Introduction

1. Which one of the following parameters is used to assess the volume of the RBC?
   A. MCV
   B. MCHC
   C. RDW
   D. Hematocrit
   E. MCH

2. Which of the following is most helpful in the workup for immune hemolytic anemia?

A. Iron indices
B. Coombs test
C. Hemoglobin electrophoresis
D. Bone marrow examination

3. All of the following are examples of microcytic anemia, except:

A. Iron deficiency anemia
B. Thalassemia
C. Megaloblastic anemia
D. Lead poisoning
E. Sideroblastic anemia

4. All the following are associated with increased reticulocyte count, except:

A. Immune hemolytic anemia
B. Spherocytosis
C. Microangiopathic hemolytic anemia
D. Aplastic anemia
E. G6PD deficiency

5. All the following are clinical manifestations of anemia of diminished production, except:

A. Skin pallor
B. Shortness of breath
C. Gallbaldder stones
D. Muscle weakness
E. Confusion

INTRODUCTION TO ANEMIA

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- Introduction to anemia including classification
- Anemia of diminished production
- Anemia of RBC loss (hemolytic and nonhemolytic) 1
- Anemia of RBC loss (hemolytic and nonhemolytic) 2
- Polycythemia

Introduction

-Definition of anemia.

-Pathophysiology of anemia.

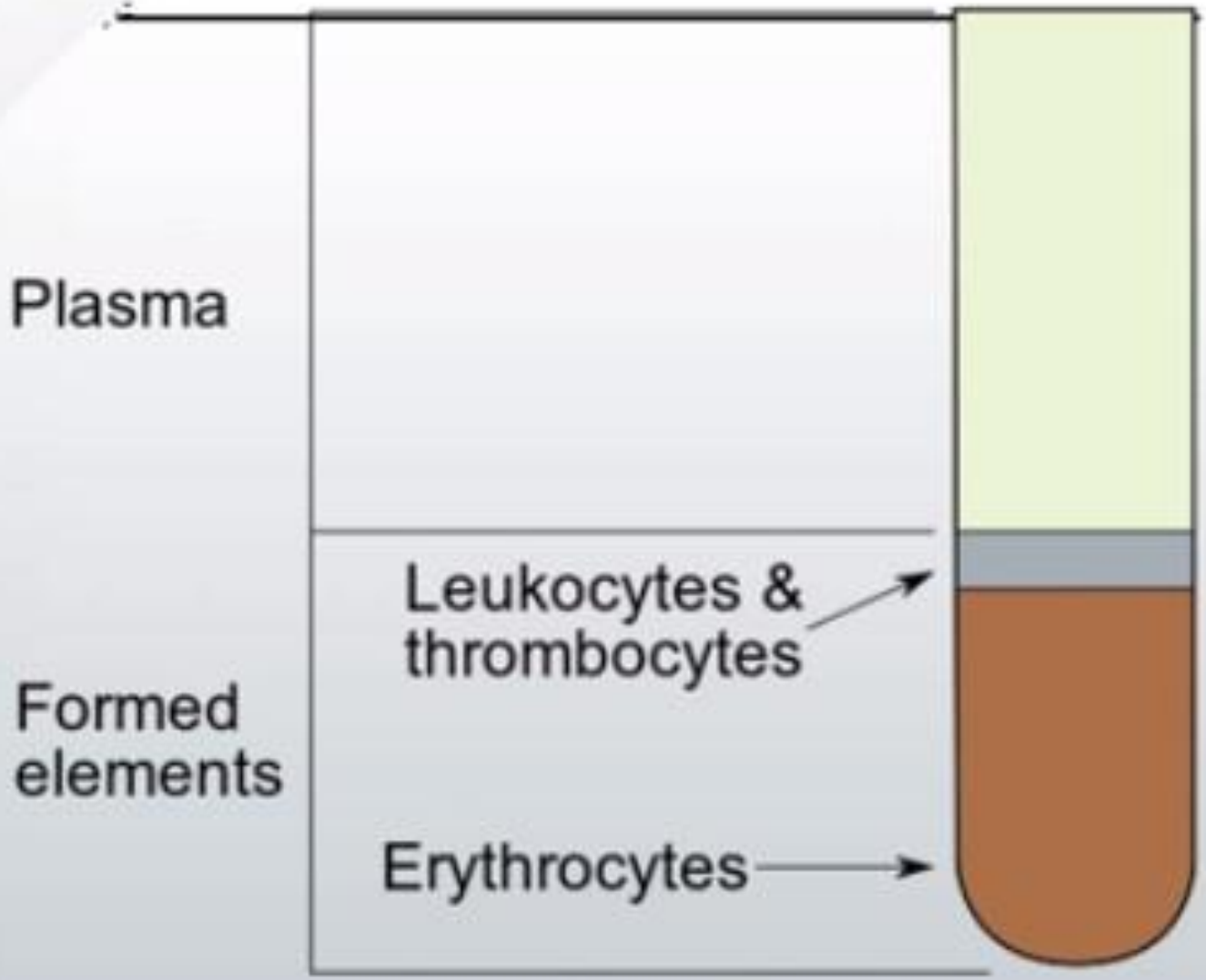
-Classification of anemia.

