

# CBC automated analyzers (3 part) – Flags & Troubleshoots

Komal Galani Deshmukh MD, DNB



# Automated analyzers

- ▶ Rapid & objective cell counting
- ▶ Correct interpretation of results
  - Extensive knowledge of the instruments
  - Clinical significance of the results

# History

- ▶ American inventor **Wallace H. Coulter** in 1956
- ▶ Electrical charge could be used to determine the size and number of microscopic particles in solution– Coulter principle

# Principles of cell counting

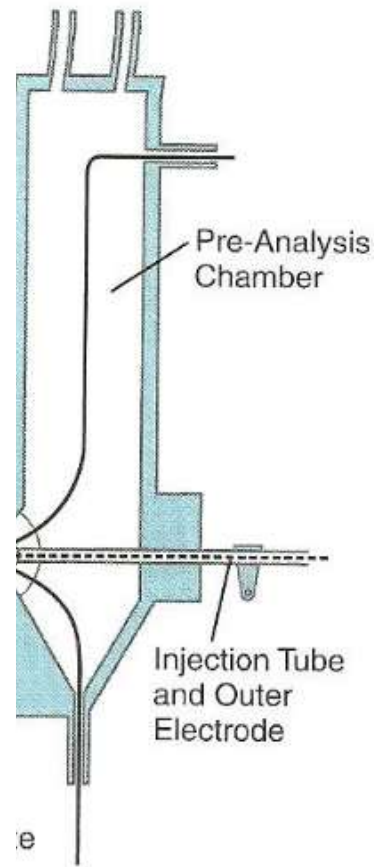
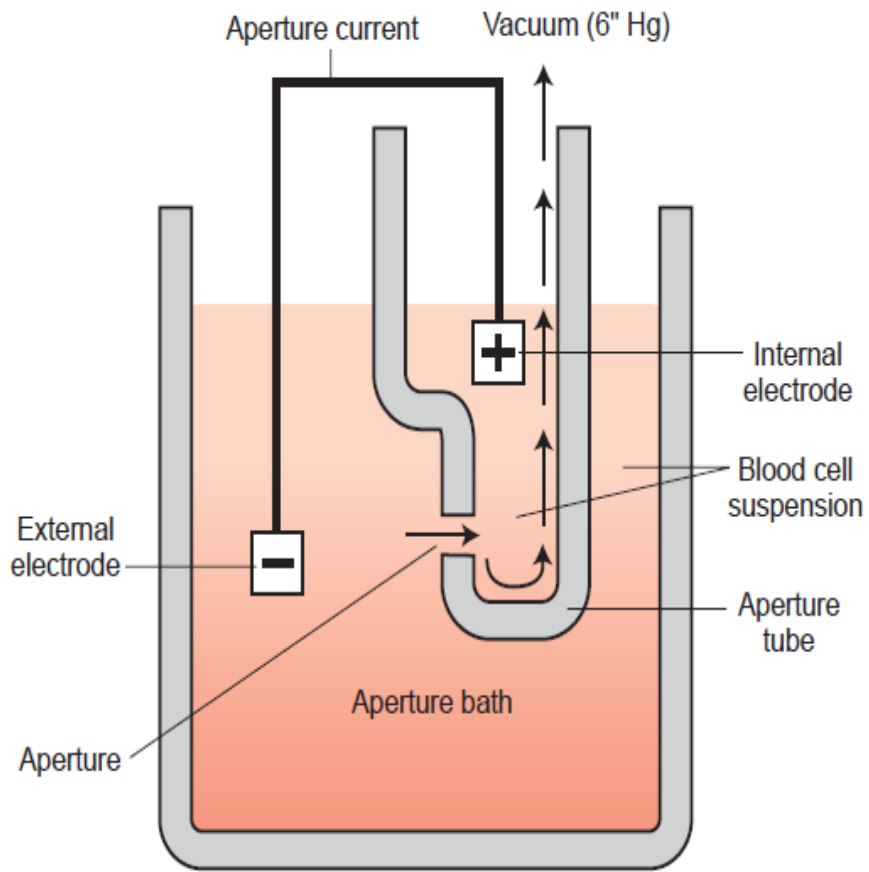
## 1. *Electrical impedance-*

