به نام خدا

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NORMAL MATURATION SERIES

Erythrocyte Series

Figure IA1-1

Pronormoblast (Rubriblast)

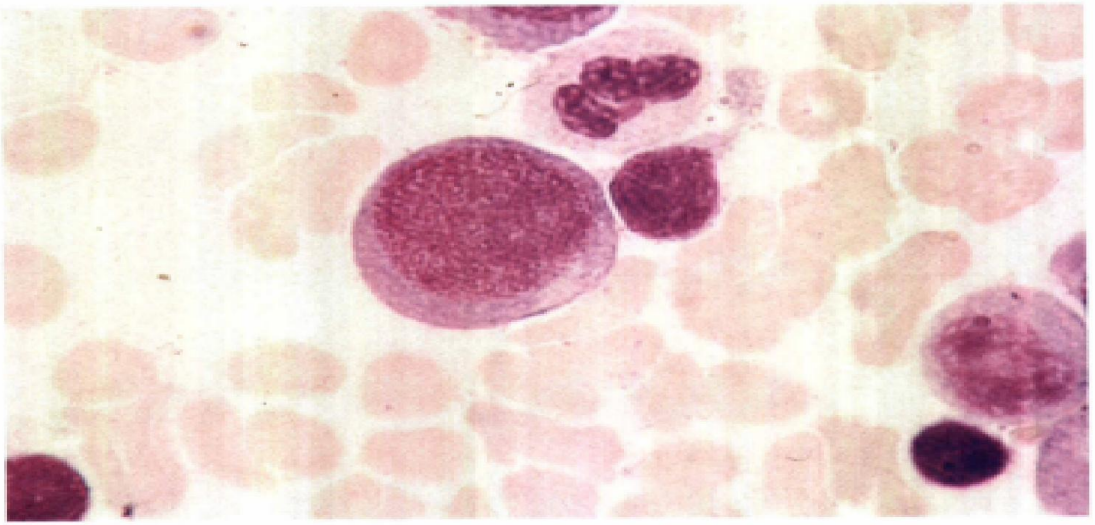

Figure IA1-2

Size: 14–22 μ

Nucleus

Shape: Round to slightly oval
N/C Ratio: 5:1–8:1
Color: Purple-red
Chromatin: Fine, but granular; parachromatin sparse
Nucleoli: 1–2 prominent; bluish tint

Cytoplasm

Color: Deep blue
Contents: Golgi, mitochondria, which produce a lighter blue color (perinuclear halo)

Clinical Conditions

- Erythroleukemia (M6a)
- Pure erythroid leukemia (M6b)
- Hemolytic disease of the newborn

Basophilic Normoblast (Prorubricyte)

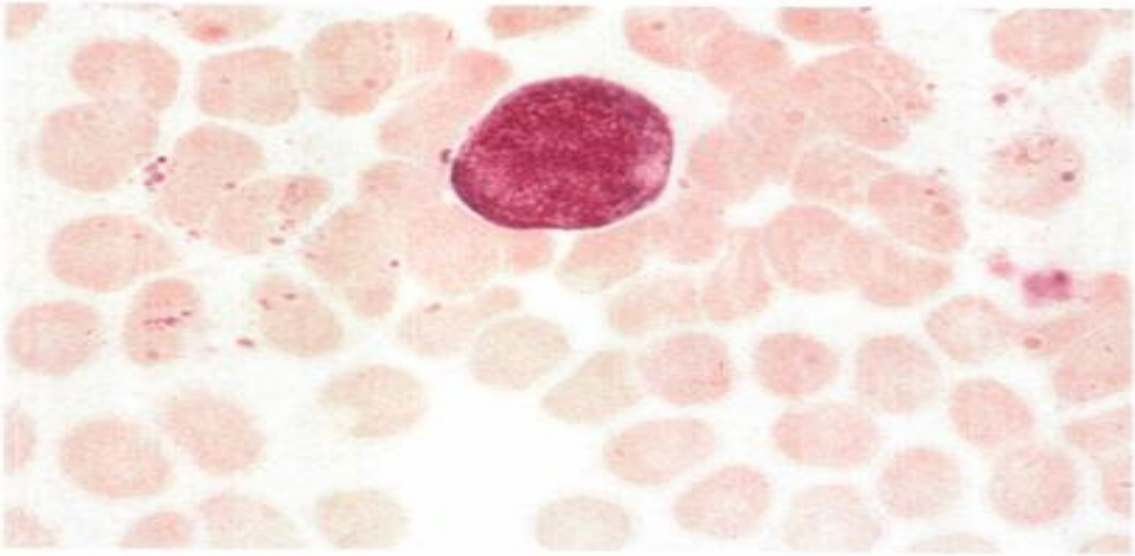

Figure IA1-3

Size: 12–17 μ

Nucleus

Shape: Round, centered
N/C Ratio: 4:1–6:1
Color: Purple interspersed with light areas
Chromatin: Coarse and somewhat condensed
Nucleoli: Usually not visible

Cytoplasm

Color: Deep blue
Contents: Golgi may produce a light blue area near the nucleus, many mitochondria

Clinical Conditions

- Erythroleukemia (M6a)
- Pure erythroid leukemia (M6b)
- Hemolytic disease of the newborn

Polychromatophilic Normoblast (Rubricyte)

