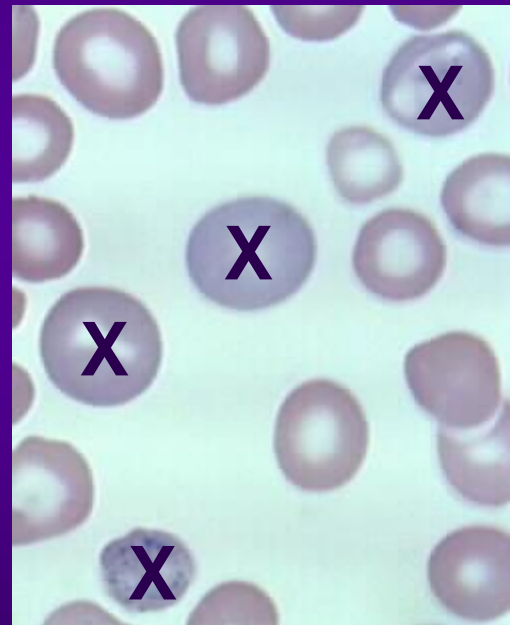
view cells

continued:

Polychromasia (polychromatophilia)



normochromic



**polychromatophilic
erythrocytes**

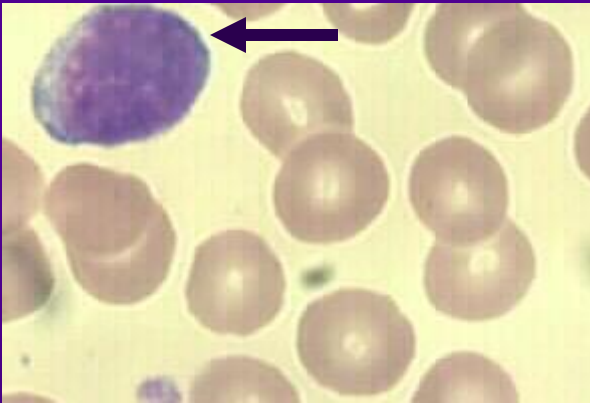


Definitions:

Microcytes

are abnormally small erythrocytes (i.e., less than $6\ \mu$ in diameter).

Compare with lymphocyte nuclei ($\approx 8-10\ \mu$ in diameter).



normocytic

RBC $\approx 6-8\ \mu$ diameter



microcytic
(predominant)



Definitions:

Macrocytes

are abnormally large erythrocytes (i.e., greater than $8\ \mu$ in diameter).

lymphocyte (with nuclei about $8-10\ \mu$ in diameter)



normocytic

RBC β $6-8\ \mu$ diameter



macrocytic



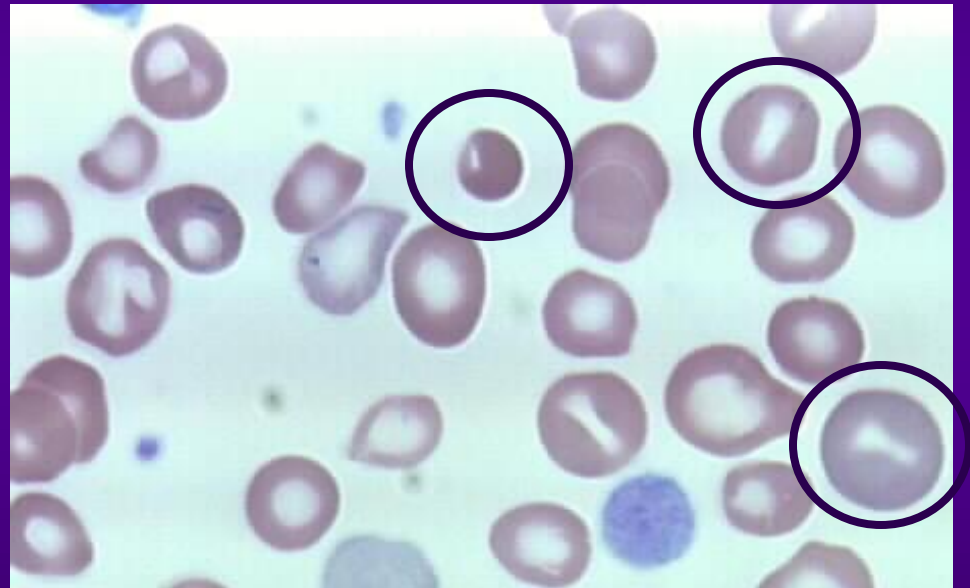
Definitions:

Anisocytosis is a “generic” term used to indicate an abnormal variation in size of erythrocytes.



normocytic

RBC 6-8 μ diameter

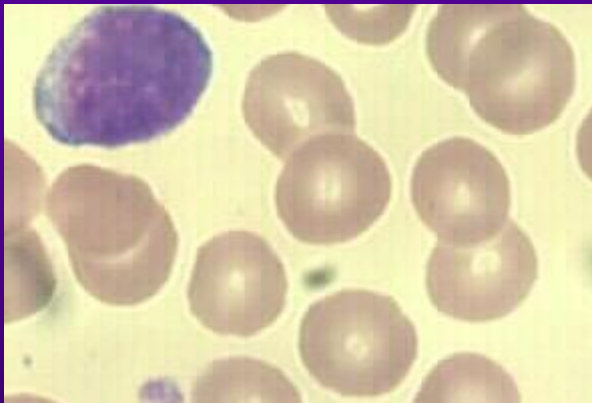


**normocytic
microcytic
macrocytic**



Definitions:

Poikilocytosis is a “generic” term used to indicate variation in shape of erythrocytes (e.g., oval, pear-shaped, teardrop-shaped, saddle-shaped, helmet-shaped, sickle-shaped, and irregularly shaped), eg:

