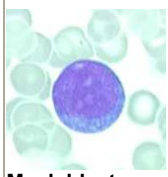
The identification of mature and immature **blood cells** in peripheral blood smears and bone marrow preparations is fundamental to the laboratory diagnosis of haematological disorders. Here, you may review the mature and immature white cells to gain more practice and confidence in their identification. Immature cells are found in peripheral blood in leukaemia.

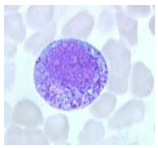
Modified to printer-friendly form from Quensland University of Tehcnology, Our Medical Science pages & University of California Davis School of Medicine)

Granulocytes

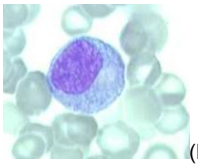
Bone Marrow



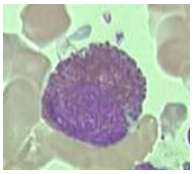
Myeloblast
Cell size: 15 -20 µm
N:C ratio: High (80%)
Cytoplasm: Medium blue colour, medium rim
Nucleus: Fine chromation, one or more nucleoi
Note: Blast cells of each series are difficult to specifically identify morphologically, immunological markers and cytochemistry are used to identify specific blasts.



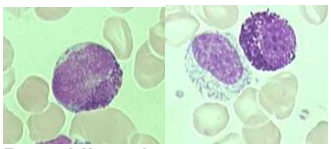
Promyelocyte
Cell size: 15 -25 µm
N:C ratio: High (70%), decreasing
Cytoplasm: Development of primary (non-specific) granules which are coarse, red- purple and may overlie both nucleus and cytoplasm
Nucleus: Slight clumping nucleoli still visible
Note: Promyelocytes are morphologically most variable.



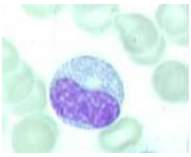
(Neutrophile)
Myelocyte
Cell size: 12 -23 µm
N:C ratio: 60%, decreasing
Cytoplasm: Development of secondary (specific) granules, some primary granules may be visible
Nucleus: Oval or round, with further clumping, nucleoli no long visible
Note: The term myelocyte infers it is a neutrophil myelocyte, also found are eosinophil myelocytes and basophil myelocytes.



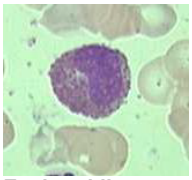
Eosinophil myelocyte
Cell size: 12-23 µm
N:C ratio: 60-50%, decreasing
Cytoplasm: Development of secondary (specific) granules (orange-brown colour), some primary granules may be visible
Nucleus: Oval or round, with further clumping, nucleoli no long visible



Basophil myelocyte
Cell size: 12 -23 µm
N:C ratio: 60%, decreasing
Cytoplasm: Development of secondary (specific) granules (overly nucleus), some primary granules may be visible
Nucleus: Oval or round, with further clumping, nucleoli no long visible
Note: Very early basophil myelocyte on the left, later basophil myelocyte on the right (with a myelocyte).



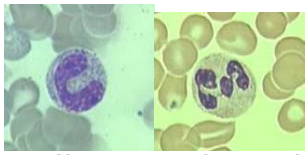
(Neutrophile) **Metamyelocyte**
Cell size: 12 -15 µm
N:C ratio: Ratio more reduced, 40%
Cytoplasm: Similar to mature cell
Nucleus: Indentation of nucleus begins; heavy chromatin clumping, nucleoli not visible



Eosinophil metamyelocyte
Cell size: 12 -15 µm
N:C ratio: Ratio more reduced, 40%
Cytoplasm: Similar to mature cell, prominent eosinophilic granulation
Nucleus: Indentation of nucleus beings; heavy chromatin clumping, nucleoli not visible

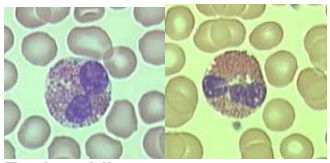
Basophil metamyelocyte
Cell size: 12 -15 µm
N:C ratio: Ratio more reduced, 40%
Cytoplasm: Difficult to see due to the specific (basophilic) granulation. Granules overly nucleus
Nucleus: When seen, indentation of nucleus begins, heavy chromatin clumping, nucleoli not visible