Aperture size- 100 $\mu$ m

Frequency = no. of cells

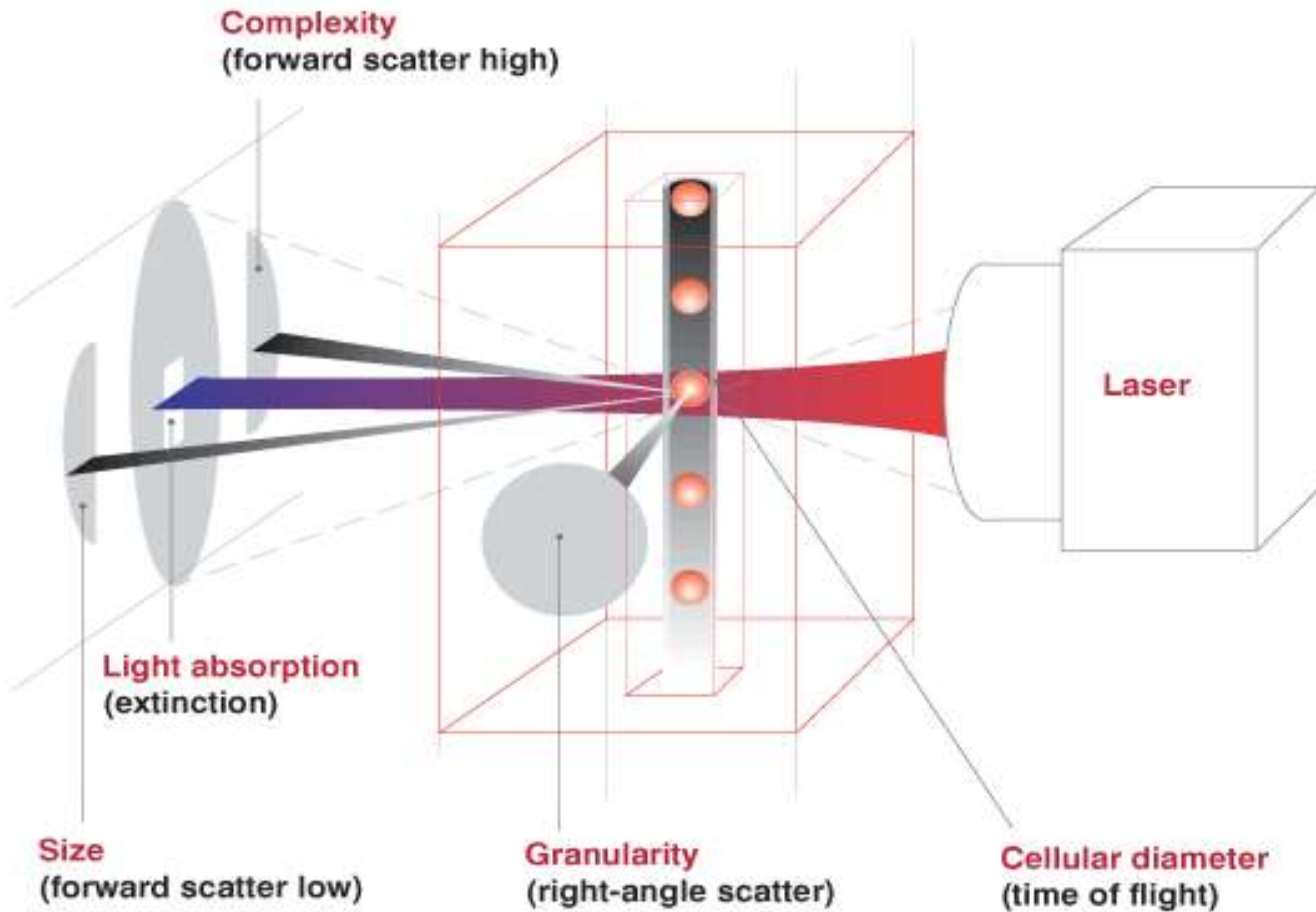
Amplitude = size of cell

Threshold setting



## 2. *Light scattering*

- ▶ A diluted cell suspension flows through an aperture in a single file in front of a light source and is scattered by the cells.
- ▶ The light scattered is measured by light sensitive detector
- ▶ Amount of light scattered is proportional to the–
  - 1– surface area of cell
  - 2– volume of cell



# Components of a cell counter

1. **Hydraulics**:– aspirating unit, dispensers, diluters, mixing chamber, aperture bath and hemoglobinometer
2. **Pneumatics**:– Vacuums and pressure for operating valves
3. **Electronics**:– Analyzer and computing circuit





# Parameters

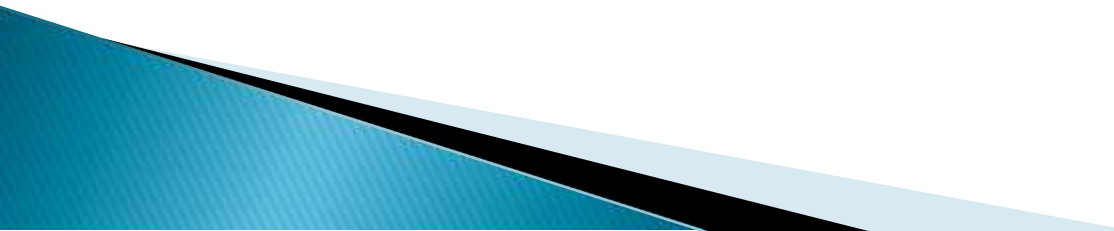
## ▶ Measured

- Red cell count (RBC),
- White cell count (WBC),
- Platelet count (Plt),
- Mean platelet volume (MPV),
- Hemoglobin concentration (Hb),
- Mean red cell volume (MCV).

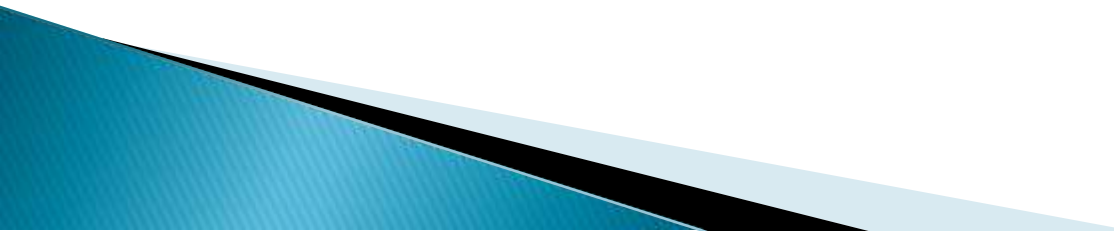
## Calculated:

- hematocrit (Hct),
- mean cell hemoglobin (MCH),
- mean cell hemoglobin concentration (MCHC),
- red cell distribution width (RDW)

# How Data Are Reported

- ▶ In most automated systems, the complete blood count is numerically reported..
  - ▶ The differential is numerically recorded and then graphically displayed
- 

# Flags

- ▶ Flags – warnings that need attention
    - indicate significant abnormality
    - varies with analyzers
  - ▶ Analyzer related
  - ▶ Sample related
  - ▶ Every instrument has its own flagging system
  - ▶ Peripheral blood smear review is mandatory
- 