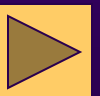


normocytic

RBC round biconcave



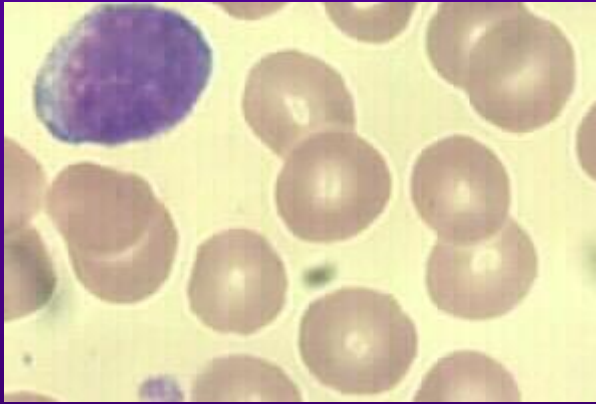
RBC variable shapes



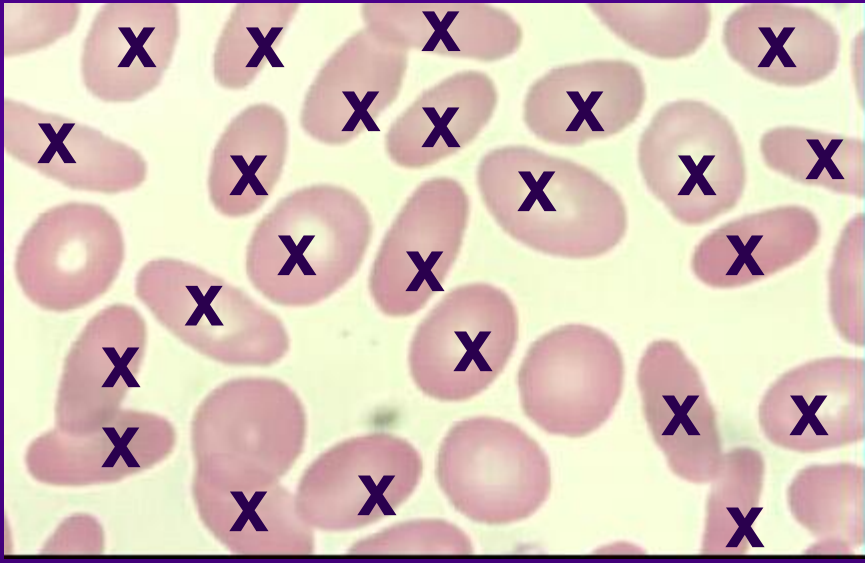
Definitions:

Elliptocytes and Ovalocytes

are interchangeable terms used to indicate ovalshaped erythrocytes.



normocytic
RBC round biconcave



RBC predominantly
ovalocytes



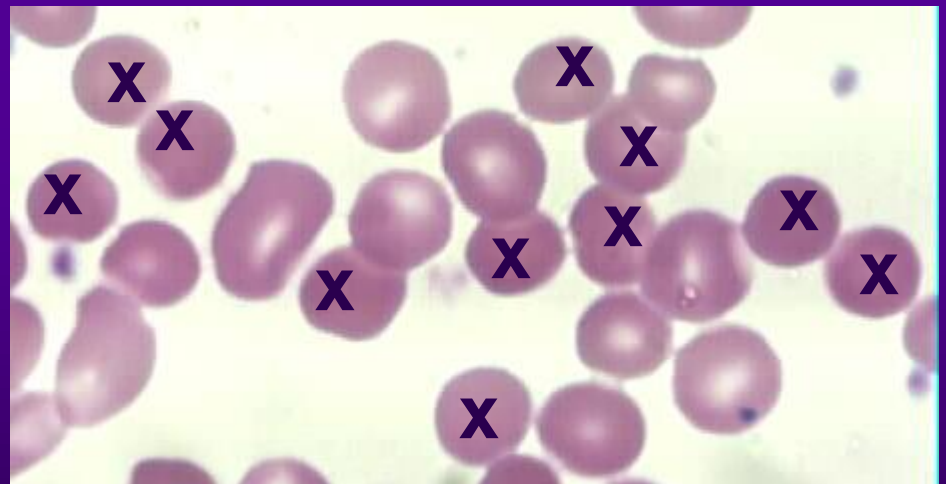
Definitions:

Spherocytes are nearly spherical erythrocytes which usually have a diameter smaller than normal. They lack the central pale area due to their **spherical** shape.

round,
biconcave
RBC



normocytic



spherocytes



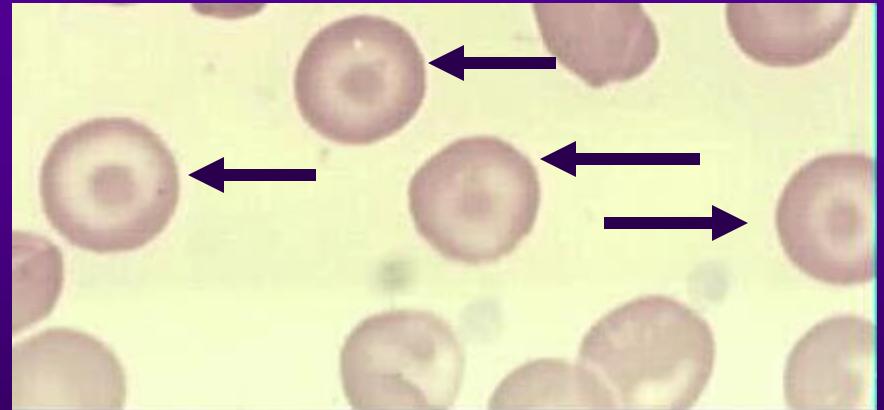
Definitions:

Target cells (leptocytes) are erythrocytes that are thinner than normal which show a peripheral rim of hemoglobin with a dark central hemoglobin-containing area. A pale unstained ring containing less hemoglobin separates the central and peripheral zones and gives the cell a **target** appearance.

