Chapter 2 Normal Myeloid Development and Morphology

Mindray Morphology Corner | Series Course-II WBC

A clear, visual guide to how neutrophils, eosinophils, basophils, and monocytes develop in the bone marrow.

0.1 Introduction: How Myeloid Cells Come to Life

- Every smear you review is a snapshot of a finely tuned production line inside the bone marrow. From blasts to fully functional immune cells, each stage reflects an orderly sequence of nuclear, cytoplasmic, and granule changes.

0.2 Throughout all myeloid lineages, look for three recurring patterns:

- Nuclear maturation: round → indented → segmented or folded
- Cytoplasmic changes: deeply blue → paler with granules
- Granule evolution: azurophilic primary granules → lineage-specific secondary granules

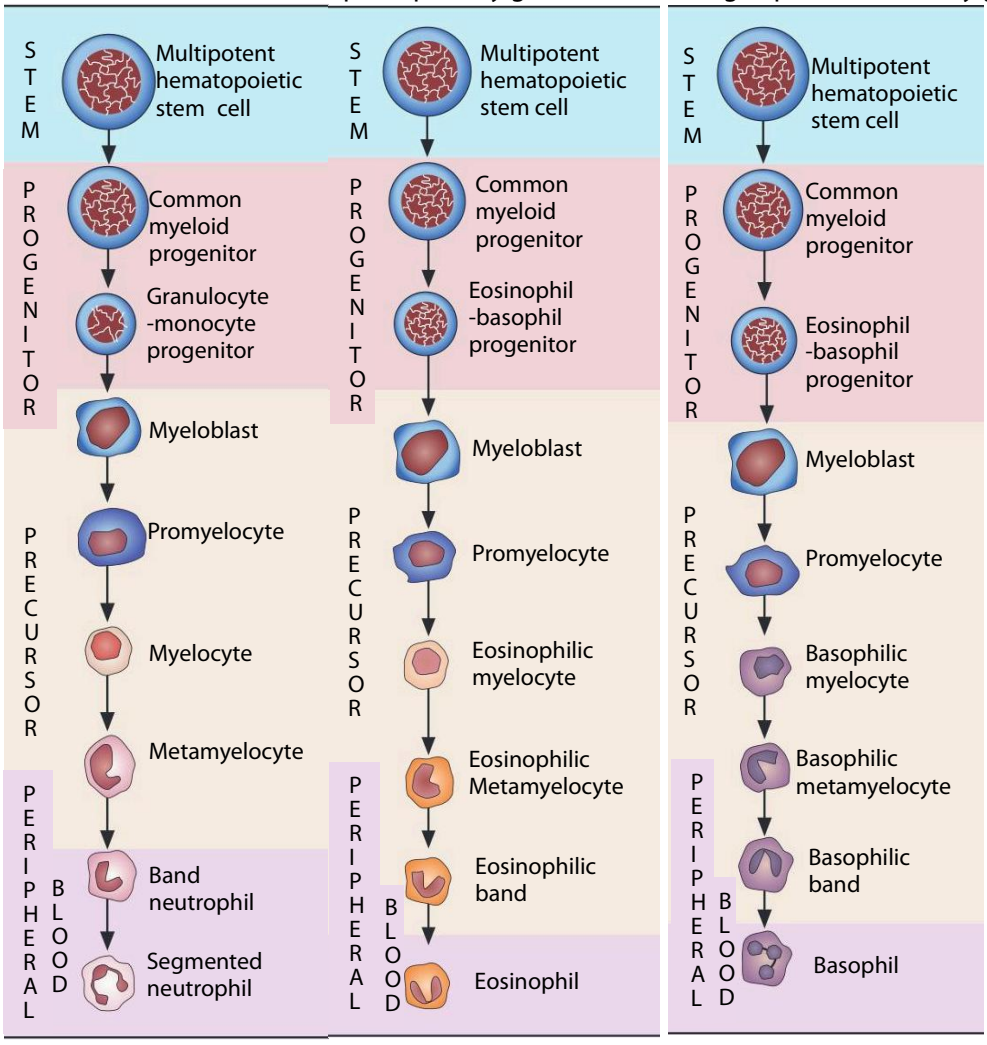
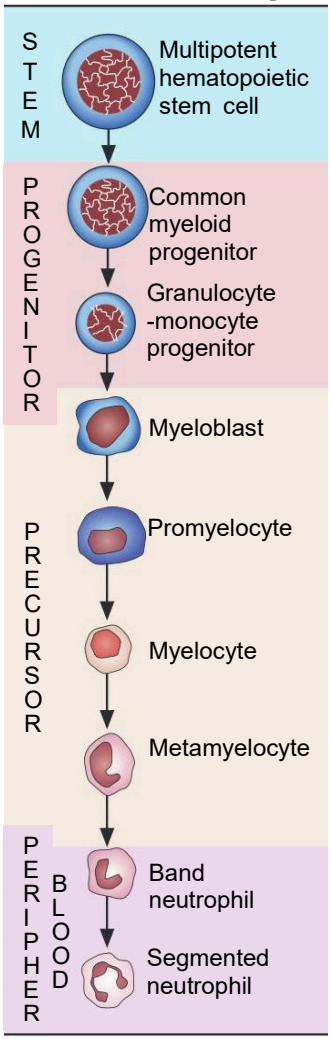


Figure1 Figure2 Figure3

Figure 1: The maturation of Neutrophil [1]
Figure 2: The maturation of Eosinophil [1]
Figure 3: The maturation of Basophil [1]

Part 1 — Neutrophil Development: Your Primary Roadmap



Imature neutrophil/granulocyte series case from Mindray hematology analyzer:

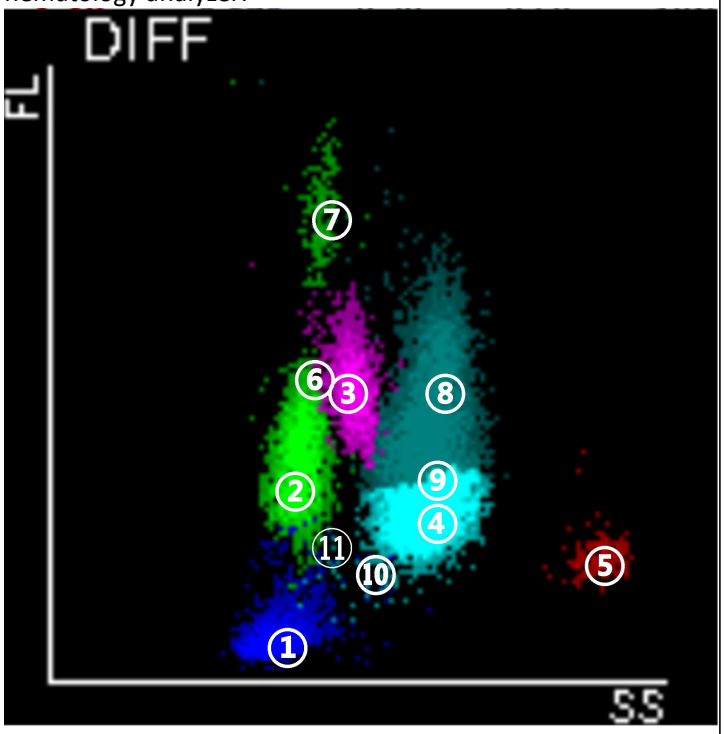


Figure4

Figure4: FL, fluorescence signal; SS, side scatter signal
①ghost ②lymphocyte ③monocyte ④neutrophil ⑤eosinophil ⑥blast ⑦High fluorescence cell (reactive lymphocyte & blast, etc.) ⑧imature granulocyte ⑨band neutrophil ⑩basophil ⑪nucleated RBC

Para.	Flag	Result	Delta(#)	07-07	07-06	Unit
WBC	& H	40.73	11.130	29.60	32.38	10^3/uL
Neu%	&R	54.7	-0.70	55.4	62.1	%
Lym%	&RL	10.8	-1.80	12.6	8.0	%
Mon%	R	4.5	0.80	3.7	4.0	%
Eos%	R	0.6	0.00	0.6	0.2	%
Bas%		0.0	0.00	0.0	0.0	%
IMG%	R	29.4	1.70	27.7	25.7	%

Figure5

WBC	Flag	Count	%
Segmented neutrophils	H	71	70.3
Lymphocytes	L	7	6.9
Eosinophils		1	1.0
Monocytes		3	3.0
Band neutrophils		9	8.9
Metamyelocytes	!	7	6.9
Myelocytes	!	2	2.0
Promyelocytes	!	1	1.0

Figure6

Figure 5: WBC & DIFF results from hematology analyzer
Figure 6: Reviewed WBC & DIFF results from MC-80 (Mindray blood film reading machine)

Neutrophils provide the clearest model for understanding granulocyte maturation. Once you grasp their pattern, the other lineages fall naturally into place.

1.1 Myeloblast *(Figure 7,8)*

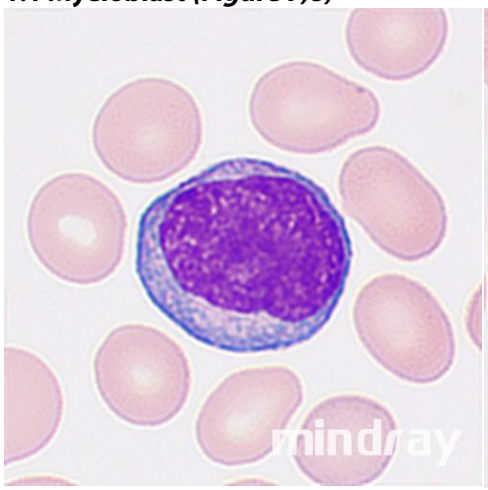


Figure7

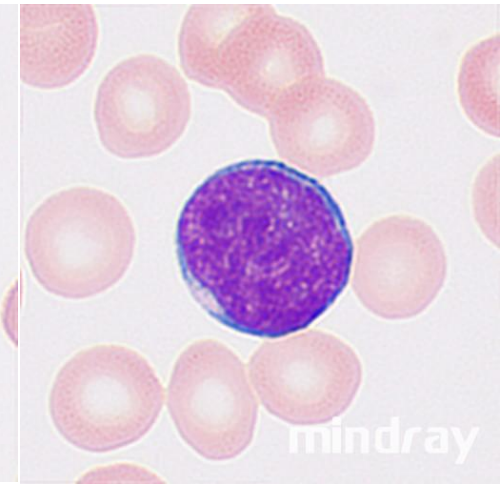


Figure8

1.1.1 Size: 12–20 μm
1.1.2 Nucleus: Round/oval, fine chromatin, clear nucleoli
1.1.3 Cytoplasm: Deep blue, no granules
1.1.4 N: C ratio: High (~4:1)
1.1.5 Remember: This is a cell full of potential—no specific functional machinery yet.

1.2 Promyelocyte *(Figure 9,10)*

Figure9

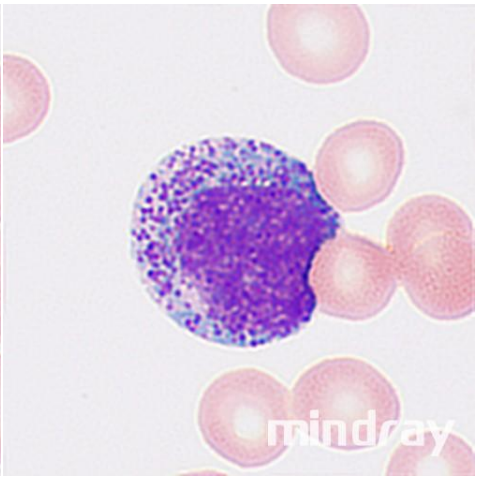


Figure10

1.2.1 Size: 15–25 μm
1.2.2 Cytoplasm: Filled with blue-violet and red (primary) granules.
1.2.3 Nucleus: Condensing; nucleoli may still be seen
1.2.4 Tips: A surge of ***reddish- purple granules***—this stage is unmistakable.

1.3 Myelocyte *(Figure 11,12)*

Figure11

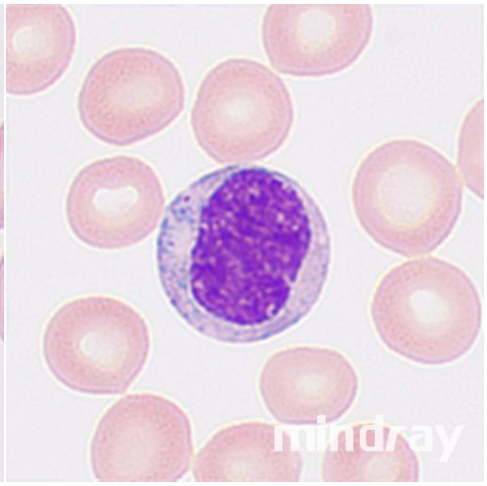


Figure12

1.3.1 Size: 10–18 μm
1.3.2 Nucleus: Condensed; nucleoli disappear
1.3.3 Cytoplasm: Appearance of secondary (specific) granules (neutrophilic, eosinophilic, or basophilic characteristics)
1.3.4 Granules: Look at neutrophils → fine lavender- pink granules
1.3.5 Tips: Look for the first cluster of ***specific granules*** near the Golgi area, ***no indentation*** on the nucleus.

