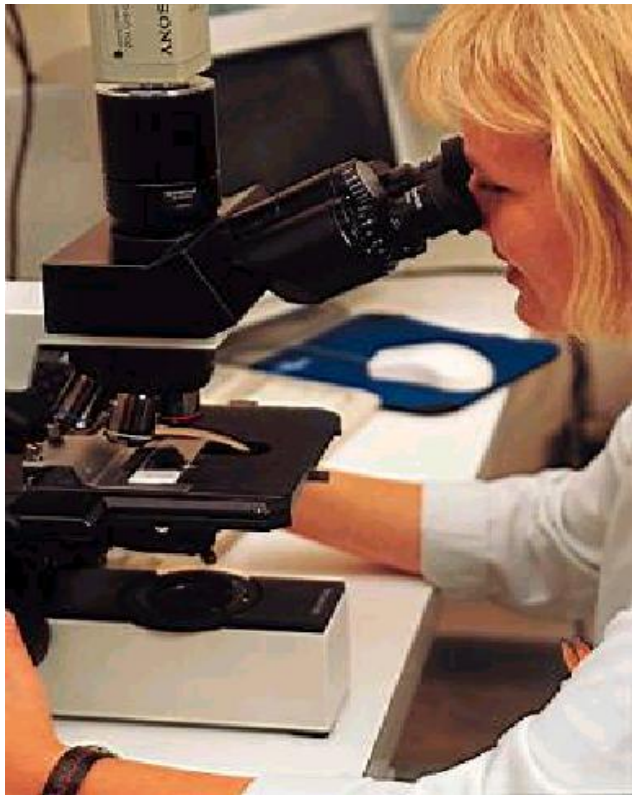
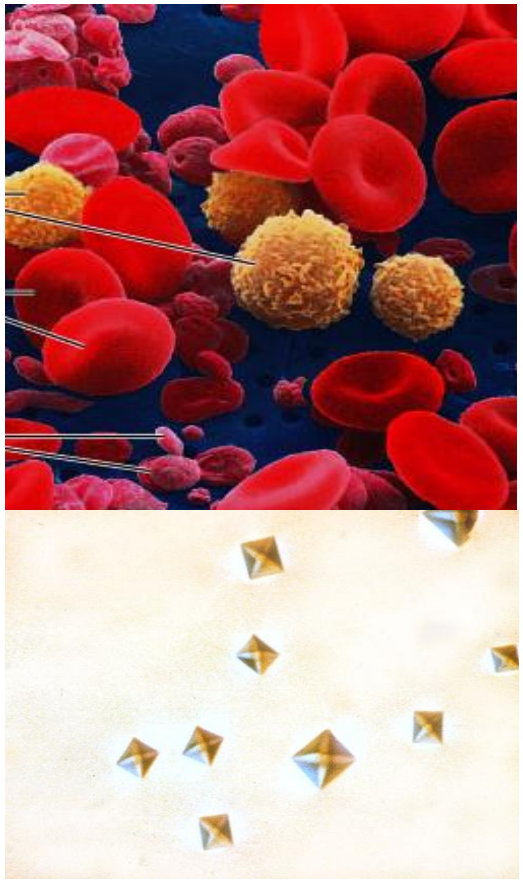
Routine Hematological Examination – How does the laboratory help in diagnosis?







Zhou Xiaoyan

Kunming Medical University

- Blood



- Urine



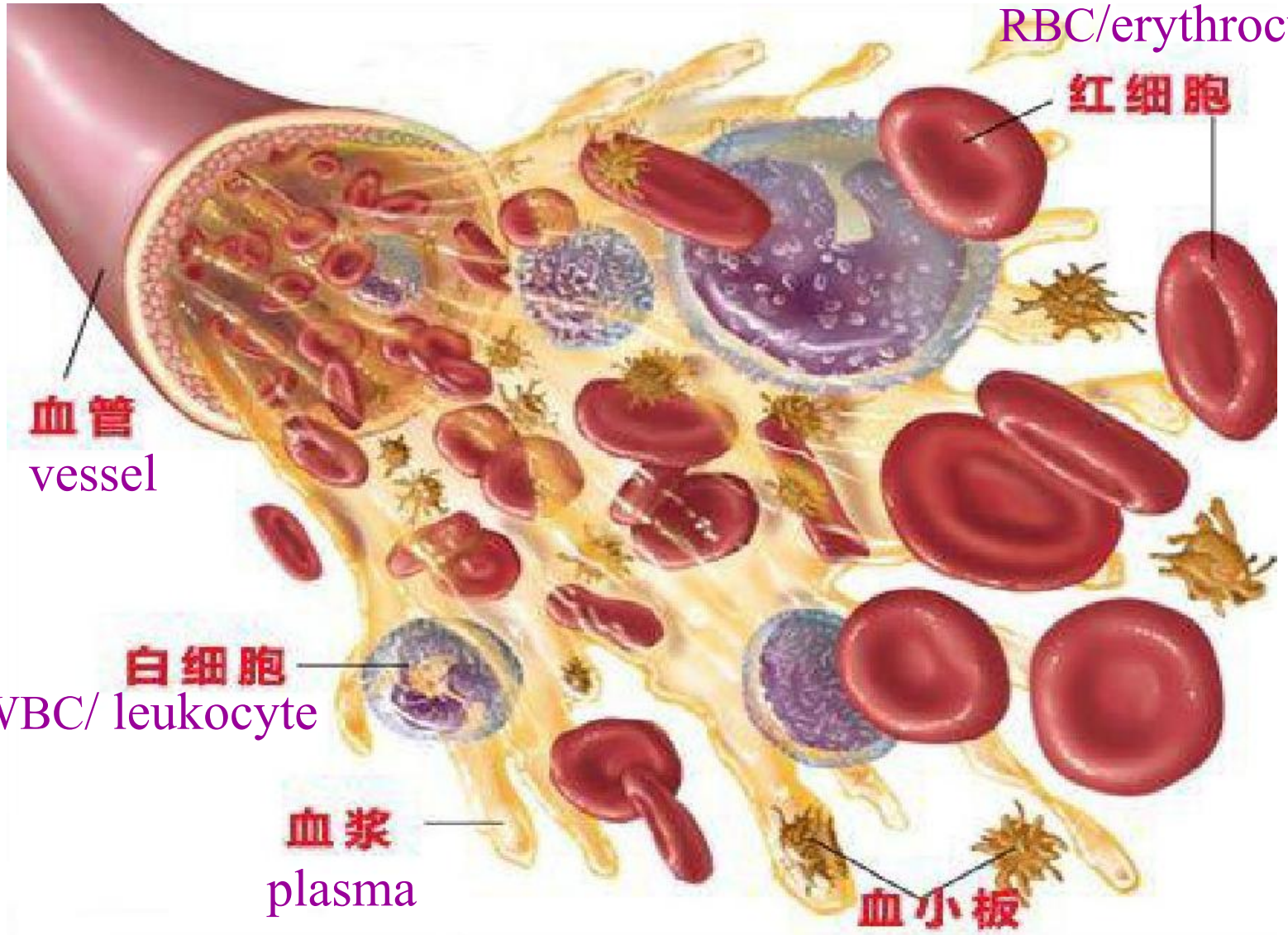
- Stool



At the end of this morning, you will be able to ….

