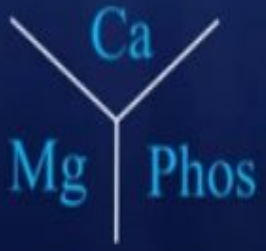
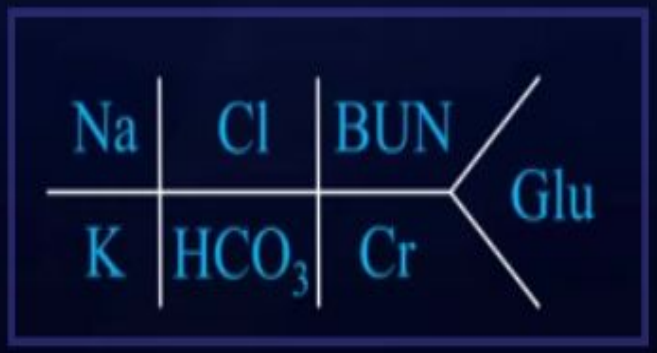
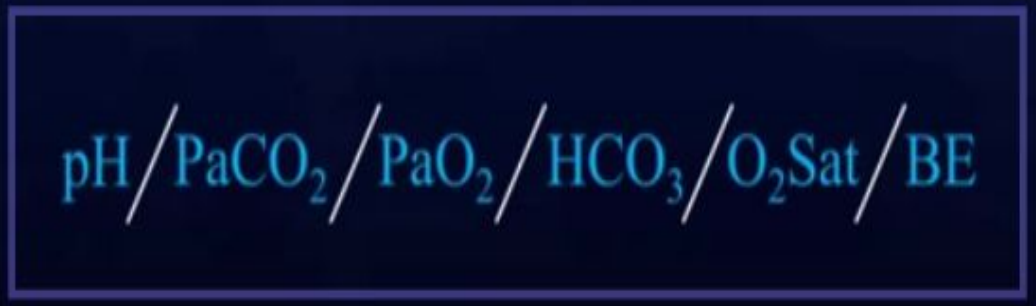
LABORATORY FISHBONES