1.4 Metamyelocyte *(Figure 13,14)*

Figure13

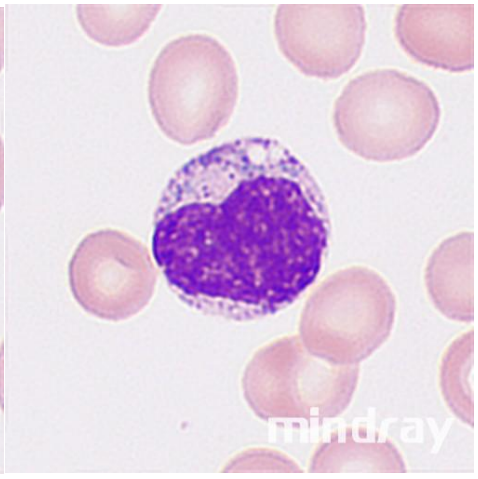


Figure14

1.4.1 Size: 10–16 μm
1.4.2 Nucleus: Kidney-shaped ***indentation <50%***
1.4.3 Cytoplasm: Lighter pink
1.4.4 Tips: The nucleus starts to ***indent***.

1.5 Band Neutrophil *(Figure 15,16)*

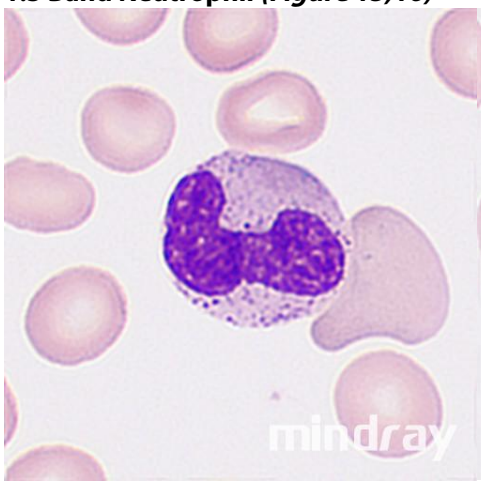


Figure15

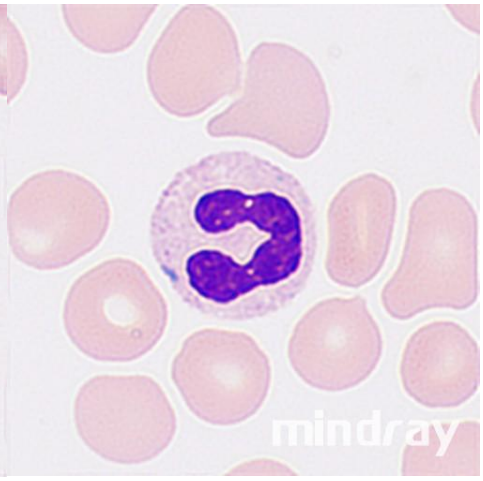


Figure16

1.5.1 Size: 10–14 μm
1.5.2 Nucleus: Band/C- shaped; ***indentation >50%***, but no thin connecting filaments
1.5.3 Clinical significance: Seen in "left shift" during infections
1.5.4 Tip: If you see ***a deep indentation but no segmentation***, it's a band.

1.6 Segmented Neutrophil *(Figure 17,18)*

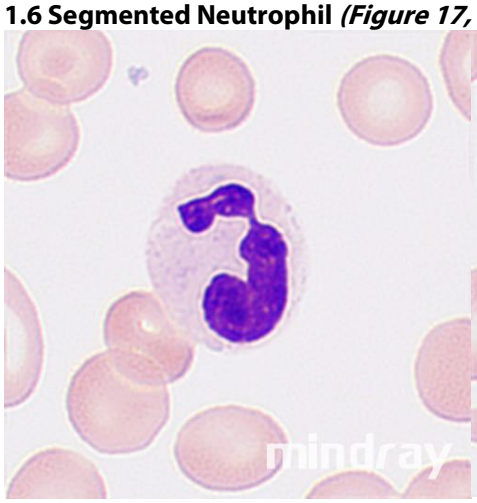


Figure17

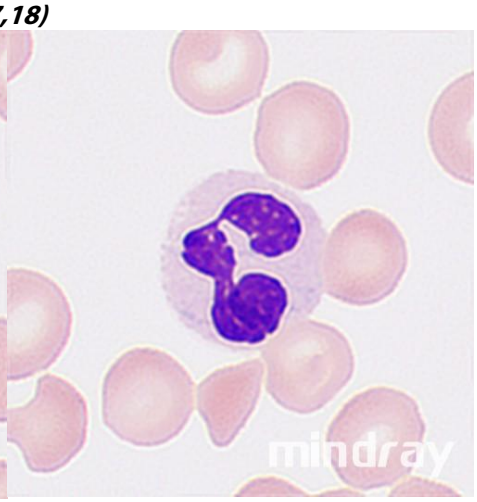


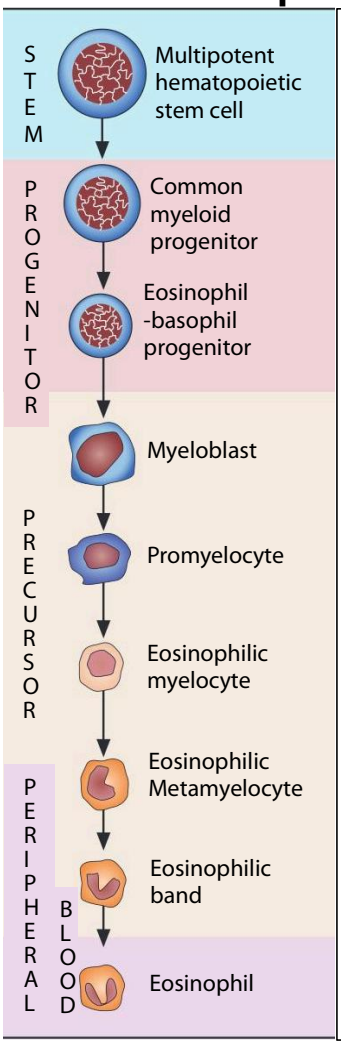
Figure18

1.6.1 Size: 10–14 μm
1.6.2 Nucleus: 2–5 lobes
1.6.3 Cytoplasm: Pale, filled with specific granules
1.6.4 Function: Rapid, frontline response to infection
1.6.5 Tips: *Thin thread* linked nuclear segmentation.