- Master the significance and purpose of routine hematological examination
- Comprehend the physiological functions and key parameters of Red blood cells (RBCs), White blood cells (WBCs) and Platelets
- Interpret the clinical correlations between abnormal laboratory values and common disorders




RBC/erythrocyte
红细胞
血管
vessel
白细胞
WBC/ leukocyte
血浆
plasma
血小板
platelet/ thrombocyte

Complete blood count



- Blood collected in a tube lined with anticoagulant is used (usually a purple EDTA tube)
- The following information can be measured or calculated using automatic hematology analyzers:
  - Red Blood Cells count(RBC)
  - Hemoglobin(Hb)
  - Hematocrit (Hct)
  - Mean corpuscular volume (MCV)
  - Mean corpuscular hemoglobin(MCH)
  - Mean Corpuscular Hemoglobin Concentration(MCHC)
  - White Blood Cells (WBCs)
  - Platelet (PLT)

昆明医科大学第一附属医院
the First Affiliated Hospital of Kunming Medical University

医学检验科检验报告
Report from Department of Clinical Laboratory

云南省HR

急诊组

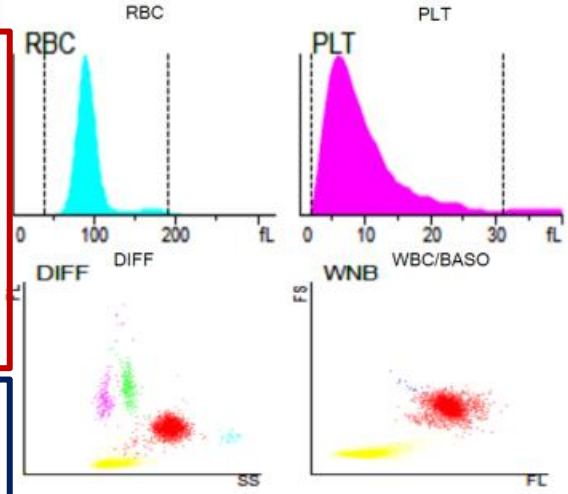
科　　室：发热门诊　　病人类型：门诊　　样 本 号：300
病　　区：　　病人编号：1236771046　　费用类别：现金
床　　号：　　标本类型：全血　　检测仪器：BC_6800Plus

临床诊断：发热,咽痛
申请项目：急诊CRP(全血)^急诊血细胞分析及一般血液学检查
检测方法：流式细胞检测技术、库尔特原理
备　　注：

1025475032

项目名称	缩 写	结 果		单 位	参考区间
超敏C反应蛋白	HS-CRP	13.00	↑	mg/L	≤6.00
*白细胞	WBC	5.39		10^9/L	3.50--9.50
中性粒细胞百分比	NEUT%	87.40	↑	%	40.0--75.0
淋巴细胞百分比	LYMPH%	5.20	↓	%	20.0--50.0
单核细胞百分比	MONO%	6.10		%	3.0--10.0
嗜酸性粒细胞百分比	EO%	1.00		%	0.40--8.00
嗜碱性粒细胞百分比	BASO%	0.30		%	<1.00
中性粒细胞绝对值	NEUT#	4.71		10^9/L	1.8--6.3
淋巴细胞绝对值	LYMPH#	0.28	↓	10^9/L	1.1--3.2
单核细胞绝对值	MONO#	0.33		10^9/L	0.1--0.6
嗜酸性粒细胞绝对值	EO#	0.05		10^9/L	0.02--0.52
嗜碱性粒细胞绝对值	BASO#	0.02		10^9/L	<0.06
*红细胞	RBC	4.78		10^{12}/L	3.80--5.10
***血红蛋白**	HGB	151	↑	g/L	115--150
*红细胞压积	HCT	43.3		%	35.0--45.0
*红细胞平均体积	MCV	90.60		fL	82.0--100.0
*平均血红蛋白量	MCH	31.60		pg	27.0--34.0
*平均血红蛋白浓度	MCHC	349.0		g/L	316.0--354.0
红细胞分布宽度变异系数	RDW-CV	12.2		%	12.2--14.8
有核红细胞百分比	NRBC%	0.00		/100WBC	<=0
有核红细胞绝对值	NRBC#	0.000		10^9/L	<=0
*血小板	PLT	201		10^9/L	125--350
血小板压积	PCT	0.20		%	0.19--0.39
平均血小板体积	MPV	9.9		fL	9.2--12.0
血小板分布宽度	PDW	16.4	↑	fL	9.6--15.2
大血小板比率	P-LCR	25.0		%	19.7--42.2
未成熟粒细胞百分比	IG%	0.1		%	
未成熟粒细胞绝对值	IG#	0.01		10^9/L	
高荧光强度淋巴细胞百分比	HFLC%	0.2		%	

图　像



Clinical Case

Chief Complaint: Recurrent dizziness and gum bleeding for 1 month.
Physical Examination: Pale complexion, scattered ecchymoses on arms, temperature 37.8 ℃.
Initial Diagnostic Order: Complete Blood Count (CBC).

What does the doctor primarily want to confirm through the CBC?

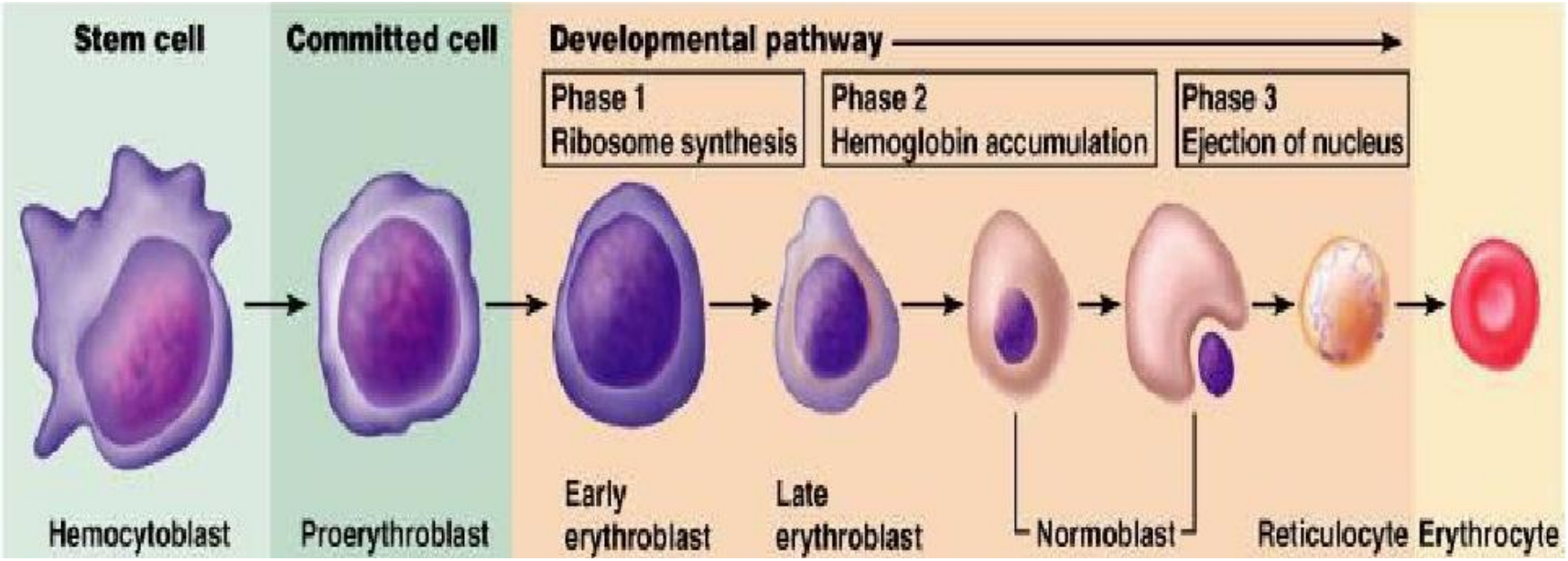
A. Whether there is a viral infection

B. Whether anemia is present

C. Whether coagulation function is abnormal

D. All of the above

RBC/Erythropoiesis



RBC/Erythropoiesis

- Growth factors produced in bone marrow and the kidney, controls the survival, proliferation, differentiation and function of the developing red blood cell precursors
- Erythropoietin (EPO) is produced by the renal tubular cells in response to hypoxia and is responsible for proliferation and maturation of the developing red blood cell precursors.
- Failure of EPO production in patients with renal failure causes anaemia.