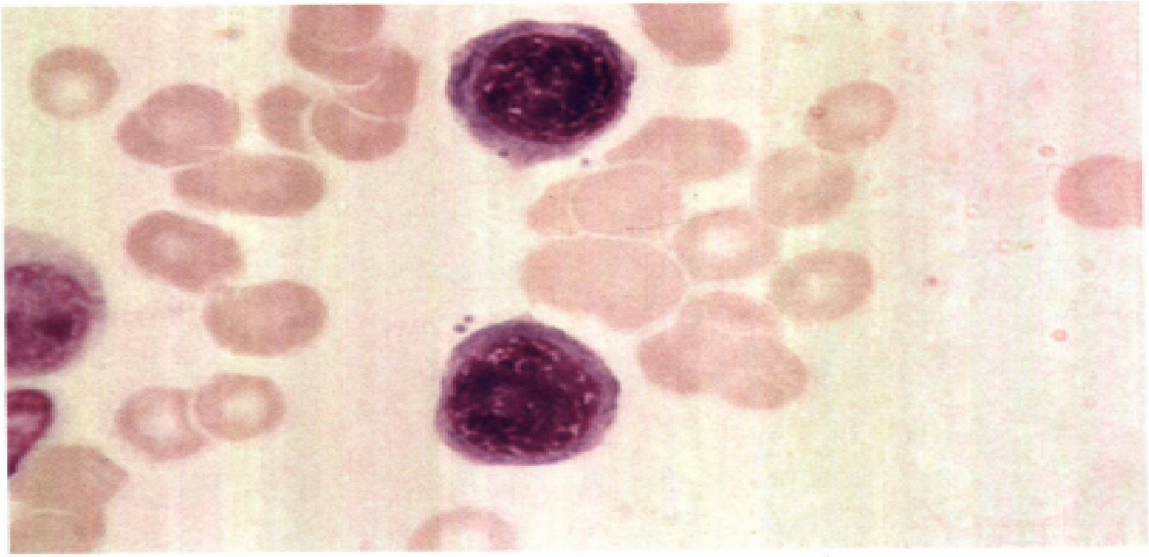

Figure **IA1-4**

Size: 11–14 μ

Nucleus

Shape: Round, centered to eccentric
N/C Ratio: 1:1–4:1
Color: Red-purple
Chromatin: Coarse and condensed; parachromatin distinct, producing a "checkerboard" appearance
Nucleoli: None

Cytoplasm

Color: Bluish-pink to grey-blue
Contents: Perinuclear halo visible; increased hemoglobin, causing the pink-grey color; decreased RNA, causing the lighter blue color

Clinical Conditions

- Erythroleukemia (M6a)
- Pure erythroid leukemia (M6b)
- Hemolytic disease of the newborn
- Myeloproliferative disease—chronic idiopathic myelofibrosis (CIMF), chronic myelocytic leukemia (CML)
- Hemolytic anemias
- Thalassemia major
- Sickle cell disease

Orthochromic Normoblast (Metarubricyte)

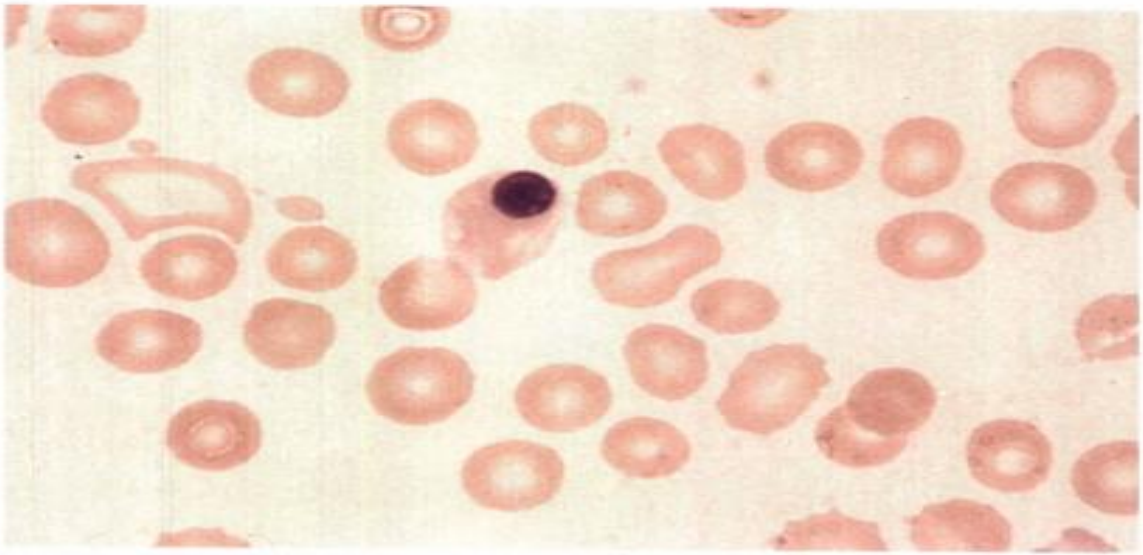

Figure IA1-5

Size: 8–12 μ

Nucleus

Shape: Round, centered to eccentric; may be fragmented or extruding
N/C Ratio: 1:4–1:2
Color: Blue-purple
Chromatin: Condensed and homogeneous (pyknotic)
Nucleoli: None

Cytoplasm

Color: Pink to orange-pink, with a hint of blue
Contents: Hemoglobin production increased

Clinical Conditions

- Erythroleukemia (M6a)
- Pure erythroid leukemia (M6b)
- Hemolytic disease of the newborn
- Myeloproliferative diseases—CIMF, CML
- Thalassemia major
- Sickle cell disease

Polychromatophilic Erythrocyte (Reticulocyte)

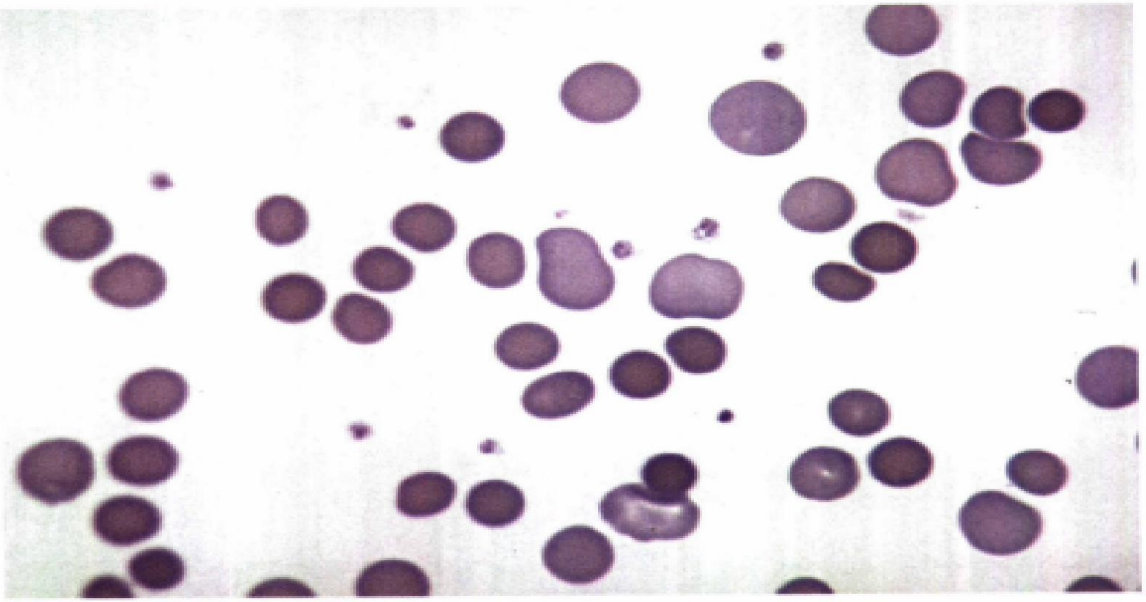

Figure IA1-6

Size: 8–11 μ

Nucleus

None

Cytoplasm

Color: Pink, with a tint of blue
Contents: Remnants of Golgi and mitochondria, residual RNA (reticulum)