Note：

- Immature granulocytes (promyelocytes, myelocytes and metamyelocytes) are not usually seen in normal peripheral blood.[2]
- It is recommended that band neutrophils be counted as segmented neutrophils in the differential. Appropriate comments may be made if increased numbers are seen in the blood film.[2]

Part 2—Eosinophil Development: "Orange Is the Signature"



High eosinophil case from Mindray hematology analyzer:

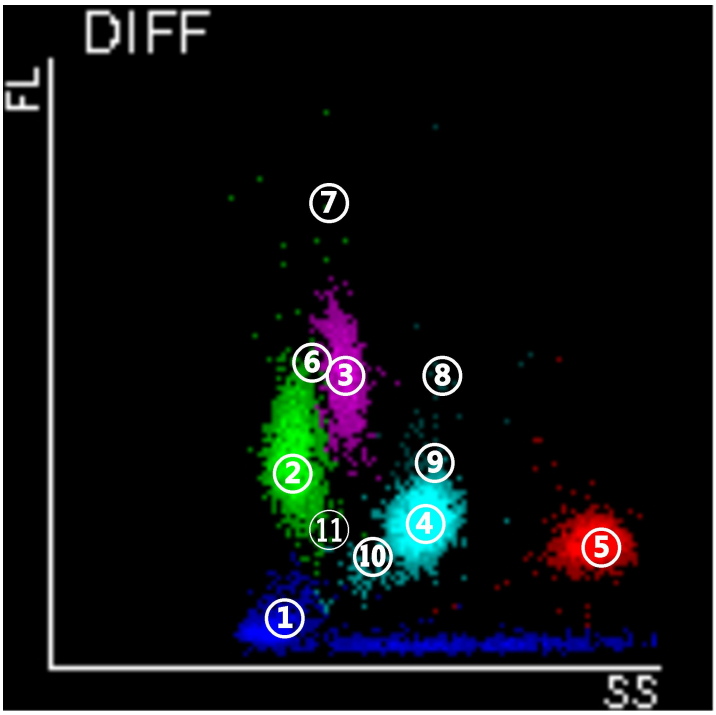


Figure19

Figure19: FL, fluorescence signal; SS, side scatter signal
①ghost ②lymphocyte ③monocyte ④neutrophil ⑤eosinophil ⑥blast ⑦High fluorescence cell (reactive lymphocyte & blast, etc.) ⑧imature granulocyte ⑨band neutrophil ⑩basophil ⑪nucleated RBC

Para.	Flag	Result	Delta(#)	07-05	07-04	Unit
WBC		5.62	-1.230	6.85	7.23	10^3/uL
Neu%	RL	37.0	-11.10	48.1	42.6	%
Lym%	R	35.5	10.10	25.4	33.6	%
Mon%	R	11.3	-3.70	15.0	15.8	%
Eos%	H	15.5	5.70	9.8	7.3	%
Bas%		0.4	-0.10	0.5	0.4	%
IMG%	R	0.3	-0.90	1.2	0.3	%

Figure20

WBC	Flag	Count	%
Segmented neutrophils		50	51.0
Lymphocytes		29	29.6
Eosinophils	H	13	13.3
Monocytes		5	5.1
Reactive lymphocytes		1	1.0

Figure21

Figure 20: WBC & DIFF results from hematology analyzer
Figure 21: Reviewed WBC & DIFF results from MC-80 (Mindray blood film reading machine)

Eosinophils follow the same nuclear progression as neutrophils, but their development is dominated by their brilliant granules.

Key features

2.1 Eosinophilic myelocyte: First appearance of large, orange- red secondary granules
2.2 Maturation: Granules increase in size and number through later stages
2.3 Mature eosinophil: (diameter 12–17 μm)
2.4 Typically bilobed nucleus
2.5 Cytoplasm packed with bright orange granules
2.6 Fragile granules may scatter on poorly prepared smears
2.7 Tips: If you see ***a bright orange galaxy***—the eosinophil has arrived.