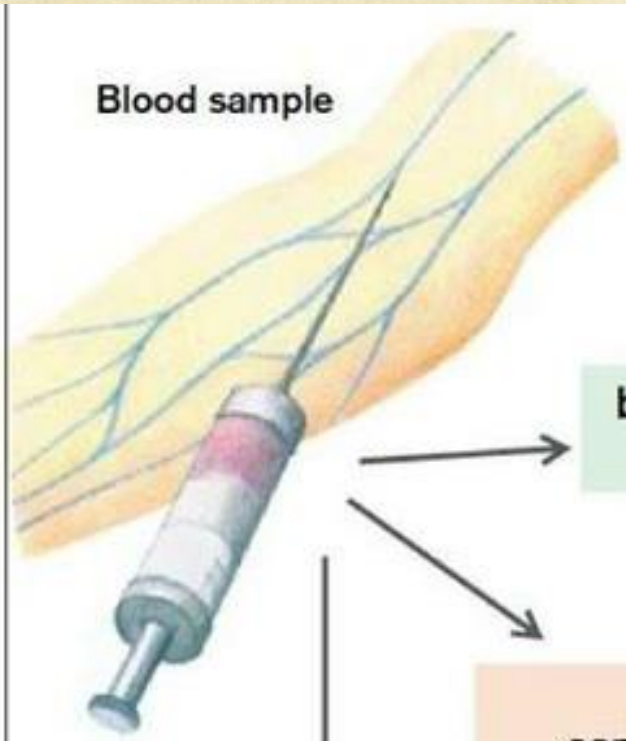
What is anemia?!

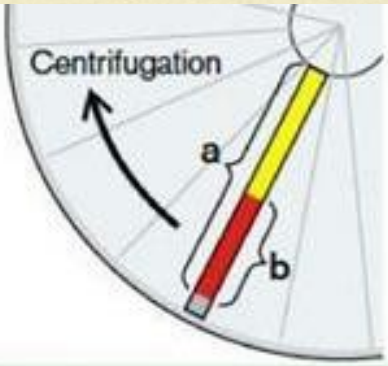
*Reduction in the oxygen-transporting capacity of blood, which usually results from a **decrease in the red cell mass** to subnormal levels.*

- Reflected in the decrease in hematocrit or hemoglobin concentration.

Hematocrit

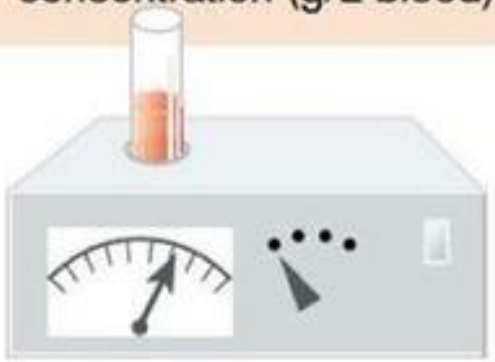

Plasma
Leukocytes &
thrombocytes
Formed
elements
Erythrocytes



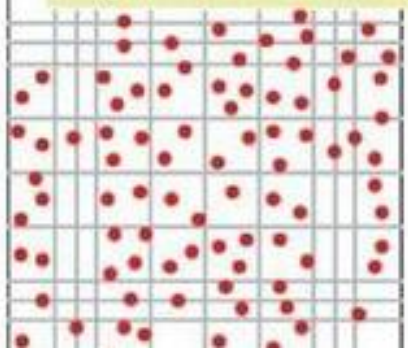


b/a = hematocrit (Hct)
(L_{RBC}/L_{blood})