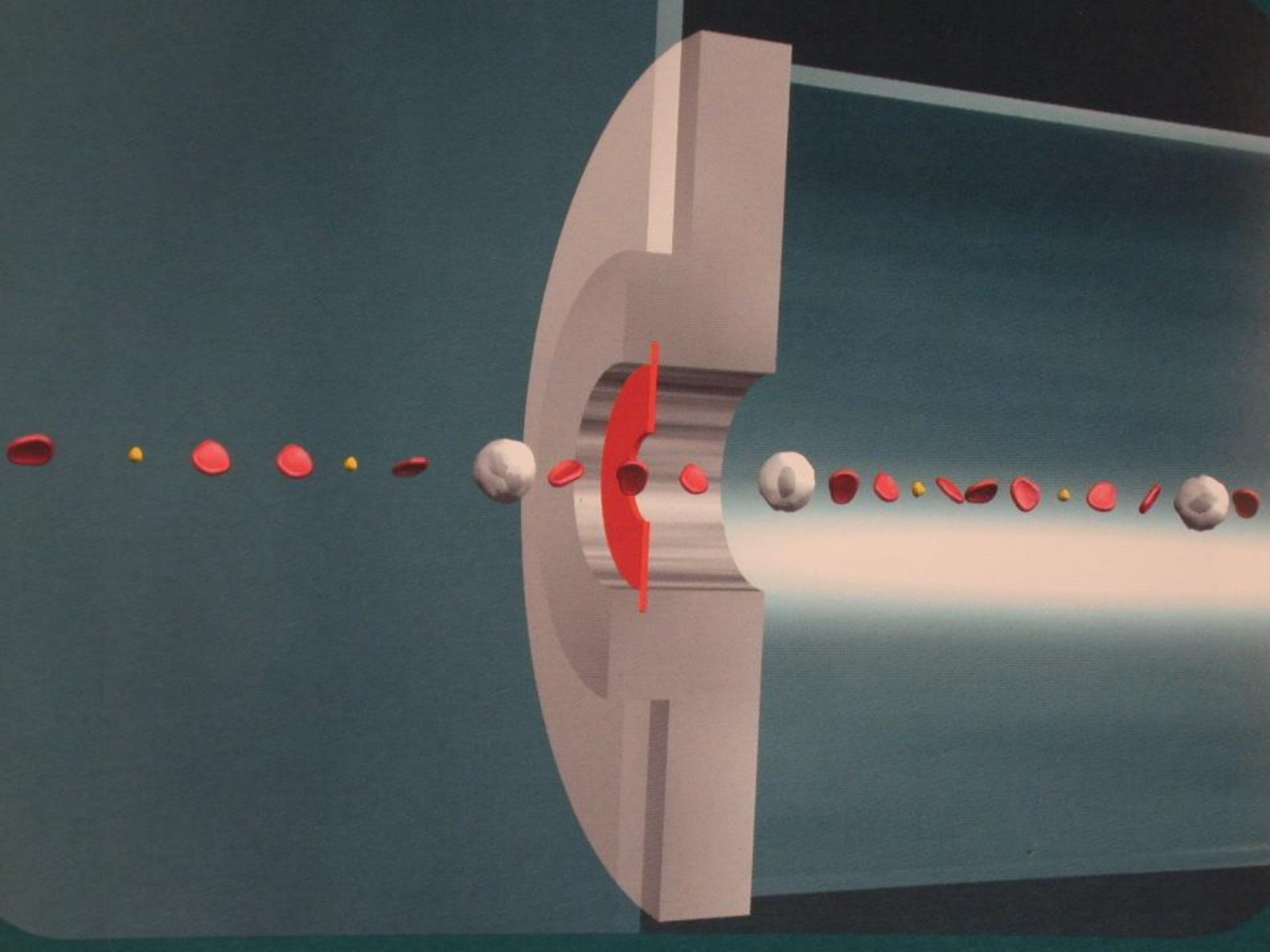


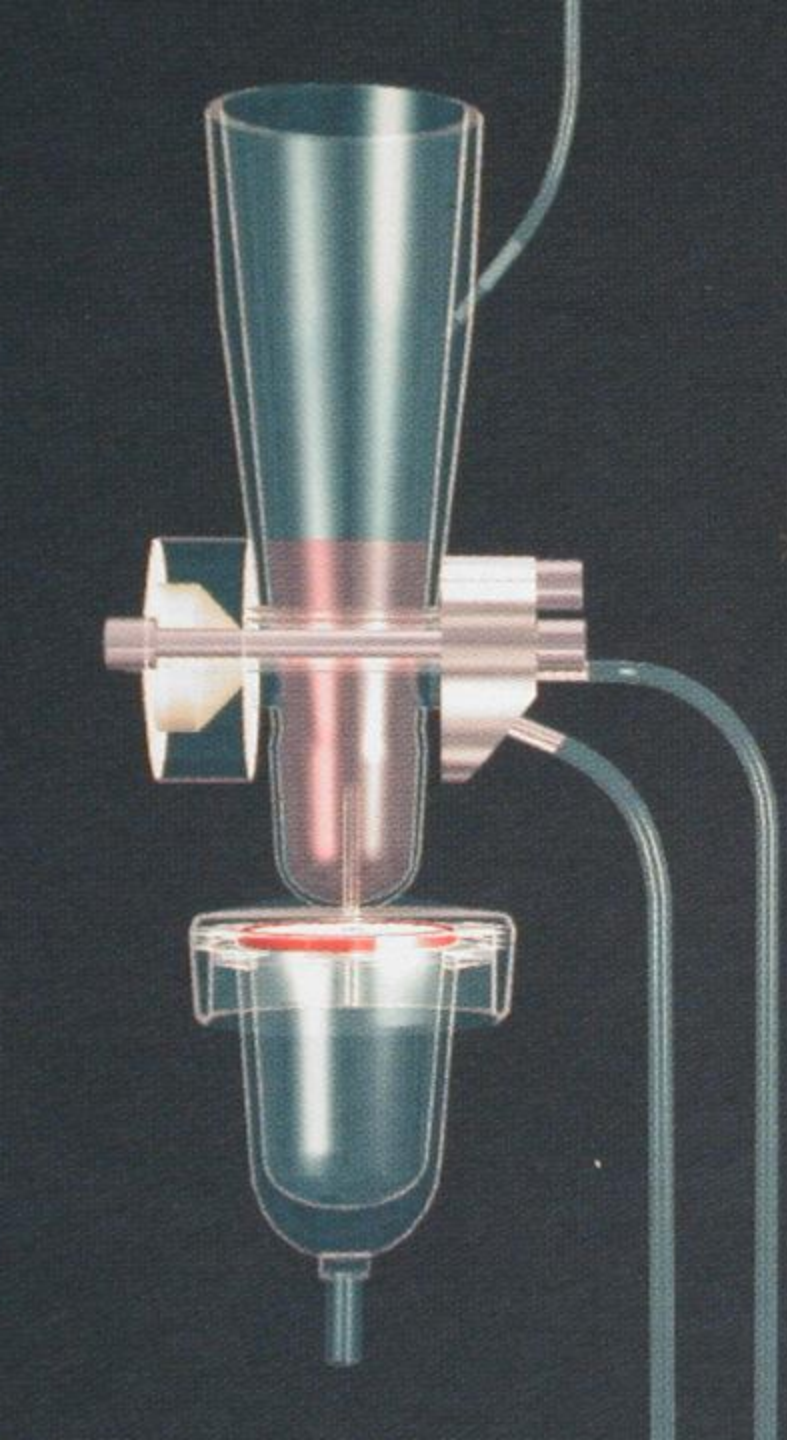


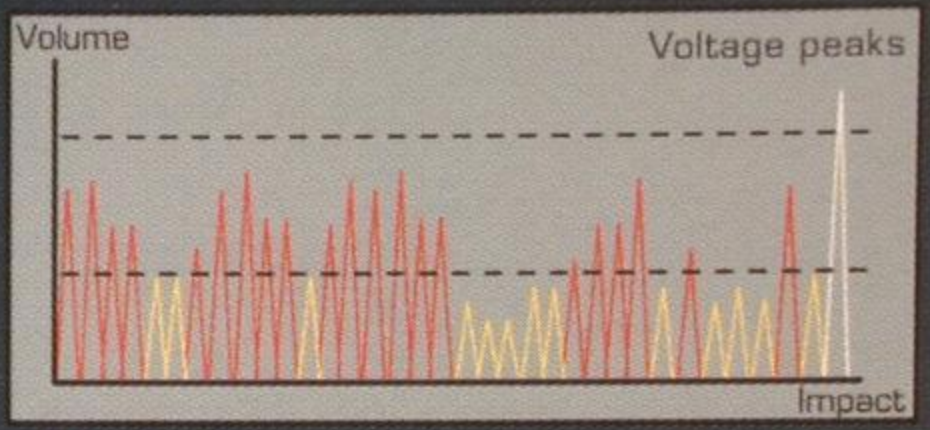


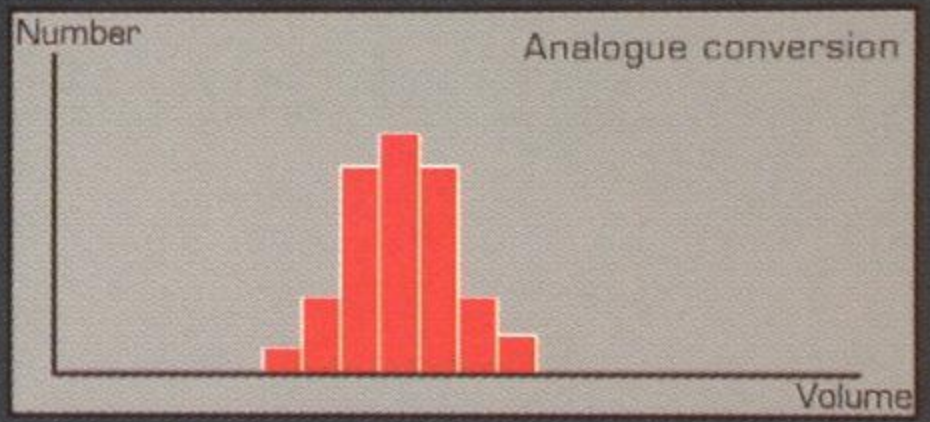
CBC: OVERVIEW

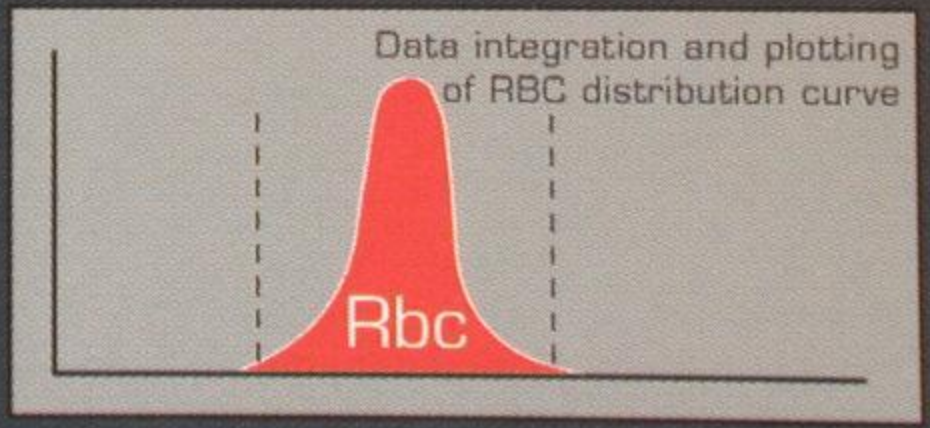
CBC W/Auto Diff	28Jul2014 0814			
	Sample		Units	Ref Rng
WBC	BLOOD	4.6	x10^3/mcL	(4.6-11.0)
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)
RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)
Platelets	BLOOD	264	x10^3/mcL	(130-400)
MPV	BLOOD	8.2	fL	(7.0-11.0)