Clinical Conditions

- Increased erythrocyte production
- Hemolytic anemias
- Membrane disorders
- Hemolytic disease of the newborn

Mature Red Blood Cell (Mature Erythrocyte)

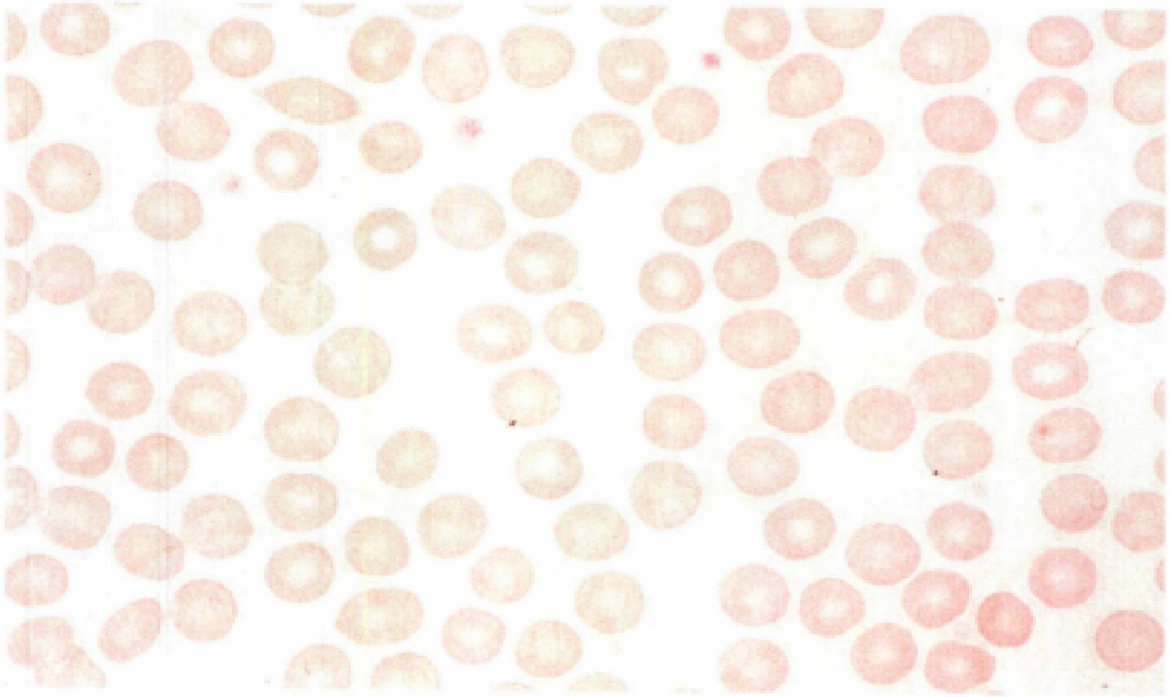

Figure IA1-7

Size: 7–7.5 μ

Nucleus

None

Cytoplasm

Color: Pink, central pallor about 1/3 of the cell
Contents: No mitochondria

MEGALOBLASTIC MATURATION SERIES

Megaloblastic Series

Figure IA1-8

Promegaloblast (Megaloblastic Rubriblast)

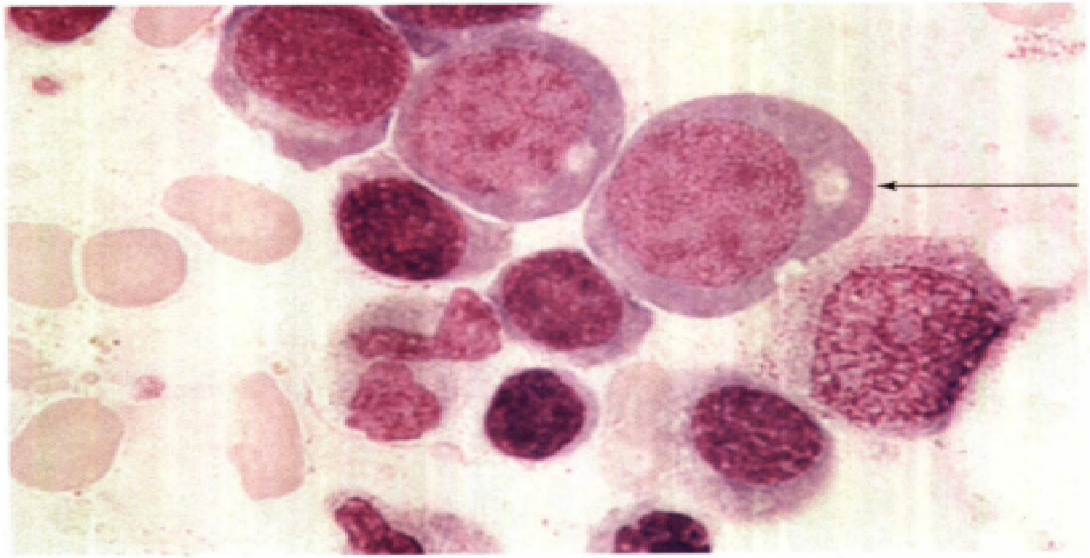

Figure IA1-9

Size: 19–27 μ

Nucleus

Shape: Round or irregular
N/C Ratio: 5:1
Color: Purple
Chromatin: Fine and closely meshed
Nucleoli: Multiple

Cytoplasm

Color: Deep blue
Contents: Nongranular with perinuclear halo

Clinical Conditions

- Vitamin B_{12} deficiency
- Folic acid deficiency
- Congenital dyserythropoietic anemia

Basophilic Megaloblast (Megaloblastic Prorubricyte)

