

Red Cells
Structure and Metabolism
Values and Indices



MICHB III
HAEMATOLOGY & BLOOD TRANSFUSION
LECTURE SERIES

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Lecture objectives



1. Describe the red cell Structure and Metabolism and explain its adaptation to function
2. Give the red cell values and indices
3. Explain their (values & indices) application to red cell defects in clinical practice

Erythropoiesis

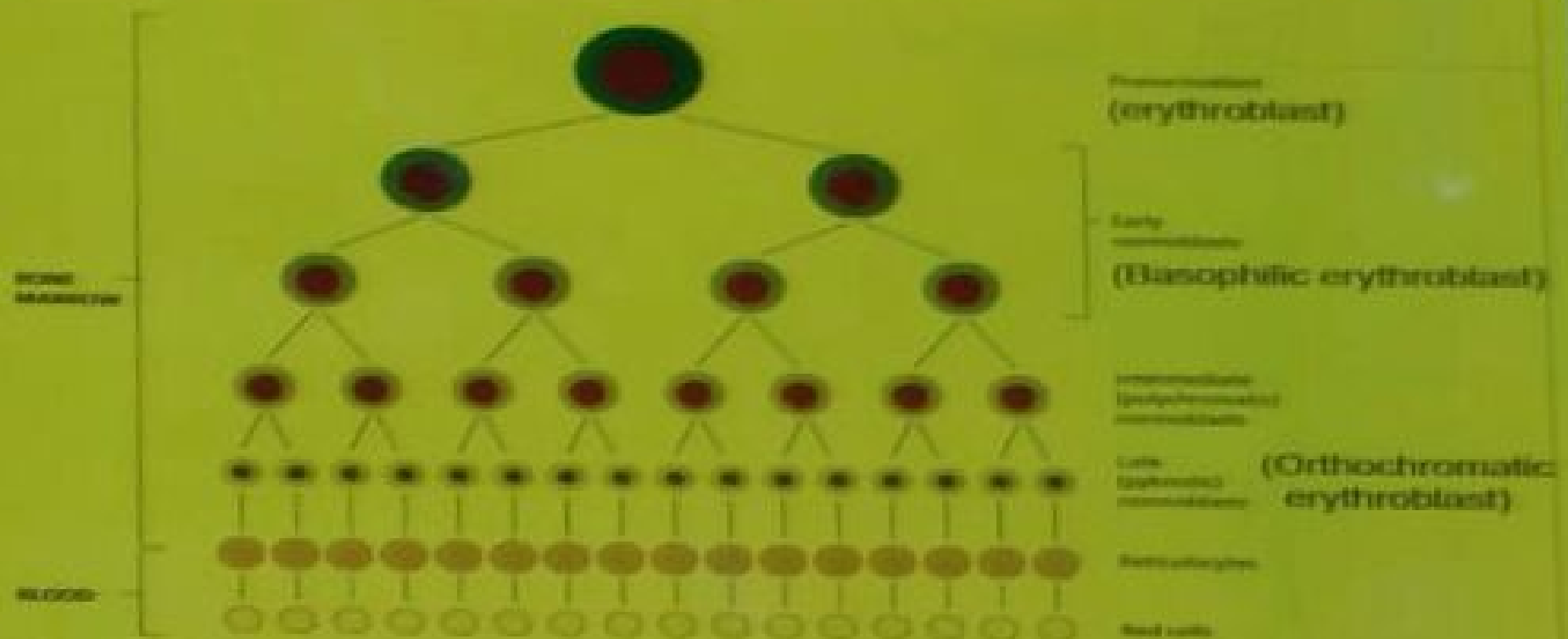


Fig. 2.2 The amplification and maturation sequence in the development of mature red cells from the proerythroblast.