round,
biconcave
RBC



normocytic



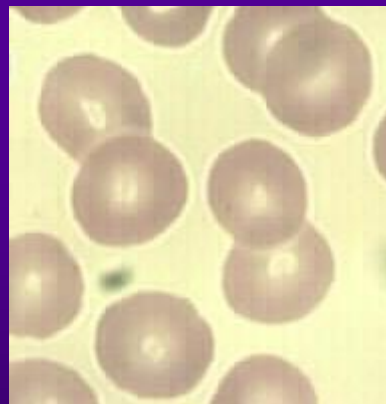
target cells



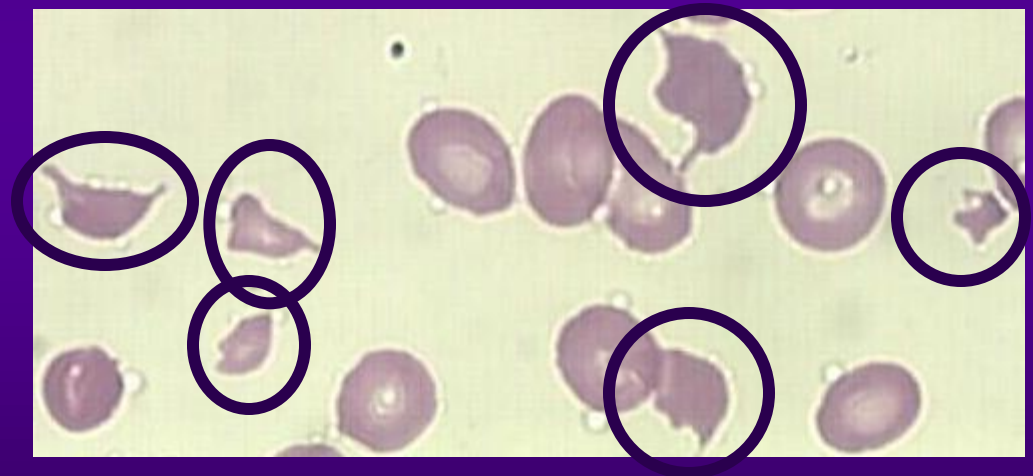
Definitions:

Schistocytes are fragmented red cell segments that are the result of some hemolytic process. The segments can be a **variety of shapes** but helmet cells and triangularly-shaped cells are particularly characteristic.

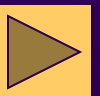
round,
biconcave
RBC



normocytic

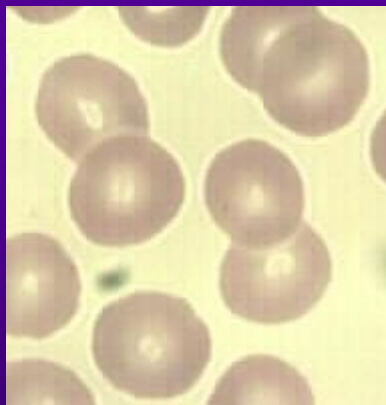


schistocytes

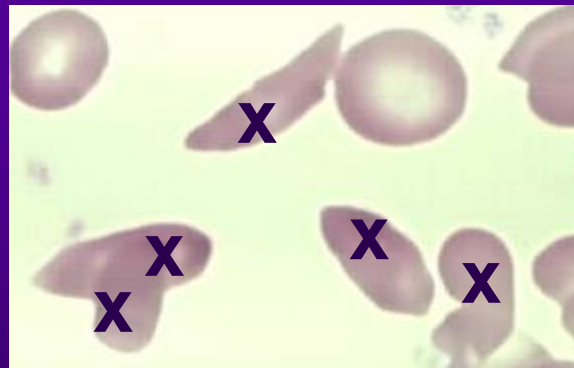


Definitions:

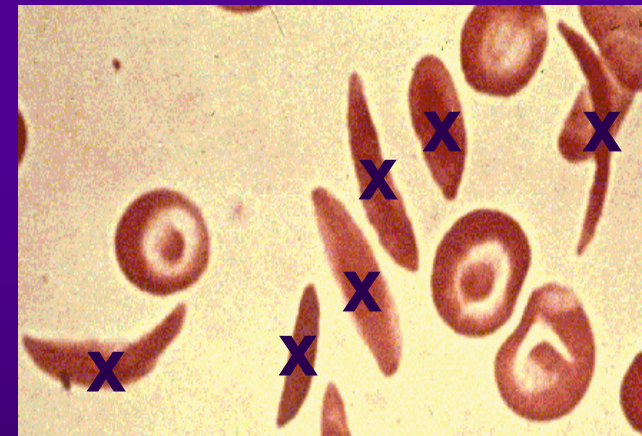
Sickle cells (drepanocytes, meniscocytes) are interchangeable terms used to indicate **sickle-like forms** of erythrocytes (crescent-shaped, irregular spines, filaments, holly-leaf appearance) noted when RBC containing HbS are subjected to reduction in oxygen tension or pH.



normocytic:
round, biconcave
RBC



sickle cells



Definitions:

Keratocytes or “Bitocytes” interchangeable terms used to indicate irregularly contracted erythrocytes which stain densely and have contraction of hemoglobin from a part of the cell membrane, thereby giving the appearance that a “bite” has been taken out of the cell. These cells are thought to be cells from which Heinz bodies have been removed by the spleen.

normocytic
RBC, round,
biconcave

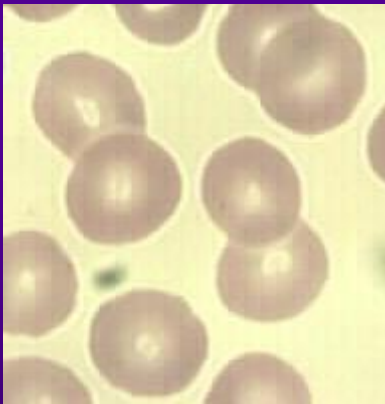


keratocytes



Definitions:

Acanthocytes are irregularly shaped red cells with spiny or thorny **projections** and dark centers which may be found in severe liver disease, infantile pyknocytosis (with underlying hemolytic process), abetalipoproteinemia, or anorexia nervosa.



normocytic
RBC round
biconcave



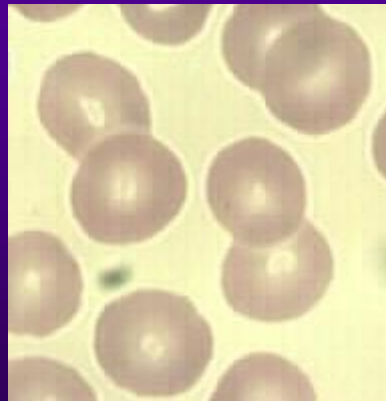
acanthocyte



Definitions:

Crenated red blood cells are uniformly shrunken red cells with **uniform irregular, wrinkled cell membranes**. Their presence is frequently an artifact of storage and all red cells in the field are usually affected. (By contrast, ecinocytes are intermixed with normal red cells.)

normocytic
RBC round
biconcave

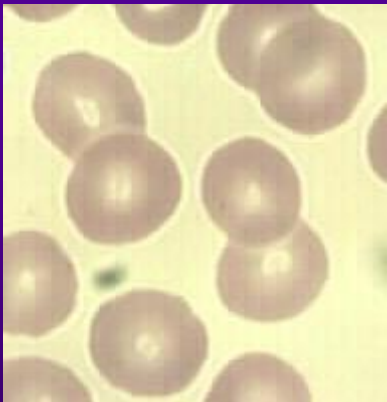


crenated RBC



Definitions:

Echinocytes are irregularly shaped red cells with **spiny projections and preserved central pallor**. While their presence may be an artifactual phenomenon, they may be seen in liver and renal disease, hyperlipidemia, and red blood cell enzymopathies.