Hemoglobin (Hb) concentration (g/L blood)



Erythrocytes (RBC) (number/L blood)



MCH (mean Hb mass/RBC)

$$= \frac{\text{Hb conc.}}{\text{No. RBC}} \text{ (g/RBC)}$$

Normal: ~30 pg

MCV (mean volume of one RBC)

$$= \frac{\text{Hct}}{\text{No. RBC}} \text{ (L/RBC)}$$

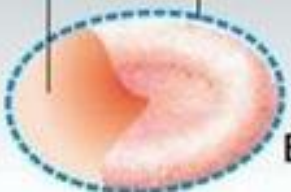
Normal: ~90 fl

MCHC (mean Hb conc. in RBCs)

$$= \frac{\text{Hb conc.}}{\text{Hct}} \text{ (g/L RBC)}$$

Normal: ~320 g/L

MCH / MCV = MCHC



- Mean cell volume (MCV): the average volume of a red cell expressed in femtoliters (fL)
- Mean cell hemoglobin (MCH): the average content (mass) of hemoglobin per red cell, expressed in pictograms.
- Mean cell hemoglobin concentration (MCHC): the average concentration of hemoglobin in a given volume of packed red cells, expressed in grams per deciliter.
- Red cell distribution width (RDW): the coefficient of variation of red cell volume.
- Hematocrit: the ratio of packed red cells to total blood volume.
- RBC count: the number of RBCs per unit volume, usually expressed in number (usually in millions) /microliter, for example $5x10^6$/microliter.

