

THE PHYSIOLOGY OF BLOOD

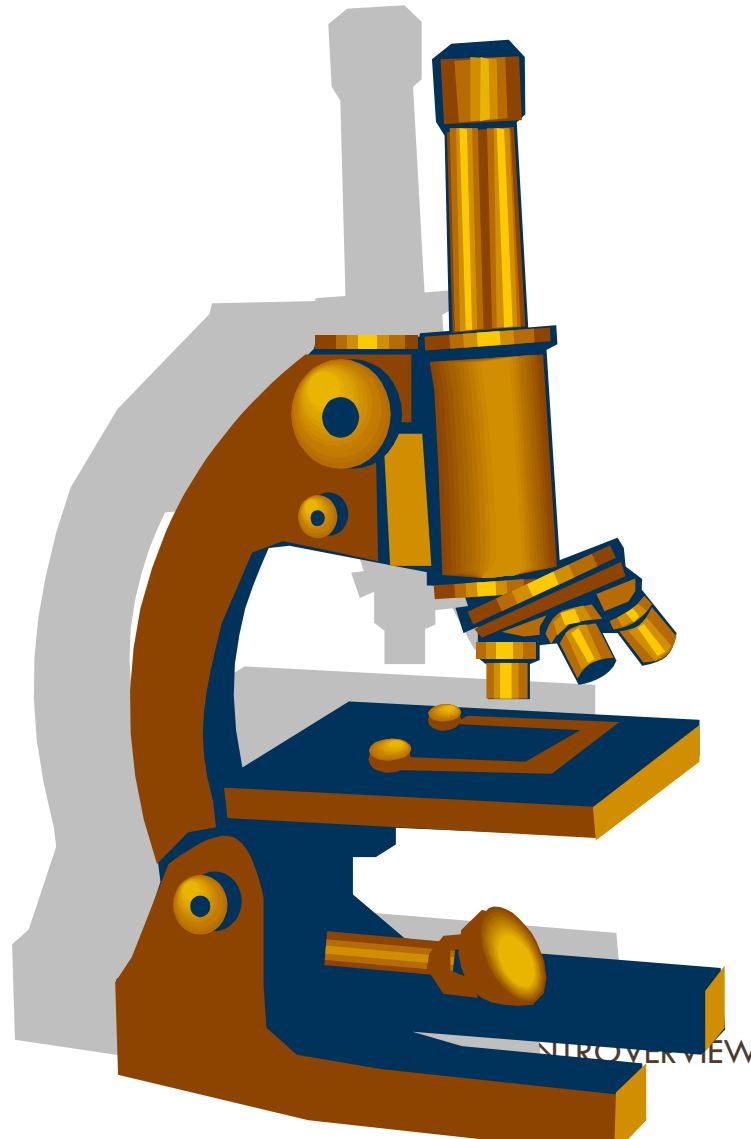
DR.MADHUR RAI

WHAT IS BLOOD?

2

- **IT IS A LIQUID CONNECTIVE TISSUE**
- **IN AN AVERAGE 70 Kg MAN:**
 - ▣ 100 Trillion cells.
 - ▣ Of which 25 trillions are **Red** Blood Cells!
 - ▣ The average blood volume is 5 – 6 lts.
 - ▣ It is roughly **7%** of the total body weight.