• The differentiation and proliferation of RBC

Erythropoiesis

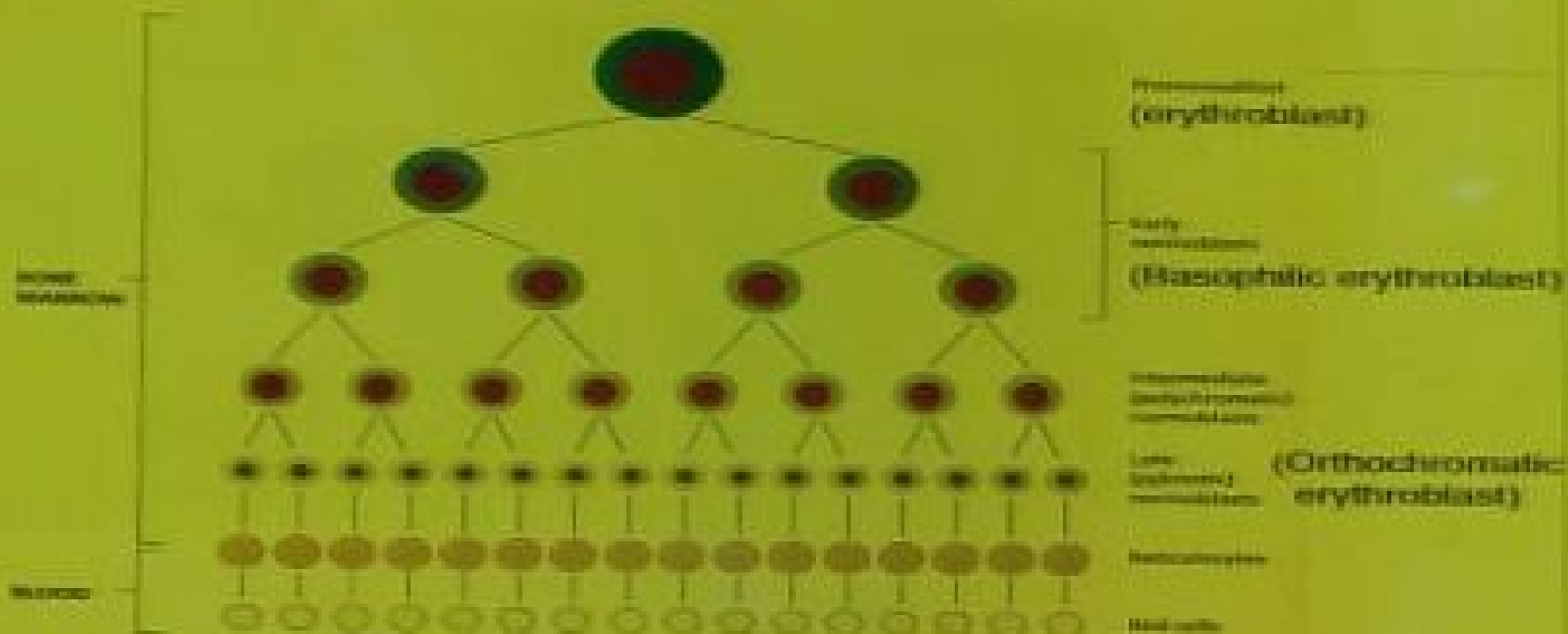


Fig. 27. The amplification and maturation sequence in the development of mature red cells from the proerythroblast.

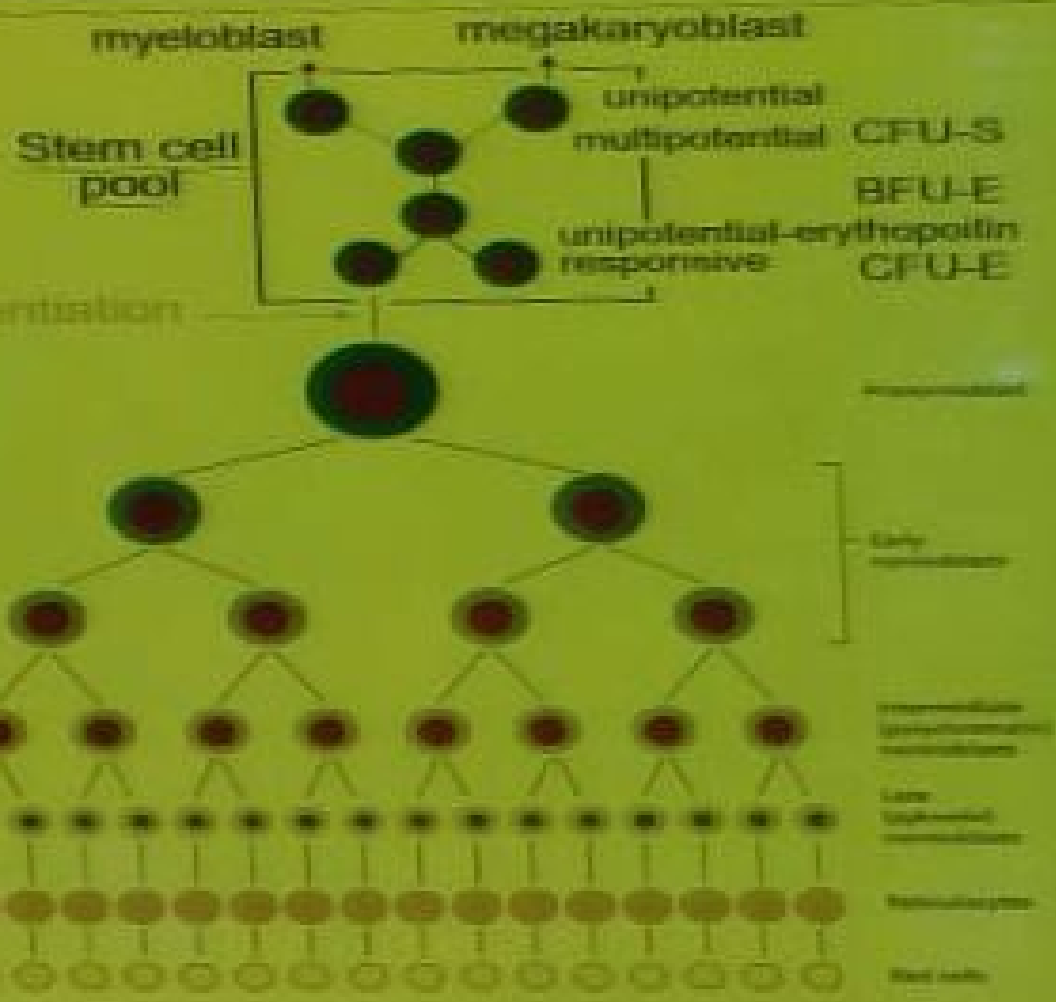
• The differentiation and proliferation of RBC