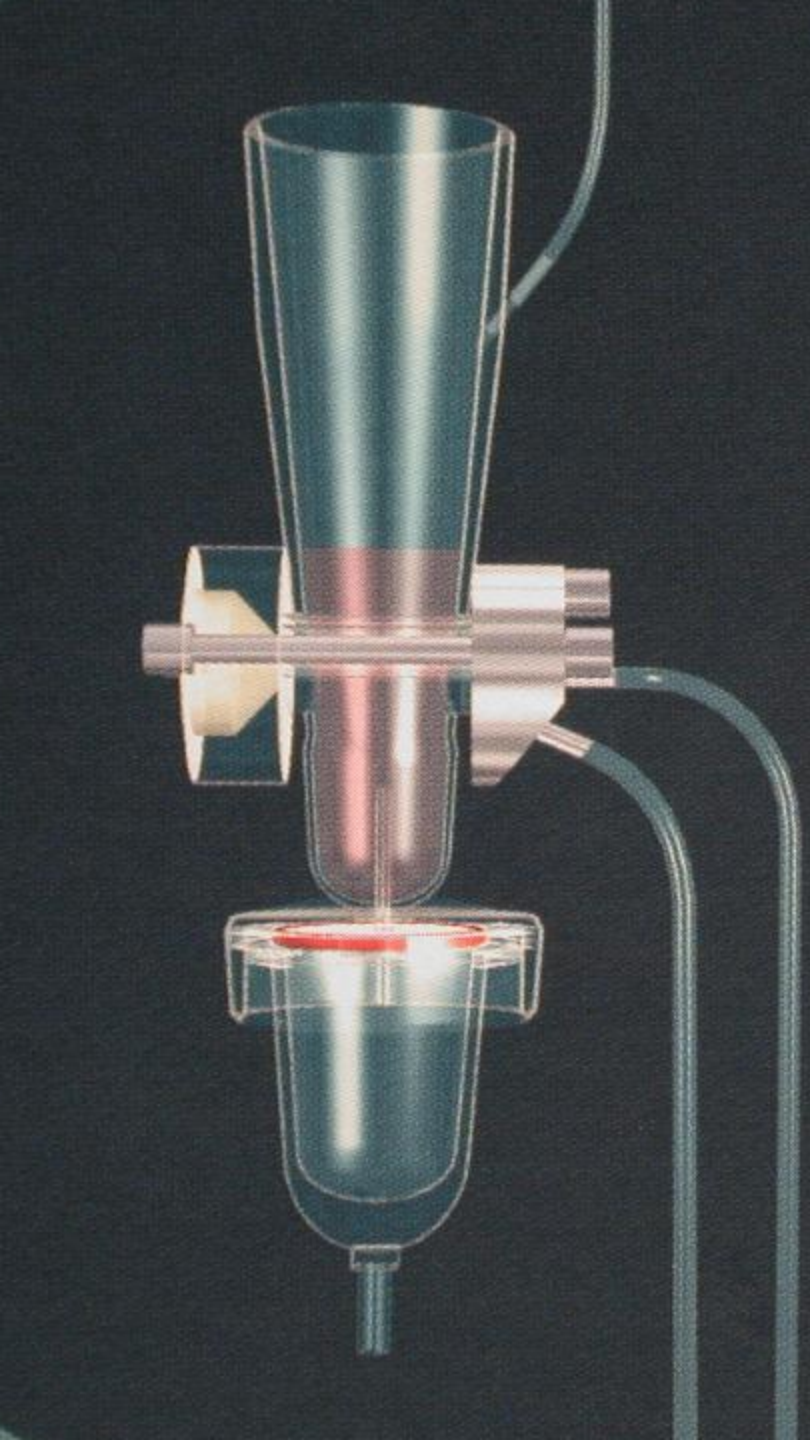


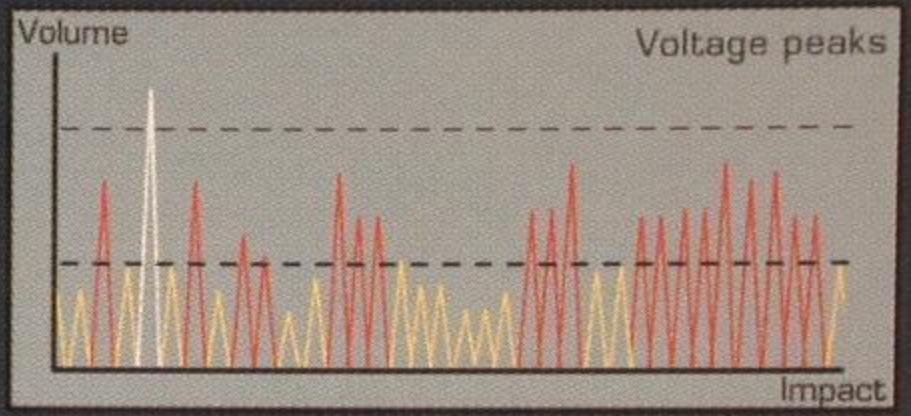


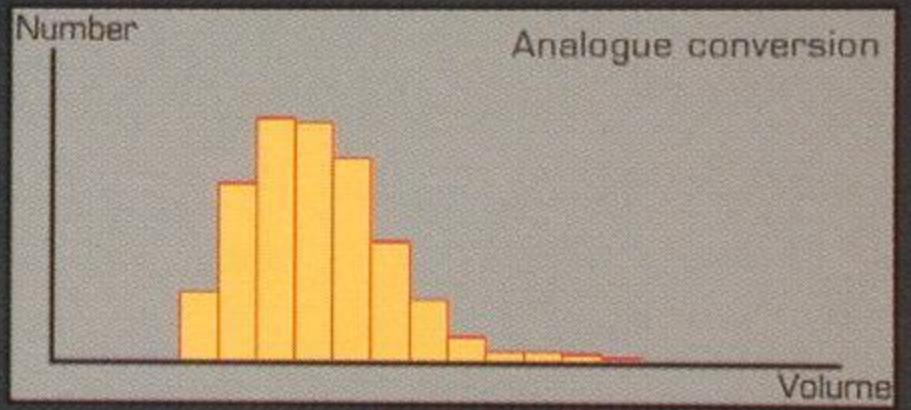

Volume
Voltage peaks
Impact

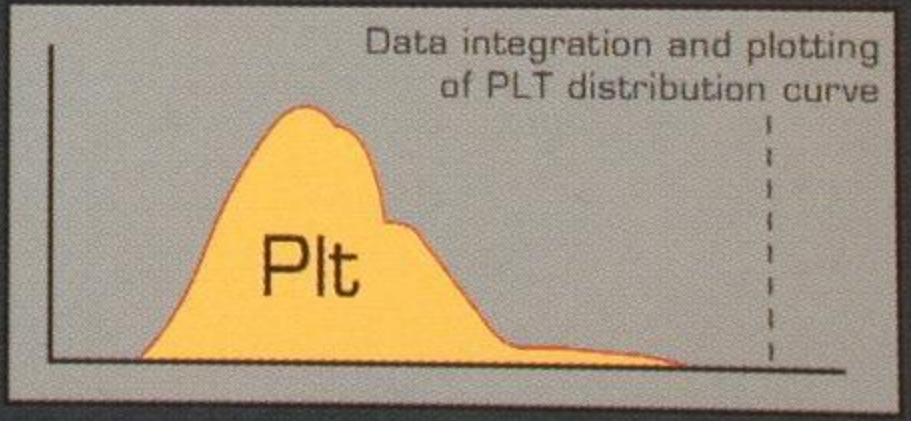

Number
Analogue conversion
Volume

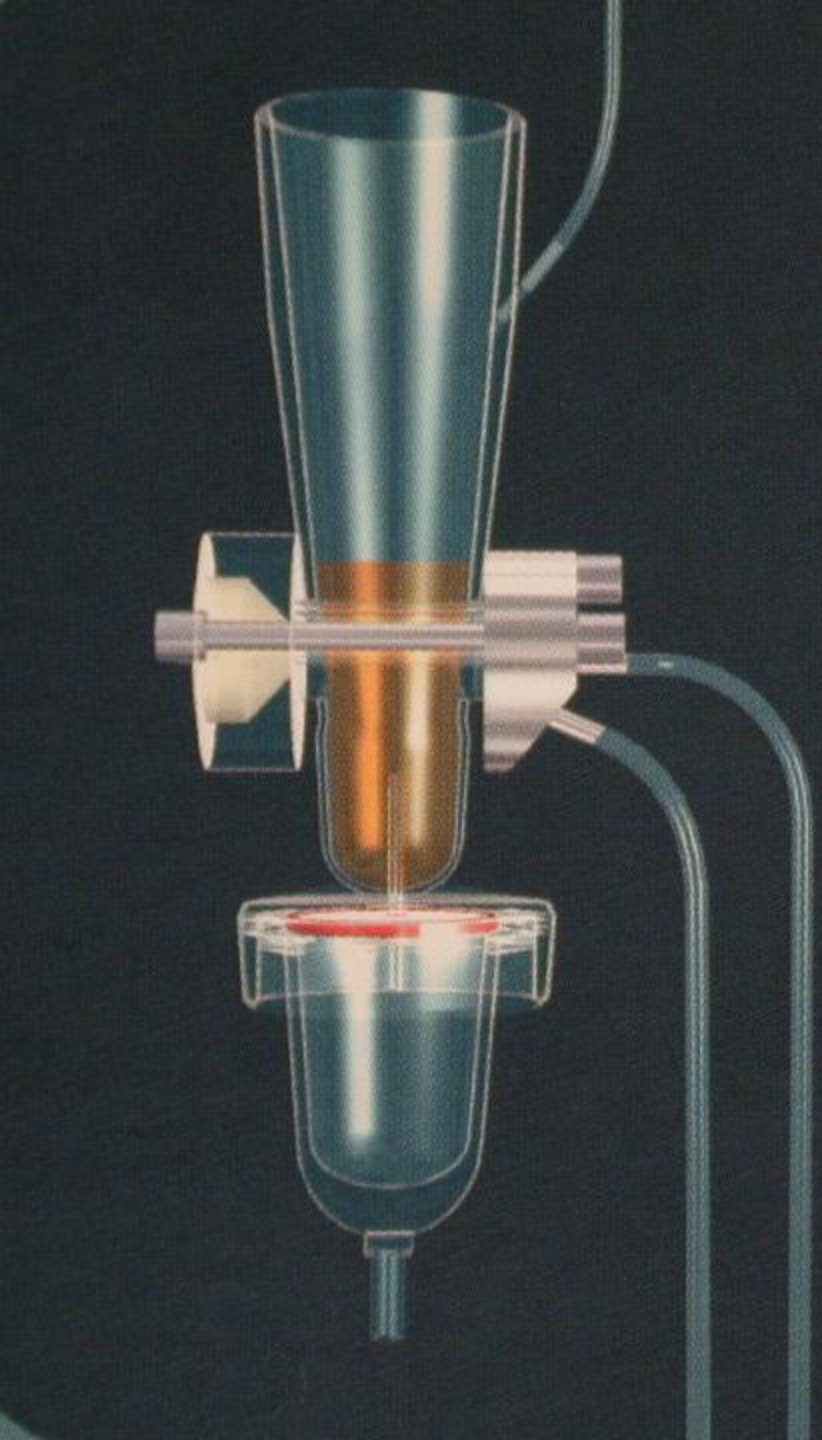

Data integration and plotting
of RBC distribution curve
Rbc

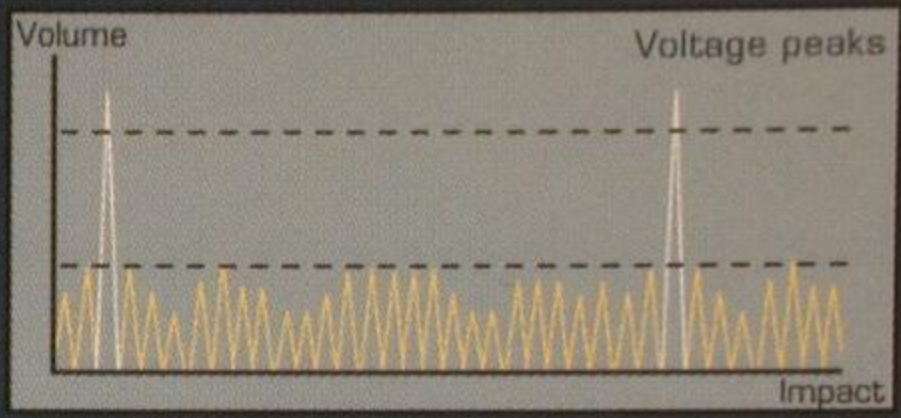


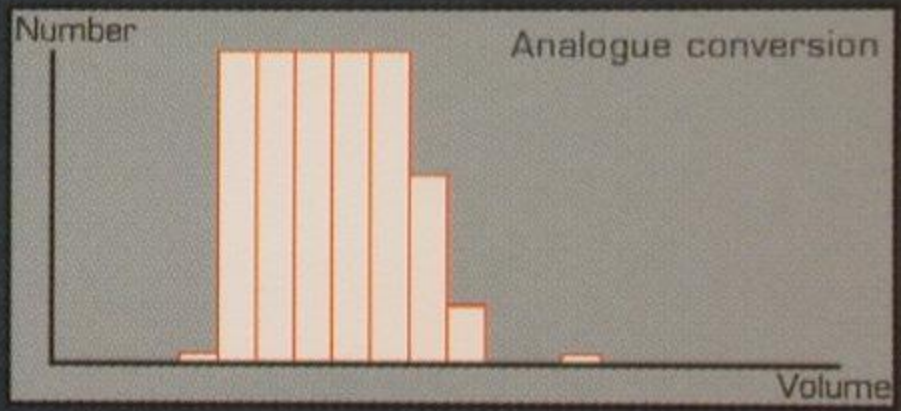

Volume
Voltage peaks
Impact

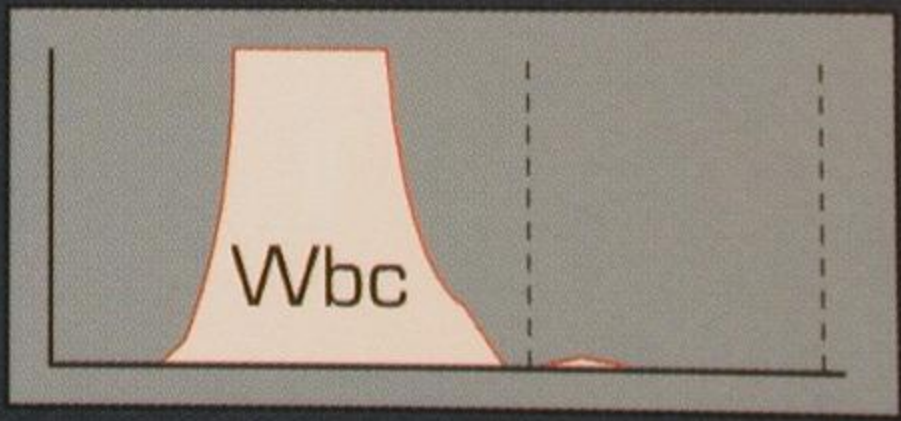

Number