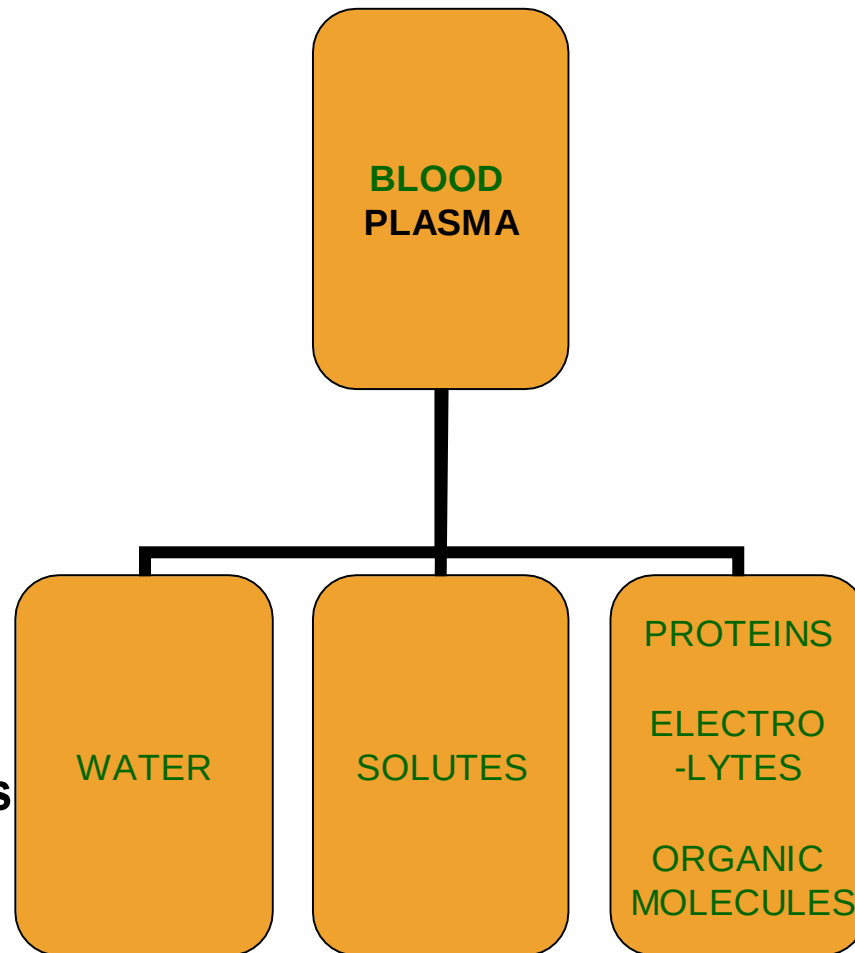
HEMATOLOGY: THE STUDY OF BLOOD MADE POSSIBLE BY MICROSCOPY



THE COMPOSITION OF BLOOD PLASMA

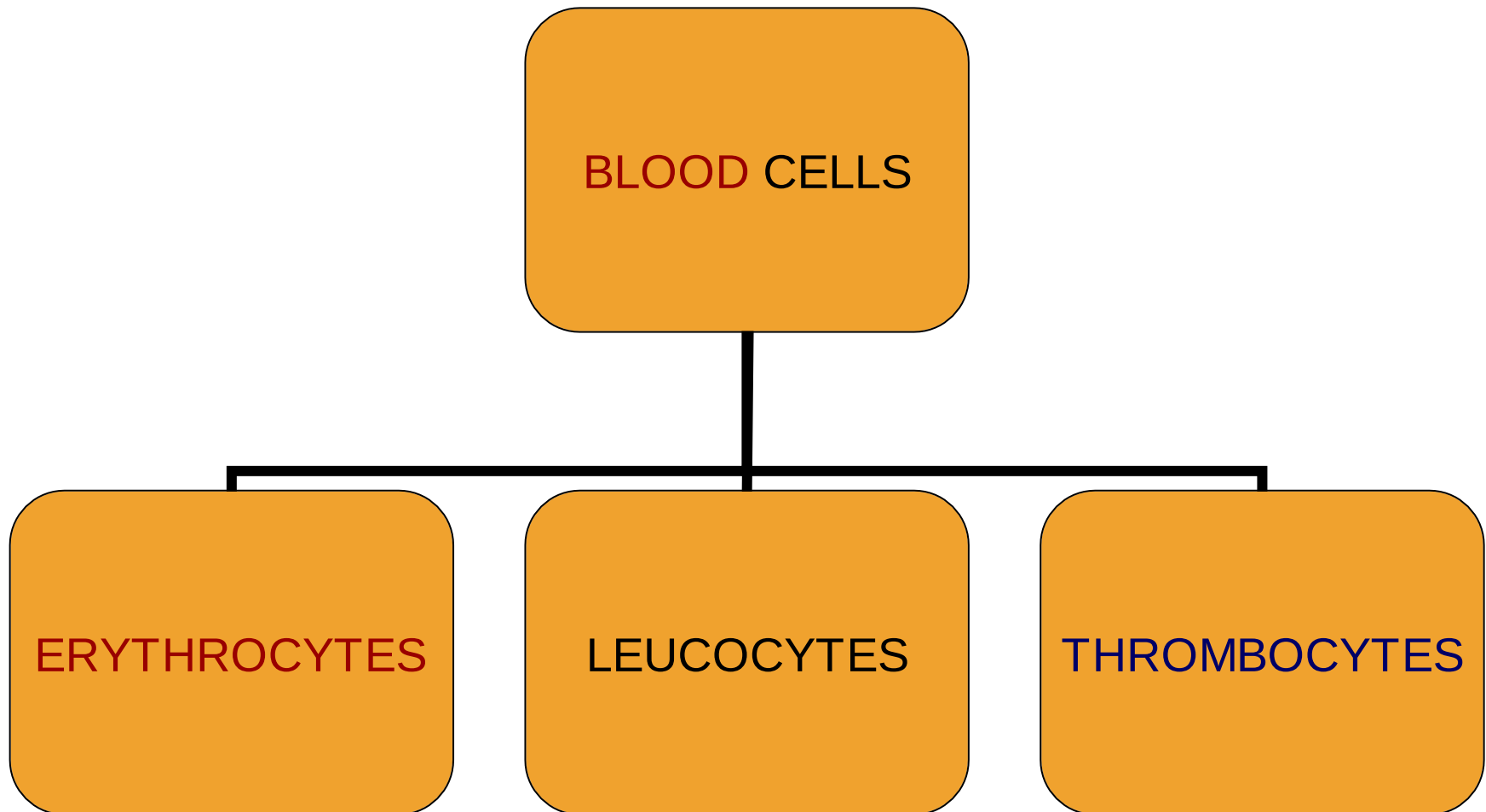
4

- The Liquid: Plasma:
 - ▣ Water, the solvent
 - ▣ The solute:
 - Proteins:
 - Albumin
 - Globulins:#
 - Fibrinogen
 - Electrolytes:
 - Na⁺
 - K⁺
 - Ca⁺⁺
 - Organic molecules
 - Urea
 - Glucose
 - Lipids