Erythropoietin responsiveness
Globin mRNA synthesis
Hgb synthesis



120 days

5 days



Red cell Structure and Metabolism



- Derived from mesenchymal stem cell
- Erythropoiesis regulated by IL3, erythropoietin
- Nutrients - Fe, B12, Folate,
- Others - B6, Riboflavin, Vit E, Cu, proteins & CHO
- Others hormones- androgens, thyroxine
- production increases with - Anoxia, high altitude, haemorrhage, haemolysis

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structure



- Biconcave, disc shape, diameter 6.7- 7.7µm
- Depends on structural integrity of the membrane and cytoskeleton.
- Sufficient energy ATP to maintain cation pump
- No Nucleus - no RNA.
- No Ribosomes - no protein.
- No Mitochondria - No cytochrome mediated oxidative phosphorylation.
- Cell Survival : preformed protein, Glycolysis for ATP.
- Life Span 120 days.

Structure



- Cell membrane composed of lipids anchored to a 2 dimensional elastic network of skeletal proteins embedded in lipid bilayer.
- lipids (alpha phospholipids, cholesterol).
- Proteins over 50 identified each with specific functions (Band 3, Aquaprotein, glut 1, Kidd, Rh)
 - Cytoskeleton - complex network of fibrous proteins within the cytoplasm - bind the membrane. Major skeletal proteins: alpha & beta Spectrin & Ankyrin-confer the biconcave shape deformability
 - Surface area 140um²

structure



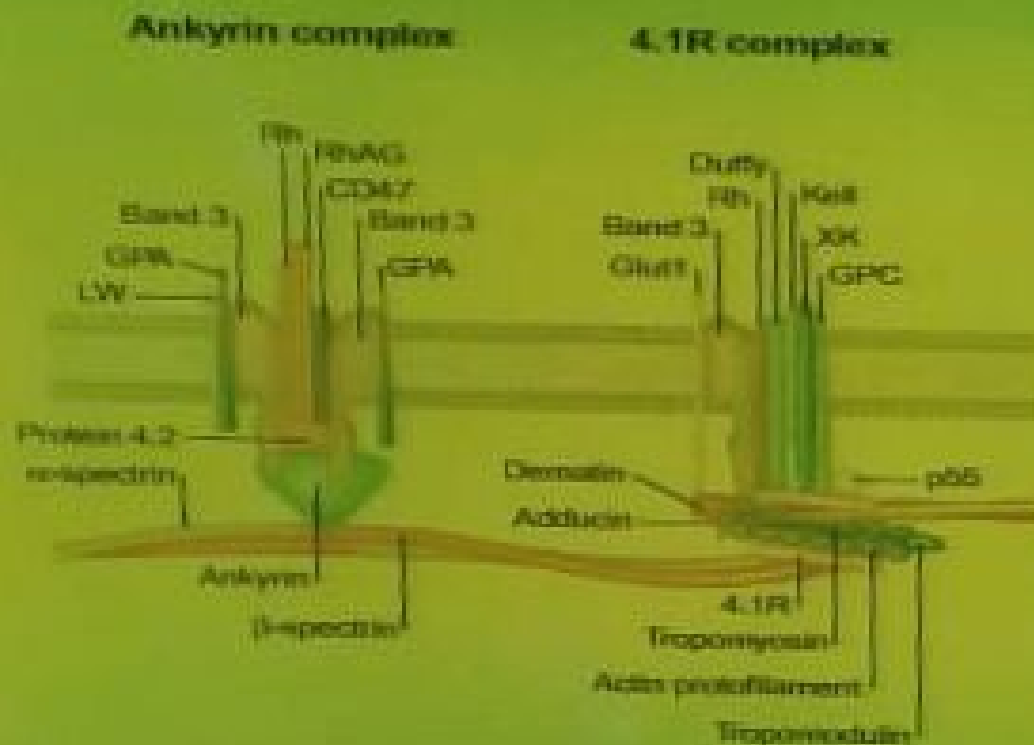
Structural organization of rbc confers;