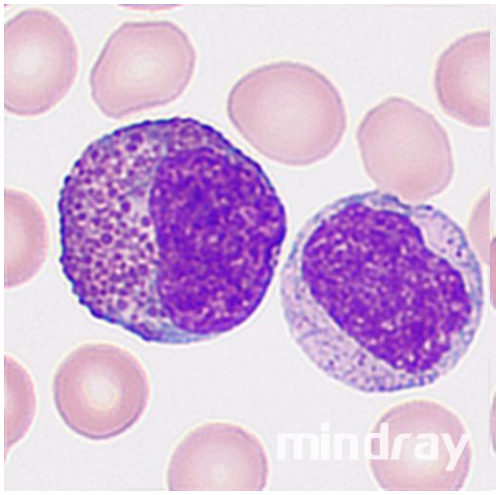


Figure22

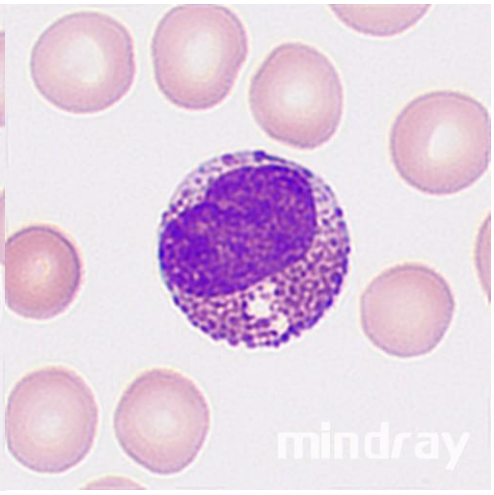


Figure23

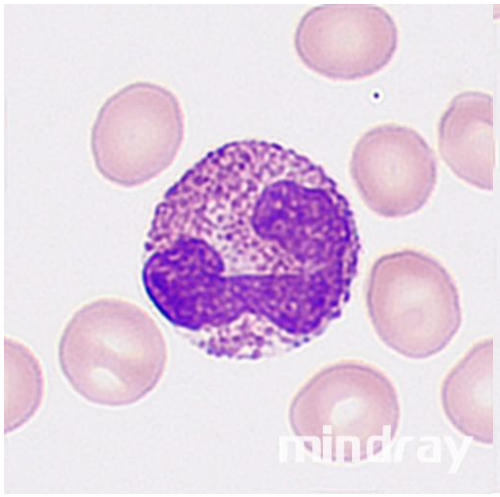


Figure24

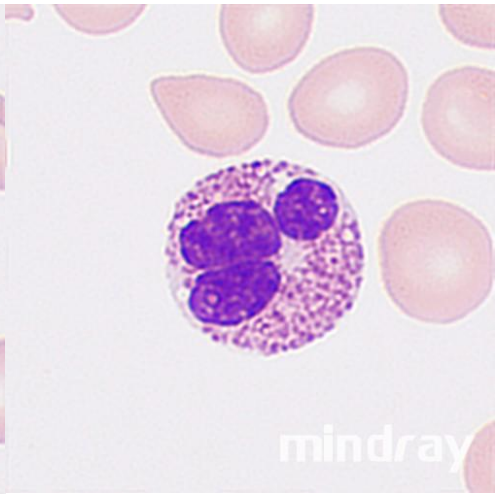
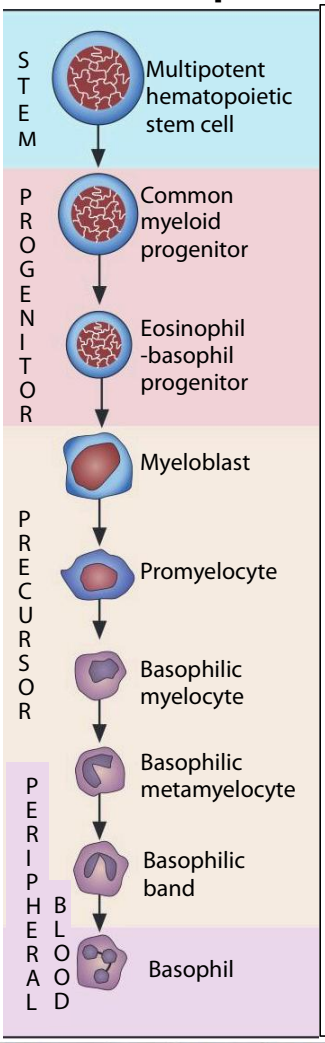


Figure25

Figure 22: Left, Eosinophilic Myelocyte; Right, Myelocyte
Figure 23: Eosinophilic Metamyelocyte
Figure 24: Band Eosinophil
Figure 25: Eosinophil

Part 3—Basophil Development: "The Dark and Mysterious One"



High basophil case from Mindray hematology analyzer:

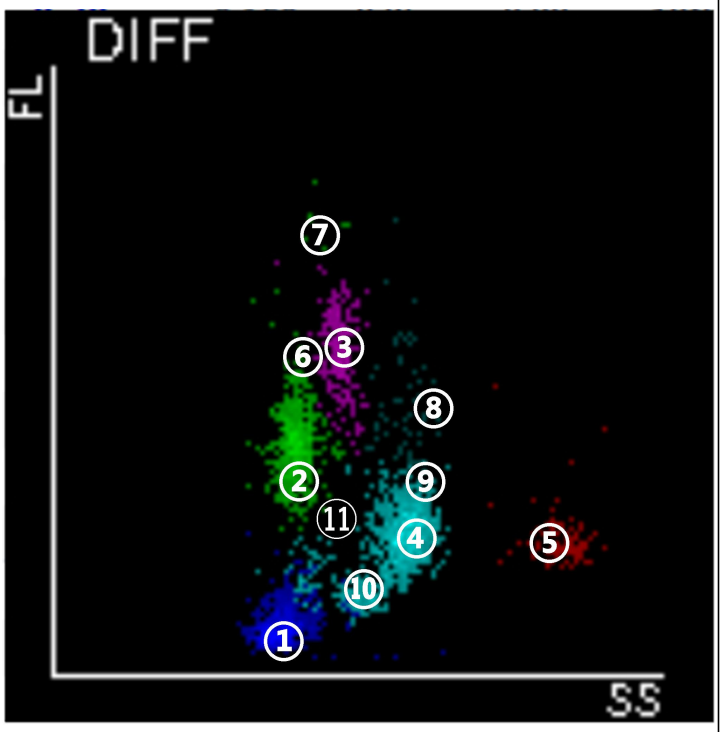


Figure26

Figure26: FL, fluorescence signal; SS, side scatter signal
①ghost ②lymphocyte ③monocyte ④neutrophil ⑤eosinophil ⑥blast ⑦High fluorescence cell (reactive lymphocyte & blast, etc.) ⑧imature granulocyte ⑨band neutrophil ⑩basophil ⑪nucleated RBC

Para.	Flag	Result	Delta(#)	07-16	07-15	Unit
WBC	L	2.35	0.040	2.31	2.46	10^3/uL
Neu%	RL	45.1	7.10	38.0	41.5	%
Lym%	R	30.3	-6.90	37.2	37.6	%
Mon%	R	8.5	-0.20	8.7	7.2	%
Eos%		4.9	-0.10	5.0	4.9	%
Bas%	H	8.4	-0.10	8.5	7.2	%
IMG%	R	2.8	0.20	2.6	1.6	%

Figure27

WBC	Flag	Count	%
Segmented neutrophils	L	47	47.4
Lymphocytes		28	28.3
Eosinophils	H	7	7.1
Monocytes		6	6.1
Basophils	H	6	6.1
Band neutrophils		2	2.0
Myelocytes	!	3	3.0

Figure28

Figure 27: WBC & DIFF results from hematology analyzer
Figure 28: Reviewed WBC & DIFF results from MC-80 (Mindray blood film reading machine)

Early basophils are subtle, but the mature form is impossible to miss.
Mature basophil hallmarks (diameter 10–16 μm)
3.1 Granules: Large, irregular, dark purple- to- black; often obscure the nucleus
3.2 Nucleus: Usually lobed but barely visible
3.3 Staining issue: Granules are water- soluble—poor staining may wash them out, mimicking vacuoles
3.4 Tips: The obvious feature of basophil is the ***dark-purple*** granules with ***uneven size, commonly cover on the nucleus***. Clear vacuoles in a purple haze often mean "basophil artifact," not cell degeneration.