**normocytic
RBC round
biconcave**



echinocyte



Definitions:

Rouleaux formation describes an aggregation of erythrocytes that are aligned one upon the other, resembling **stacks of coins**, caused by elevated plasma fibrinogen or globulins. This phenomenon causes an increased erythrocyte sedimentation rate. This finding is especially characteristic of paraproteinemia (monoclonal gammopathy).

normal



rouleau

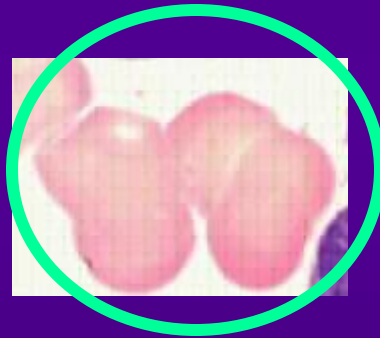


Definitions:

Agglutination of red cells is caused by agglutinins and resembles rouleaux but is more **irregular with round clumps** rather than linear rouleaux.



normal

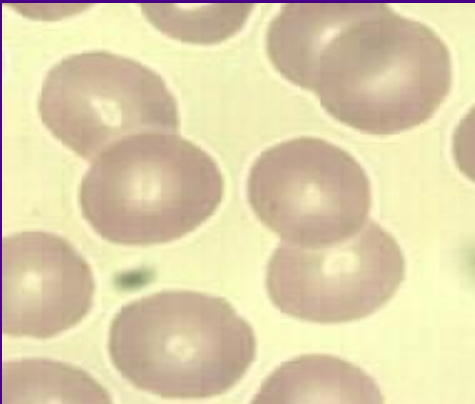


agglutination
of red cells



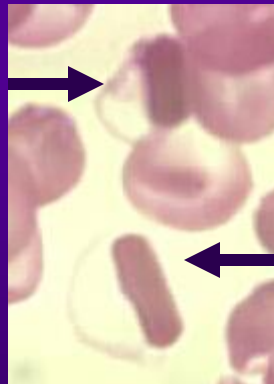
Definitions:

Hemoglobin C crystals are **hexagonal crystals** that may be found in individuals with HbC syndromes. The crystals may be intracellular or extracellular.



Normocytic RBC
(round,
biconcave,
without
inclusions)

**intracellular
HbC crystals**

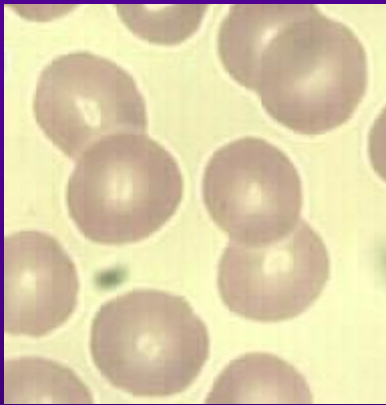


**extracellular
HbC crystal**



Definitions:

Basophilic stippling is the term used to indicate the presence of irregular basophilic granules in the cytoplasm of erythrocytes. The granules are composed of unstable RNA and may be **fine or coarse**.

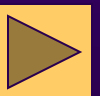


normocytic
RBC round
biconcave

basophilic
stippling (fine)

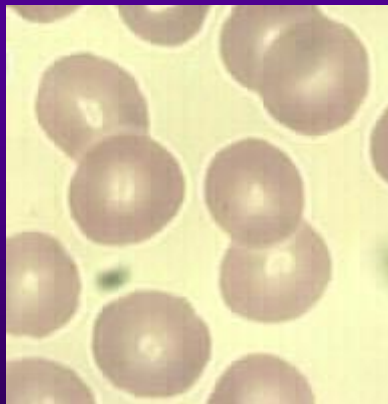


basophilic
stippling (coarse)



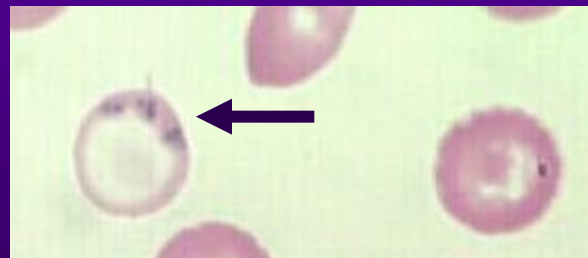
Definitions:

Pappenheimer bodies are intracellular inorganic **iron-containing granules** that may be observed on Wright's stained peripheral blood smears in iron-loading disorders. When the inclusion bodies are demonstrated by stains for iron (e.g., Prussian Blue), the cells are called siderocytes.



normocytic

Pappenheimer
bodies



(Wright stain)

siderocytes

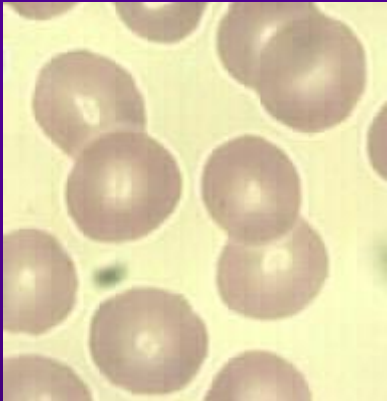


Prussian Blue stain
(Prussian Blue stain)



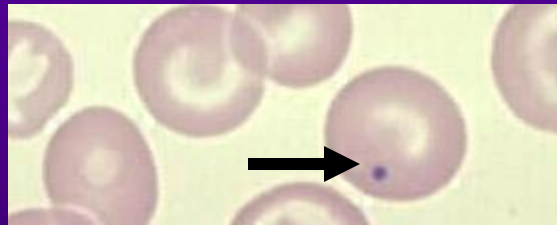
Definitions:

Howell-Jolly bodies are intracellular particles which are smooth, round remnants of **nuclear chromatin (DNA)**. Usually, only one per cell is seen but, occasionally, there may be more than one.