# Flagging system

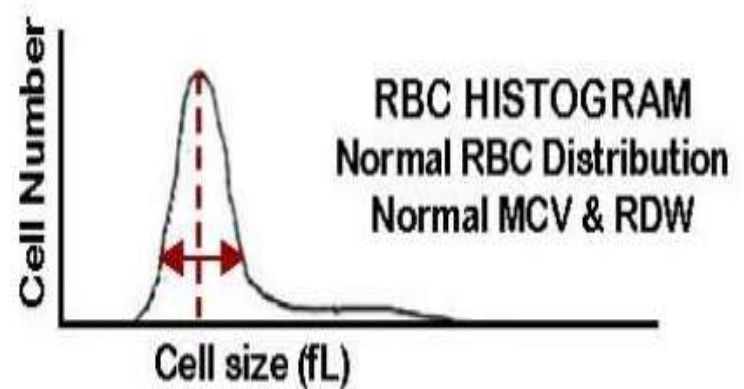
- @ Data is outside the linearity limits
- \* Data is doubtful
- + Or - data is outside the reference range limits
- ----- Data doesn't appear due to analysis error or abnormal sample
- + + + + Data exceeds display limit

# Rule of “3”

- ▶ Correlating Hemoglobin and Hematocrit Values
  - $Hb \times 3 = HCT$
  - Exception: hypochromic red cells. (HCT more than three times the hemoglobin)

# Red Cells Histogram

- Normal red cell histogram displays cells form (36–360 ) fl
- (24– 36 fl ) flag may be due
  - 1– RBCs fragments,
  - 2– WBC's fragments
  - 3– Giant plts
  - 4– Microcyte



# Red Cells Histogram

Shift to right :

- Macrocytic anemia
- Megaloblastic anemia

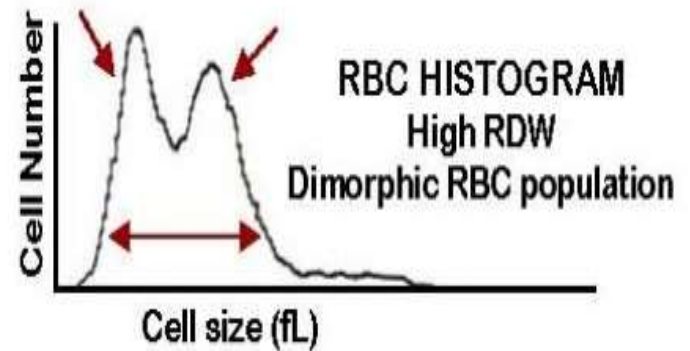
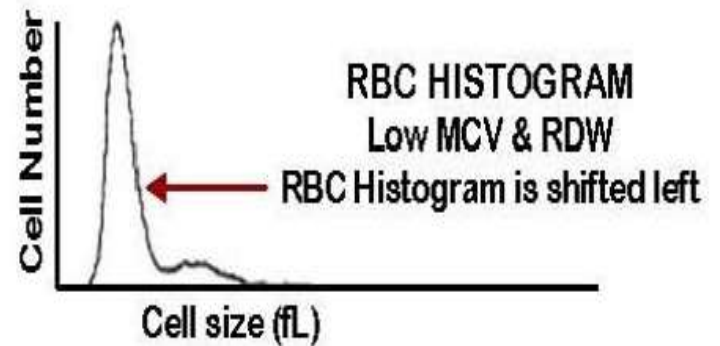
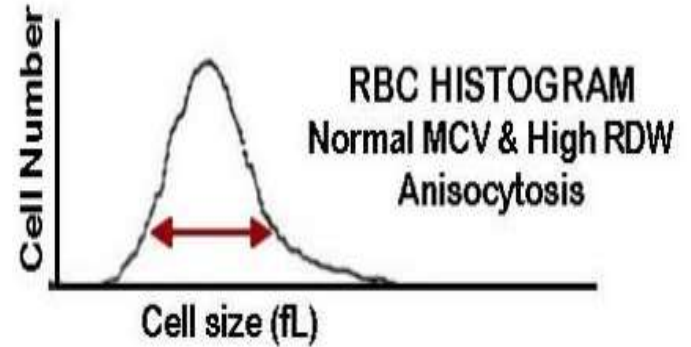
Shift to left :

- Microcytic anemia

Bimodal

- Cold agglutinin
- IDA, Megaloblastic anemia with transfusion.
- Sideroblastic anemia.

Abnormal RBC histograms:



# Platelets Histogram

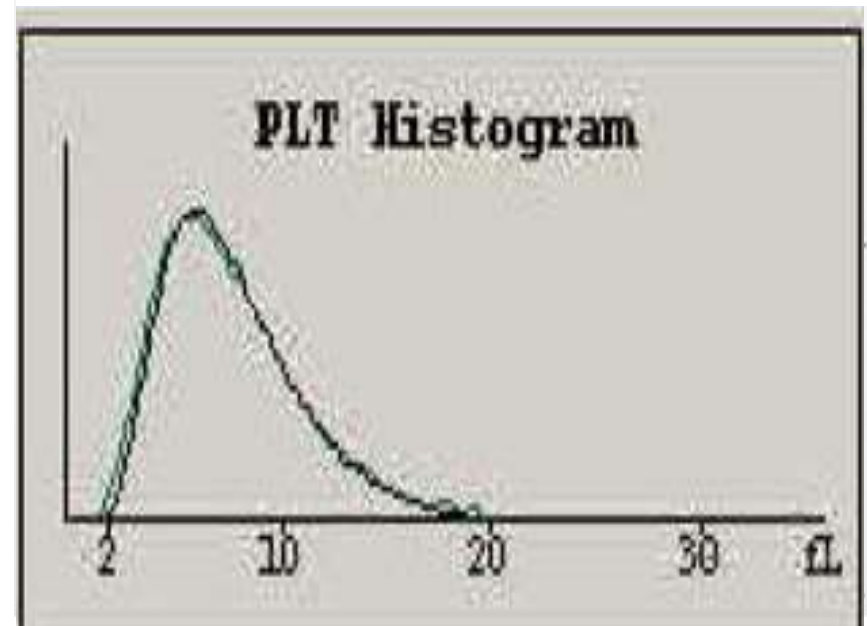
Normal platelet histogram displays cells from (2-20 fL).