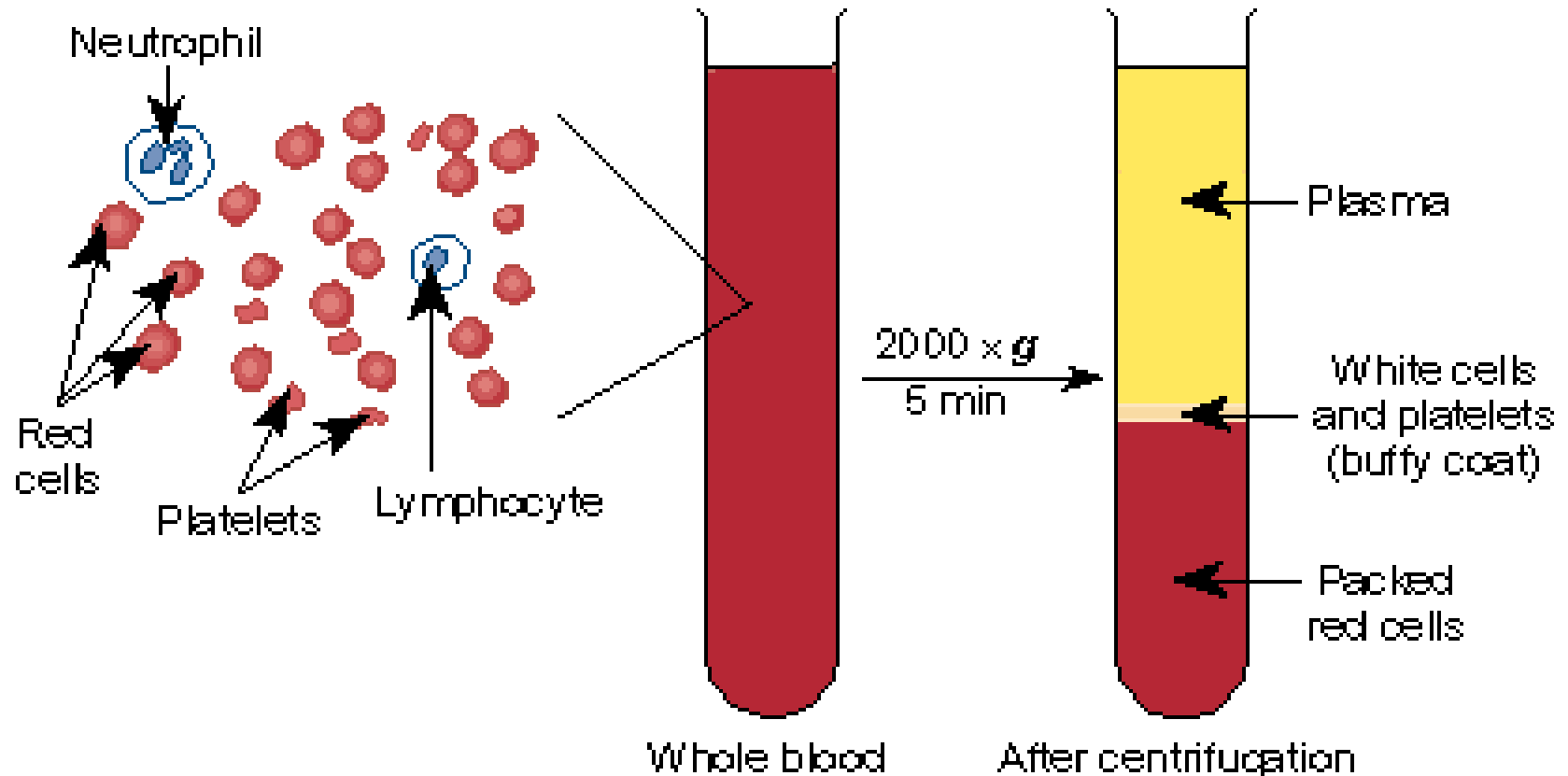
THE FORMED ELEMENTS: CELLS

5



BLOOD: COMPOSITION

6



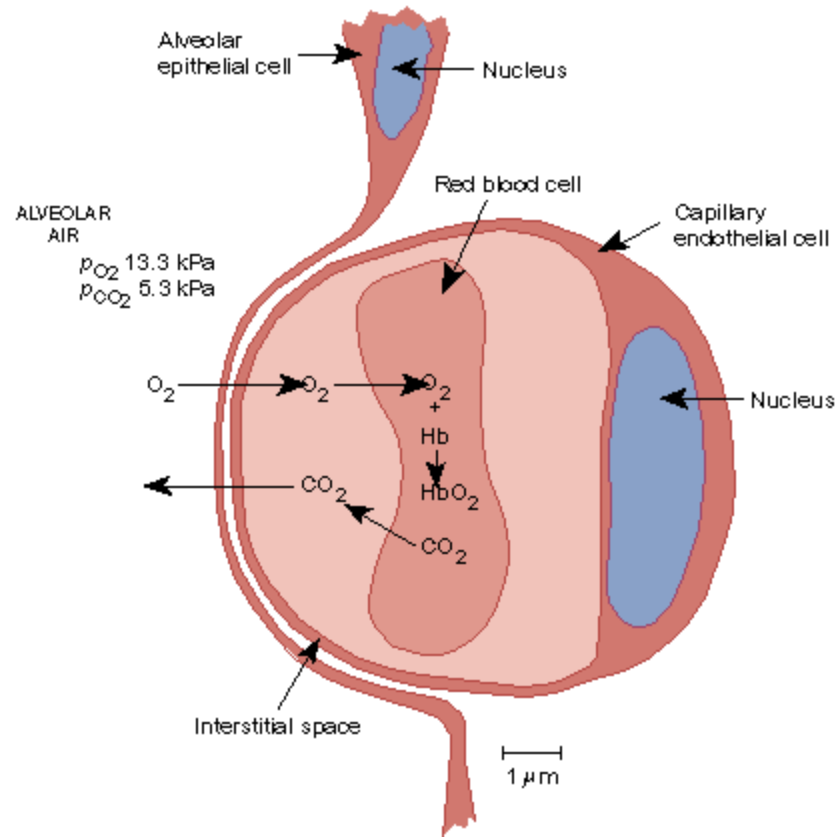
FUNCTIONS OF BLOOD

7

- ☐ **NUTRITIVE**
- ☐ **RESPIRATORY**
- ☐ **EXCRETORY**
- ☐ **BODY DEFENCE: IMMUNITY**
- ☐ **TRANSPORT:**
 - ☐ **HORMONES**
 - ☐ **VITAMINS**
 - ☐ **DRUGS**

OXYGEN & CO₂ TRANSPORT

8



FUNCTIONS OF BLOOD

9

- HOMEOSTATIC FUNCTION:
 - ▣ ACID BASE BALANCE.
 - ▣ ELECTROLYTE BALANCE.
 - ▣ HEMOSTASIS.
 - ▣ THERMOREGULATION.



WHAT IS BLOOD VOLUME?

10

DEFINITION

- Blood volume is the amount of blood that is circulating inside the circulatory system and stored in certain organs like spleen. It represents the TOTAL BLOOD in the body.
- NORMAL VALUE
 - = 80 ml/kg
 - = 5 – 6 lit / 70kg body wt



EXPRESSION OF BLOOD VOLUME

11

- Usually Blood Volume is expressed in **liters**.
- It can also be expressed in **relation to body weight**.
 - ▣ It is 7% Body Weight
- Another way to express it is in terms of **Body Surface Area**.
 - ▣ Whole Blood : 2.8 Lts/M²
 - ▣ Plasma : 1.5 Lts/M²

HEMATOCRIT (PCV)

12

- The volume of erythrocytes in the whole blood expressed in percentage is the **Hematocrit**.
- This is also called as Packed Cell Volume or **PCV**.
- This is determined by the **Wintrobe's tube**, using a Centrifuge.