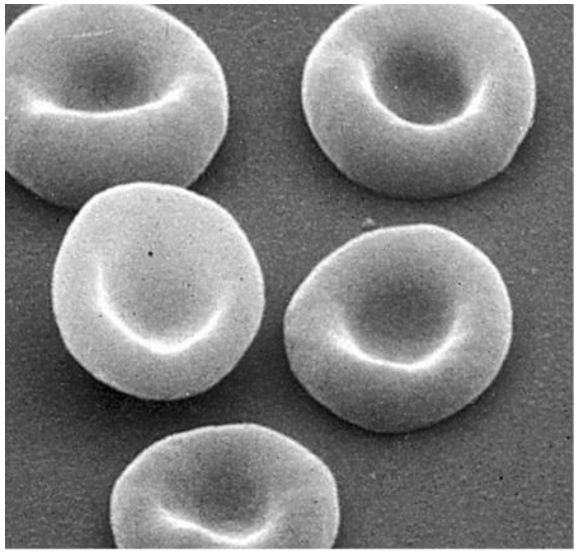
RET you will not normally see in the circulation

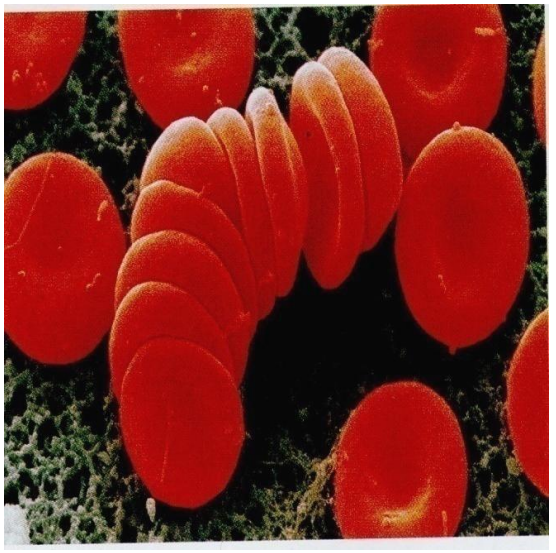
- Reticulocyte – first non nucleated red cell with ribosomal material in the cytoplasm; large cells with a faint blue tinge

- IF reticulocytes are seen in increased numbers in the circulation, this suggests increased erythropoiesis.

Function of RBC/Erythropoiesis

- Carry oxygen and carbon dioxide





Destruction of the RBC

- Normal RBC life span is 120 days.
- Senescent red blood cells are normally removed in the reticuloendothelial system
- Unstable hemoglobin, abnormally shaped red cell or autoimmune, mechanical, infective or medication factors may result in shortened life span of the red cell and increased red cell destruction. This is called hemolysis .

Normal values

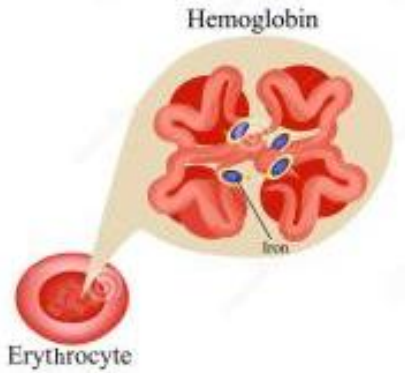
(According to the population and region)

Red blood cell count (RBC)

- male: $4.0 \sim 5.5 \times 10^{12}$ /L
- female: $3.5 \sim 5.0 \times 10^{12}$ /L
- infant: $6.0 \sim 7.0 \times 10^{12}$/L

Hemoglobin (Hb)

- Composed normally of four globin chains (two alpha and two non alpha chains
- Hemoglobin A (αα/ββ) represents over 90% of adult hemoglobin; inherited abnormalities in the globin chains will result in unstable hemoglobins, called hemoglobinopathies.
- Binds oxygen reversibly
- Releases oxygen under conditions of low tissue oxygen concentration



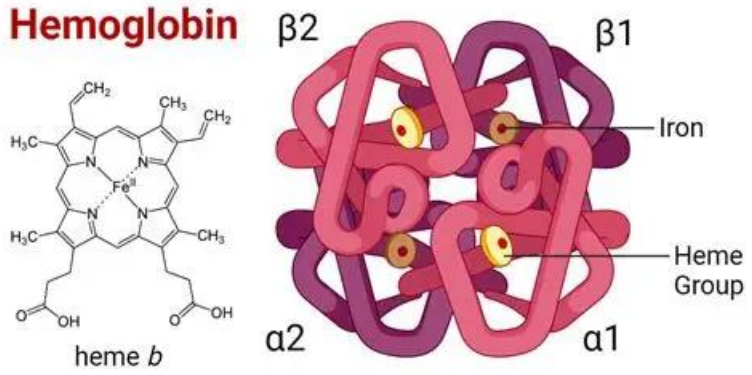
Hemoglobin(Hb)

- Normal hemoglobin concentration:

  120-160g/L (male)

  110-150g/L(female)

  infant：170～200g/L



The Diagnostic Significance of Hb in Anemia

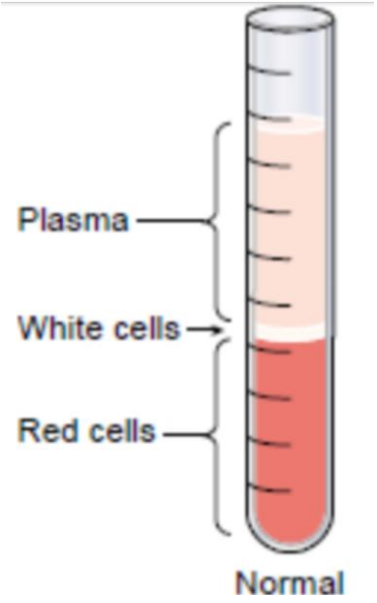
- Hb: 90 g/L-lower limit of the reference range — **Mild Anemia**
- Hb: 61-90 g/L — **Moderate Anemia**
- Hb: 30-60 g/L — **Severe Anemia**