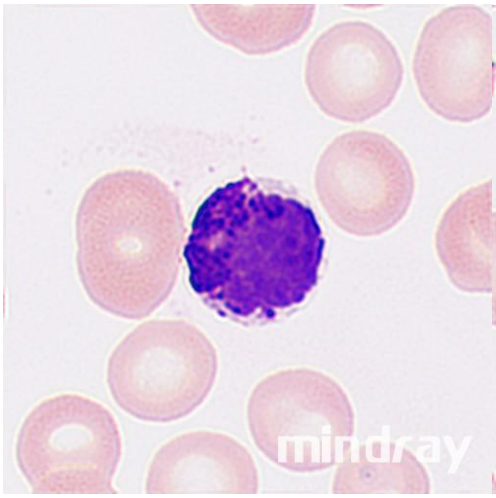


Figure29

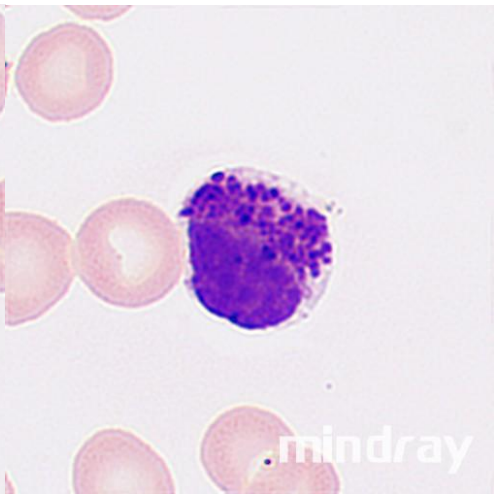


Figure30

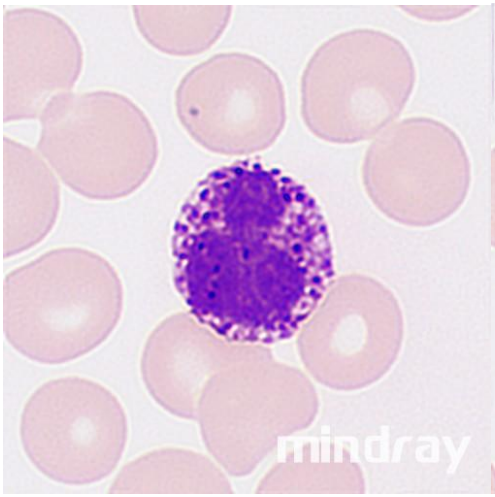


Figure31

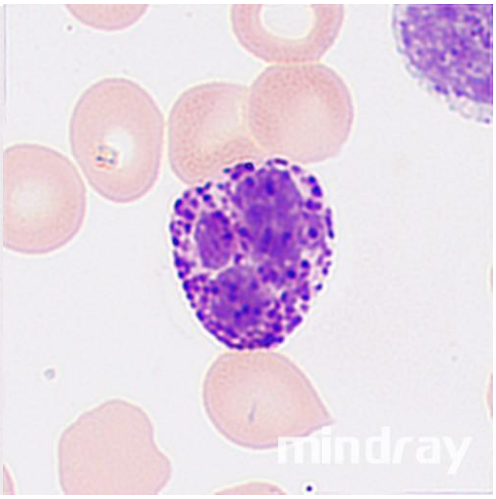


Figure32

Figure 29: Basophilic Myelocyte; Figure 30: Basophilic Metamyelocyte
Figure 31: Band Basophil; Figure 32: Basophil

Note: For all granulocytes, ***including neutrophil, basophil, and eosinophil,*** the most popular criteria to differentiate **myelocyte from metamyelocyte, band, and segmented** is the nucleus's ***intended degree*** *(Figure 33)*