▶ **(0-2)fL**

- Air Bubbles
- Dust
- Electronic noise






▶ **Over 20 fL**

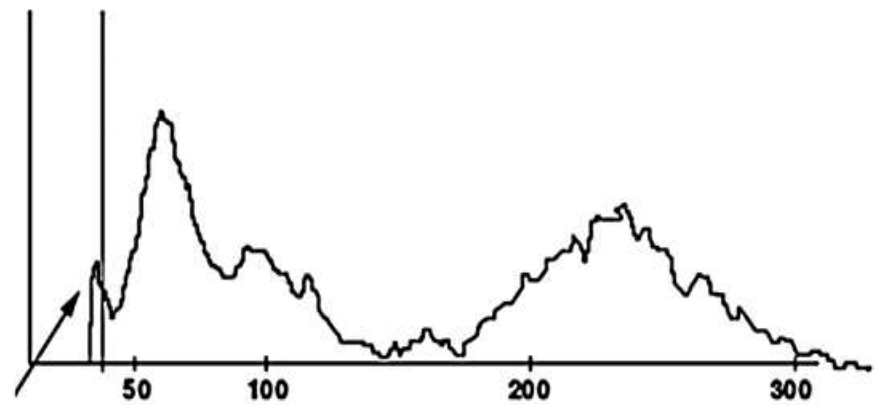
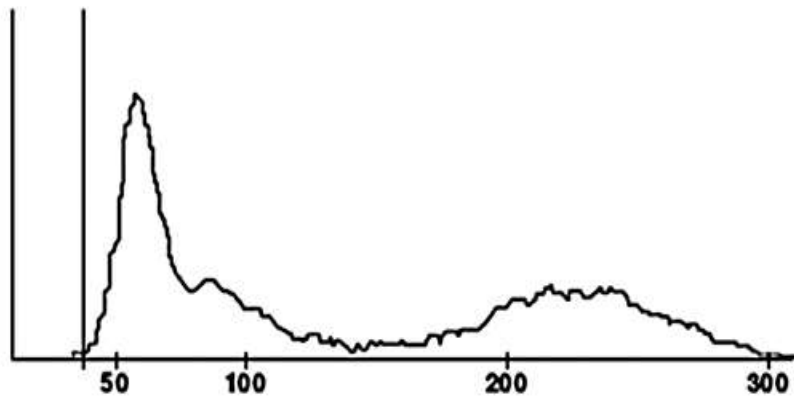
- Microcyte
- Scishtocyte
- WBC's fragments
- Giant Plts
- Clumped plts





# WBC differential count

WBC Subtype					
3-part	Granulocytes	Monocytes / Mid-Cells		Lymphocytes	
5-part	Neutrophils	Basophils	Monocytes	Eosinophil	Lymphocytes



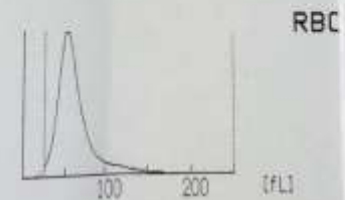
# Case 1

- ▶ RBC flags
  - H&H mismatch
  - Lower RBC indices
  - high RDW
- ▶ Platelet flags
  - PU flag- ? clumps

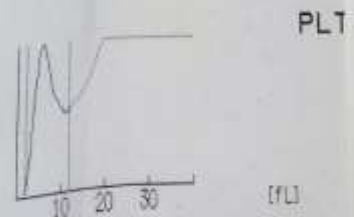
WBC  
RBC  $13.7 \times 10^9 / \mu\text{L}$   
HGB  $! 8.58 \times 10^6 / \mu\text{L}$   
HCT  $14.9 \text{ g/dL}$   
MCV  $+ 50.4\%$   
MCH  $- 58.7 \text{ fL}$   
MCHC  $- 17.4 \text{ pg}$   
PLT  $- 29.6 \text{ g/dL}$   
PU\*  $149 \times 10^3 / \mu\text{L}$



LYM%  $17.5\%$   
MXD%  $5.6\%$   
NEUT%  $76.9\%$   
LYM#  $2.4 \times 10^3 / \mu\text{L}$   
MXD#  $0.8 \times 10^3 / \mu\text{L}$   
NEUT#  $10.5 \times 10^3 / \mu\text{L}$