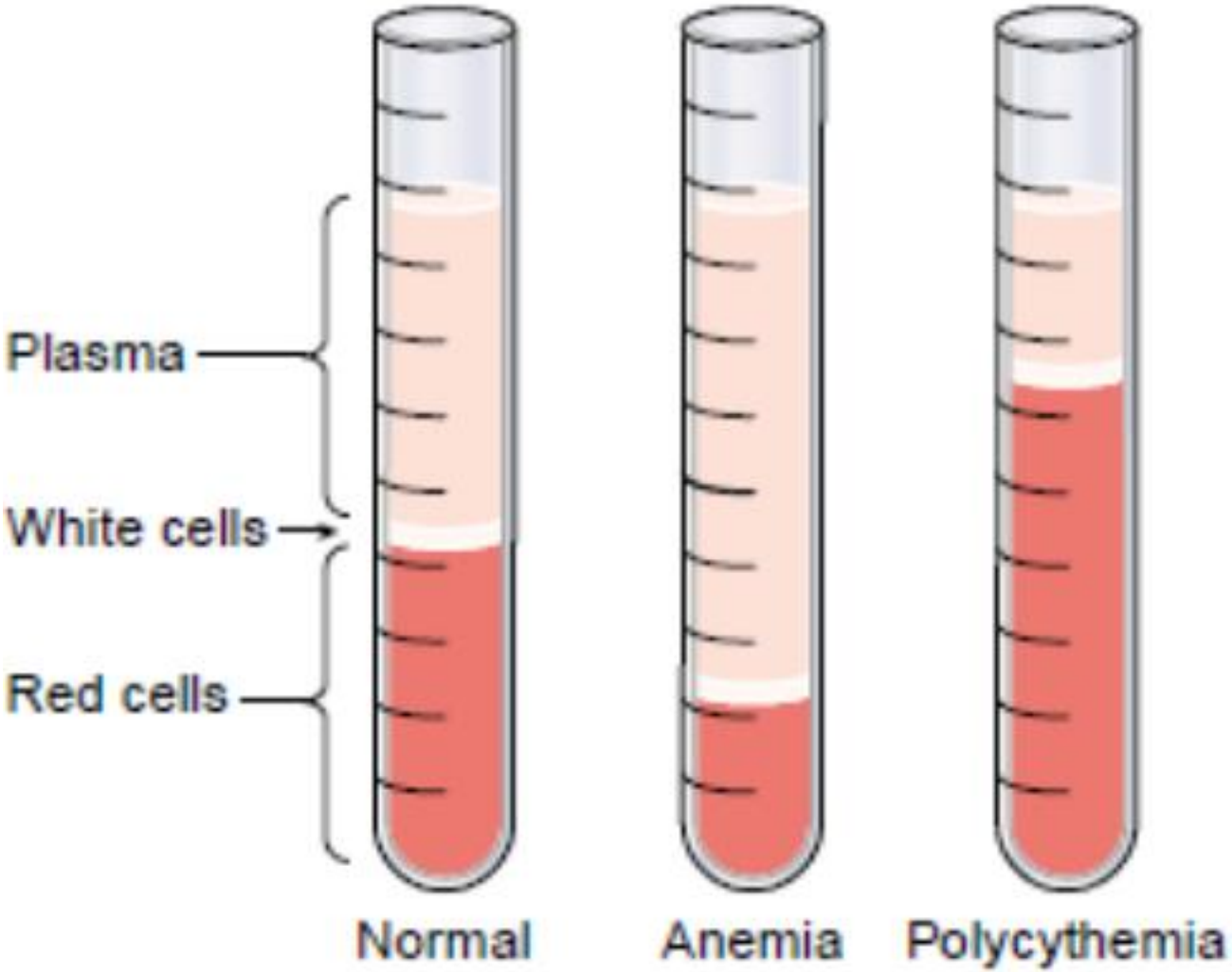
Hematocrit (HCT)

- Percentage of blood volume occupied by RBC.
- Normal HCT:

  Men 40~45%

  Women 37~47%




Plasma
White cells
Red cells
Normal
Anemia
Polycythemia

RBC parameters“3M+1R”

- MCV(fl) =HCT/RBC

  Mean cell volume of the red cell.
- MCH(pg) =Hb/RBC

  Mean cell hemoglobin content of the red cell.
- MCHC (g/L)=Hb/HCT

  Mean cell hemoglobin concentration.

RBC parameters“3M+1R”

- RDW (red cell distribution width).
- Normal red blood cells are uniform in size, and if RDW is elevated, it is often suggested that the size is different and may be pathological.
- MCV,MCH,MCHC and RDW are referred to as RBC indices and serve to describe RBC changes and to differentiate erythropoietic disorders.

Physiological changes

- **High Altitude:** Low oxygen triggers EPO release, boosting RBC and Hb production to enhance oxygen carry capacity. **Hb↑, RBC↑**
- **Infancy:** Higher levels result from active bone marrow and a relatively hypoxic state.**Hb↑**
- **Exercise:** A temporary rise occurs and fluid loss.**Hb↑**
- **Hemodilution:** Excessive water intake dilutes the blood, lowering measured Hb. **Hb↓**
- **Pregnancy:** Plasma volume expands more than RBC mass, leading to a relative anemia**.Hb↓**

Clinical significance

- The Hb concentration combined with the HCT and the RBC count is an important criterion for the diagnosis and differentiation of anemias, erythrocytoses, and polycythemias

Clinical significance

- MCV MCH, MCHC, and RDW are important tools for :

- the classification of anemia

- the early detection of processes that will cause anemia

- the investigation of the underlying etiology of anemia(in some cases)

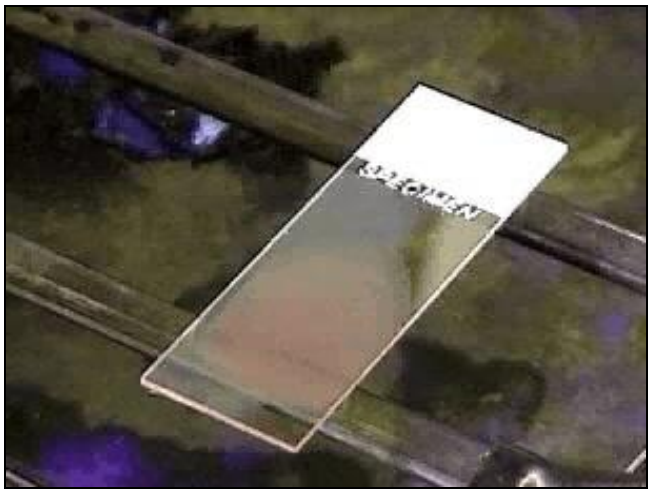
Blood film examination

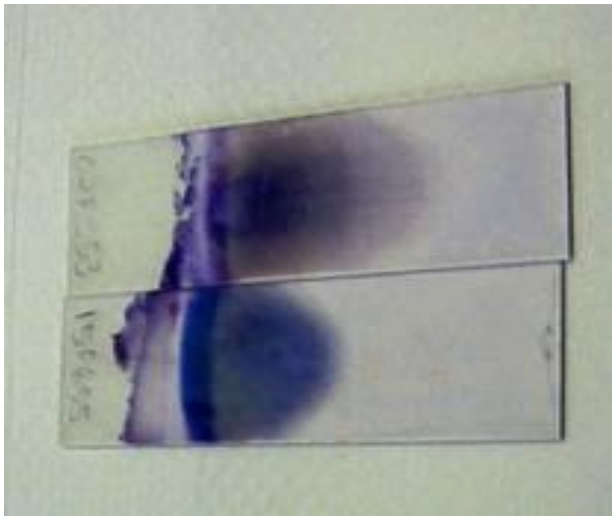
Manual observation of blood components on a prepared microscope slide (“blood film”) can also yield invaluable information like:

- morphology
- Content of the cell

Interpreting RBC indices together with peripheral blood smear morphology

- Size、 color、 shape、 structure、RBC inclusions
- Abnormal RBC parameters are indicative of RBC abnormalities.