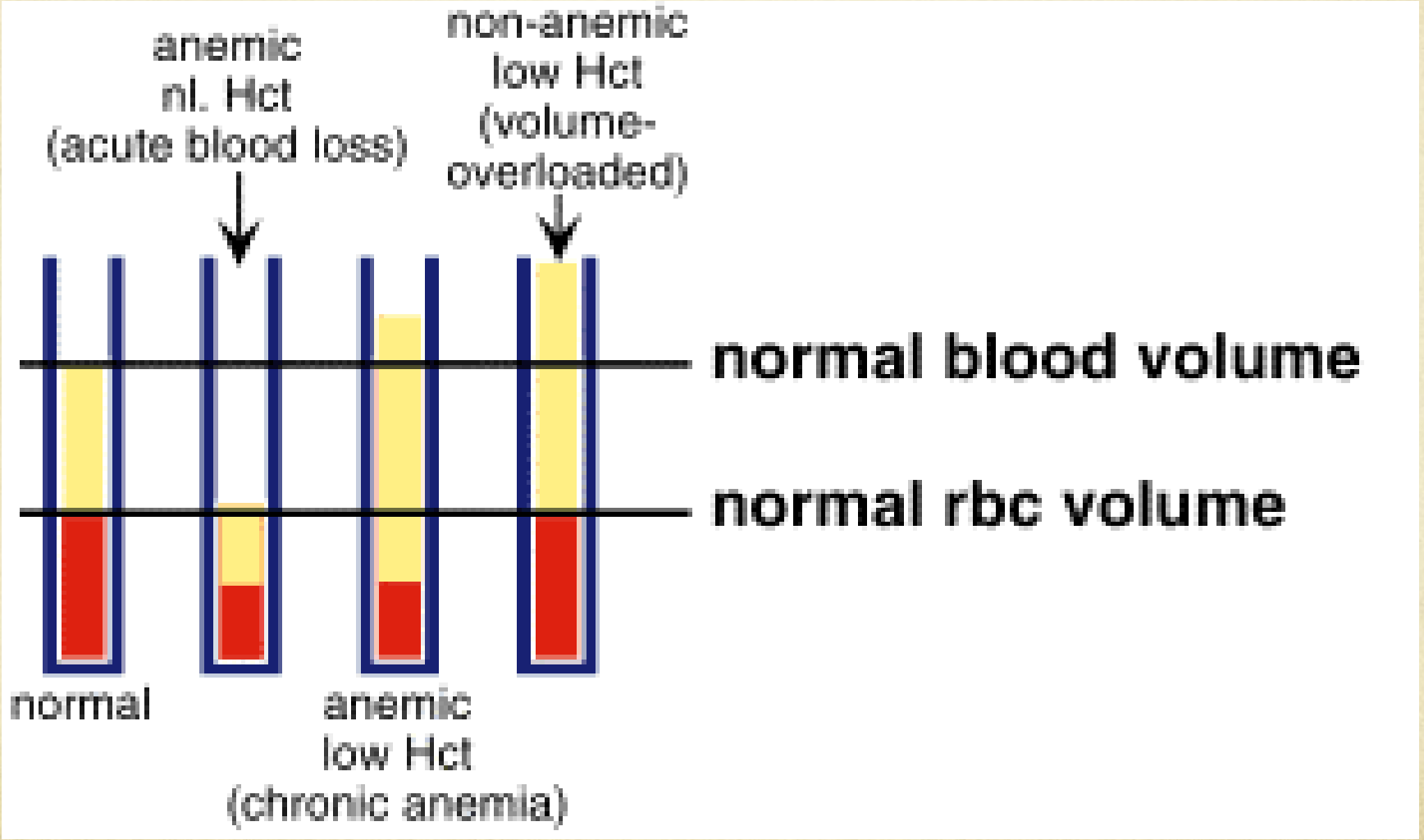
Measurement (units)	Men	Women
Hemoglobin (gm/dL)	13.6-17.2	12.0-15.0
Hematocrit (%)	39-49	33-43
Red cell count ($\times 10^6/\mu L$)	4.3-5.9	3.5-5.0
Reticulocyte count (%)	0.5-1.5	
Mean cell volume (fL)	82-96	
Mean cell hemoglobin (pg)	27-33	
Mean cell hemoglobin concentration (gm/dL)	33-37	
Red cell distribution width	11.5-14.5	

Question time!!!

- 45 year old male, was injured in a car accident, he bled profusely. Upon presentation he was obtunded, pale and distressed
- Vital signs were as follows:
  - heart rate 140 beat/minute.
  - Respiratory rate 25/minute
  - Blood pressure 80/30
- His hemoglobin and hematocrit were **within reference range.**

A 29 year old female, 8months pregnant, in a routine prenatal visit, she was found to have a hematocrit that is slightly below normal limits