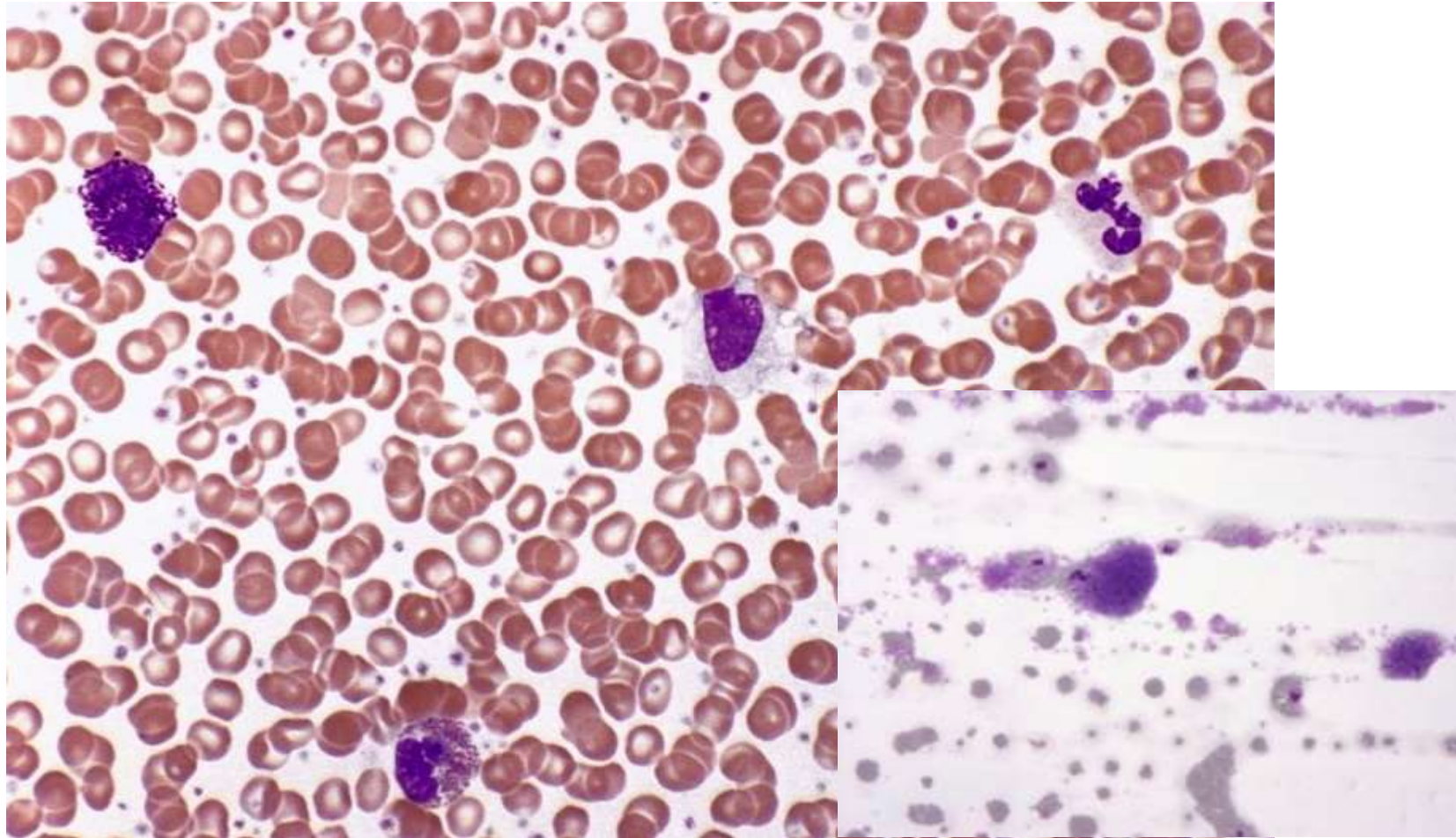


RDW  $+ 22.8\%$



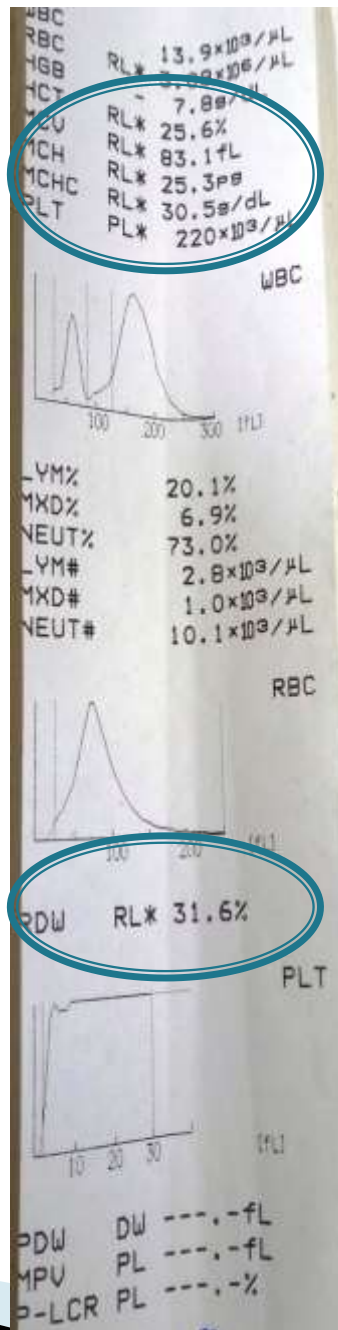
PDW DW ---, -fL  
MPV PU ---, -fL  
P-LCR PU ---, -%