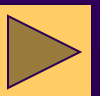
normocytic

Howell-Jolly
body (single)



Howell-Jolly
body (multiple)

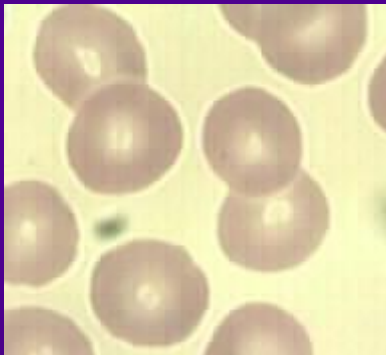
image
pending



Definitions:

Nucleated red blood cells (NRBC)

are precursors of the non-nucleated mature red cells, usually **orthochromatic erythroblasts** when noted in peripheral blood in disease states but **earlier forms** may also be seen, eg:



mature RBC



orthochromatic
erythroblast



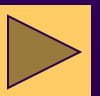
polychromatophilic
erythroblast



proerythroblast

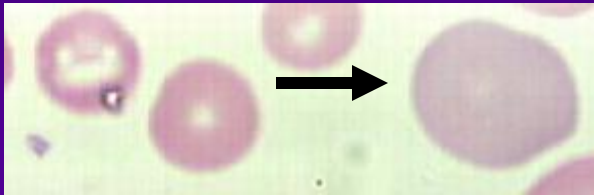


basophilic
erythroblast



Definitions:

Reticulocytes are anucleated slightly immature erythrocytes, identified as polychromatophilic erythrocytes on **Wright stained** smears.



polychromatophilic erythrocyte
(Wright's stain)

The cells are identified as reticulocytes only after exposure to a supravital stain which causes the cytoplasmic organelles of the cells to clump into an easily recognized **blue-staining reticulum**.



reticulocyte
(supravital stain)

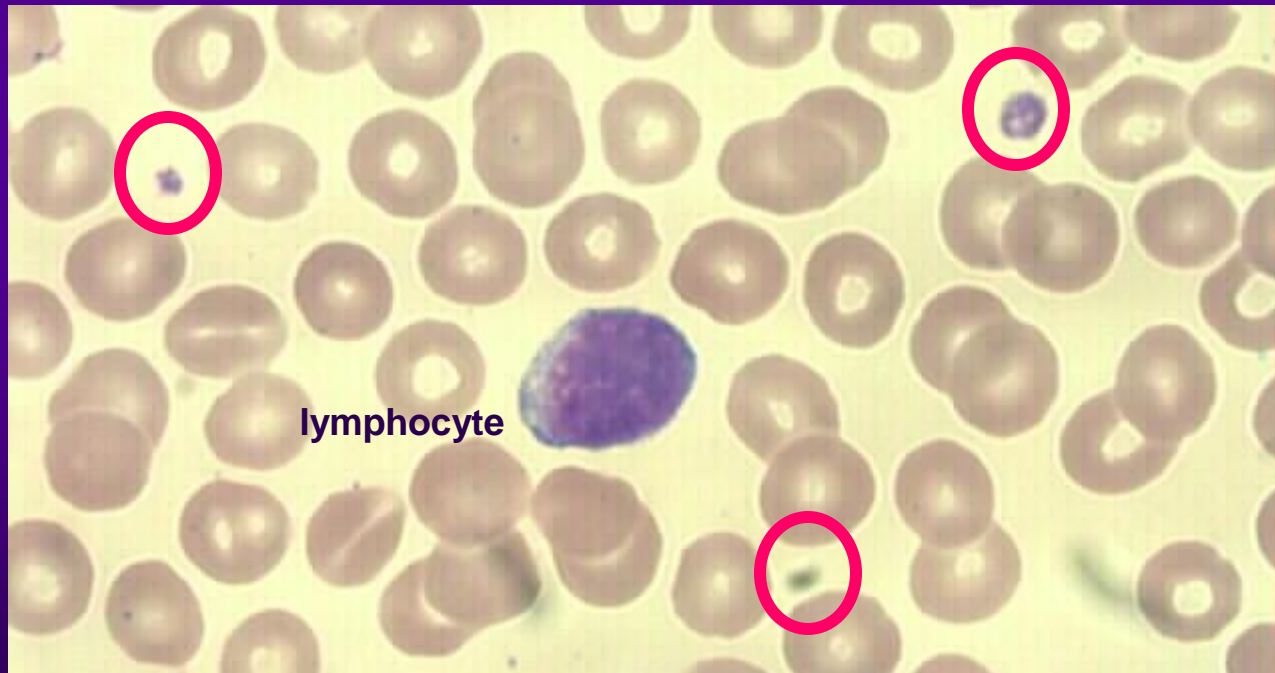


Platelets



Platelets

Normally, **platelets** are round or oval, 2 - 4 μ diameter, contain small fine granules that usually fill the cytoplasm, and are separated from one another.