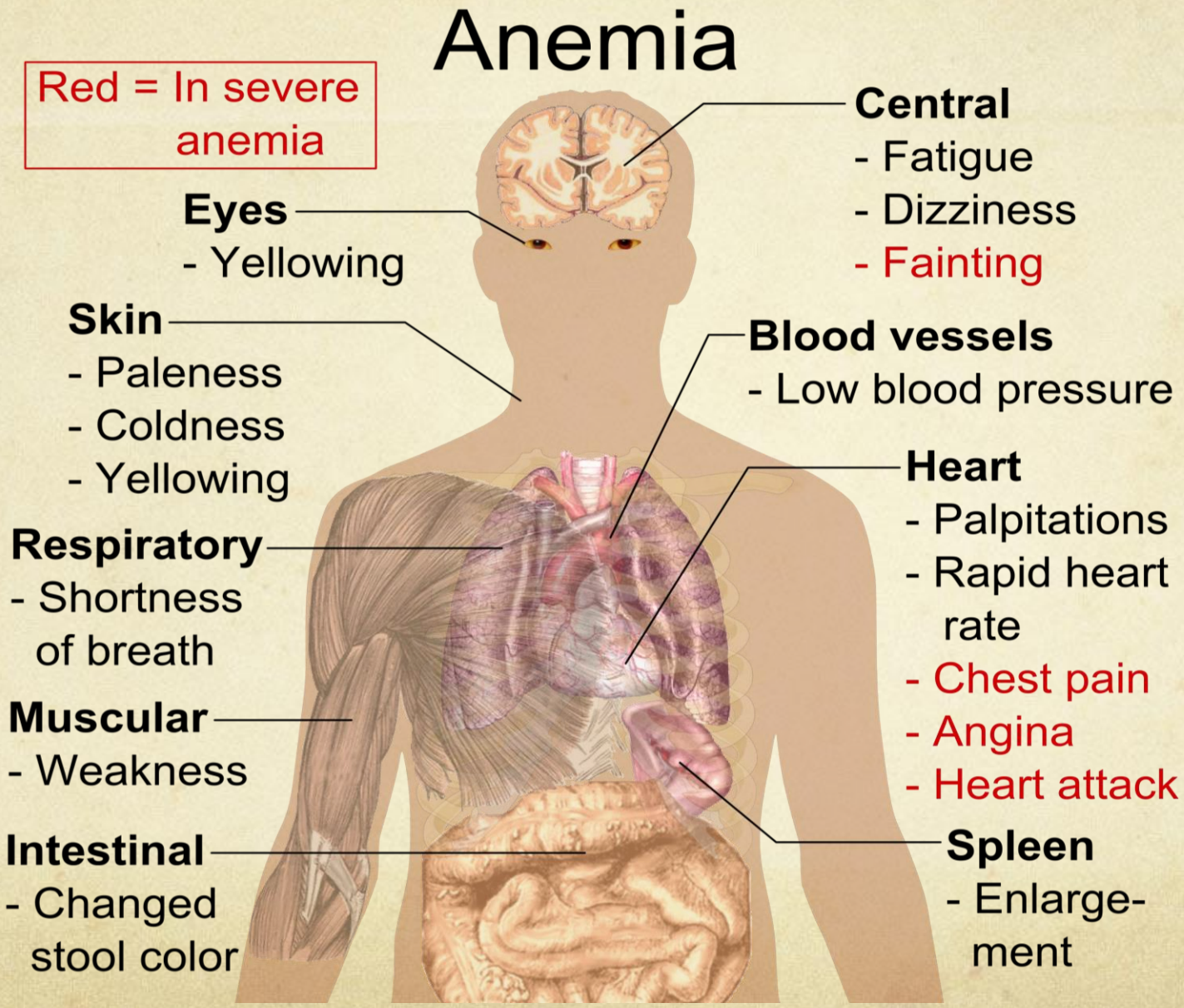
ARE THE PATIENTS ANEMIC???!!!


anemic
nl. Hct
(acute blood loss)
non-anemic
low Hct
(volume-
overloaded)
normal blood volume
normal rbc volume
normal
anemic
low Hct
(chronic anemia)

Clinical manifestations of anemia

- Result from decreased tissue oxygenation as well as from the underlying disease.

Pathophysiology of anemia




Free
2B
Me

Work up

Depending on the differential diagnosis, a number of other blood tests also may be performed to evaluate anemia, including

(1) iron indices (serum iron, serum iron-binding capacity, transferrin saturation, and serum ferritin concentrations), which help distinguish among anemias caused by iron deficiency, chronic disease, and thalassemia.

(2) plasma unconjugated bilirubin, haptoglobin, and lactate dehydrogenase levels, which are abnormal in hemolytic anemias.

(3) serum and red cell folate and vitamin B12 concentrations, which are low in megaloblastic anemias.