- **High elasticity**
- **High structural resistance**
- **Ability to respond rapidly to applied fluid stress**

Thus highly deformable(can traverse microvasculature $1/3$ its size.

Deformability regulated by a) *cell geometry SA to vol. ratio*, b) *cytoplasm viscosity (haemoglobin)*, c) *membrane elasticity*

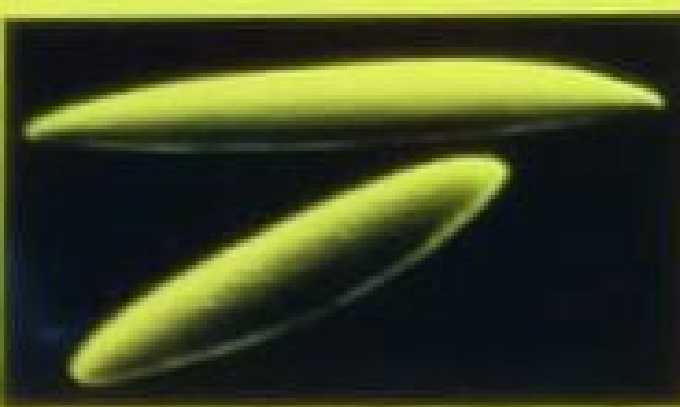
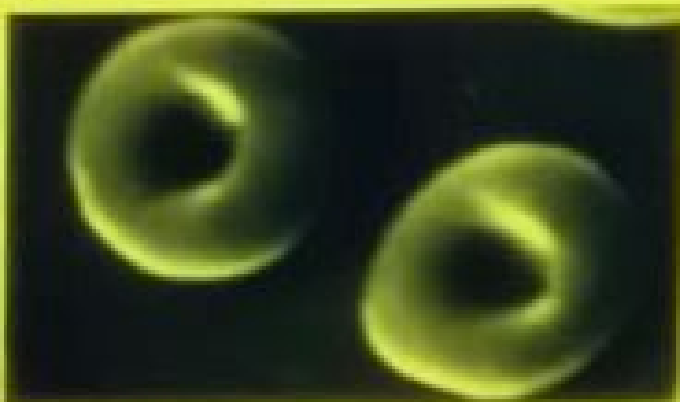
A schematic representation of red cell membrane.



Mohandas N., Gallagher P. G. *Blood* 2008; 112: 3939-3948

||||| blood

is reticulocyte (top left panel), the precursor of the mature discoid red cell (top right panel).



Michaels N., Coltrough P. G. Blood 2000; 112: 2626-2648

Metabolism



Energy required for membrane integrity & maintain Haemoglobin in functional state

- Glycolysis – Glucose \longrightarrow lactate- 2 ATPS also generates 2,3DPG(interacts with Hb to regulate oxygen affinity) and NADP
- NADP/NADPH system provides redox potential(pentose phosphate pathway, & Glutathione reductase) maintains Hbfe²⁺ from methHb

Red cell values & Indices



- Normal ref. ranges known for age & sex, physiological status

VALUES

- Red cell count(RBC) Male 4.5-6.5, Female 3.8-5.8 $\times 10^{12}$
- Haemoglobin concentration g/dl (eg neonate 18- 22g/dl, adult female 11.5 - 14.5g/dl)
- Packed Cell Volume or haematoerit (PCV, Hct)
- Reticulocyte count 0.2-2% ($10-100 \times 10^9$) Infants-2-6% ($100-150 \times 10^9$)
- Red Cell Mass

INDICES



- Mean Cell Volume (MCV) fl
- Mean Corpuscular Haemoglobin (MCH) pg
- Mean Cell Haemoglobin Concentration (MCHC) g/dl

values



- Red blood cell count

Manual – Neubauer counting chamber

- Automated haematology analyzer

- Red Cell Mass

comparison of total blood volume to plasma volume

Males 36mls/kg

females 32mls/Kg

Packed Cell Volume(PCV) Haematocrit(Hct)