Analogue conversion
Volume


Data integration and plotting
of PLT distribution curve
Plt




Volume
Voltage peaks
Impact

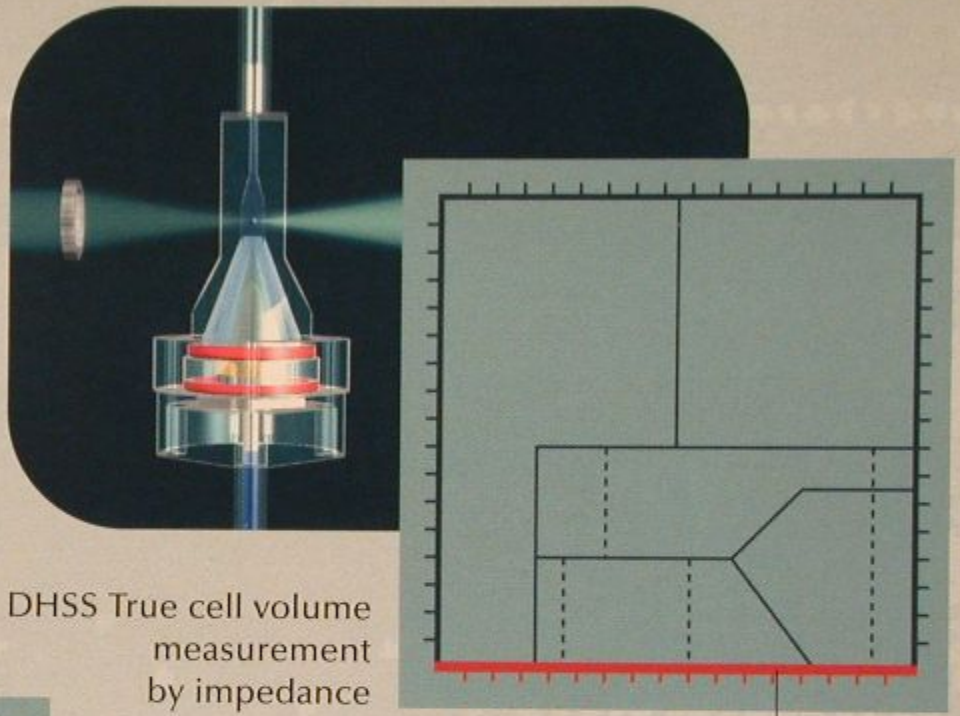

Number
Analogue conversion
Volume


Wbc

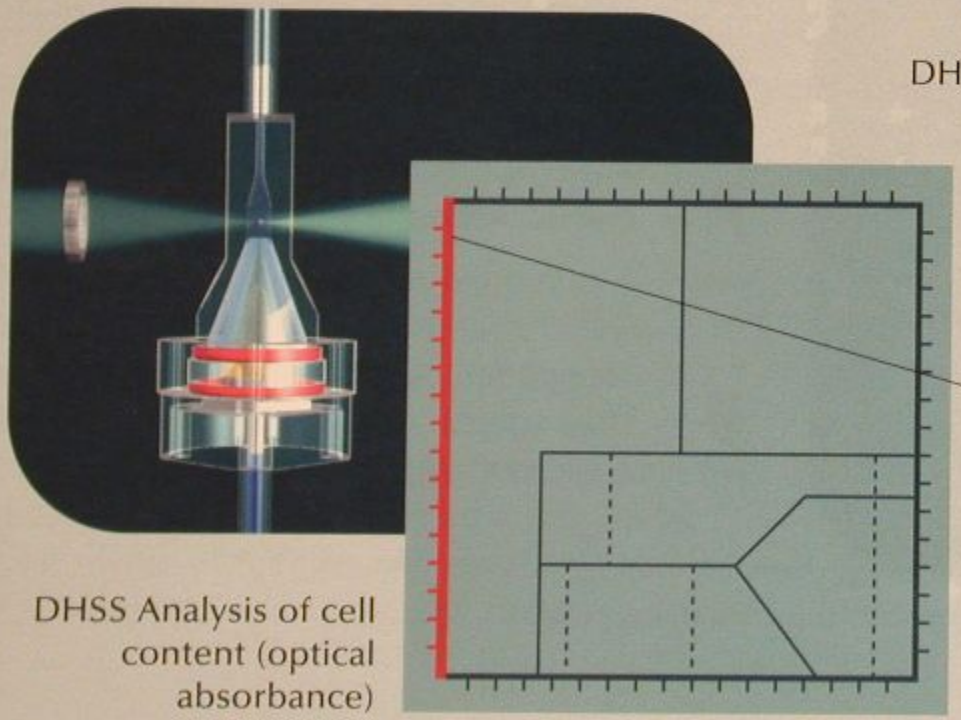
Focused Flow Impedance

Measurement of the true cellular volume by impedancemetry after incubation with stabilizing reagent.

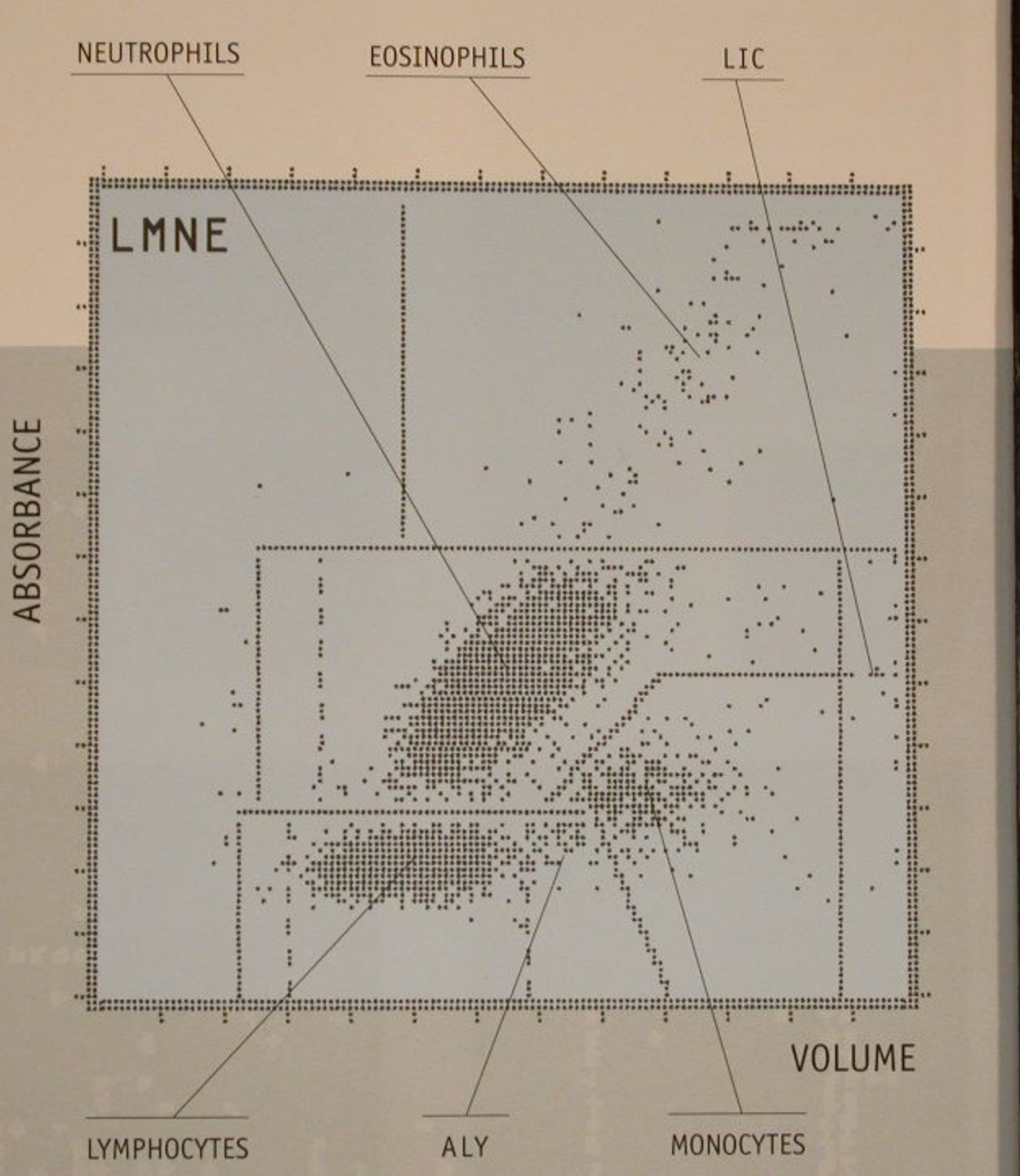
Analysis of the internal structure by measuring the cellular absorbance of light.