(4) hemoglobin electrophoresis, which is used to

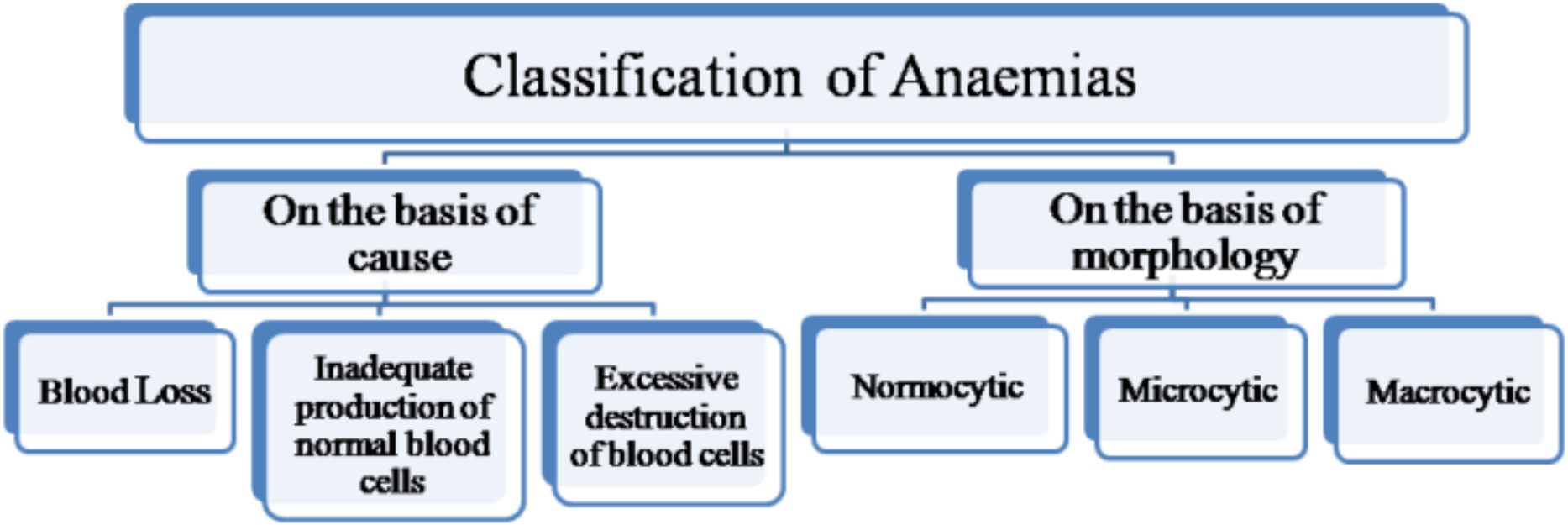
detect abnormal hemoglobins.

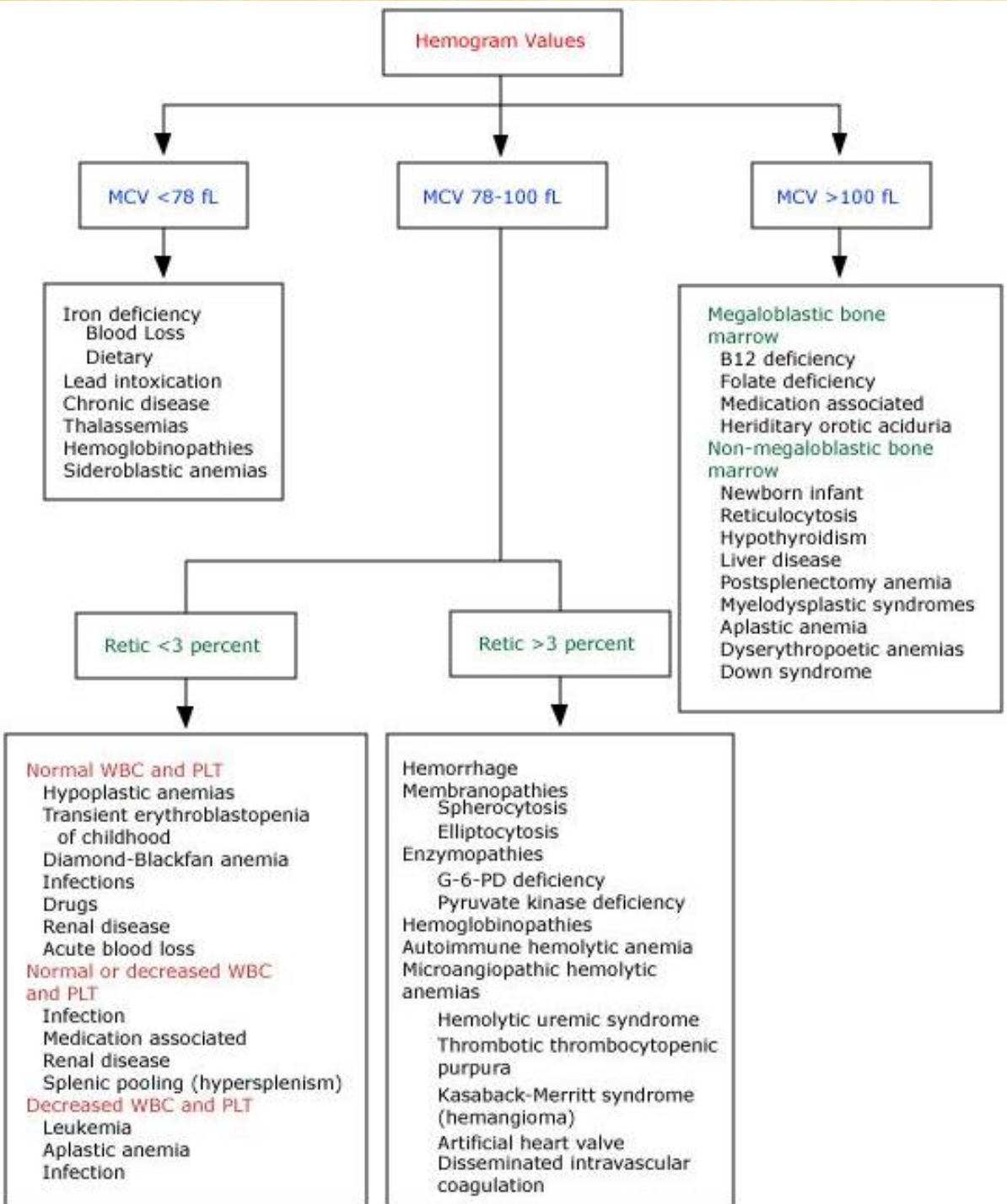
(5) the Coombs test, which is used to detect antibodies or complement on red cells in suspected cases of immunohemolytic anemia