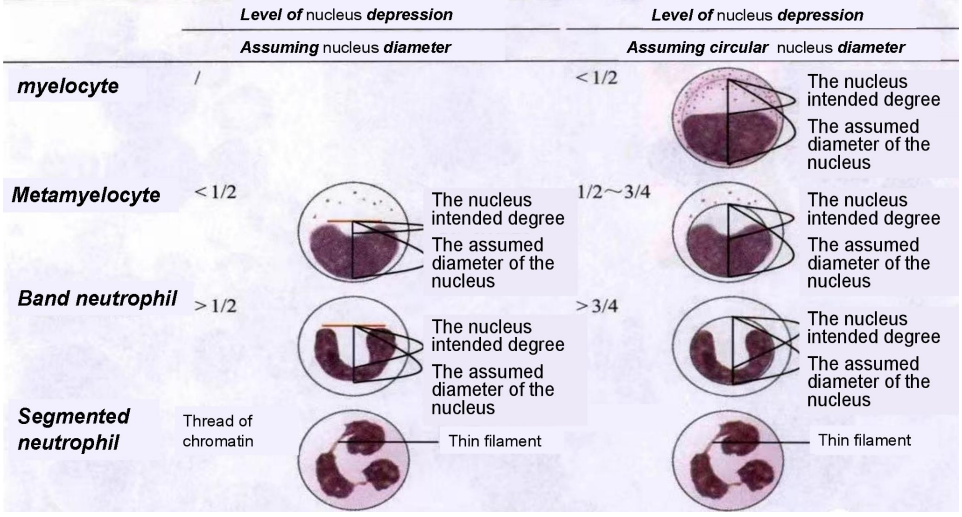


Figure33

Part 4—Monocyte/Macrophage Development: The Strategic Phagocytes

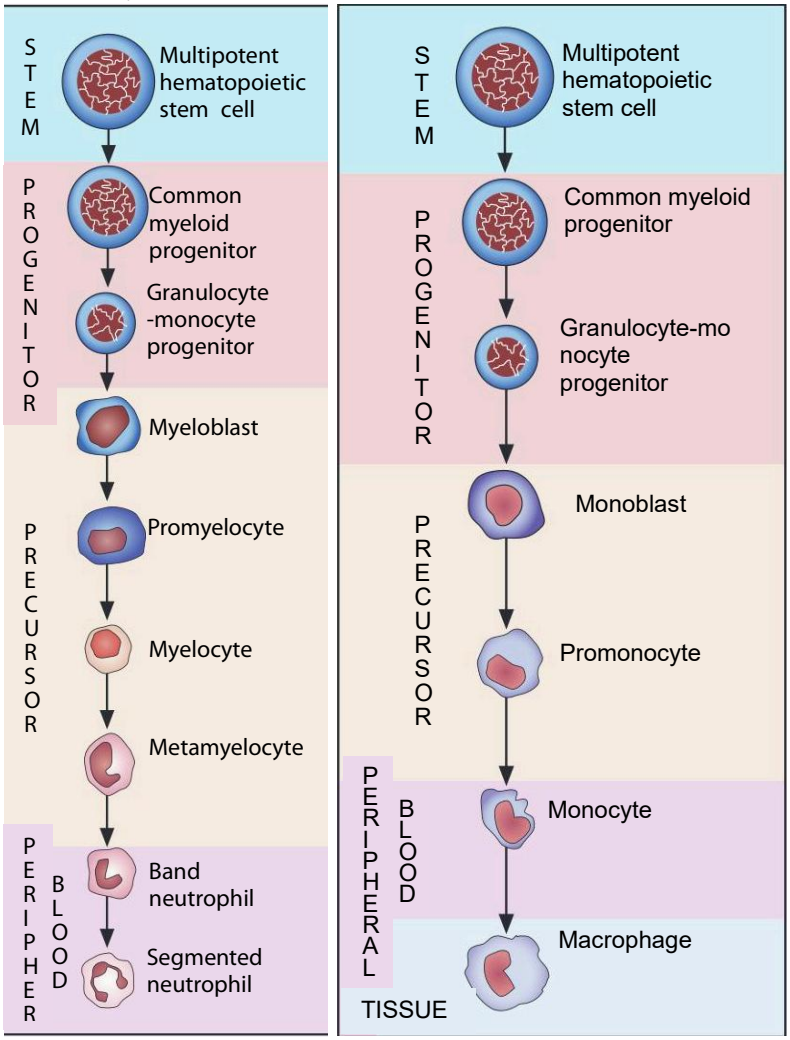


Figure34

This lineage doesn't rely on specific granules. Instead, **nuclear shape and cytoplasmic** texture provide the clues.

High monocyte case from Mindray hematology analyzer:

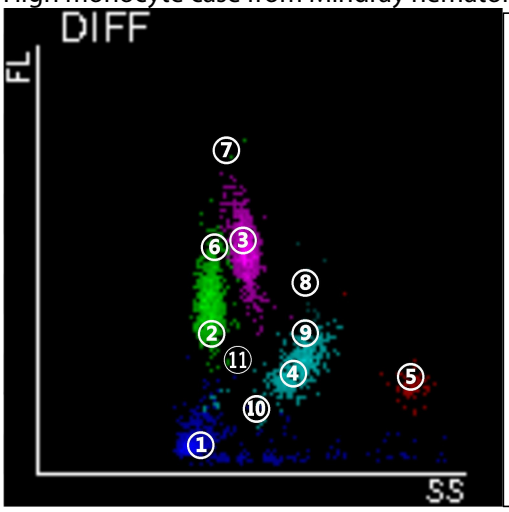


Figure35: FL, fluorescence signal; SS, side scatter signal
①ghost ②lymphocyte ③monocyte ④neutrophil ⑤eosinophil ⑥blast ⑦High fluorescence cell (reactive lymphocyte & blast, etc.) ⑧imature granulocyte
⑨band neutrophil ⑩basophil ⑪nucleated RBC

Figure35

STAT	Para.	Flag	Result	Delta(#)	07-06	07-04	Unit
	WBC	& L	2.73	1.400	1.33	0.83	10^3/uL
	Neu%	&RL	28.0	6.60	21.4	14.6	%
	Lym%	&R	38.3	5.90	32.4	44.9	%
	Mon%	RH	30.6	-11.80	42.4	35.6	%
	Eos%		2.5	-1.20	3.7	4.8	%
	Bas%		0.1	0.10	0.0	0.0	%
	IMG%	R	0.5	0.40	0.1	0.1	%

Figure36

WBC	Flag	Count	%
Segmented neutrophils	L	29	29.9
Lymphocytes		30	30.9
Eosinophils		2	2.1
Monocytes	H	27	27.8
Metamyelocytes	!	2	2.1
Myelocytes	!	1	1.0
Reactive lymphocytes	!	6	6.2

Figure37

Figure 36: WBC & DIFF results from hematology analyzer
Figure 37: Reviewed WBC & DIFF results from MC-80 (Mindray blood film reading machine)

4.1 Monoblast *(Figure 38)*

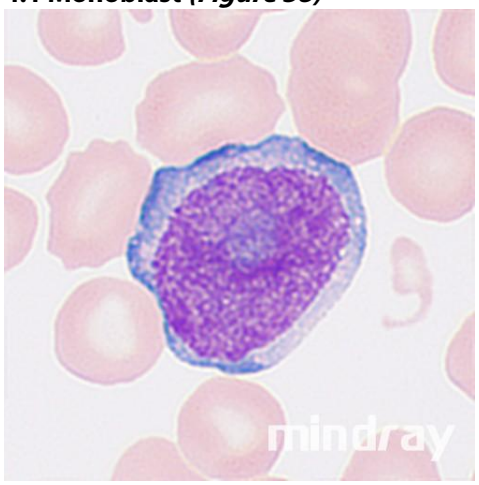


Figure38

4.1.1 Nucleus: Large, with a folded or convoluted nucleus
4.1.2 Cytoplasm: Blue- gray cytoplasm, no granules
4.1.2 Tips: Very big nucleoli