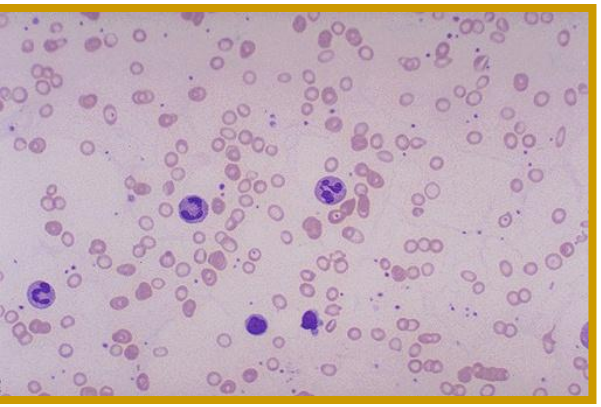




(1) RBC Size relative to lymphocyte in the blood film

Normocytic

MCV (80~100fl)

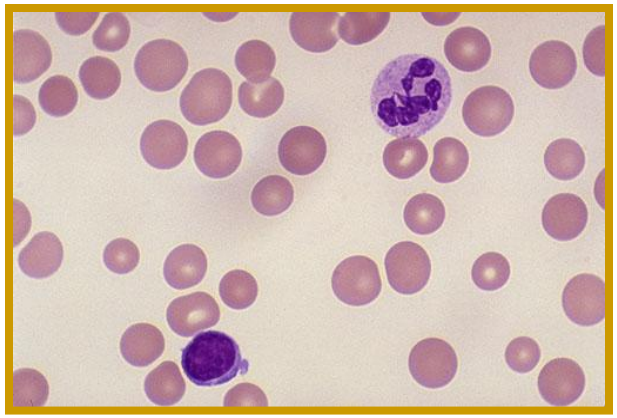


microcytic(<79fl)

Iron Deficiency Anemia (IDA)

Thalassemia

Sideroblastic Anemia



Macrocytic(>100fl)