# Myeloproliferative neoplasm – ?Polycythemia vera



# Case 2

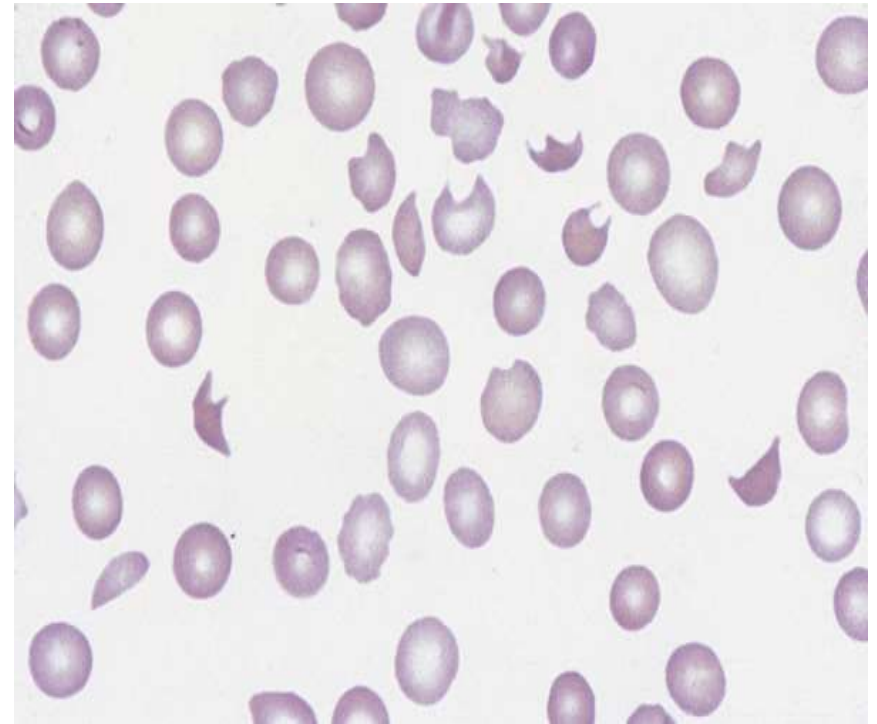
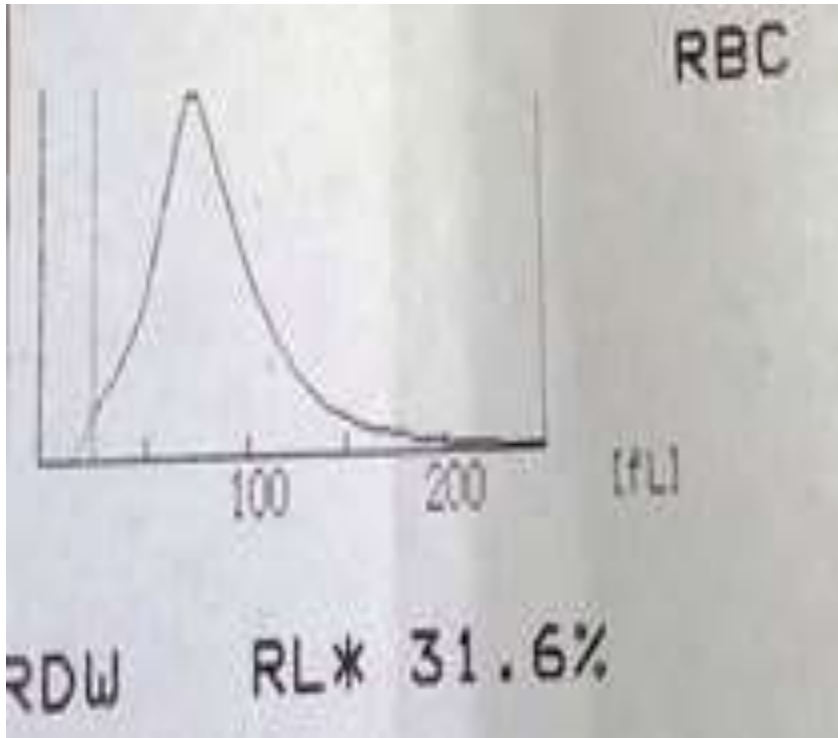
- RBC flags
  - anemia+
  - Lower RBC indices
  - Very high RDW
  - ?schistocytes