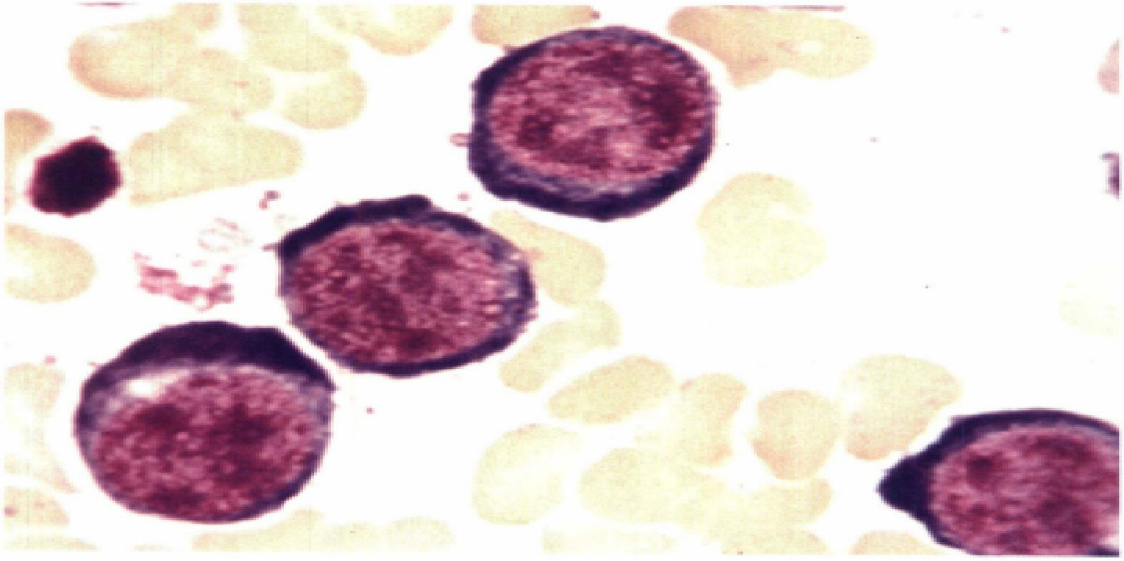

Figure IA1-10

Size: 17–24 μ

Nucleus

Shape: Round
N/C Ratio: 4:1
Color: Purple
Chromatin: Coarser than previous cell but still fine and open
Nucleoli: Not visible

Cytoplasm

Color: Deep blue
Contents: Faint perinuclear halo

Clinical Conditions

- Vitamin B_{12} deficiency
- Folic acid deficiency
- Congenital dyserythropoietic anemia

Polychromatophilic Megaloblast (Megaloblastic Rubricyte)

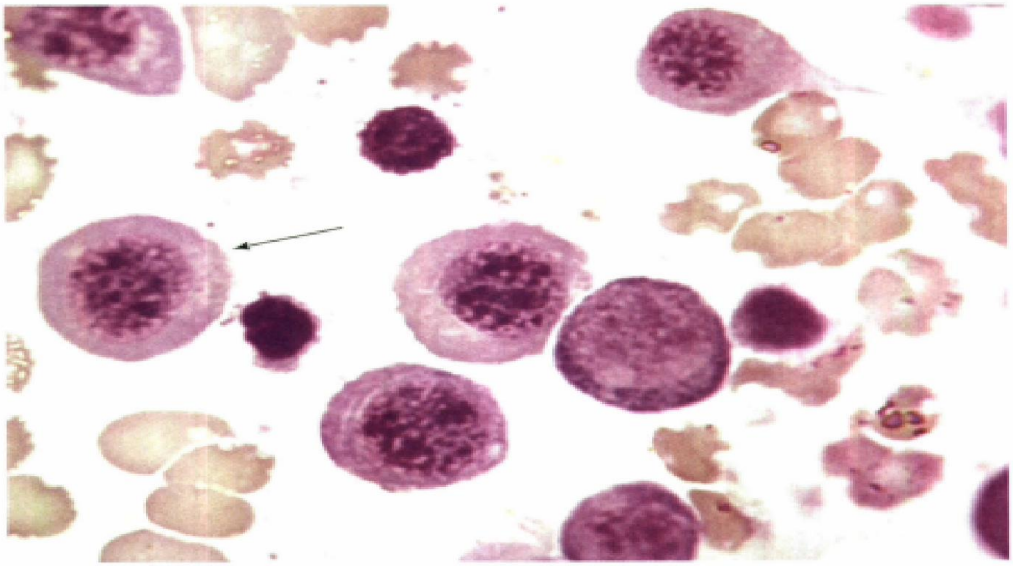

Figure IA1-11

Size: 15–20 μ

Nucleus

Shape: Round and central
N/C Ratio: 2:1
Color: Purple
Chromatin: Minimal clumping, loosely defined
Nucleoli: Not visible

Cytoplasm

Color: Blue-grey to pink-grey
Contents: More cytoplasm than in normoblastic cell

Clinical Conditions

- Vitamin B_{12} deficiency
- Folic acid deficiency
- Congenital dyserythropoietic anemia

Orthochromic Megaloblast (Megaloblastic Metarubricyte)

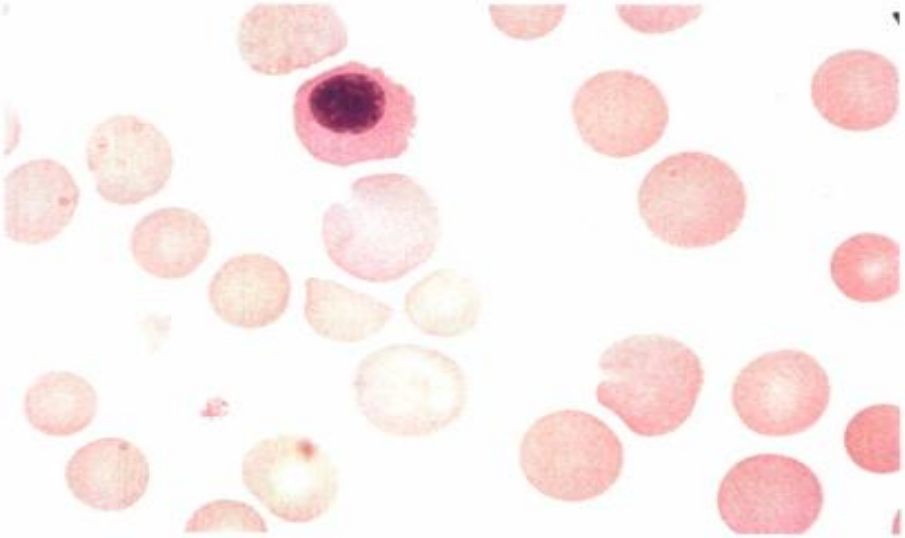

Figure IA1-12

Size: 10–15 μ

Nucleus

Shape: Round to slightly irregular, central or slightly eccentric
N/C Ratio: 1:1
Color: Deep purple but still some chromatin structure
Chromatin: Clumped, but less than in normoblastic cell
Nucleoli: Not visible

Cytoplasm

Color: Pink, with a hint of blue
Contents: More cytoplasm than in normoblastic cell