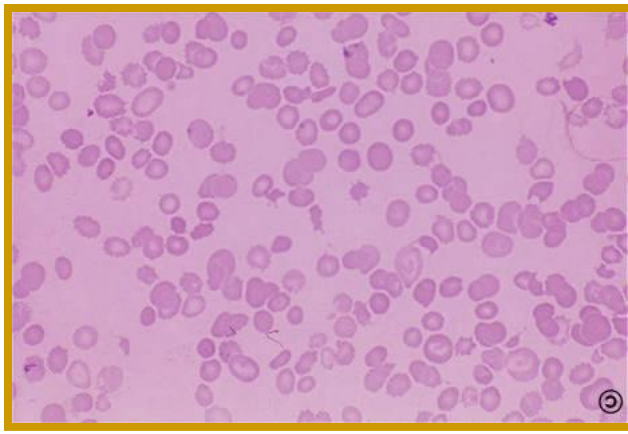
Vitamin B12 or folate deficiency

Liver disease or alcohol

Hypothyroidism

Hemolytic Anemia

Myeloprolieferative diseases

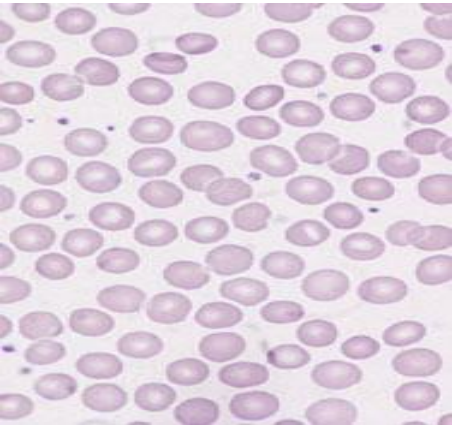


Anisocytosis/RBC Distribution Width ↑

Severe anaemia of any cause

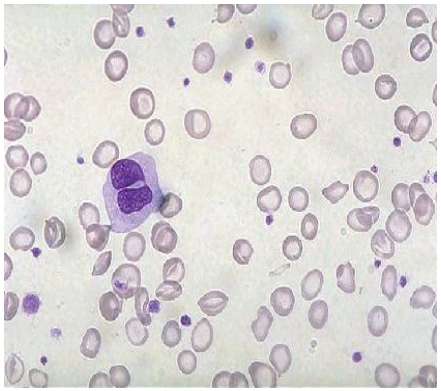
(2) Color

MCHC (Normal value) 320~360g/L



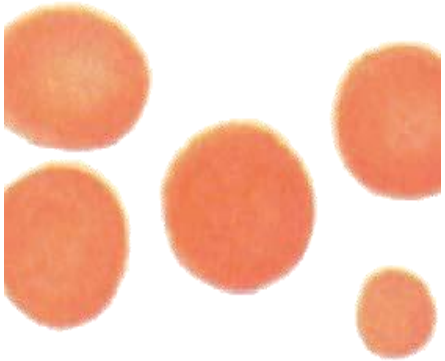
normochromic

hemolysis
blood loss



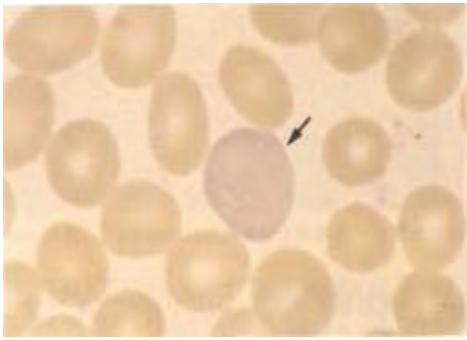
hypochromic

IDA
thalassemia



hyperchromic

megaloblastic
anemia



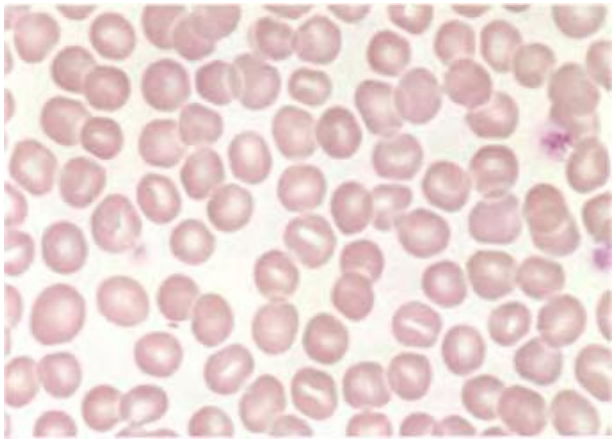
polychromatic

Acute
haemolysis or
haemorrhage
Increased red
cell turnover

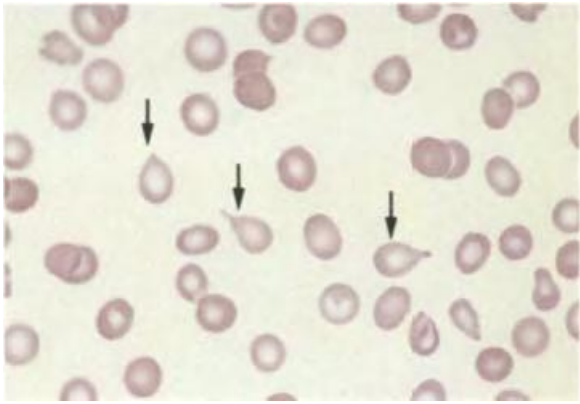
(3) shape



target cell
- Liver disease
- thalassemia



Stomatocytosis
- Hereditary stomatocytosis



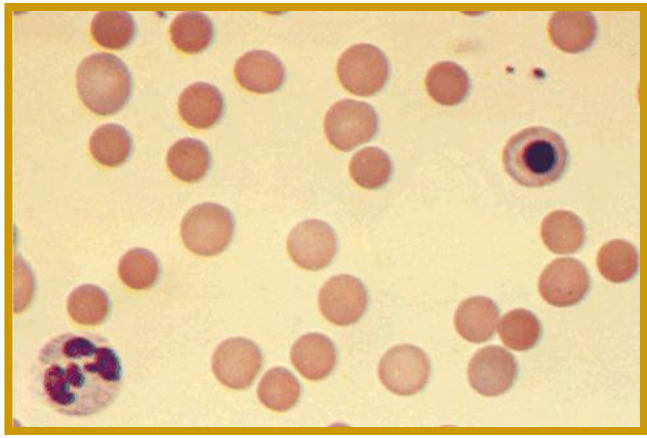
tear drop cell
-myelofibrosis



sickle cell
- Sickle cell anemia

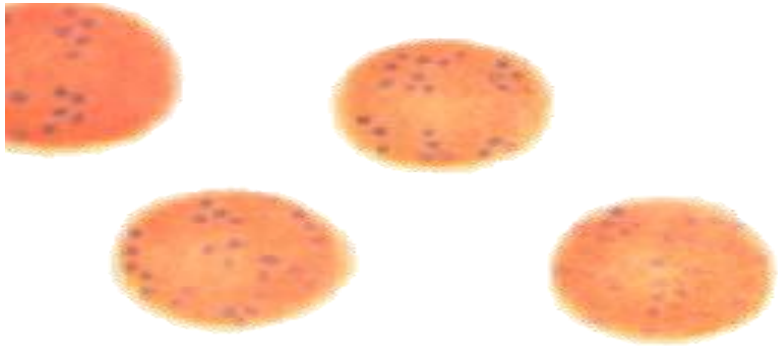


Roulette
- multiple myeloma

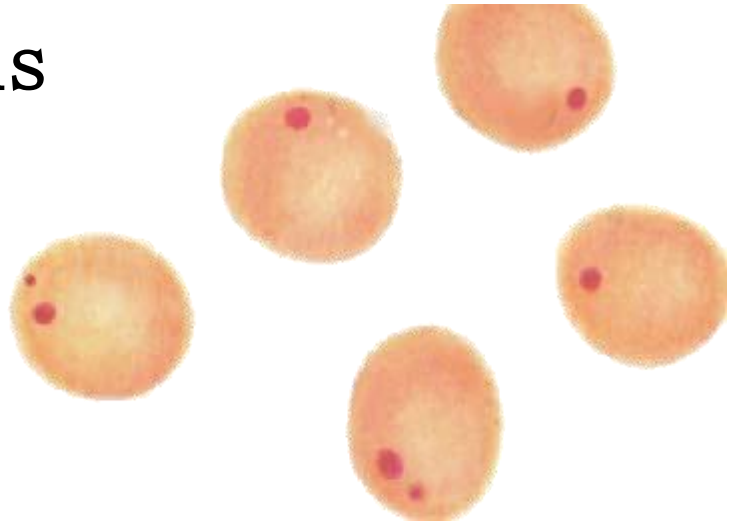


Spherocyte
-hereditary spherocytosis
Autoimmune haemolysis

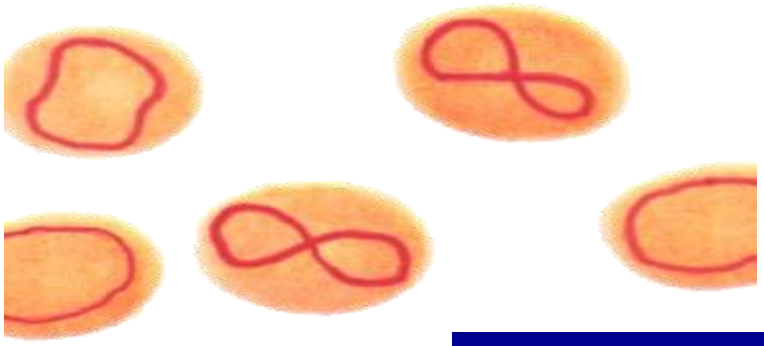
(4) structure / inclusions



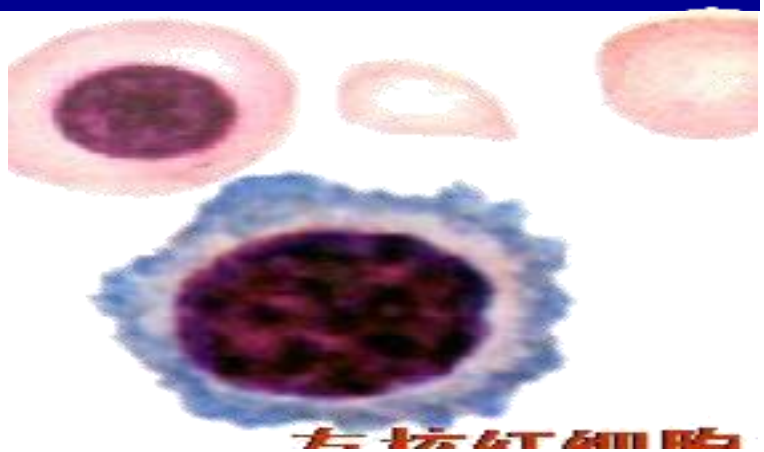
basophilic stippling
- Lead poisoning



Howell-Jolly's body
- splenectomy



Cabot's ring



nucleated erythrocyte – bone marrow infiltration, acute blood loss, severe hemolysis, myelofibrosis

Clinical Case

Female
35 years



Chief Complaint

Recurrent fatigue, dizziness, and palpitations after physical activity for 3 months, worsened in the past week.

Past Medical History

Menstrual history: Significantly increased menstrual flow with prolonged periods lasting 7-10 days over the past year.
Dietary habits: A predominantly vegetarian diet, reportedly "to maintain body shape," with minimal intake of red meat, liver, or other iron-rich foods.

Physical Examination

Pallor of the complexion, conjunctivae, nail beds, and palmar skin.

CBC Test：

Item	Result	reference range
Hb	78 g/L	115-150 g/L
RBC	3.5×10^{12}/L	$3.8\text{-}5.1 \times 10^{12}$/L
MCV	75 fL	82-100 fL
MCH	22 pg	27-34 pg
MCHC	290 g/L	316-354 g/L
RDW	16.5%	11.5%-14.5%

1 **what is the most likely diagnosis?**

Anemia→ Moderate Anemia → Microcytic Hypochromic Anemia→IDA

2 **what are the next steps**

1.Correct anemia Iron Supplementation

2. Investigate underlying gynecological disorders

Iron Studies , Gynecological Examination .....

Function of White Blood Cells (WBCs)/Leukocytes

Essential immune cells in the blood

- Defense: combating pathogens (bacteria, viruses, fungi, parasites);
- Cleanup: clearing damaged and senescent cells;
- Immune Surveillance: identifying and eliminating abnormal cells (e.g., cancer cells).