DHSS True cell volume measurement by impedance



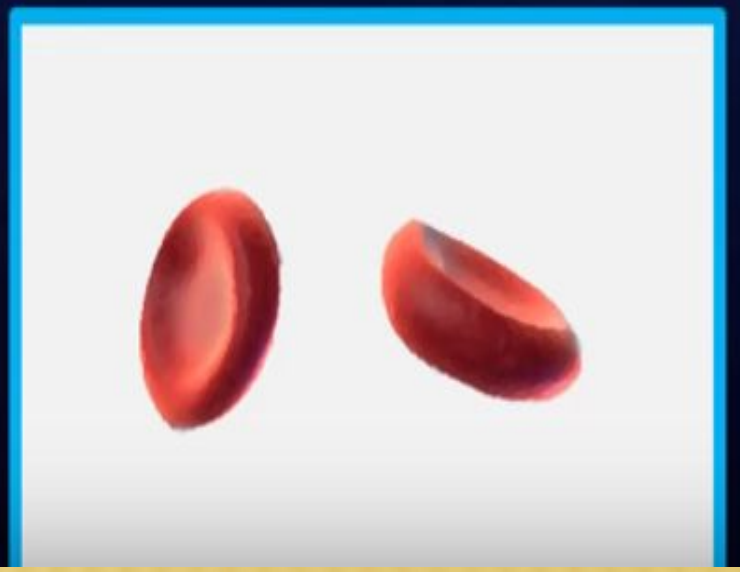
DHSS Analysis of cell content (optical absorbance)


NEUTROPHILS
EOSINOPHILS
LIC
LMNE
ABSORBANCE
VOLUME
LYMPHOCYTES
ALY
MONOCYTES

RBC

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

- Most abundant cell in blood
- Involved in O2 & CO2 transportation
- Cell membrane, filled with Hemoglobin
- No nucleus
- Shape = Biconcave disc

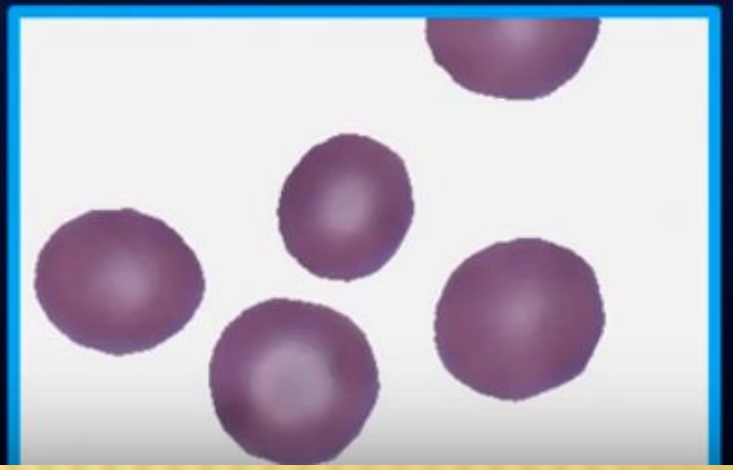


RBC II

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

Polycythemia (↑)
- Polycythemia vera
- High altitude
- Congenital heart disease
- COPD

Anemia (↓)
- Aplastic anemia
- Chronic renal failure
- Iron deficiency
- Pernicious anemia
- Pregnancy



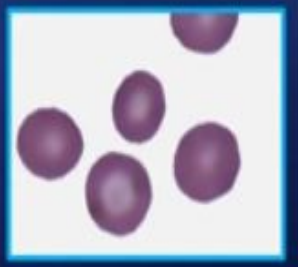
HEMOGLOBIN

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

- Oxygen-transport
- Abbreviated "Hgb"
- >95% of the dry weight of RBCs
- Quaternary structure
  - 4 Globular Proteins
    - Heme group
      - Fe^{++}

HEMOGLOBIN II

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)



Polycythemia (↑)

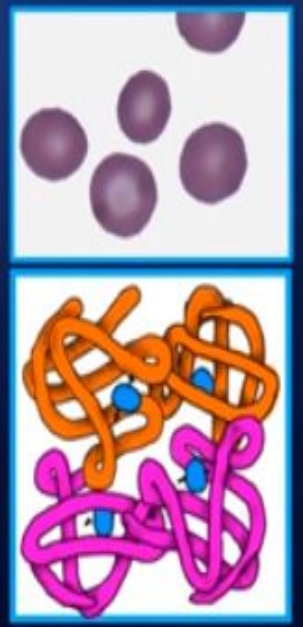
- Polycythemia vera
- High altitude
- Congenital heart disease
- COPD

Anemia (↓)

- Aplastic anemia
- Chronic renal failure
- Iron deficiency
- Pernicious anemia

HEMATOCRIT

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)



- AKA: Packed cell volume (PCV)
- Abbreviated "Hct"
- Volume % of RBCs in blood
- Historically measured by centrifugation of whole blood

MCV

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

- Mean Corpuscular Volume
- Average volume of the red blood cells

45.2 / 4.89 = 9.24

MCV II

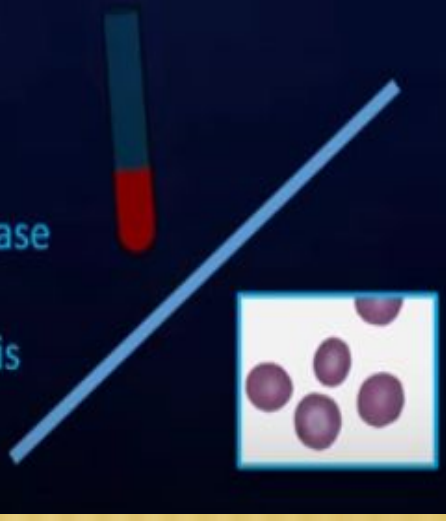
RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

Macrocytosis (↑)

- Reticulocytosis
- Folate deficiency
- B12 deficiency
- Methotrexate
- Phenytoin

Microcytosis (↓)

- Iron deficiency
- Thalassemia
- Anemia of Chronic Disease
- Hemolytic Anemia
- Hereditary spherocytosis
- Lead poisoning



MCH

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

- Mean Corpuscular Hemoglobin
- Average mass of hemoglobin per RBC

14.7 / 4.89 = 3.02

MCH II

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

MCH (↑)

- Alcoholism
- Folate deficiency
- B12 deficiency
- Liver disease
- Hemochromatosis

MCH (↓)

- Sideroblastic anemia
- Lead poisoning
- Iron deficiency anemia
- Anemia of Chronic Disease
- Thalassemia

MCHC

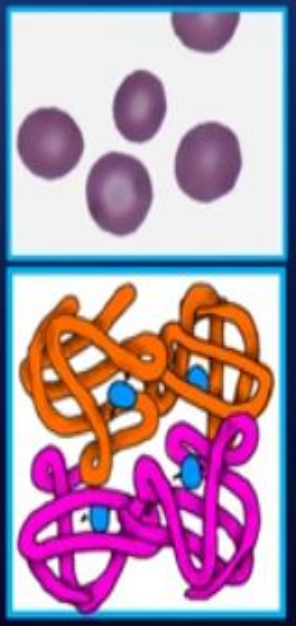
RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

- Mean Corpuscular Hemoglobin Concentration
- Concentration of Hgb in a given volume of RBCs