Clinical Conditions

- Vitamin B_{12} deficiency
- Folic acid deficiency
- Congenital dyserythropoietic anemia

Polychromatophilic Megalocyte (Megaloblastic Reticulocyte)

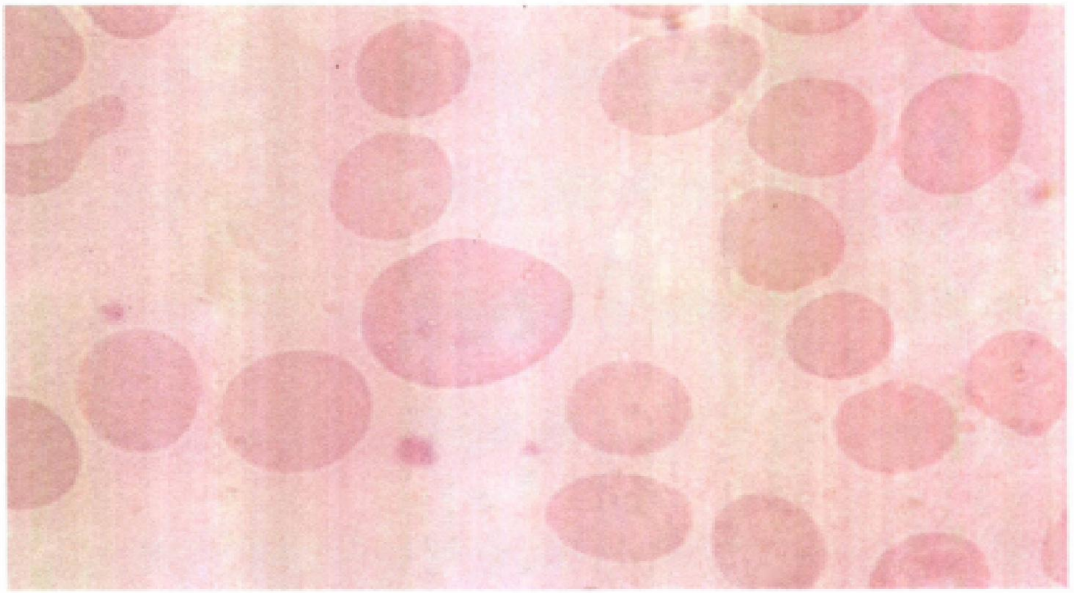

Figure IA1-13

Size: 9–15 μ

Nucleus

None

Cytoplasm

Color: Pink, with a hint of blue

Clinical Conditions

- Vitamin B_{12} deficiency
- Folic acid deficiency
- Congenital dyserythropoietic anemia

Megalocyte (Oral Macrocyte)

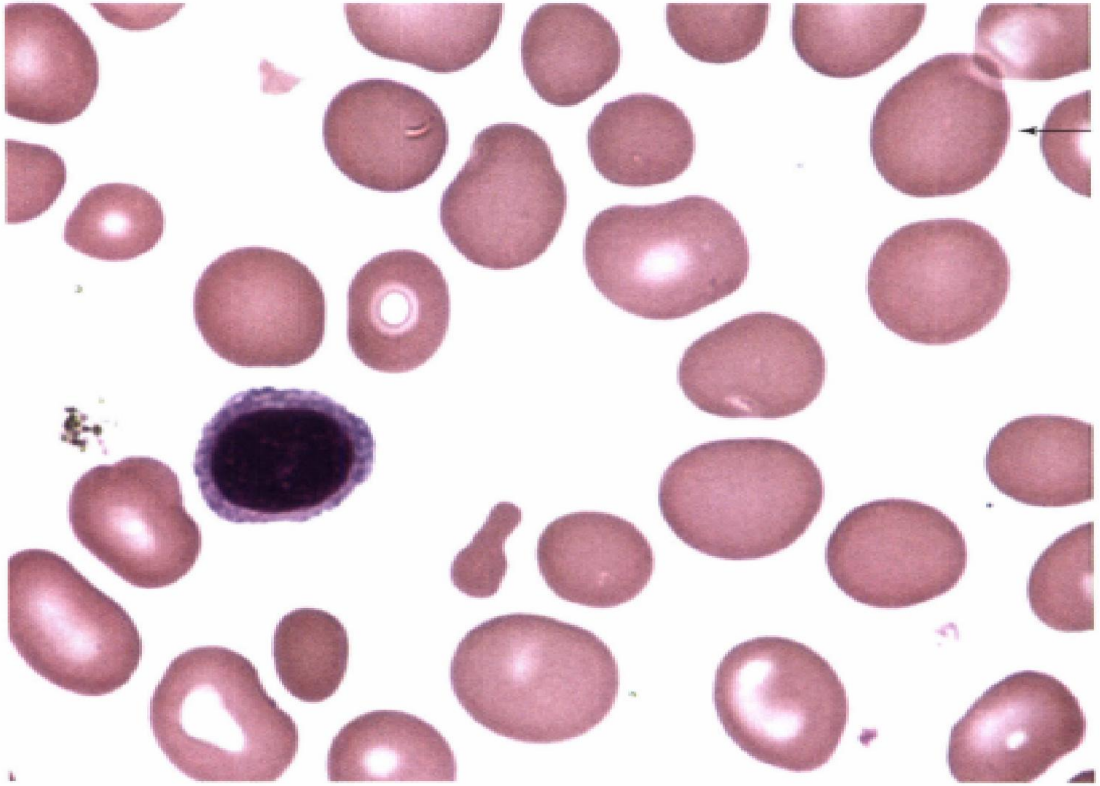

Figure IA1-14

Size: 9–12 μ

Nucleus

None

Cytoplasm

Color: Pink, central pallor less distinct
Contents: Increased hemoglobin content

Clinical Conditions

- Vitamin B_{12} deficiency
- Folic acid deficiency
- Congenital dyserythropoietic anemia
- Myelodysplastic syndromes
- Newborn

IRON-DEFICIENT MATURATION SERIES

Iron-Deficient Series

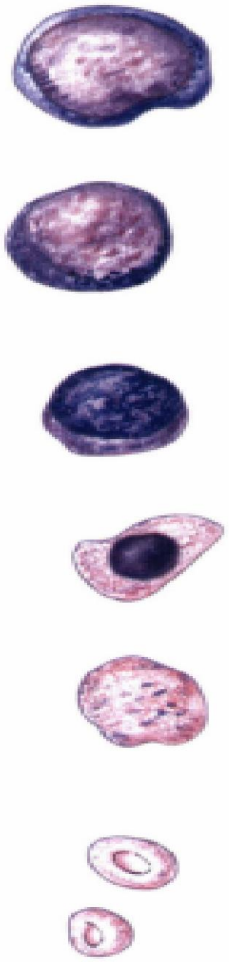

Figure IA1-15

Iron-Deficient Pronormoblast (Iron-Deficient Rubriblast)