Peripheral Blood

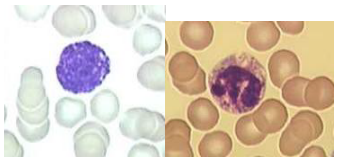


Left - **Nonsegmented neutrophil**
Cell size: 10-16 µm
N:C ratio: Ratio more reduced 30 - 40%
Cytoplasm: Similar to mature cell
Nucleus: Curved, without distinct lobes
Note: Also referred as "band forms" or "stab cells".

Right - **Segmented Neutrophil**
Cell size: 10-16 µm
N:C ratio: Ratio more reduced 20 - 30 %
Cytoplasm: Fine specific granules, pink-tan cytoplasm.
Nucleus: Segmented nucleus (normal up to 5 lobes)



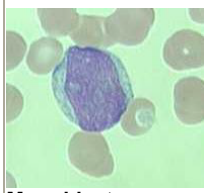
Eosinophil
Cell size: 10-16 µm
N:C ratio: Ratio 30 %
Cytoplasm: Prominent specific granules (orange-brown), blue cytoplasm (often not seen)
Nucleus: Segmented nucleus, usually two lobes



Basophil
Cell size: 10-14 µm
N:C ratio: Ratio 30%
Cytoplasm: Large irregular dark purple-black granules. These granules may dissolve during staining to give a "washed out" appearance as seen in the basophil on the right.
Nucleus: Usually masked by granules, may be bilobed or non segmented.

Monocytes

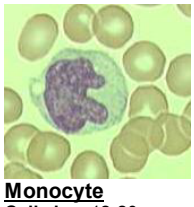
Bone Marrow



Monoblast
Cell size: 12 -20 µm
N:C ratio: High (80%)
Cytoplasm: Medium blue colour, cytoplasm frequently irregular with pseudopods
Nucleus: Fine chromation, one or more nucleoli
Note: Blast cells of each series are difficult to specifically identify morphologically, immunological markers and cytochemistry are used to identify specific blasts.

Promonocyte
Cell size: 12 -20 µm
N:C ratio: 60-40%
Cytoplasm: Medium blue-grey colour, cytoplasm frequently irregular with pseudopods
Nucleus: Lace like chromatin, 1 or 2 nucleoli, nucleus elongated, folded.

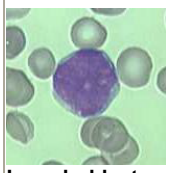
Peripheral Blood



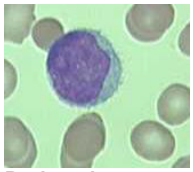
Monocyte
Cell size: 12-20 µm
N:C ratio: 50 % or less.
Cytoplasm: Blue-grey cytoplasm, fine red-purple granules may be seen. Vacuoles often present.
Nucleus: Convoluted or kidney shaped, rarely round oval or band.

Lymphocytes

Bone Marrow

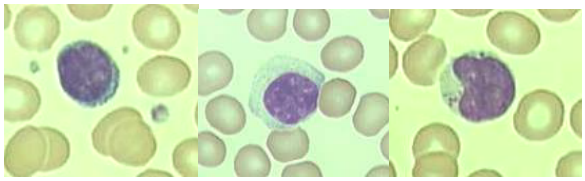


Lymphoblast
Cell size: 15-20 µm
N:C ratio: 90-80 %
Cytoplasm: Medium blue, sometimes with a darker blue border
Nucleus: Round or oval, delicate chromatin. Nucleoli 1-2
Note: Blast cells of each series are difficult to specifically identify morphologically, immunological markers and cytochemistry are used to identify specific blasts.