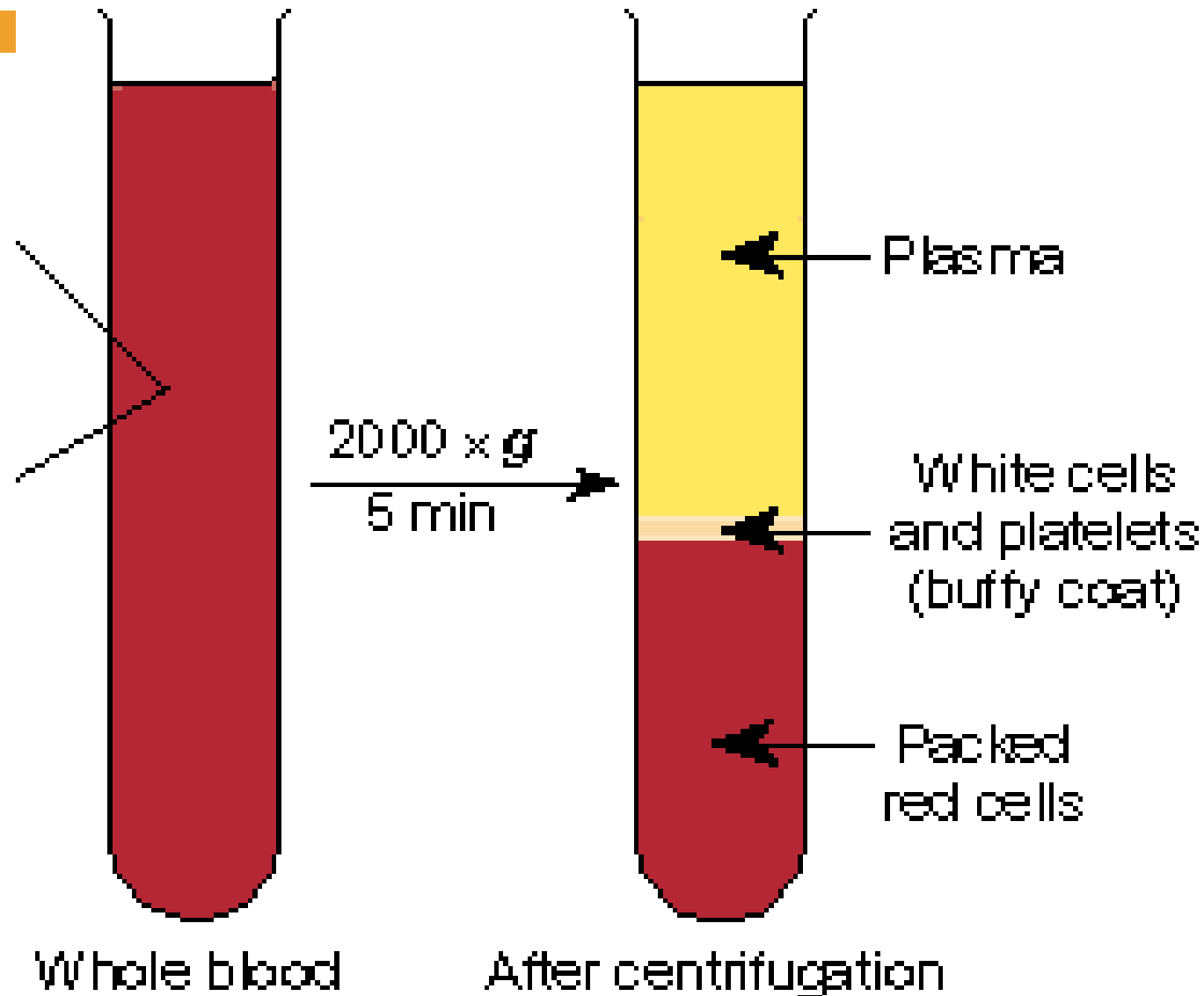
HEMATOCRIT

13

- A mixture of **blood and double oxalate (K – NH₄)** is taken upto 100 mark in the Wintrobe's tube.
- The tube is placed in the centrifuge.
- It is rotated at 3,000 rpm for 30 minutes.
- The Hematocrit is then read off the tube.
- Blood Volume = $\frac{\text{Plasma Volume} \times 100}{100 - \text{PCV}}$

HEMATOCRIT

14



BLOOD VOLUME: PHYSIOLOGICAL VARIATIONS

15

- AGE
- SEX
- TEMPERATURE
- BODY WEIGHT
- BODY SURFACE AREA
- HYPOXIA
- EMOTIONS
- PREGNANCY
- EXERCISE
- POSTURE

BLOOD VOLUME & AGE

16

AGE	BLOOD VOLUME in Liters
AT BIRTH	0.3
6 Months	0.5
1 year	0.7
2yrs 6 months	1.0
4 years	1.3
7 years	1.7
10 years	2.5(Girls); 3.2 (Boys)
ADULTS	5 (Men) 4.5 (Women)

BLOOD VOLUME: PHYSIOLOGICAL VARIATIONS

17

1. SEX:

- ▣ Males have more blood volume than females.

2. TEMPERATURE:

- ▣ Acute exposure to cold causes reduction in blood volume due to Plasma water loss to tissues.



BLOOD VOLUME: PHYSIOLOGICAL VARIATIONS

18

3. BODY WEIGHT:

- ▣ It is usually **7%** of the Body Weight.

4. BODY SURFACE AREA:

- ▣ **2.8 Lts/Square Meters** of BSA

BLOOD VOLUME: PHYSIOLOGICAL VARIATIONS

19



5. HYPOXIA:

- ▣ Seen in High altitudes.
- ▣ ↑ Erythrocytes
- ▣ So ↑ Blood volume.

6. EMOTIONS:

- ▣ Excitement causes an increase in the Blood volume.

BLOOD VOLUME: PHYSIOLOGICAL VARIATIONS

20

7. PREGNANCY:

- ▣ Increases by 20 – 30% due to mass of fetus.

8. EXERCISE:

- ▣ Vigorous exercise causes an increase.

9. POSTURE:

- ▣ Changing from lying down to erect.



Normal pregnancy

↑ Systemic vasodilation
 ↓ MAP
 ↑ Vasoactive factors
 ↑ Blood volume
 ↑ Cardiac output
 ↑ CO₂ sensitivity
 ↓ PaCO₂
 ↑ Insulin resistance



↔/↓ CBF



Moderate intensity exercise

↑ MAP
 ↑ Cardiac output
 ↑ PaCO₂
 ↑ Cerebral neural activity
 ↑ Cerebral metabolism
 ↑ SNA



↑ CBF

Globally, CBF regulation seems maintained during normal pregnancy, with the brain resisting pregnancy-related changes in order to maintain CBF within normal values at rest and possibly during exercise

Cardiovascular changes (4)