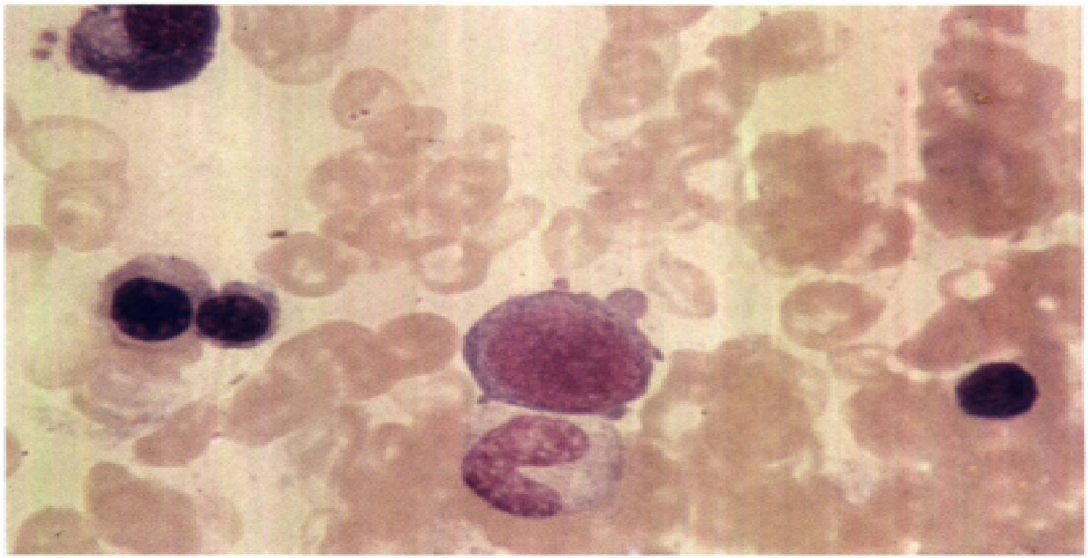

Figure IA1-16

Size: 14–20 μ

Nucleus

Shape: Irregularly round to slightly oval
N/C Ratio: 5:1
Color: Purple-red
Chromatin: Fine, but granular
Nucleoli: Present, but not distinct

Cytoplasm

Shape: Irregular
Color: Deep blue
Contents: Golgi; mitochondria, which produce a lighter blue perinuclear halo

Clinical Conditions

- Iron deficiency
- Anemia of chronic disease

Iron-Deficient Basophilic Normoblast (Iron-Deficient Prorubricyte)

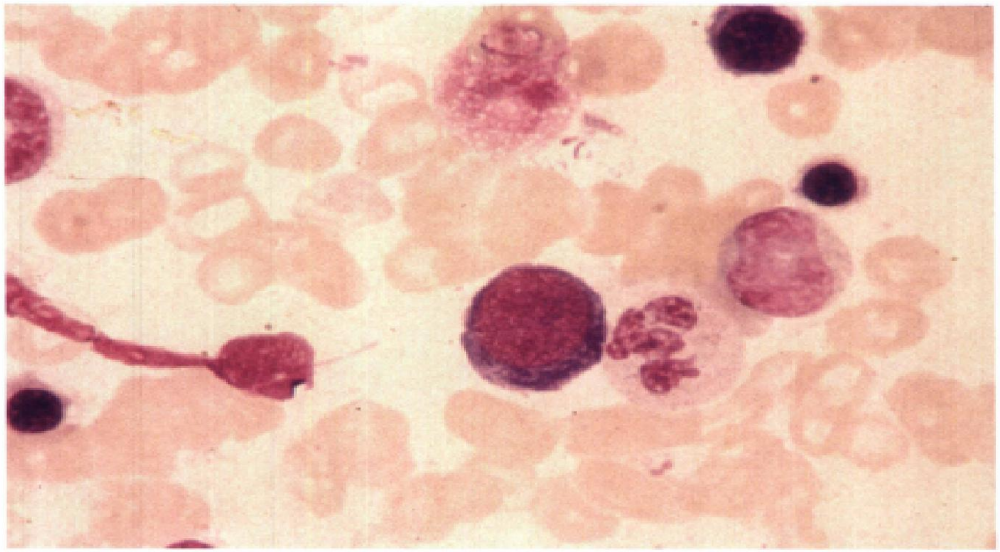

Figure IA1-17

Size: 10–15 μ

Nucleus

Shape: Round, centered
N/C Ratio: 5:1
Color: Purple, interspersed with light areas
Chromatin: Granular to slightly lumpy
Nucleoli: Usually not visible

Cytoplasm

Shape: Irregular
Color: Deep blue
Contents: Golgi may produce a light blue area near the nucleus; many mitochondria

Clinical Conditions

- Iron deficiency
- Anemia of chronic disease

Iron-Deficient Polychromatophilic Normoblast (Iron-Deficient Rubricyte)

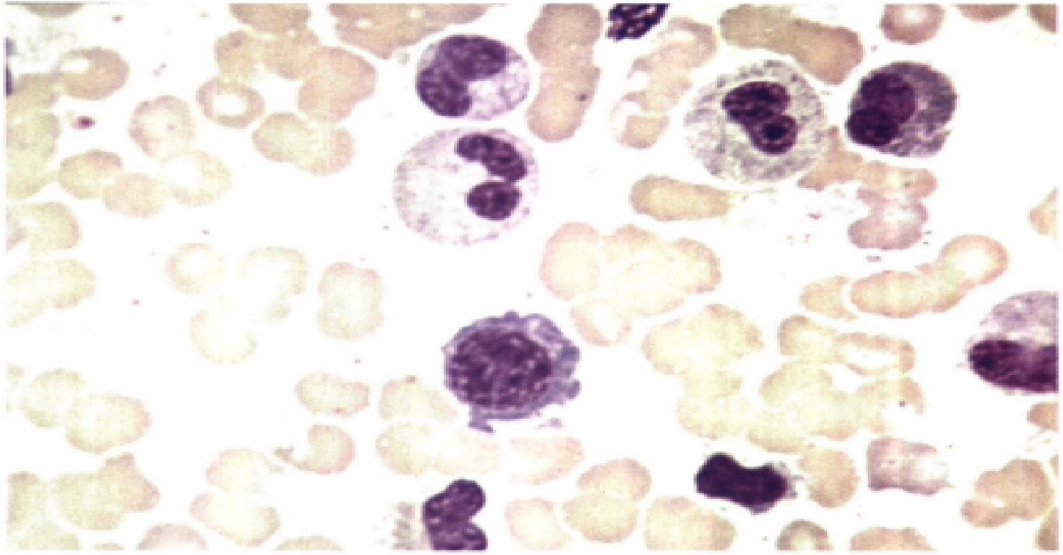

Figure IA1-18

Size: 9–12 μ

Nucleus

Shape: Round
N/C Ratio: 2:1
Color: Purple-red
Chromatin: Lumpy, with lighter parachromatin
Nucleoli: None