14.7 / 45.2 ≈ 0.326

MCHC II

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)



Hyperchromic (↑)

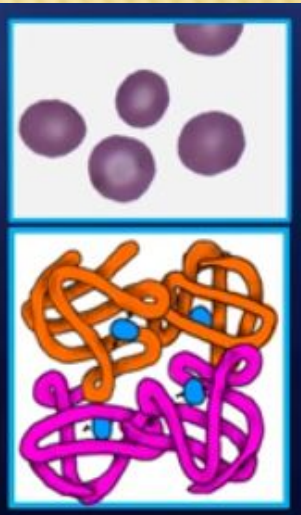
- Hereditary spherocytosis
- Hemolysis
- Sickle cell disease

Hypochromic (↓)

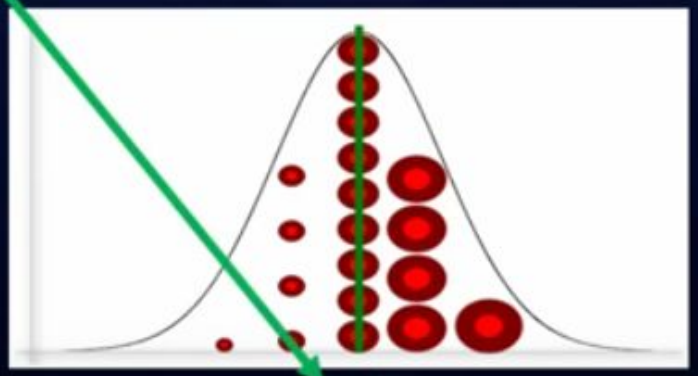
- Sideroblastic anemia
- Lead poisoning
- Iron deficiency anemia
- Anemia of Chronic Disease
- Thalassemia

RDW

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

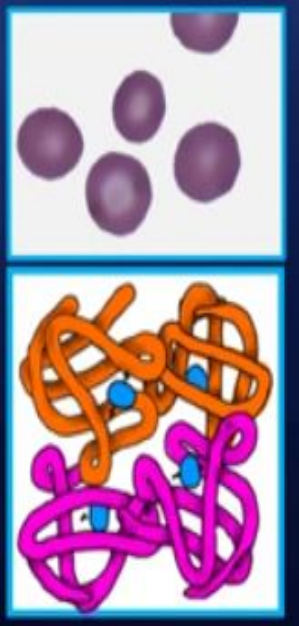


- Red Cell Distribution Width (RDW)
  - RDW CV
  - RDW SD
- A measurement of ***variation*** in RBC size or volume.

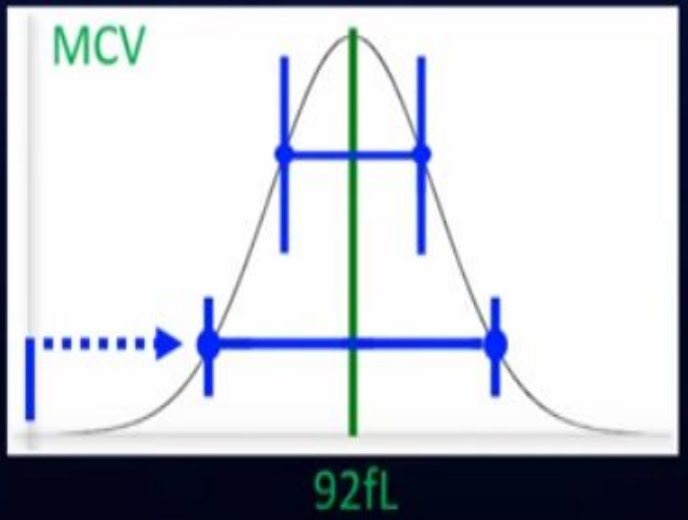


RDW II

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)



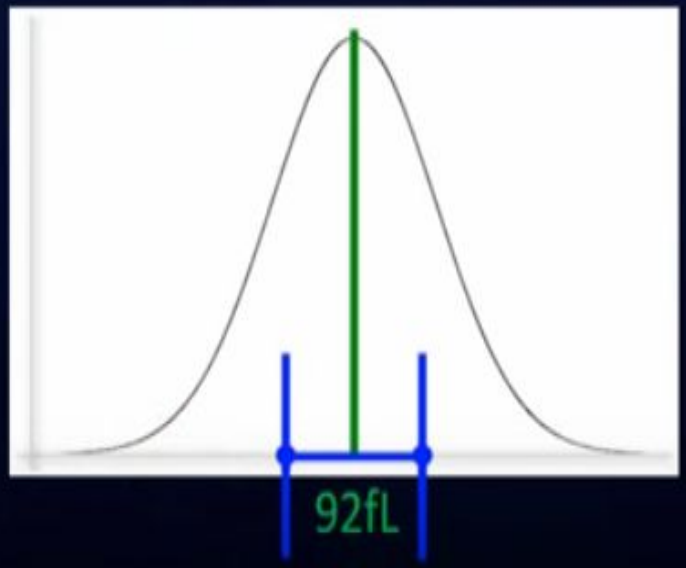
- Red Cell Distribution Width (RDW)
  - RDW CV
  - RDW SD
- A measurement of ***variation*** in RBC size or volume.



RDW III

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

$$\text{RDW CV} = \frac{10.6\text{fL}}{92\text{fL}} * 100\% = 11.5\ \%$$



RDW IV

RBC	BLOOD	4.89	x10^6/mcL	(4.70-6.10)
Hemoglobin	BLOOD	14.7	g/dL	(14.0-18.0)
Hematocrit	BLOOD	45.2	%	(42.4-48.8)
MCV	BLOOD	92	fL	(77-102)
MCH	BLOOD	30.2	pg	(27-32)
MCHC	BLOOD	32.6	g/dL	(32-36)
RDW CV	BLOOD	11.5	%	(10.0-15.0)

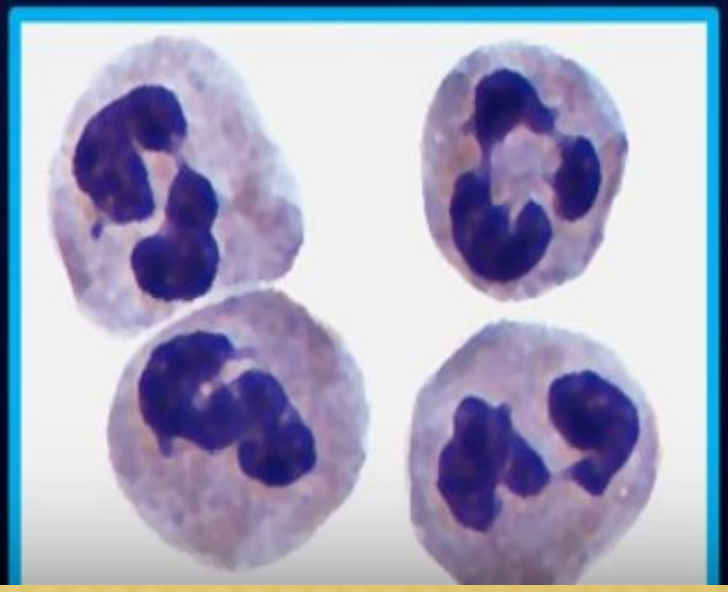
Anisocytosis

- Vitamin B12 Deficiency
- Folate Deficiency
- Iron Deficiency
- Hemolytic Anemia
- RBC fragmentation
- Liver disease

WHITE BLOOD CELLS

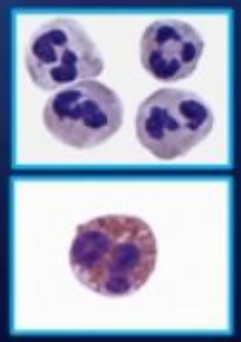
WBC	BLOOD	4.6	x10^3/mcL	(4.6-11.0)
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)

- Polymorphonuclear cells, (PMNs)



WBC: EOSINOPHIL GRANULOCYTES

WBC	**BLOOD**	**4.6**	**x10^3/mcL**	**(4.6-11.0)**
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)



Eosinophilia (↑)

- Allergies
- Parasitic infections
- Leukemia
- Polyarteritis nodosa
- Autoimmune disease

Eosinopenia (↓)

- Nutritional deficiency
- Glucocorticoids

WBC: NEUTROPHIL GRANULOCYTES

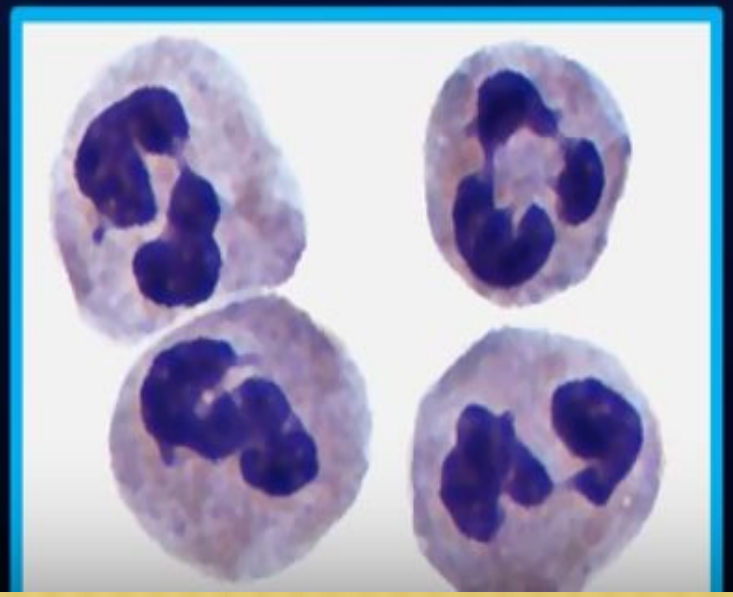
WBC	**BLOOD**	**4.6**	**x10^3/mcL**	**(4.6-11.0)**
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)