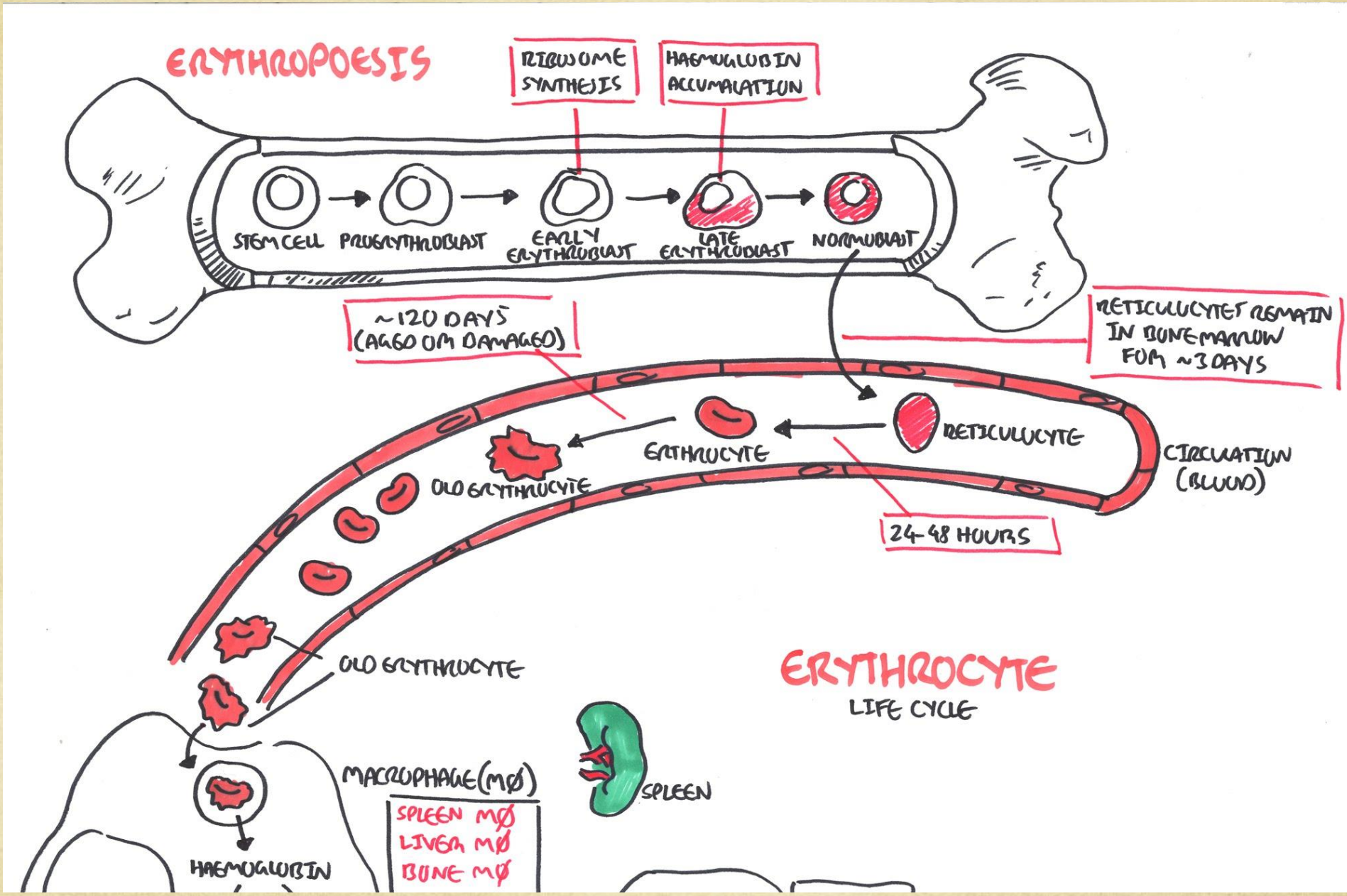
In isolated anemia, tests performed on the peripheral blood usually suffice to establish the cause.