Cytoplasm

Color: Bluer than in normoblastic maturation
Contents: Lesser amount with shaggy blunt extensions

Clinical Conditions

- Iron deficiency
- Anemia of chronic disease

Iron-Deficient Orthochromic Normoblast (Iron-Deficient Metarubricyte)

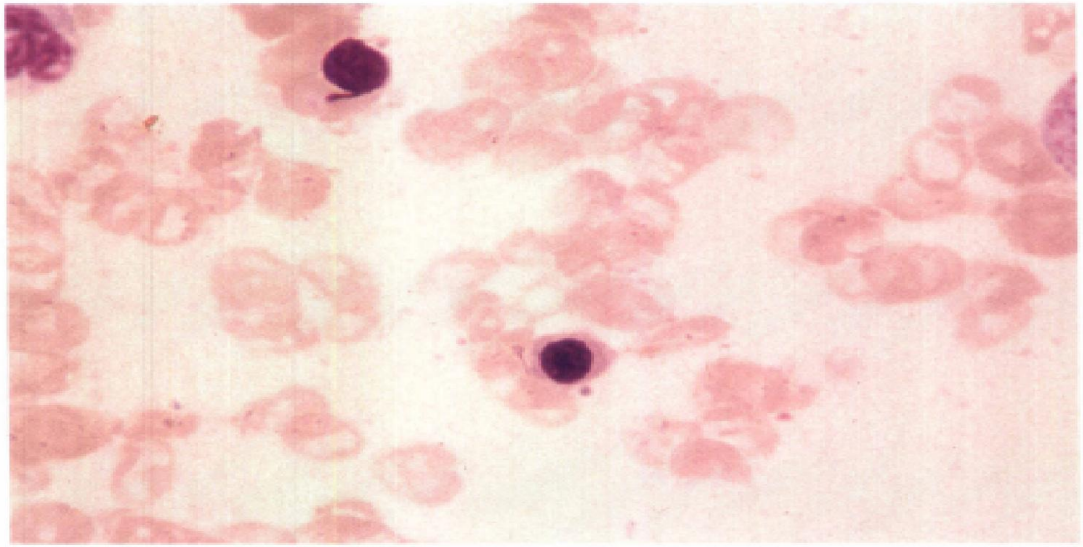

Figure IA1-19

Size: 7–11 μ

Nucleus

Shape: Round
N/C Ratio: 1:2
Color: Blue-purple
Chromatin: Condensed and homogeneous
Nucleoli: None

Cytoplasm

Shape: Irregular
Color: Pink, with residual blueness of RNA

Clinical Conditions

- Iron deficiency
- Anemia of chronic diseases

Iron-Deficient Polychromatophilic Erythrocyte

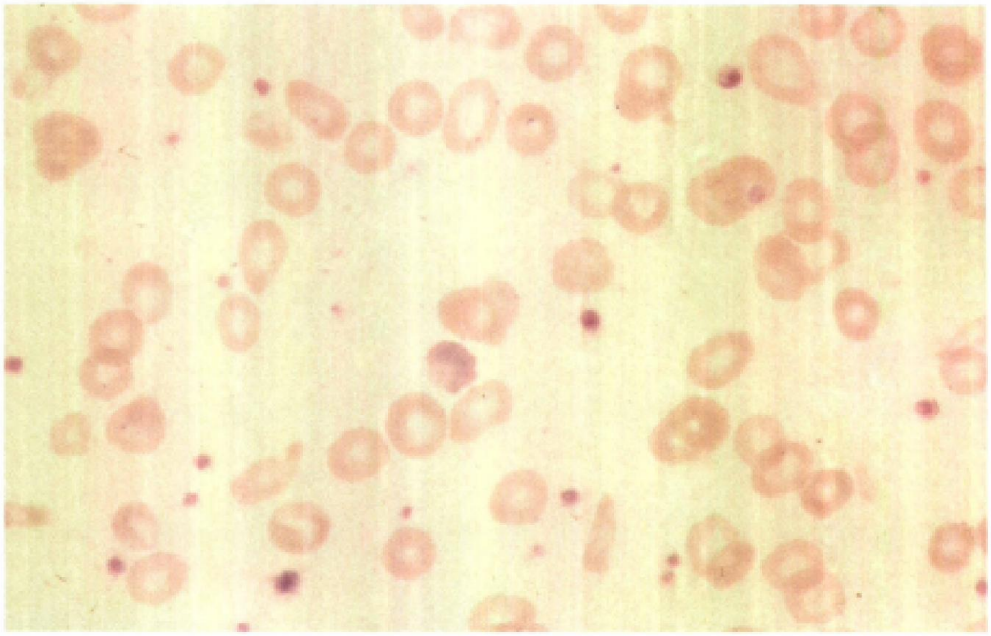

Figure IA1-20

Size: *<6.5–10 μ*

Nucleus

None

Cytoplasm

Color: Pink, with a hint of blue

Clinical Conditions

- Iron deficiency
- Anemia of chronic diseases

Iron-Deficient Erythrocyte (Hypochromic/Microcytic)