Normal values

(According to the population and region)

White Blood Cells (WBCs)

- Adults: $3.5–9.5 \times 10^9/L$
- 6 months to 2 years: $11–12 \times 10^9/L$
- Newborns: $15.0–20.0 \times 10^9/L$

Clinical significance

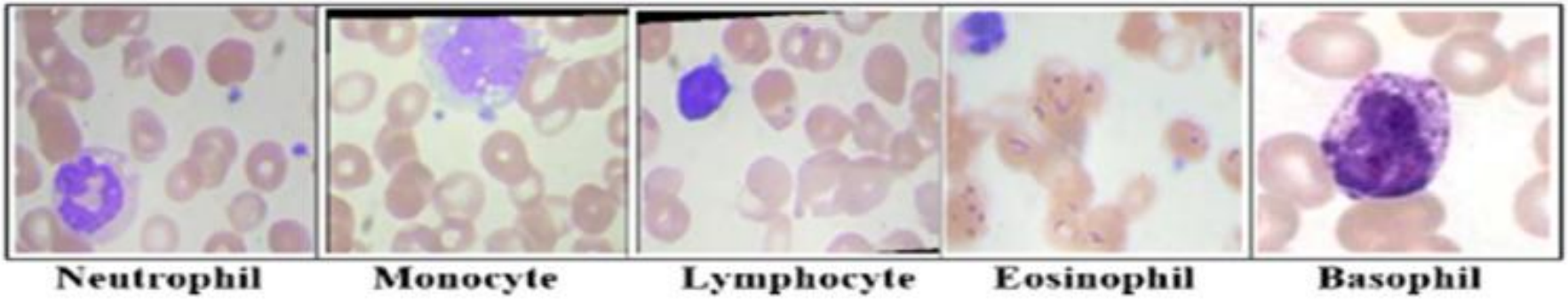
An increased white blood cell count can be seen in conditions such as **acute infections**, uremia, severe burns, acute hemorrhage, tissue injury, major surgery, and leukemia

Clinical significance

- A decreased white blood cell count may occur in cases including typhoid and paratyphoid fever, malaria, aplastic anemia, acute agranulocytosis, hypersplenism, exposure to X-rays or radioactive isotopes, and the use of certain anticancer agents.

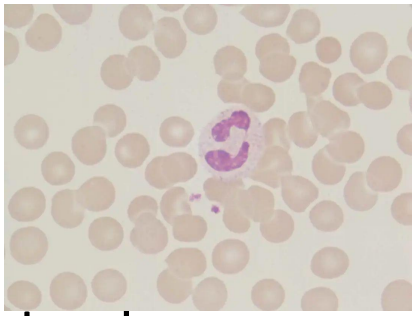
Classification of WBCs

- Based on the presence and staining characteristics of specific granules in the cytoplasm visible under a light microscope, they are classified into granulocytes and agranulocytes.



White Blood Cell Differential Count
(According to the population and region)

Neutrophils



- Polymorphonuclear cells (PMNs)
- Most abundant of WBCs
- Highly motile and play a large role in the acute phase of inflammation (especially bacterial infections)

Neutrophilia(↑)

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

Neutropenia(↓)

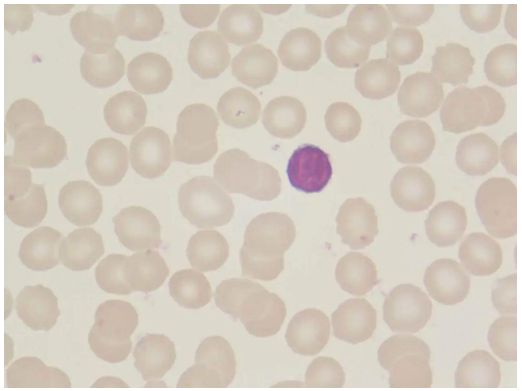
- ✓ Folate/ B12 deficiency
- ✓ Aplastic anemia
- ✓ Chemotherapy
- ✓ Chloramphenicol/Sulfonamides

WBCs Differential Count

(According to the population and region)

Lymphocytes

- Three main types of lymphocytes: T, B, NK
- Viral Infection Indicator
- Immune Status Marker
- Hematologic Disorder Clue



Lymphocytosis(↑)

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

Lymphocytopenia(↓)

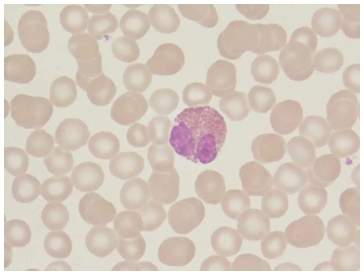
- ✓ HIV- destroys T cells ($CD4^+$)
- ✓ Aplastic anemia
- ✓ Glucocorticoids
- ✓ SLE
- ✓ RA

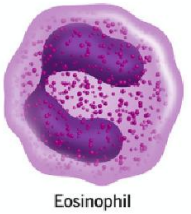
WBCs Differential Count

(According to the population and region)

Eosinophils

- Marker for Allergic and Parasitic Infections
- Disease Activity Monitoring
- Reduced Levels Have Limited Clinical Significance





Eosinophilia(↑)

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

Eosinopenia(↓)

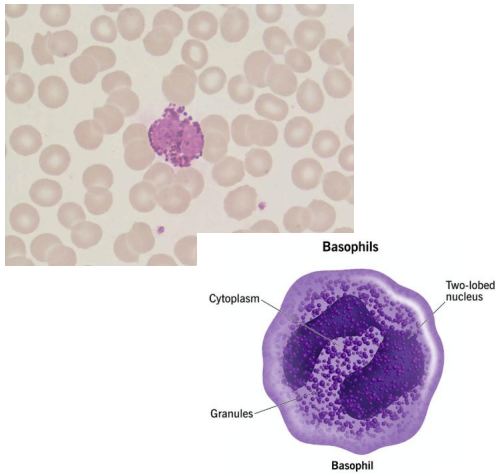
- ✓ Nutritional deficiency
- ✓ Glucocorticoids

WBCs Differential Count

(According to the population and region)

Basophils

- Trigger allergic reactions allergens and infections.
- They release histamine, which triggers symptoms of an allergic reaction.



Basophilia

- ✓ Infections
- ✓ Allergic reactions to chronic (long-term) conditions, like autoimmune diseases, hypothyroidism or cancer

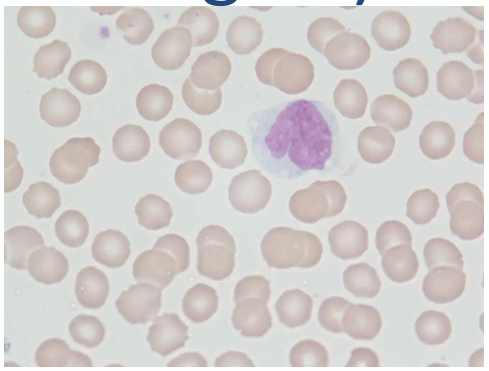
Basopenia

- ✓ Overactive thyroid gland
- ✓ Medication side effect

WBCs Differential Count

(According to the population and region)

Monocytes



- Largest of the white blood cells
- Chronic inflammation
- Stored in the spleen
- Very motile
- What they do: Phagocytosis, Antigen presentation, Cytokine production

Monocytosis(↑)

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

Monocytopenia(↓)

- ✓ Aplastic Anemia
- ✓ AML
- ✓ Glucocorticoids
- ✓ Myelotoxic drugs

Key Abnormal Patterns

- Total WBC↑ + Neutrophils↑ = Bacterial infection
- Total WBC ↓+ Lymphocytes↑ = Viral infection
- Eosinophils↑ = Allergy/Parasitic disease (dietary history should be checked)
- Pseudoelevation of WBC after glucocorticoid (steroid) use

Clinical Case

Male 25 years



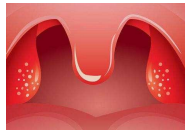
Chief Complaint

Sore throat with fever for 2 days.

Physical Examination and Investigations:

Temperature: 39.2°C, Pharyngeal erythema, tonsillar enlargement.