However, if the anemia is associated with other cytopenias, then a more serious etiology should be sought and a bone marrow examination is warranted.

Classification of Anemia




Hemogram Values
MCV <78 fL
MCV 78-100 fL
MCV >100 fL
Iron deficiency
Blood Loss
Dietary
Lead intoxication
Chronic disease
Thalassemias
Hemoglobinopathies
Sideroblastic anemias
Megaloblastic bone marrow
B12 deficiency
Folate deficiency
Medication associated
Heriditary orotic aciduria
Non-megaloblastic bone marrow
Newborn infant
Reticulocytosis
Hypothyroidism
Liver disease
Postsplenectomy anemia
Myelodysplastic syndromes
Aplastic anemia
Dyserythropoetic anemias
Down syndrome
Retic <3 percent
Retic >3 percent
Normal WBC and PLT
Hypoplastic anemias
Transient erythroblastopenia of childhood
Diamond-Blackfan anemia
Infections
Drugs
Renal disease
Acute blood loss
Normal or decreased WBC and PLT
Infection
Medication associated
Renal disease
Splenic pooling (hypersplenism)
Decreased WBC and PLT
Leukemia
Aplastic anemia
Infection
Hemorrhage
Membranopathies
Spherocytosis
Elliptocytosis
Enzymopathies
G-6-PD deficiency
Pyruvate kinase deficiency
Hemoglobinopathies
Autoimmune hemolytic anemia
Microangiopathic hemolytic anemias
Hemolytic uremic syndrome
Thrombotic thrombocytopenic purpura
Kasaback-Merritt syndrome (hemangioma)
Artificial heart valve
Disseminated intravascular coagulation


ERYTHROPOESIS
RIBOSOME SYNTHESIS
HAEMOGLOBIN ACCUMULATION
STEM CELL
PROERYTHROBLAST
EARLY ERYTHROBLAST
LATE ERYTHROBLAST
NORMOBLAST
~120 DAYS (AGED OR DAMAGED)
RETICULOCYTES REMAIN IN BONE MARROW FOR ~3 DAYS
ERYTHROCYTE
RETICULOCYTE
CIRCULATION (BLOOD)
OLD ERYTHROCYTE
24-48 HOURS
OLD ERYTHROCYTE
ERYTHROCYTE
LIFE CYCLE
MACROPHAGE (MØ)
SPLEEN
SPLEEN MØ
LIVER MØ
BONE MØ
HAEMOGLOBIN