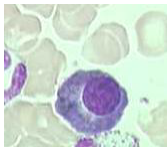
Prolymphocyte
Cell size: 15-18 µm
N:C ratio: 80-60 %
Cytoplasm: Medium blue, sometimes with a rim of darker blue
Nucleus: Oval, condensed chromatin. Nucleoli 0-1

Peripheral Blood



Lymphocyte
Cell size: 8-15 µm (small, intermediate and large)
N:C ratio: Ratio 80 % small, 50 % large
Cytoplasm: Blue cytoplasm, paler in large lymphocytes.
Clusters of azurophilic granules may be seen (**see note**).
Nucleus: Round, dense chromatin. Nucleus may be clefted. Nucleoli are occasionally visible in mature lymphocytes.
Note: In high magnification, the cytoplasmic cluster of dark granules in the lymphocyte in picture 3 actually seem to lie in a 'vacuole', i.e. it might represent a **morula of Human Monocytic Ehrlichia !**
Single Ehrlichia are often seen in the cytoplasm of leukaemia cells inoculated with Ehrlichia, see CDC, Google. Tick bites are very common. New facts are that Ehrlichia species are found in ticks all over the world and that most Ehrlichia infections probably go unnoticed, only causing other infections, because of immune inhibition - it is very likely, also in previous eras, that inclusions of Ehrlichia were found now and then in WBCs, but nobody new what it was and considered it to be a normal finding, just because it was so common ?

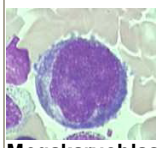
Tissues



Plasma cell (in):
Cell size: 8-20 µm
N:C ratio: Ratio 40-30%
Cytoplasm: Cytoplasm stains dark blue, with a lighter area near the nucleus (perinuclear halo)
Nucleus: Round, eccentric (off centre)

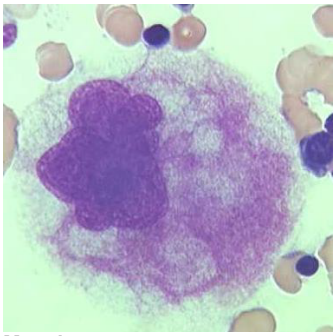
Thrombocytes:

Bone Marrow



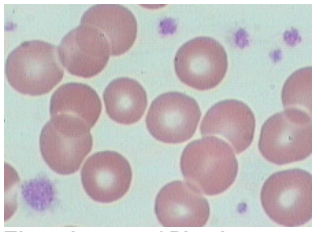
Megakaryoblast
Cell size: 15-20 µm
N:C ratio: High, ratio 90-80 %
Cytoplasm: Relatively small amount, non granular, basophilic (intensely)
Nucleus: Large oval, kidney shaped nucleus, fine chromatin structure, several nucleoli.
Note: Blast cells of each series are difficult to specifically identify morphologically, immunological markers and cytochemistry are used to identify specific blasts.

Promegakaryocyte
Cell size: 20-80 µm
N:C ratio: Ratio 70 - 50%
Cytoplasm: More abundant, basophilic cytoplasm contains granules
Nucleus: Oval or irregular nucleus, slightly dense chromatin pattern, nucleoli may be still visible



Megakaryocyte
Cell size: 35-160 µm
N:C ratio: Ratio low
Cytoplasm: Abundant - light blue/purple colour, packed with fine azurophilic granules
Nucleus: Irregularly lobed, ring or doughnut shaped nucelus, may have up to 16 (occas 32) lobes, dense chromatin pattern, nucleoli not visible.

Peripheral Blood

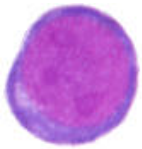


Thrombocytes / Platelets
(located between red blood cells.)
Cell size: 2-5 µm
Platelets are highly variable, round-oval anuclear cytoplasmic fragments of a megakaryocyte, staining pale blue; smaller platelets tend to be older, while large platelets tend to be young.

Erythrocytes

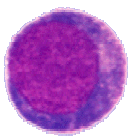
Bone Marrow

Percentages refer to average bone marrow distribution.
Not shown are Monocyte: 4.0%, Lymphocyte: 12.5%, and Plasma Cell: 2.5%

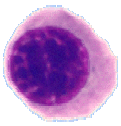


Erythroblast
Proerythroblast 0,5%
Cell size: 15-20 µm
N:C ratio: 90-80 %
Cytoplasm: Relatively small amount, non granular, basophilic (intensely)
Nucleus: Large oval, kidney shaped nucleus, fine chromatin structure, several nucleoli.
Note: Blast cells of each series are difficult to specifically identify morphologically, immunological markers and cytochemistry are used to identify specific blasts.