- Platelet flags
  - PL

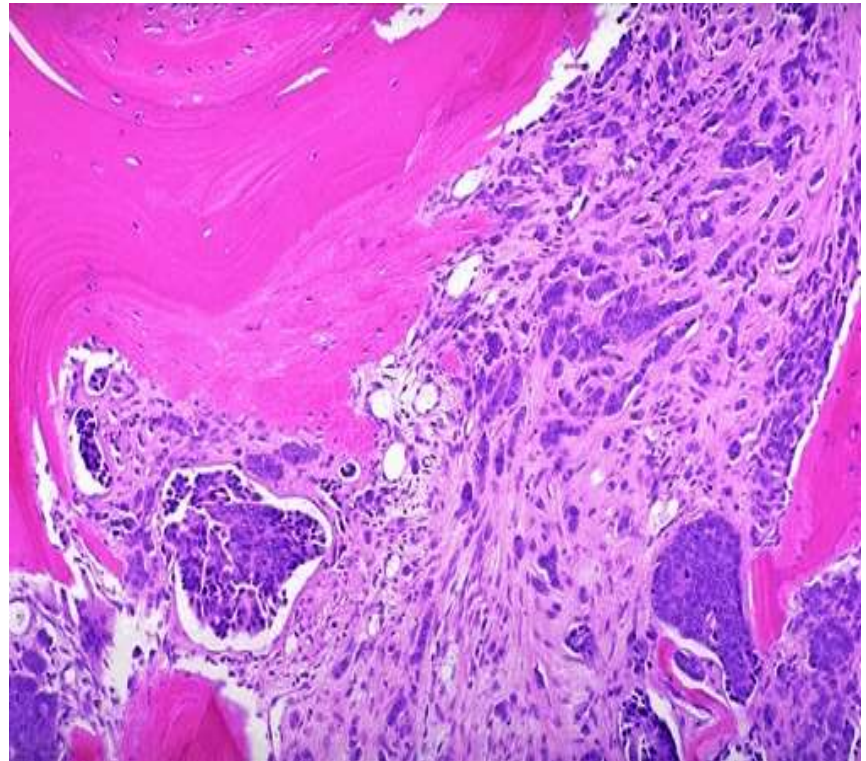


# Case 2

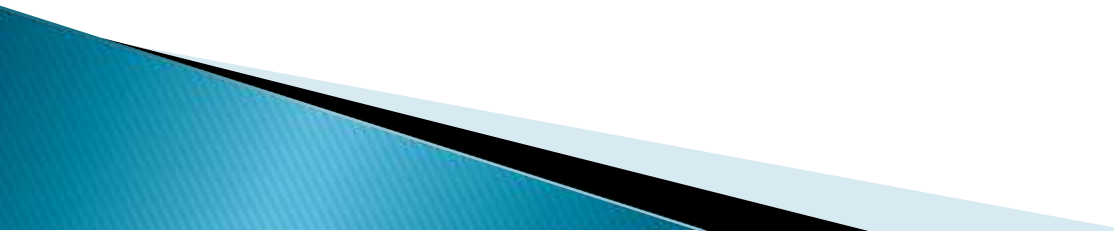


# Additional tests

- ▶ Bone marrow examination
- ▶ Metastatic disease



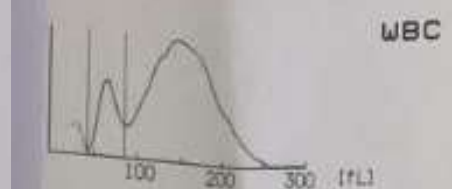
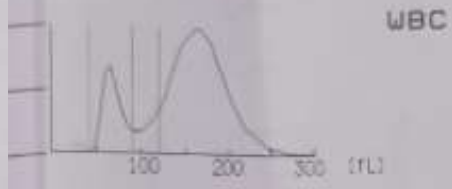
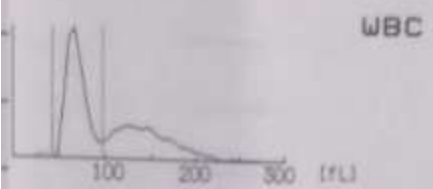
# Take home messages

- ▶ Peripheral smear review is a must.
  - ▶ Rule of “3” is to be checked
  - ▶ Histograms and flags to be correlated.
  - ▶ Advice for bone marrow examination.
- 

BC	
BC	4.4x10 <sup>9</sup> /μL
GB	4.89x10 <sup>6</sup> /μL
CT	13.3g/dL
CV	37.9%
CH	- 77.5fL
CHC	27.2ps
CHC	35.1g/dL
LT	287x10 <sup>9</sup> /μL

BC	
BC	12.0x10 <sup>9</sup> /μL
GB	3.20x10 <sup>6</sup> /μL
CT	12.6g/dL
CV	35.6%
CH	+111.3fL
CHC	+ 39.4ps
CHC	35.4g/dL
LT	233x10 <sup>9</sup> /μL

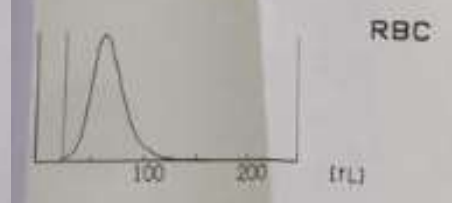
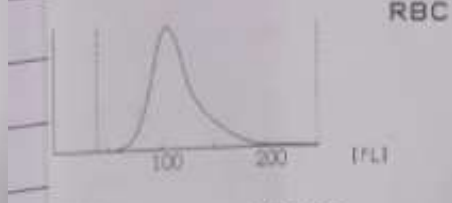
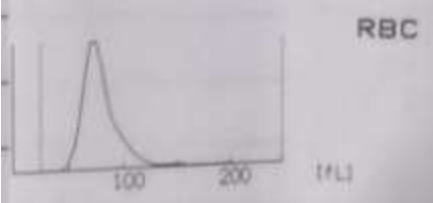
BC	
BC	6.4x10 <sup>9</sup> /μL
GB	2.68x10 <sup>6</sup> /μL
CT	- 5.4g/dL
CV	- 17.8%
CH	- 66.4fL
CHC	- 20.1ps
CHC	- 30.3g/dL
LT	+ 402x10 <sup>9</sup> /μL



YM%	52.5%
XD%	T2 ---, -%
EUT%	T2 ---, -%
YM#	2.3x10 <sup>3</sup> /μL
XD#	T2 ---, -x10 <sup>3</sup> /μL
EUT#	T2 ---, -x10 <sup>3</sup> /μL

YM%	17.4%
XD%	7.2%
EUT%	75.4%
YM#	2.1x10 <sup>3</sup> /μL
XD#	0.9x10 <sup>3</sup> /μL
EUT#	9.0x10 <sup>3</sup> /μL

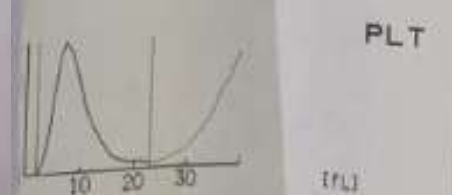
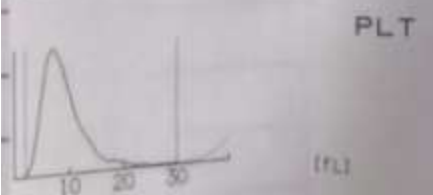
YM%	14.3%
XD%	T2 ---, -%
EUT%	T2 ---, -%
YM#	0.9x10 <sup>3</sup> /μL
XD#	T2 ---, -x10 <sup>3</sup> /μL
EUT#	T2 ---, -x10 <sup>3</sup> /μL