- **Macro method – Wintrobe tubes**
- **Micro method - Capillary tubes**
- **Automated haematology analyzers**
 - derived indirectly from RBC and MCV

Red cell Indices



- Derived from PCV and Rbc

$$\text{MCV} = \frac{\text{PCV}}{\text{RBC}} \quad \text{Femtolitres (fl)}$$

- determined directly by automated haematology analyzers

- Mean Cell Haemoglobin (MCH)

$$\frac{\text{Hb}}{\text{RBC}} \quad - \text{ Picograms (pg)}$$

indices



- Mean Cell Haemoglobin Concentration (MCHC)

$\frac{\text{HB}}{\text{PCV}}$ - g/dl

- Normal Adults

- MCV=86 +/- 10fl

- MCH=29.5 +/- 2.5pg

- MCHC=32.5 +/- 2.5g/dl

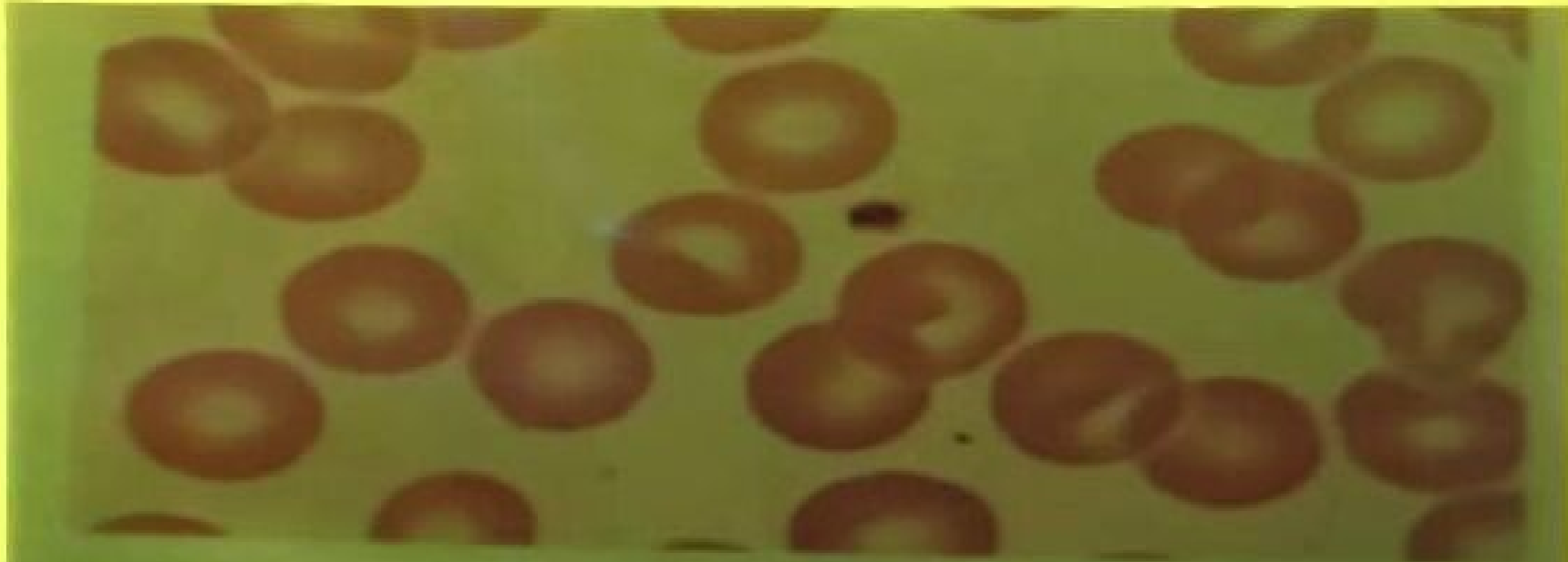


Fig. 1.44

Normal red cells: 7–8 μ m in diameter with minor

Application to red cell abnormalities

- Changes in red cell membrane structure and seen in various clinical conditions of red cell membrane defects (membranopathies) and in metabolic defects (Enzymopathies)
- Indices useful in classification of red cell morphological changes (size, shape, haemoglobinization) that occur in various pathological states
- Values and indices can be determined or derived by automated and manual methods as part of the Total Blood Count (TBC) in diagnostic haematology

Morphologic classification eg changes in rbc size (MCV)



Microcytic
MCV <76fl



Normocytic
MCV normal



Macrocytic
MCV >96fl