4.2 Promonocyte *(Figure 39)*

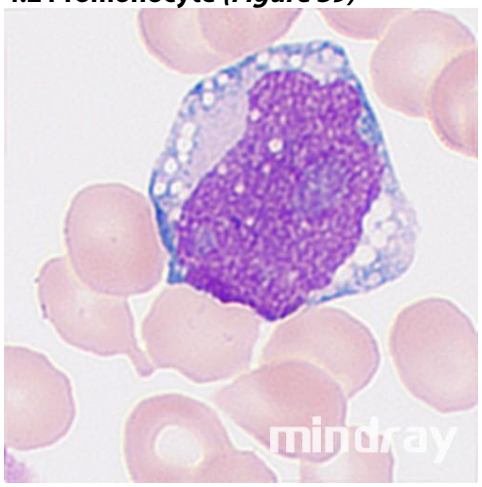


Figure39

4.2.1 Nucleus: Very irregular, lacy chromatin
4.2.2 Cytoplasm: Begins to show fine azurophilic granules

4.3 Mature Monocyte *(Figure 40,41)*

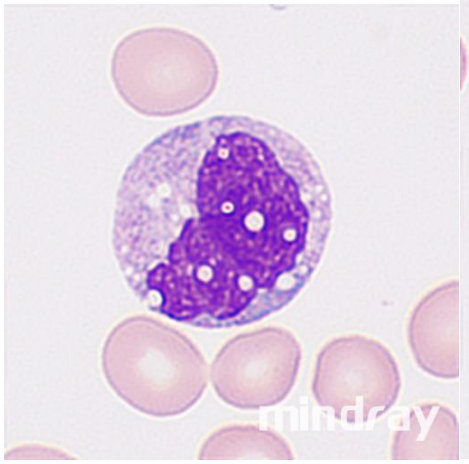


Figure40

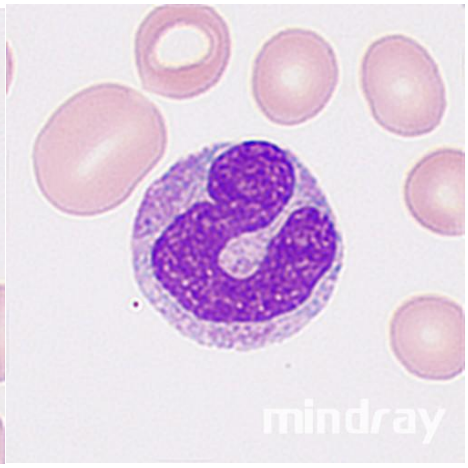


Figure41

4.3.1 Size: 15–22 μm(largest normal blood cell)[2]
4.3.2 Cytoplasm: Abundant, gray- blue, "ground- glass" appearance; may have vacuoles
4.3.3 Nucleus: Kidney- shaped, folded, or brain- like
4.3.4 Tips: ***Cloudy cytoplasm*** + deeply ***folded nucleus***.

4.4 Macrophage *(Figure 42,43)*[1]

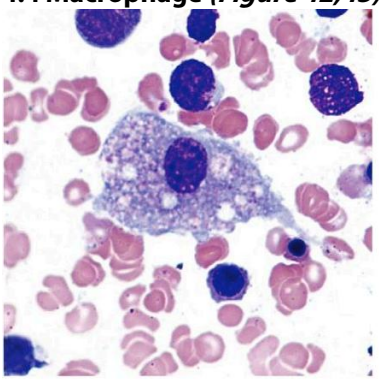


Figure42

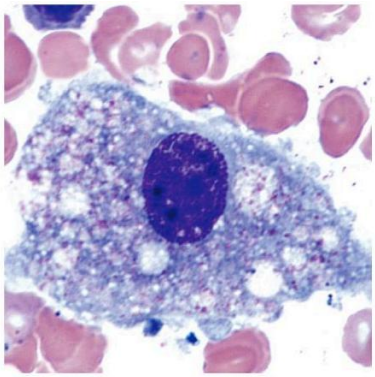


Figure43

4.4.1 Tissue - resident form
4.4.2 Large, foamy cytoplasm containing ingested debris
4.4.3 Often seen in marrow aspirates as histiocytes

Quick- Reference Table: Key Identifiers

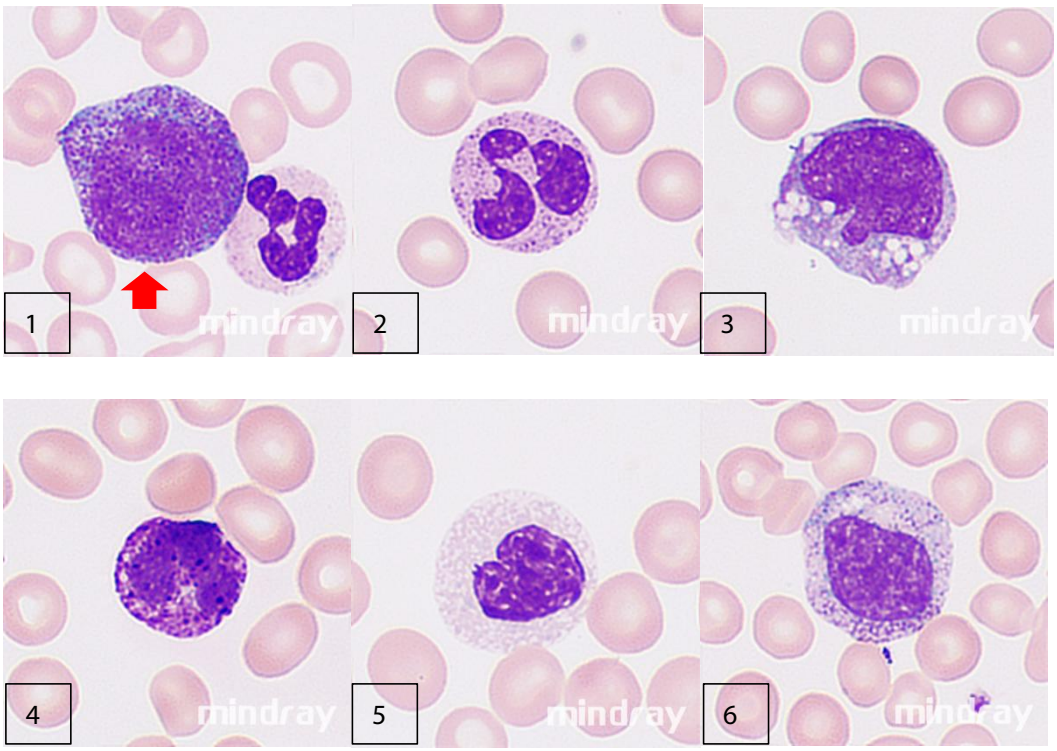
Stage	Neutrophil Line	Eosinophil Line	Basophil Line	Monocyte Line
Blast	No granules; nucleoli present	Not distinct	Not distinct	Folded nucleus; no granules
Promyelocyte	Many primary granules	—	—	—
Myelocyte	Secondary granules	Orange granules appear	—	—
Metamyelocyte /promonocyte	Kidney- bean nucleus	Same + orange granules	Early granules	Increasing nuclear folds
Band	>50% indentation, no filament	Same + orange granules	Rarely used stage	—
Mature Cell	Segmented nucleus	Bilobed, orange granules	Dark granules obscure nucleus	Ground- glass cytoplasm, folded nucleus

References & Image Sources

References:
1. Carr JH. Clinical Hematology Atlas. 6th ed. Elsevier; 2021.
2. Palmer, Lynn, et al. "ICSH Recommendations for the Standardization of Nomenclature and Grading of Peripheral Blood Cell Morphological Features." International Journal of Laboratory Hematology, vol. 37, 2015, pp. 1-17. Wiley Online Library, https://doi.org/10.1111/ijlh.12327.

Images & Technical Support: Most morphology images in this course are derived from analysis by the Mindray automated digital morphology analyzer MC-80.

Practice



[The answers will be at the end of the next chapter]

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— Coming Next: ***Normal Lymphocyte Development and Morphology*** —