CBC: WBC: 15.2 × 10^9/L ↑ (Reference Range: 4-10 × 10^9/L), Neutrophils %: 88% ↑ (Reference Range: 50-70%), Hb / PLT: Within normal limits.



1 What is the diagnostic direction for this case?

Acute bacterial upper respiratory tract infection

2 what are the next steps?

Antibiotic therapy; Symptomatic and supportive treatment

Function of Platelet (PLT)

AKA: “Thrombocytes”

2-3 µm diameter, Produced from Megakaryocytes

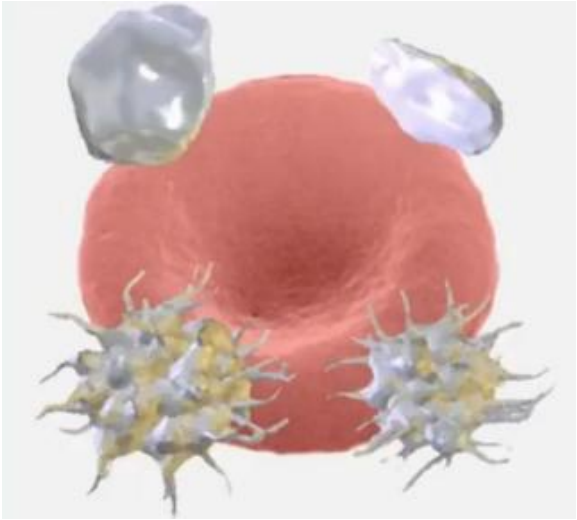
Contribute to Hemostasis

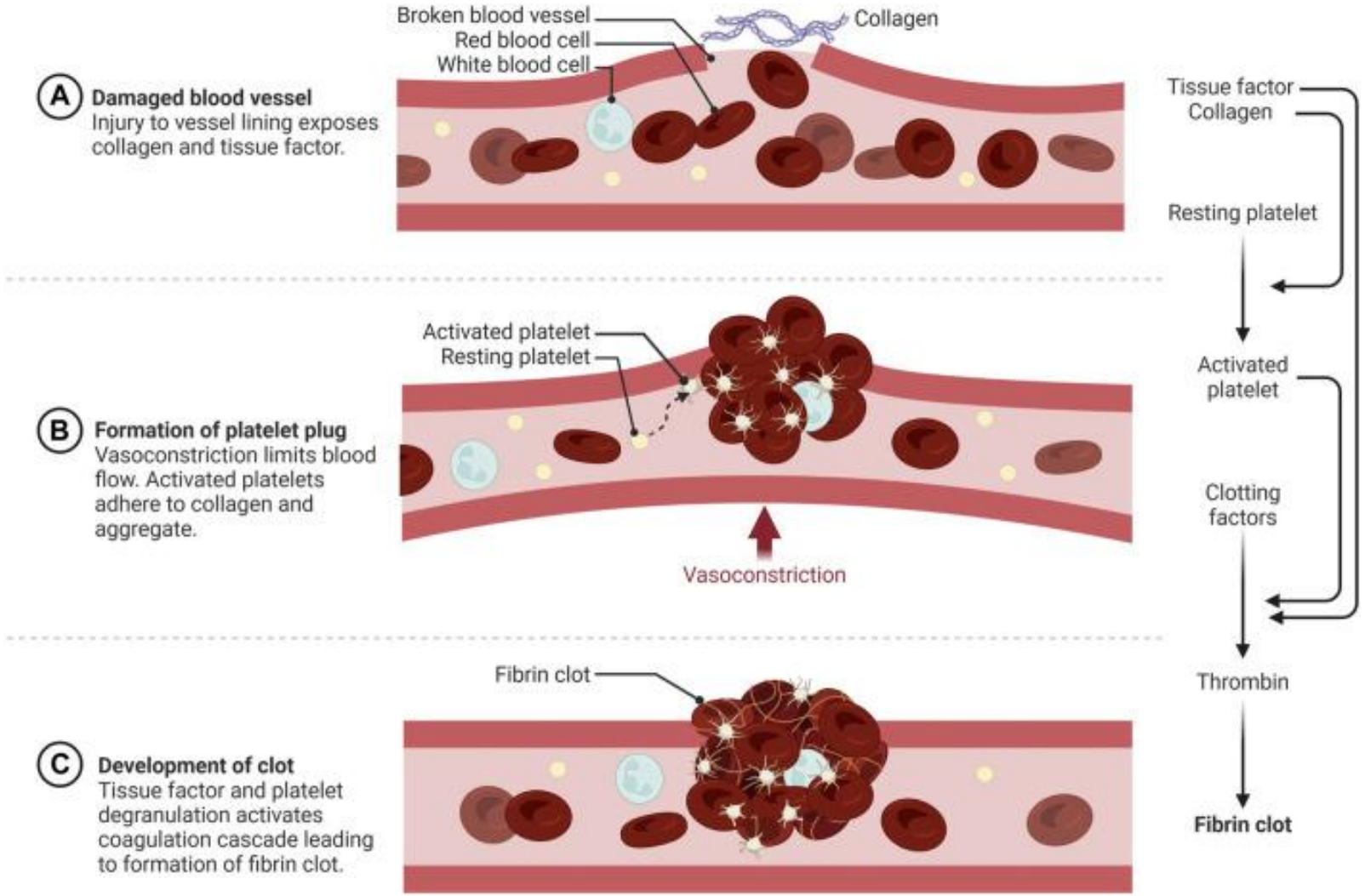
Work with the Coagulation Cascade to form a platelet plug

Adhesion

Activation

Aggregation





Schematic overview of hemostasis

Normal values

(According to the population and region)

Platelets (PLT)

- $(100 \sim 300) \times 10^9$ /L

Clinical significance

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)

Mean platelet volume (MPV)

- Calculated measurement of the mean platelet size
- Platelet size often increases with increased production

MPV(↑)	MPV(↓)
✓ Immune thrombocytopenicpurpura (ITP) ✓ Myeloproliferative diseases ✓ Bernard-Soulier syndrome ✓ Pre-eclampsia	✓ Aplastic anemia ✓ Cytotoxic drug therapy ✓ Viral infections

Critical value

Item	Critical value	Clinical significance
Hb	≤60 g/L (in individuals >3 days old)	Potential for life-threatening infections
	>200 g/L (in individuals >7 days old) >200 g/L (in neonates <7 days old)	Possible acute leukemia or sepsis
WBC	≤$1.0x10^9$/L	Acute significant blood loss or severe anemia
	≥$30x10^9$/L (in individuals >3 days old) ≥$40x10^9$L (in neonates ≤3 days old)	olycythemia, suspect erythroleukemia or cor pulmonale
PLT	≤$20x10^9$/L (for other departments) ≤$50x10^9$/L (for Obstetrics)	Significant risk of hemorrhage; this is the clinical threshold for platelet transfusion
	≥$1000x10^9$/L	Hypercoagulable state

Handling of critical values

Confirm the result and exclude testing errors

Immediate Verification

Prompt Reporting

Inform the attending clinician for urgent intervention

Ensure all actions are recorded and tracked appropriately

Documentation and Follow-up



Summary

- ☑ The CBC provides a crucial overview of health by quantifying blood cells (erythrocyte, leukocyte, and platelets) through automated analysis.
- ☑ This fast and economical test is a foundational diagnostic tool, screening for conditions like anemia, infection, and bleeding disorders.
- ☑ It serves as an essential first step, Triggers further diagnostic action: Guides the need for more specific tests (e.g., smears, cultures, biopsies).

THANK YOU

For Your Attention & Support