Estimated Platelet Count

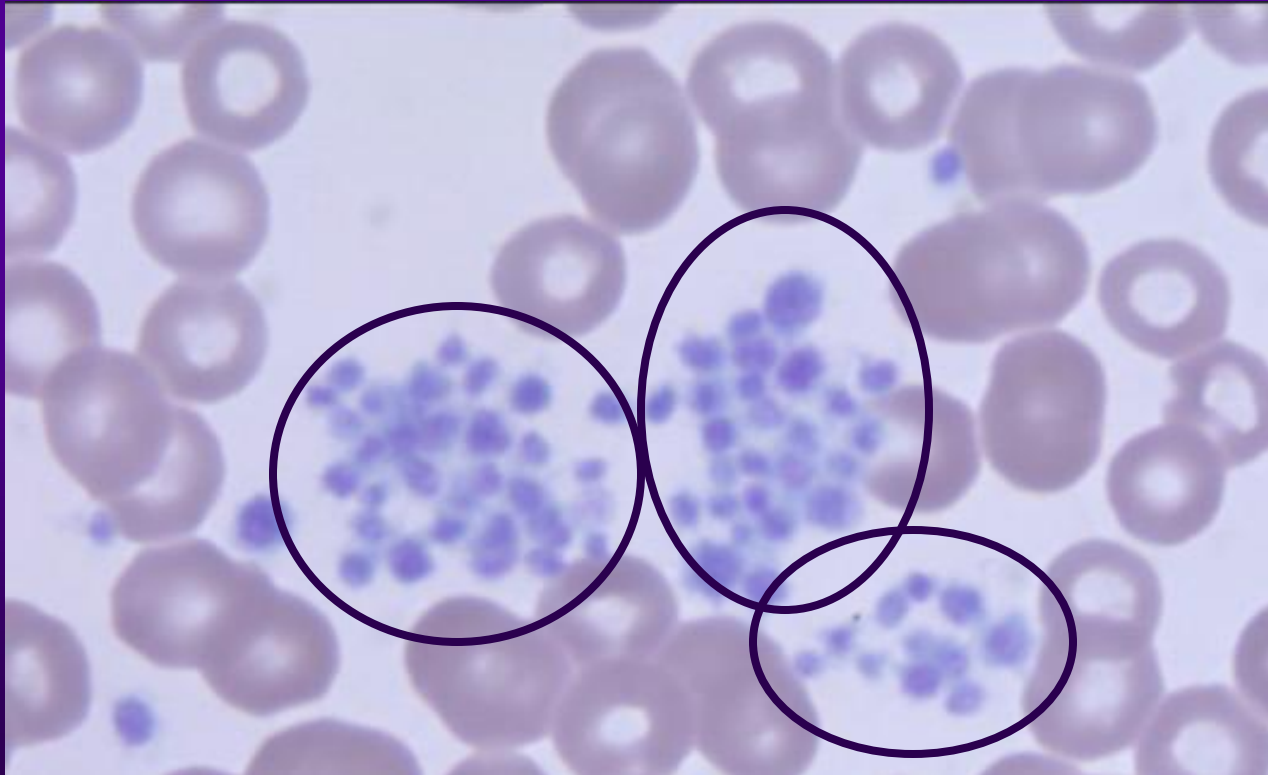
An estimated platelet count can be made on a peripheral blood smear. If the platelet count is normal, an average of about one platelet per 10 to 30 red blood cells. Using the oil immersion lens at 1000x magnification, that is about 5 to 25 platelets per field.

In Clinical Pathology 201, < 5 platelets/oil immersion field will be considered decreased and > 25 platelets/oil immersion field will be considered increased.



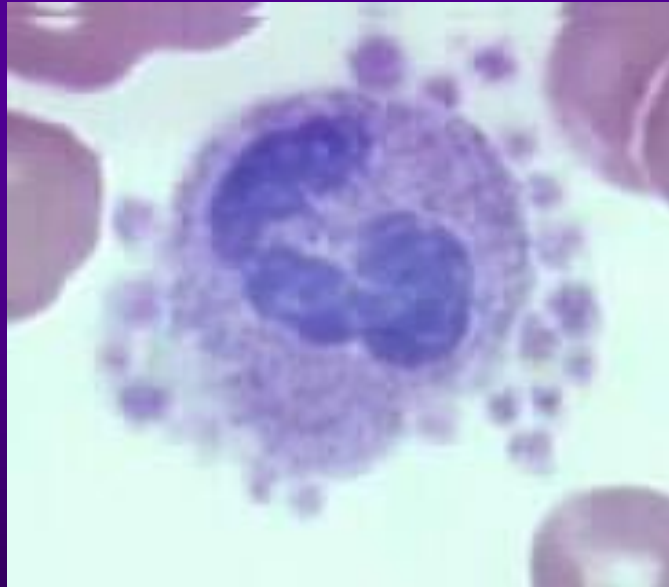
Platelets

Platelet clumps may be found on blood smears that have been improperly prepared. They may also be seen in clotting disorders. Platelet estimates cannot be made from blood smears with platelet clumps.



Platelets

Occasionally, **platelet satellites** may also be seen. Platelets adhere to the outer surface of neutrophils. When platelet satellites are present, platelet estimates cannot be made from blood smears.



Platelets

In some disorders, platelets may be larger than normal (i.e., **giant** platelets).



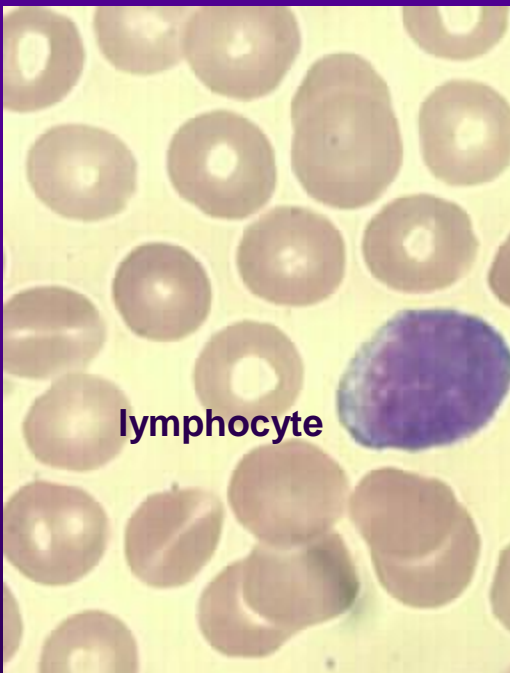
Disorders Characteristic Morphology



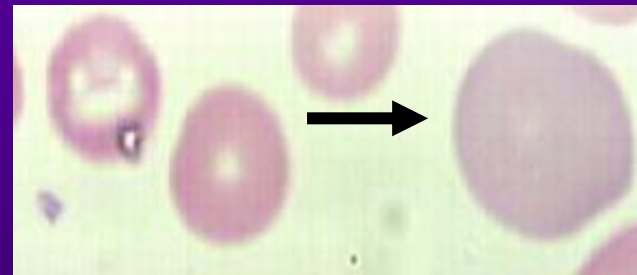
Macrocytic Non-Megaloblastic Anemias

Characteristic abnormalities associated with macrocytic non-megaloblastic anemias in diseases associated with reticulocytosis.