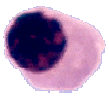
Normoblast



Basophilic (8%)
Cell size:
N:C ratio: 75%
Cytoplasm: intense dark blue (basophile)
Nucleus: Large round, chromatin slight clumping, nucleoli may not be visible

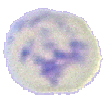


Polychromatic (17,5%)
Cell size:
N:C ratio: 60%
Cytoplasm: slight basophilia
Nucleus: Large round, chromatin darker, more condensed



Orthrochromatic (2,5%)
Cell size:
N:C ratio: 40%
Cytoplasm: slight acidophilia
Nucleus: small, very dark blue-black (pyknotic)

Peripheral Blood



Reticulocyte
(methylene-blue stain)
Cell size:
N:C ratio: Cytoplasm: moderate t acidophilia
Nucleus: extruded at the orthochromatic stage. Reticulocytes are positively identified with supravital dyes (precipitating E.R.)
Note: ~polychromasia

Erythrocyte
Cell size: ~7 µm
N:C ratio:
Cytoplasm: moderate t acidophilia
Nucleus: none
Note: biconcave cell shape

Normal distribution of white blood cells in peripheral blood:
Neutrophile (granulocytes) 40-75%, Lymphocytes 20-45%, Monocytes 2-8%, Eosinophile 1-4%, Basophile 0-1%

Red cell abnormalities

Red cell abnormalities	Causes
Normal	
Macrocyte	Liver disease, alcoholism. Oval in megaloblastic anaemia
Target cell	Iron deficiency, liver disease, haemoglobinopathies, post-splenectomy
Stomatocyte	Liver disease, alcoholism
Pencil cell	Iron deficiency
Ecchinocyte	Liver disease, post-splenectomy
Acanthocyte	Liver disease, abetalipoprotein-aemia, renal failure
Sickle cell	Sickle cell anaemia
Microcyte	Iron deficiency, haemoglobinopathy

Red cell abnormalities	Causes
Spherocyte	Hereditary spherocytosis autoimmune haemolytic anaemia, septicaemia
Fragments	DIC, microangiopathy, HUS, TTP, burns, cardiac valves
Elliptocyte	Hereditary elliptocytosis
Tear drop poikilocyte	Myelofibrosis, extramedullary haemopoiesis
Basket cell	Oxidant damage–e.g. G6PD deficiency, unstable haemoglobin
Howell–Jolly body	Hyposplenism, post-splenectomy
Basophilic stippling	Haemoglobinopathy, lead poisoning, myelodysplasia, haemolytic anaemia
Malarial parasite	Malaria. Other intra-erythrocytic parasites include *Bartonella bacilliformis*, babesiosis
Siderotic granules (Pappenheimer bodies)	Disordered iron metabolism e.g. sideroblastic anaemia, post-splenectomy

(from page 28, Haematology at a Glance, by Atul Metha & Victor Hoffbrand. Blackwell Science. 2000. ISBN 0-632-04793-3)

Howell-Jolly bodies
Also known as: Howell's bodies, Jolly's bodies. Associated persons: William Henry Howell Justin Marie Jolly
Description:
Spherical granules, 1-2 µ, seen in erythrocytes in slides of stained blood. **They are thought to be nuclear particles.** The bodies are seen in cases of congenital absence of the spleen; following splenectomy, **in haemolytic anaemia**, in percicious anaemia, in thalassaemia, and in leukaemia.

Bibliography:

W. H. Howell: *The life-history of the formed elements of the blood, especially the red blood corpuscles.* Journal of Morphology, New York, 1890-91, 4: 57-116.
J. M. J. Jolly: *Sur la formation des globules rouges des mammifères.* Comptes rendus de la Société de Biologie, Paris, 1905, 58: 528-531.
Recherches sur la formation des globules rouges des mammiféres. Archives d'anatomie microscopique, 1907, 9: 133-314.