Neutrophilia (↑)

- Acute bacterial infection
- Acute stress
- Burns
- Leukemia
- Steroid use
- Rheumatoid arthritis

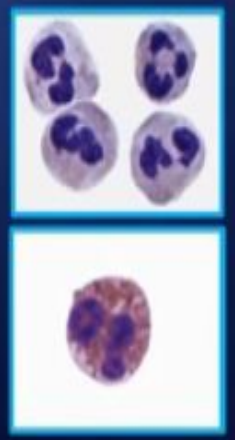
Neutropenia (↓)

- Folate / B12 deficiency
- Aplastic anemia
- Chemotherapy
- Chloramphenicol / Sulfonamides



WBC: BASOPHIL GRANULOCYTES

WBC	**BLOOD**	**4.6**	**x10^3/mcL**	**(4.6-11.0)**
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)



Basophilia (↑)

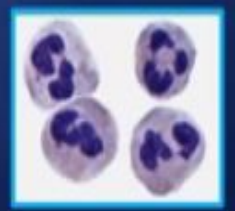
- Allergic reactions
- CML
- Hodgkin's disease
- Oral contraceptive pills

Basopenia (↓)

- Nutritional deficiency
- Glucocorticoids

WBC: MONOCYTES

WBC	BLOOD	4.6	x10^3/mcL	(4.6-11.0)
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)



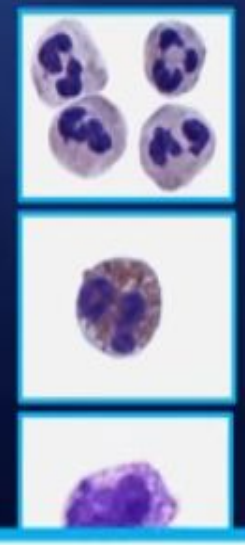
Largest of the white blood cells
Chronic inflammation
Stored in the spleen
Very motile

What they do:

- Phagocytosis
- Antigen presentation
- Cytokine production

WBC: MONOCYTES II

WBC	BLOOD	4.6	x10^3/mcL	(4.6-11.0)
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)



Monocytosis (↑)

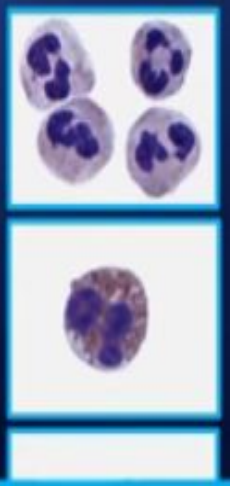
- Chronic inflammatory state
- Stress
- Cushing's syndrome
- Viral infection
- Sarcoidosis

Monocytopenia (↓)

- Aplastic Anemia
- AML
- Glucocorticoids
- Myelotoxic drugs

WBC: LYMPHOCYTES

WBC	BLOOD	4.6	x10^3/mcL	(4.6-11.0)
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)

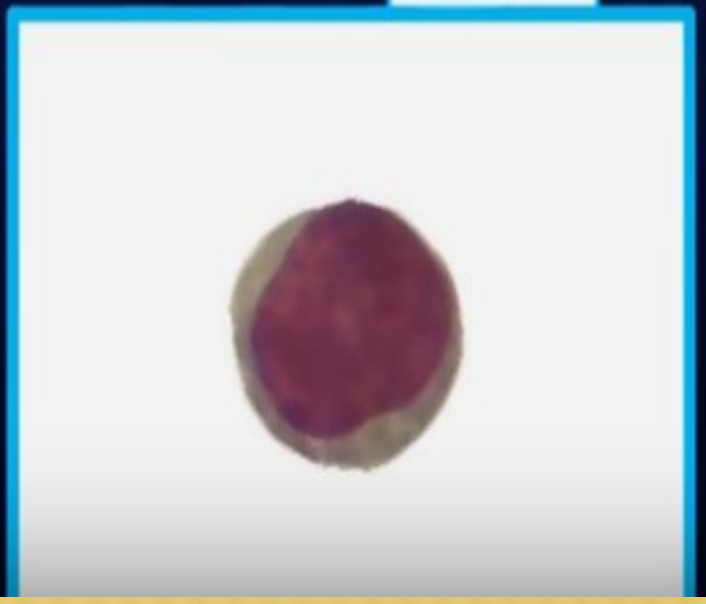


Three main types of lymphocytes: T, B, NK

T cells – (mature in the thymus)

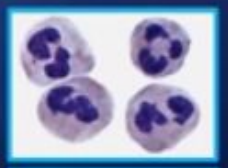
Multiple subtypes but only 3 mentioned here

- Helper – help other cells mature and activate and function (through cytokine production)
- Cytotoxic – destroy cells infected with viruses
- Memory – remember the antigens of past infections



WBC: B LYMPHOCYTES

WBC	BLOOD	4.6	x10^3/mcL	(4.6-11.0)
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)



Three main types of lymphocytes: T, B, NK

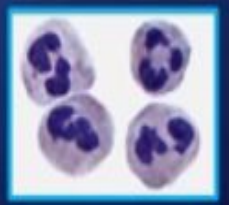
B cells – (formed in the bone)

Multiple subtypes but only 2 mentioned here

- Plasma – produce large amounts of antibodies
- Memory – remember past infections

WBC: NK CELLS

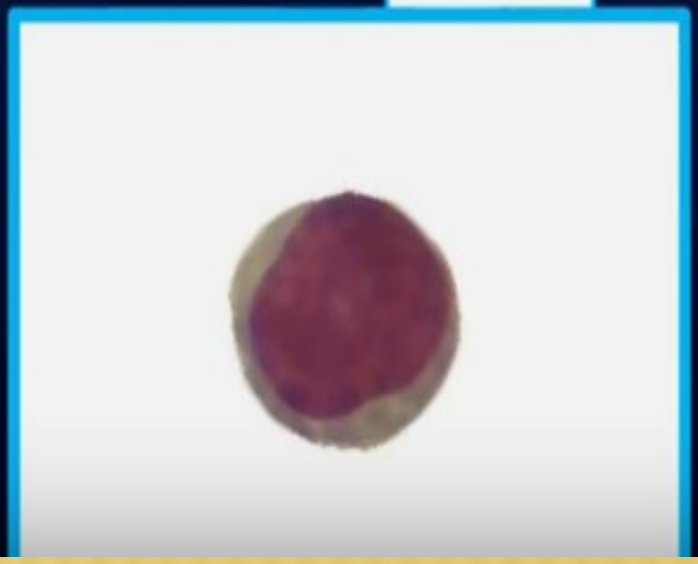
WBC	BLOOD	4.6	x10^3/mcL	(4.6-11.0)
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)



Three main types of lymphocytes: T, B, NK

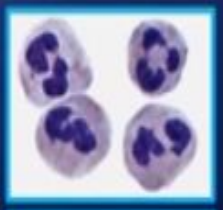
NK cells

Play a role similar to "Cytotoxic T cells"... they kill virus-infected cells and tumor cells



WBC: LYMPHOCYTES IV

WBC	**BLOOD**	**4.6**	**x10^3/mcL**	**(4.6-11.0)**
Neutrophils	BLOOD	52.1	%	(55-75)
Eosinophils	BLOOD	2.2	%	(0-4)
Basophils	BLOOD	0.4	%	(0-2)
Monocytes	BLOOD	13.5	%	(1-10)
Lymphocytes	BLOOD	31.8	%	(15-41)

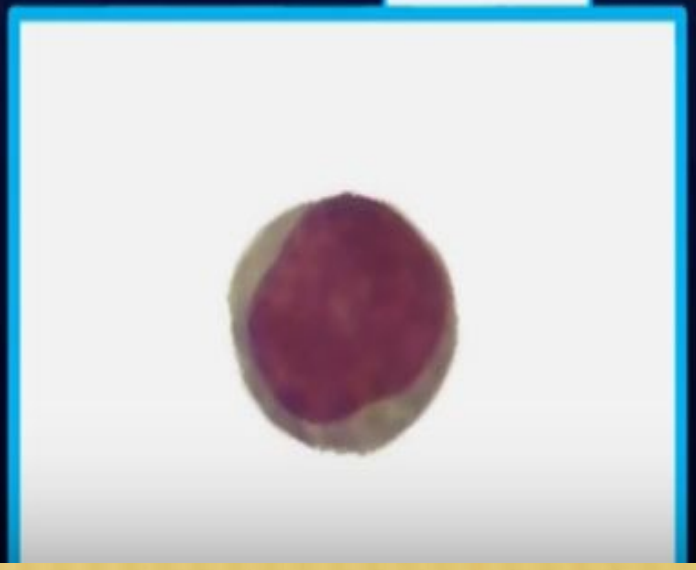


Lymphocytosis (↑)

- Viral infection
- Leukemias: CLL, ALL
- Adrenal insufficiency

Lymphocytopenia (↓)

- HIV – destroys T cells (CD4+)
- Aplastic anemia
- Glucocorticoids
- SLE
- RA



CORRECT USE OF CBC DATA

To make diagnoses, we then frequently combine tests.