normal



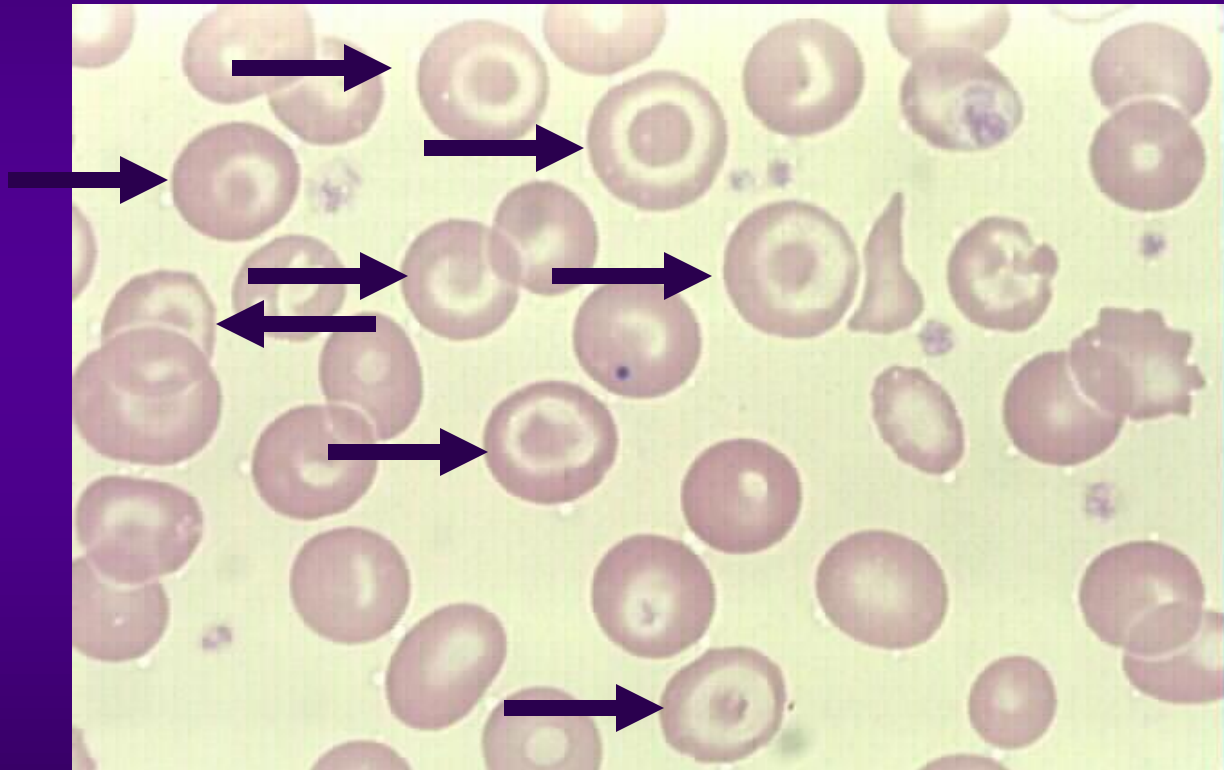
numerous polychromatophilic erythrocytes like the one indicated by the arrow



Macrocytic Non-megaloblastic Anemia

Characteristic abnormalities associated with macrocytic non-megaloblastic anemia in liver disease.

macrocytes
and
target cells

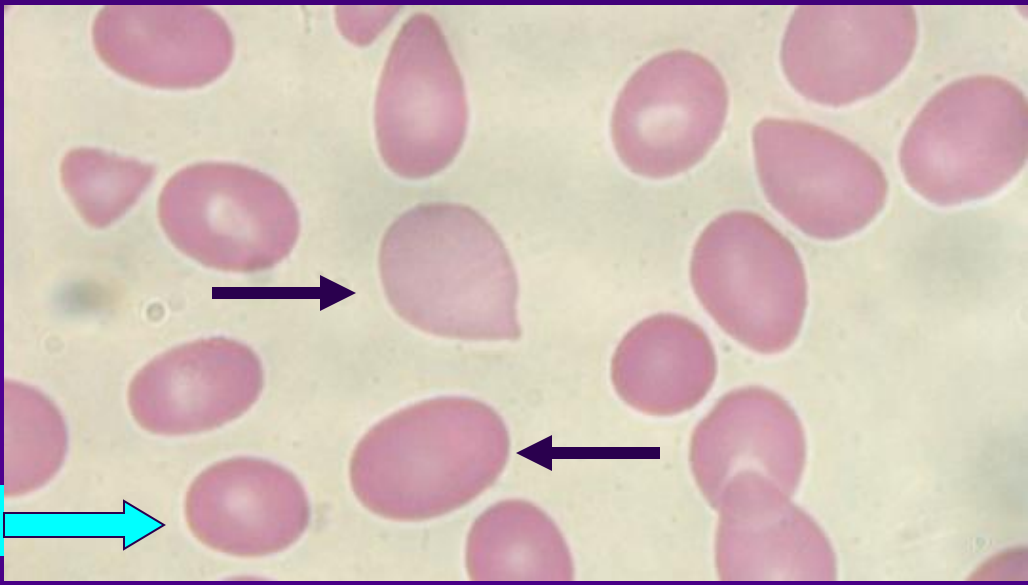


Macrocytic Megaloblastic Anemias

Examples of **characteristic abnormalities** associated with megaloblastic macrocytic anemias

macrocytes
and
macro-tear drops
and
macro-ovalocytes

Normocytic RBC



and erythrocytic precursors with **asynchrony** in nuclear and cytoplasm maturation