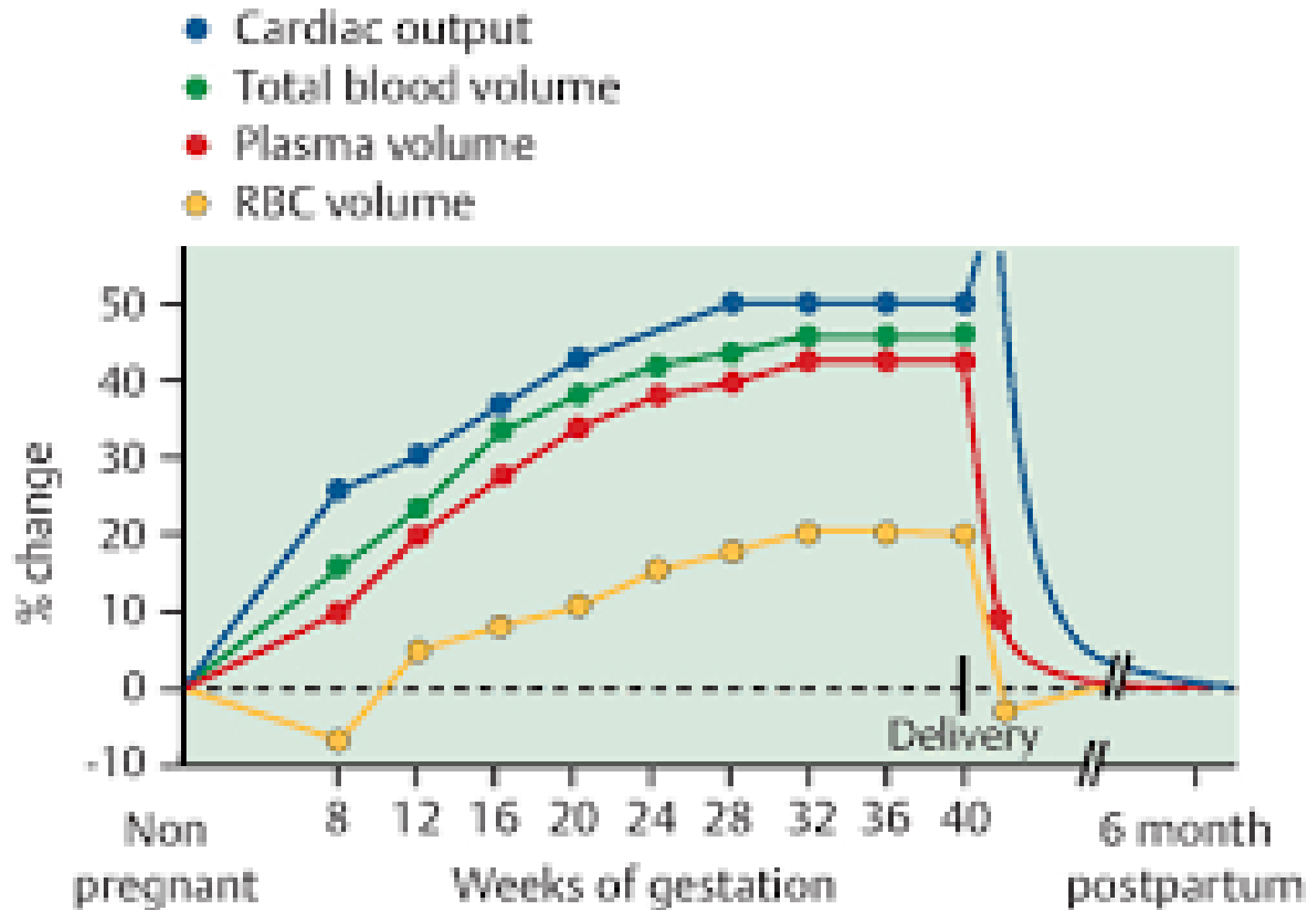
- Blood volume +30%
- Plasma volume +40%
- Red blood cell volume +20%
- Dilutional anemia

Increase cardiac output

Decrease blood viscosity

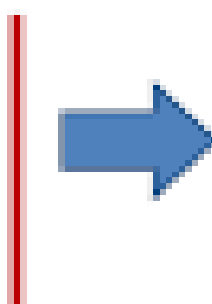
Vasodilatation

Right shift oxyhemoglobin dissociation curve



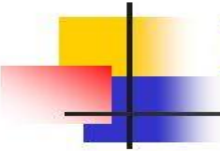
Maternal Cardiovascular Adaptations to Pregnancy

(1) Blood volume

- Increase blood volume
 - Decrease blood viscosity
- 
- Facilitate fetal perfusion
 - Minimize the increase in maternal stroke work
-
- Blood volume and blood viscosity *(compared to non-pregnant state)*
 - Total blood volume: up to a 40 % increase
 - Plasma volume: up to a 50% increase
 - Red blood cell volume: up to a 30% increase
 - Hematocrit: down by 2-3% ("physiological anemia")

REGULATION OF BLOOD VOLUME

25



Regulation of Blood Volume

Effects of deranged blood volume:

- **↑ BV → ↑ work load on the heart → ↑ BP, CO**
Cardiac hypertrophy → cardiac failure
- **↓ BV → ↓ CO & BP → ↓ Tissue perfusion → hypovolemic shock**

BLOOD VOLUME: **PATHOLOGICAL VARIATIONS**

26

- DECREASE IN BLOOD VOLUME IS **HYPOVOLEMIA.**
- **CAUSES:**
 - 1. BLOOD LOSS:**
 - 2. SHOCK:**
 - Crushing Injury
 - Cardiogenic
 - Neurogenic
 - Psychogenic.