- A 15 y.o. male presents with right lower quadrant pain.
- Patient's temperature is 102°
- No other history of illness.
- White blood cell count is elevated.
- Appendicitis is diagnosed

WBC DIFFERENTIAL

WBC Differential

- Identifies specific cell types that are present
  - Neutrophils: primarily elevate with bacterial infections.
    - Segmented/Segs: mature neutrophils, right shift
    - Bands/Stabs: immature neutrophils, left shift
  - Lymphocytes: viral infections
  - Monocytes: fungal infections
  - Eosinophils: allergic reactions, autoimmune diseases
  - Basophils: blood cancers, hypothyroidism

11/17/93 05:15

Test name	Result	units	Ref. range
WBC	9.3	K/uL	4.3 - 10.9
RBC	3.56 L	M/uL	4.7 - 6.1
HGB	11.5 L	g/dL	14 - 18
HCT	34.4 L	%	40 - 54
MCV	96.7	fl	80 - 100
MCH	32.3 H	uug	28 - 32
MCHC	33.4	%	32 - 36
RDW	14.9 H	%	11.5 - 14.5
PLT	101 L	K/uL	150 - 450
NEUT %	92.7 H	%	50 - 76
LYMPH %	3.0 L	%	20 - 40
MONO %	3.6	%	1 - 8
EOSINO %	.0	%	0 - 6
BASO %	.1	%	0 - 2
LUC %	.6	%	0 - 4

omment: ABNORMAL DIFF CONSIST. [AUTOMATED DIFF DESIGNATED BY %]

KEY: "L"=Abnormal low, "H"=Abnormal high, "*"=Critical value

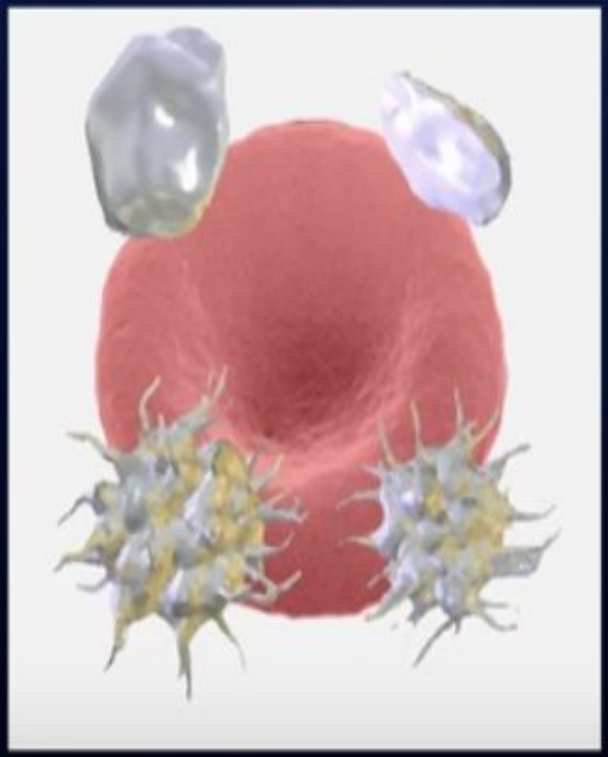
Test Name	Result	units	Ref. range
WBC	8.8	K/uL	4.3 - 10.9
RBC	6.36 H	M/uL	4.7 - 6.1
HGB	18.9 H	g/dL	14 - 18
HCT	61.0 H	%	40 - 54
MCV	95.8	fl	80 - 100
MCH	29.6	uug	28 - 32
MCHC	30.9 L	%	32 - 36
RDW	16.4 H	%	11.5 - 14.5
PLT	180	K/uL	150 - 450
NEUT %	69.9	%	50 - 76
LYMPH %	14.9 L	%	20 - 40
MONO %	6.0	%	1 - 8
EOSINO %	1.8	%	0 - 6
BASO %	1.7	%	0 - 2
LUC %	5.6 H	%	0 - 4
SEGS	51	%	50 - 70
BANDS	11 H	%	0 - 6
LYMPHS	28	%	20 - 40
MONOS	10 H	%	1 - 8
PLT (ESTM)	Adeq.		Adeq
ANISOCYTOSIS	OCC		

CBC AUTOMATED DIFF				
CBC				
WBC	*	0.5	4.5-11.0	Th/cmm
RBC	*	3.15	4.30-5.90	Mil/cmm
HGB	*	10.1	13.9-16.3	g/dL
HCT	*	29.0	39-55	%
MCV		92	80-100	fL
RDW	*	16.2	11.5-14.5	%
MCH		32.1	25-35	pg
MCHC		34.8	31-37	g/dL
PLT	*	45	140-440	Th/cmm
DIFFERENTIAL				
METHOD		MAN		
% NEUT	*	15	40-76	%
% LYMPH	*	84	24-44	%
% EOS		1	0-5	%
# NEUT	*	0.1	1.73-7.13	Th/cmm
# LYMPH	*	0.4	1.15-4.75	Th/cmm
# EOS	*	0.0	0.05-0.43	Th/cmm
PLATELET ESTIMATE		2 TO 5		
RBC MORPHOLOGY		ANISOCYTES 1+		
		TEARDROP CELLS OCCASIONAL		

PLATELETS

Platelets	BLOOD	264	x10^3/mcL	(130-400)
MPV	BLOOD	8.2	fL	(7.0-11.0)

- AKA: "Thrombocytes"
- 2-3nm diameter, Produced from Megakaryocytes
- Contribute to Hemostasis
  - Work with the Coagulation Cascade to form a platelet plug
    - Adhesion
    - Activation
    - Aggregation



PLATELETS II

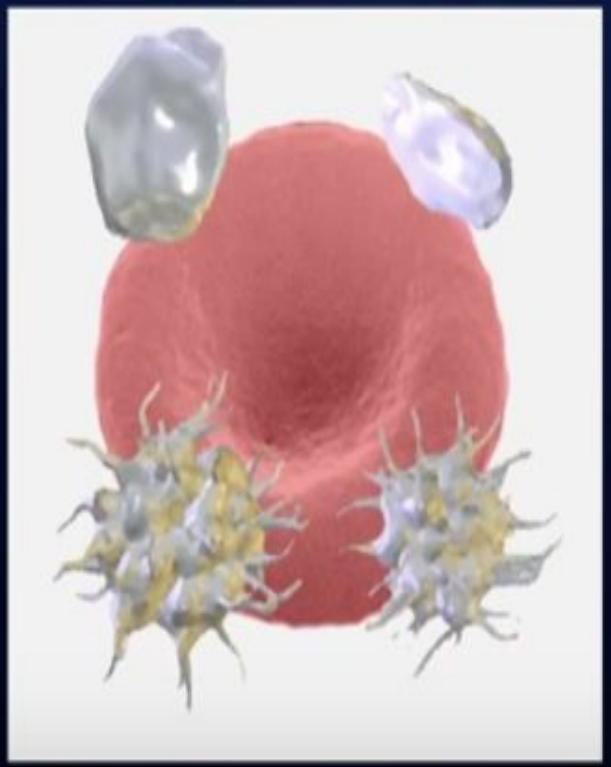
Platelets	BLOOD	264	x10^3/mcL	(130-400)
MPV	BLOOD	8.2	fL	(7.0-11.0)

Thrombocytosis (↑)

- Acute blood loss
- Chronic Myelogenous Leukemia (CML)
- Iron deficiency
- Polycythemia vera
- Hyposplenism

Thrombocytopenia (↓)

- Idiopathic thrombocytopenic purpura
- HELLP syndrome
- Hemolytic-uremic syndrome
- Disseminated Intravascular Coagulation (DIC)



MPV

Platelets	BLOOD	264	x10^3/mcL	(130-400)
MPV	BLOOD	8.2	fL	(7.0-11.0)

- Mean platelet volume (MPV)
- Calculated measurement of the mean platelet size

**Platelet size often increases with increased production*

MPV II

Platelets	BLOOD	264	x10^3/mcL	(130-400)
MPV	BLOOD	8.2	fL	(7.0-11.0)

↑ MPV

- Immune thrombocytopenic purpura (ITP)
- Myeloproliferative diseases
- Bernard-Soulier syndrome
- Pre-eclampsia

↓ MPV

- Aplastic anemia
- Cytotoxic drug therapy
- Viral infections