DW 11.9%

DW 13.6%

DW + 17.3%

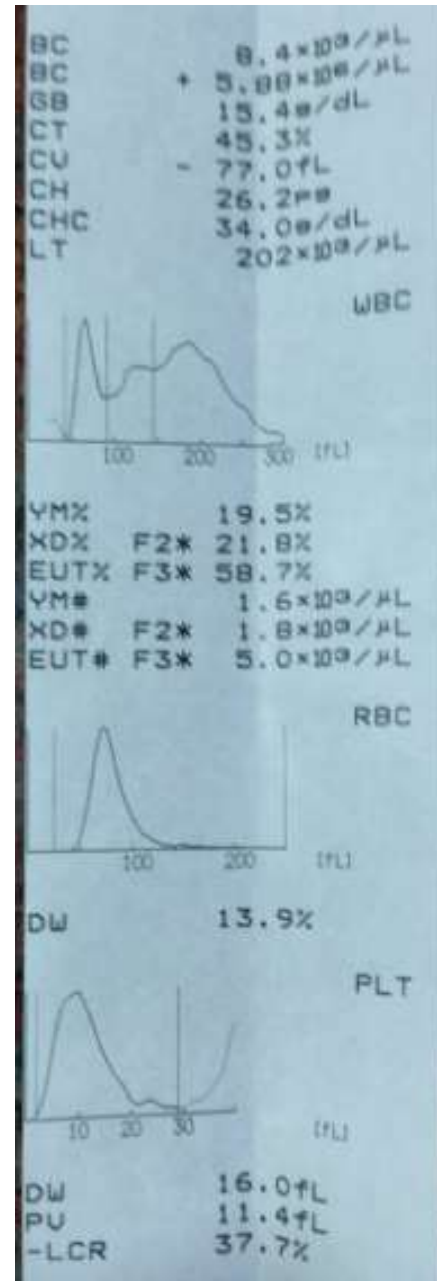
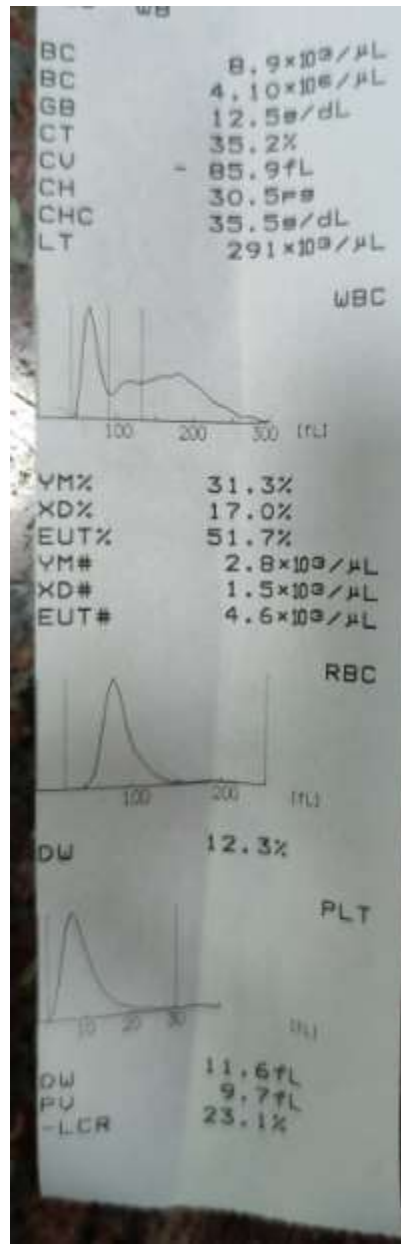


DW	11.1fL
PU	9.4fL
-LCR	20.0%

DW	11.3fL
PU	9.5fL
-LCR	22.1%

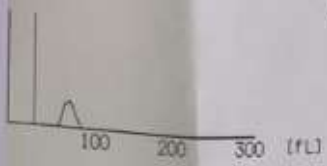
DW	11.1fL
PU	9.2fL
-LCR	19.9%





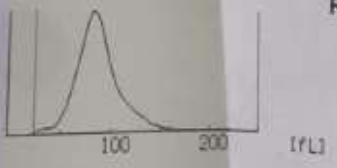
BC 0.7x10<sup>9</sup>/μL  
 BC 3.36x10<sup>6</sup>/μL  
 GB 10.3g/dL  
 CT 28.7%  
 CV - 85.4fL  
 CH 30.7ps  
 CHC 35.9g/dL  
 LT PU\* 27x10<sup>9</sup>/μL

WBC



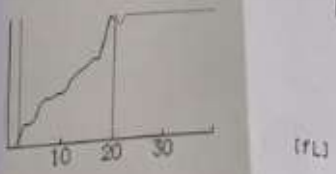
YM% ----.-%  
 XD% ----.-%  
 EUT% ----.-%  
 YM# ----.-x10<sup>9</sup>/μL  
 XD# ----.-x10<sup>9</sup>/μL  
 EUT# ----.-x10<sup>9</sup>/μL

RBC



DW + 18.6%

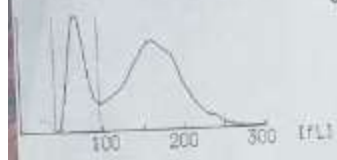
PLT



DW DW ----.-fL  
 IPU PU ----.-fL  
 -LCR PU ----.-%

BC + 17.3x10<sup>9</sup>/μL  
 BC 4.95x10<sup>6</sup>/μL  
 GB + 17.7g/dL  
 CT 49.3%  
 CV 99.6fL  
 CH 35.8ps  
 CHC 35.9g/dL  
 LT AG 196x10<sup>9</sup>/μL

WBC



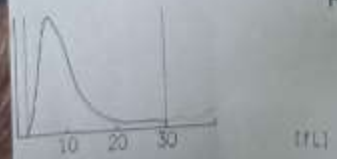
YM% 29.2%  
 XD% T2 ----.-%  
 EUT% T2 ----.-%  
 YM# 5.1x10<sup>9</sup>/μL  
 XD# T2 ----.-x10<sup>9</sup>/μL  
 EUT# T2 ----.-x10<sup>9</sup>/μL

RBC



DW + 18.6%

PLT



DW 12.2fL  
 IPU 10.2fL  
 -LCR 25.7%

# THANK YOU