HYPOVOLEMIA: CAUSES (CONTD)

27

3. HEMOLYSIS:

- ▣ Mismatched transfusion
- ▣ Snake bite
- ▣ Black water fever
- ▣ Hemorrhagic Plagues/Dengue
- ▣ Measles



HYPOVOLEMIA: CAUSES (CONTD)

28

4. DEHYDRATION:

- ▣ Diarrhoea
- ▣ Cholera
- ▣ Gastroenteritis
- ▣ Burns
- ▣ Hyperemesis.



HYPOVOLEMIA: CAUSES (CONTD)

29

5. ANEMIA:

- ▣ Decreased RBC volume
- ▣ Plasma may increase.

6. OBESITY:

- ▣ Blood volume per body weight decreases though Blood volume per BSA may be normal.

7. HYPOTHYROIDISM (MYXEDEMA):

- ▣ Decrease in Blood volume.

8. ACUTE COLD: Decreases blood volume.

CLINICAL PICTURE OF A PATIENT IN HYPOVOLEMIC SHOCK

ALTERED MENTAL STATUS -
RESTLESSNESS AND
DISORIENTATION MAY
BE PRESENT

DYSPNEA - DUE TO BLOOD LOSS
AND LACK OF RED BLOOD CELLS
WHICH CARRY OXYGEN

TACHYCARDIA-
RAPID HEART
RATE

COOL, CLAMMY SKIN DUE TO
BLOOD LOSS

OBVIOUS
BLEEDING

HYPOTENSION-
(DROP IN BLOOD PRESSURE) DUE
TO A DECREASE IN BLOOD VOLUME

FOLEY
CATHETER

DECREASED URINARY
OUTPUT DUE TO LOW
FLUID VOLUME

IV FLUID
REPLACEMENT

BLOOD
TRANSFUSION

FLUID REPLACEMENT THERAPY FOR
THE PATIENT IN HYPOVOLEMIC SHOCK
IS NECESSARY TO REVERSE THE
SIGNS AND SYMPTOMS OF SHOCK.

TREATMENT FOR BLOOD LOSS

31

- TRANSFUSION OF **WHOLE BLOOD** OF THE SAME BLOOD GROUP & TYPE.
- INFUSION OF **PLASMA**
- INFUSION OF **DEXTRAN OR NORMAL SALINE.**

Treatment contd...

32

Definition

- It is most commonly defined as replacing 1 blood volume or more within 24 hours
- One blood volume corresponds to 70 mL/Kg of a typical adults body weight (15 units of blood for a 70 Kg patient; however many facilities estimate 10 units as 1 blood volume).
- Half of the patient's blood volume is replaced within 3 hours.
- More than 4 red cell units transfused within 4 hours with continuous bleeding.

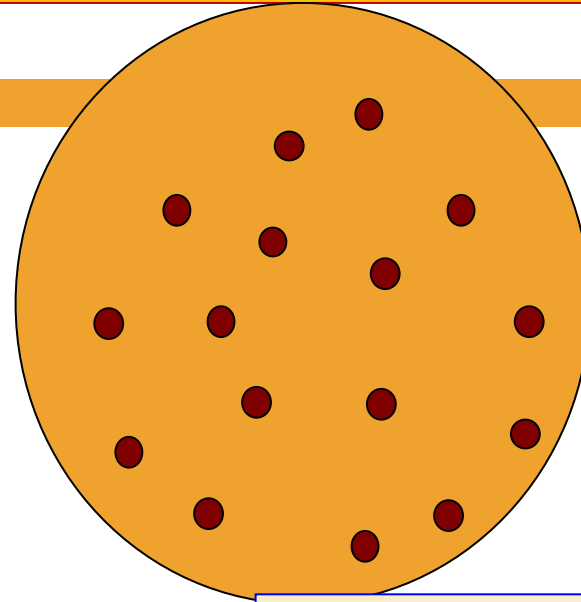
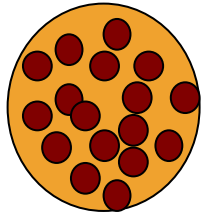
METHODS OF MEASURING BLOOD VOLUME

33

- IN HUMANS: ONLY INDIRECT METHODS
- DYE DILUTION TECHNIQUE:
- PRINCIPLE:
 - Injection of a known volume of non toxic substance into the circulation.
 - Measuring the dilution of this injected dye after some time.