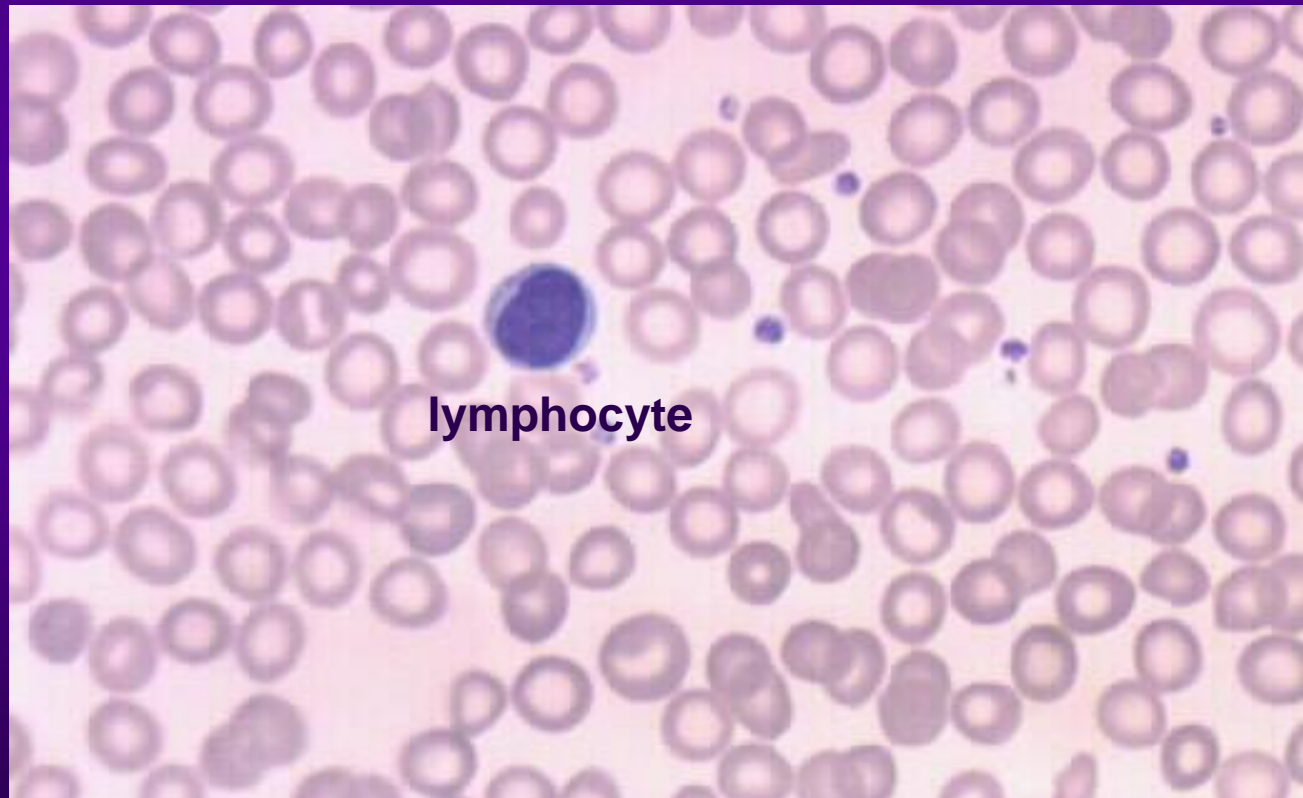
and hypersegmented PMN



Microcytic Hypochromic Anemias

Characteristic abnormalities associated with microcytic hypochromic anemias (eg, iron deficiency, chronic disease).

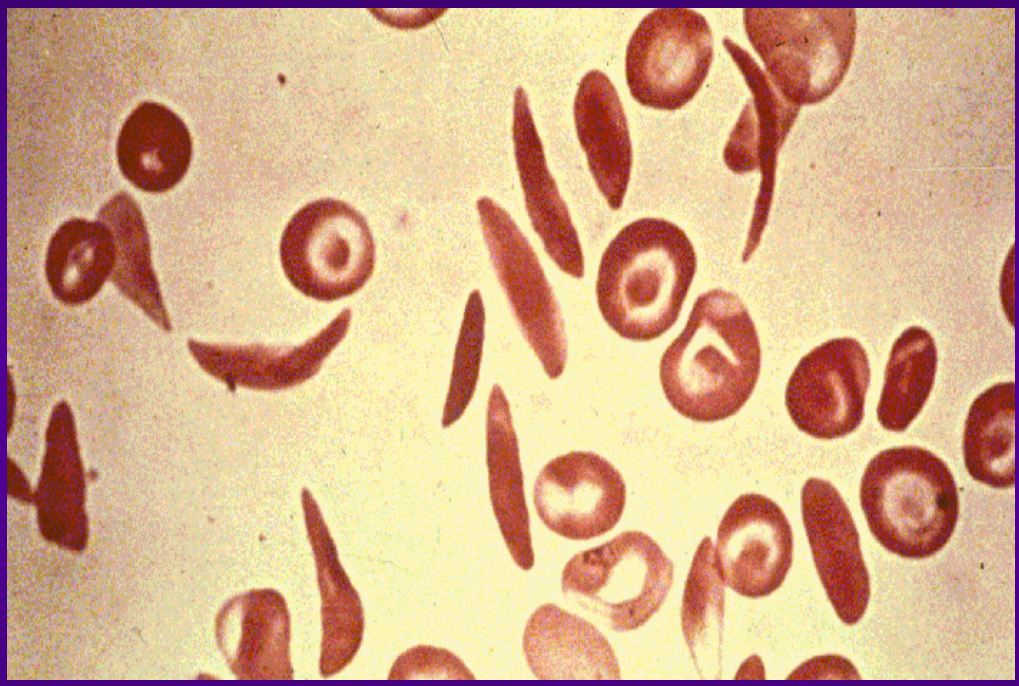
predominant cells are microcytic hypochromic erythrocytes



Anemia in Sickle Cell Disease

Characteristic abnormalities associated with anemia in sickle cell disease

Sickled cells (may be crescent-shaped, irregular spines, filaments, holly-leaf appearance) and target cells



and also

NRBC



polychromasia



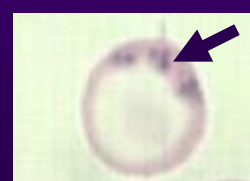
Howell-Jolly body



basophilic stippling



Pappenheimer bodies



THE END

Click on  to return to the main menu.

Click on  to exit the program.