DYE DILUTION TECHNIQUE

34



$V_1 = \text{VOLUME}$
 $C_1 = \text{CONCENTRATION}$
 OF DYE

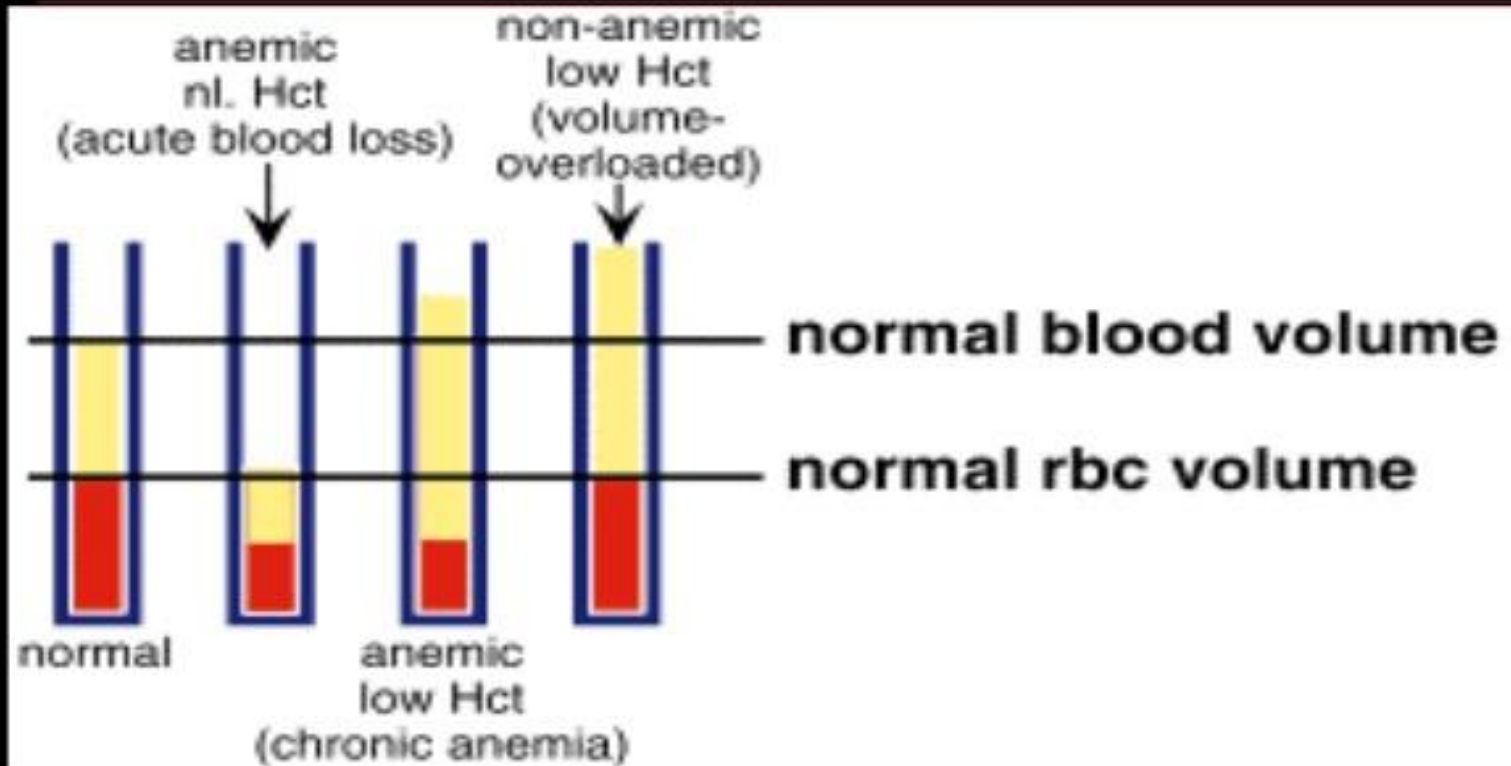
$V_2 = \text{VOLUME}$
 $C_2 = \text{CONC. OF DYE}$

$$V_1 \times C_1 = V_2 \times C_2$$

OR

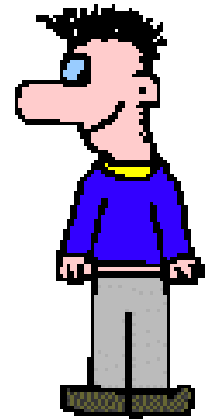
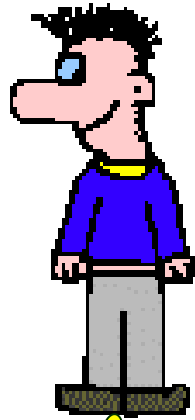
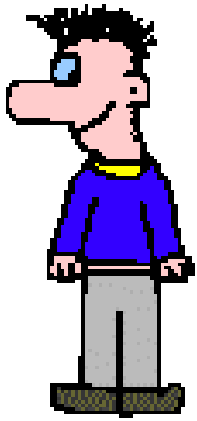
$$V_2 = \frac{V_1 \times C_1}{C_2} = \frac{\text{Amount of Dye injected}}{\text{Conc. Of the dye in the Plasma}}$$

APPLIED PHYSIOLOGY



RECAP

- **Definition**
- **Physiological variations**
- **Pathological variations**
- **Measurement of blood volume**
- **Factors regulating blood volume**
- **Applied physiology**



It's finished!