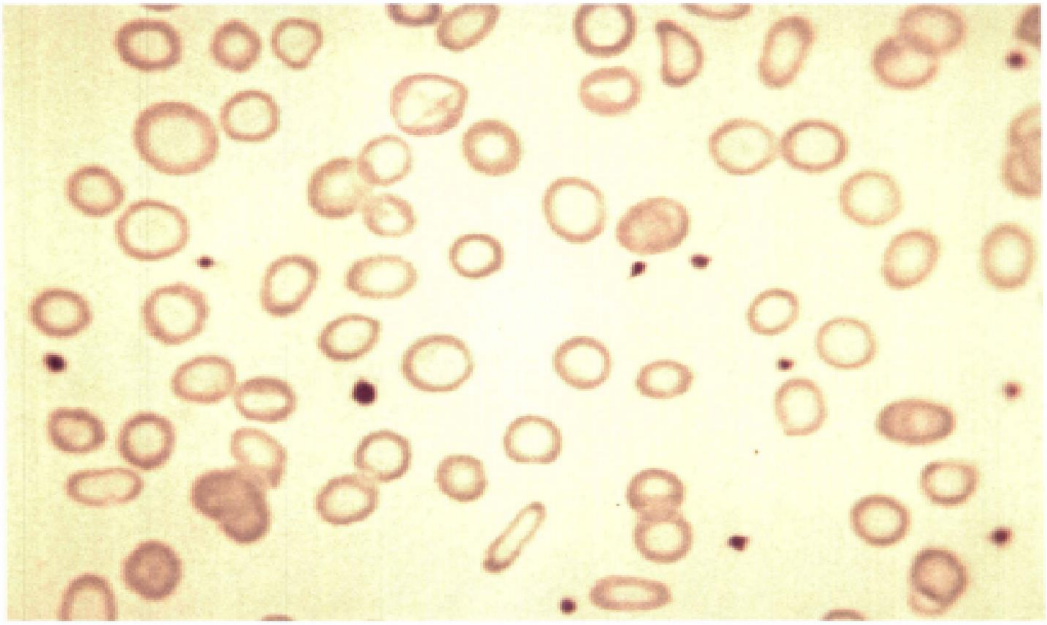

Figure IA1-21

Size: $< 6.5\ \mu$

Nucleus

None

Cytoplasm

Color: Pink, central pallor greater than one-third of cell
Contents: Hemoglobin decreased

Clinical Conditions

- Iron deficiency
- Anemia of chronic disease

DISTRIBUTION

Agglutination

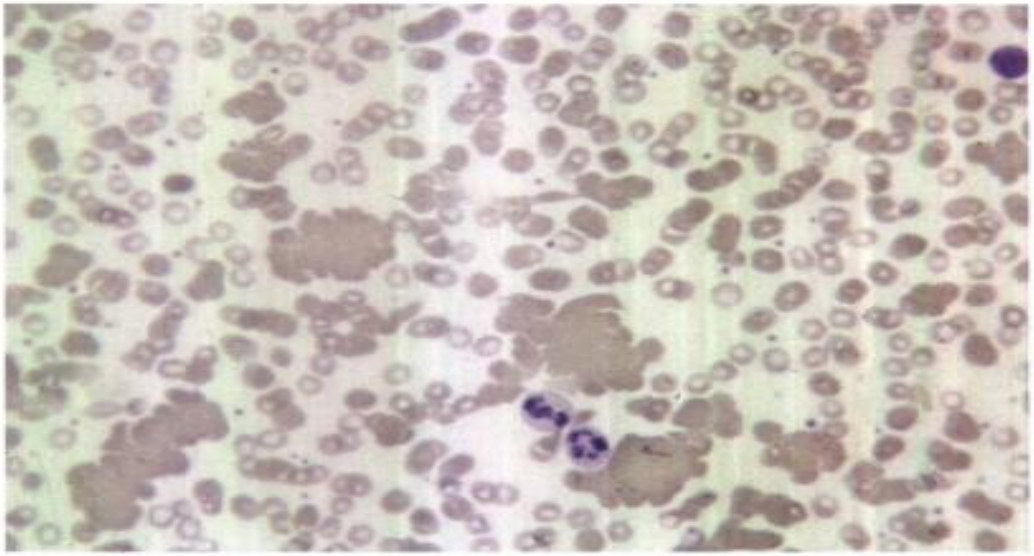

Figure IA1-22

Cell Type

Mature red blood cells

Description

Random masses or clusters of cells

Clinical Conditions

- Exposure to a variety of antibodies
- Hemolytic anemia (autoimmune)
- Atypical pneumonia
- Staphylococcal infections
- Trypanosomiasis
- Cold agglutinin disease

Rouleaux

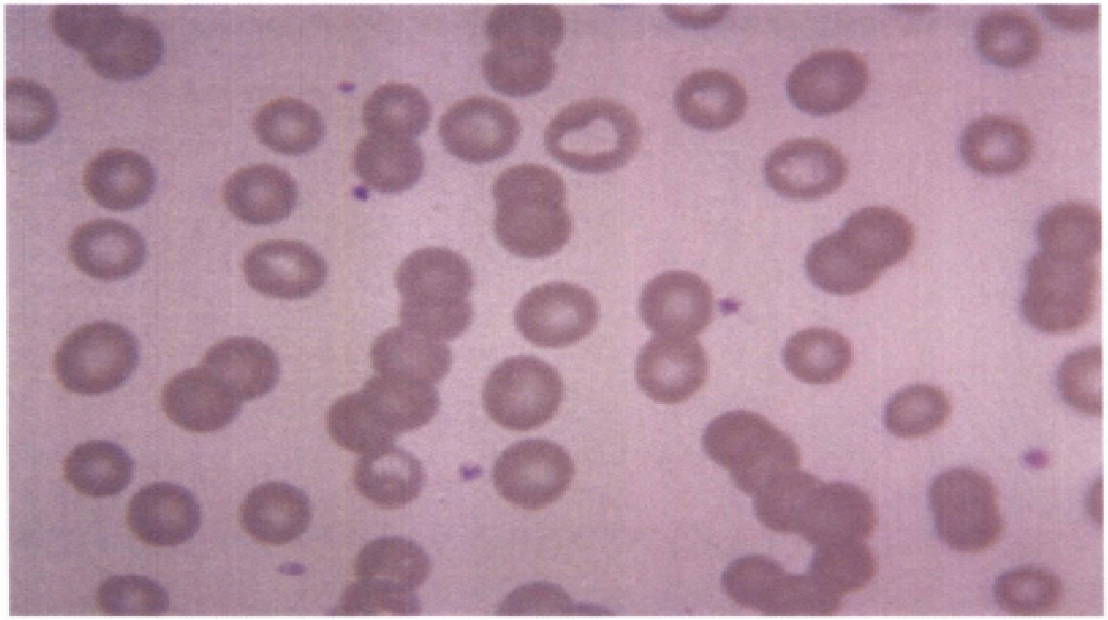

Figure IA1-23

Cell Type

Mature red blood cell

Description

Short or long stacks of cells (three or four or more) resembling coins; often a blue-staining background is also present

Clinical Conditions

- Hyperproteinemia
- Multiple myeloma
- Macroglobulinemia
- Increased fibrinogen (infection, pregnancy)

SHAPES

Acanthocyte

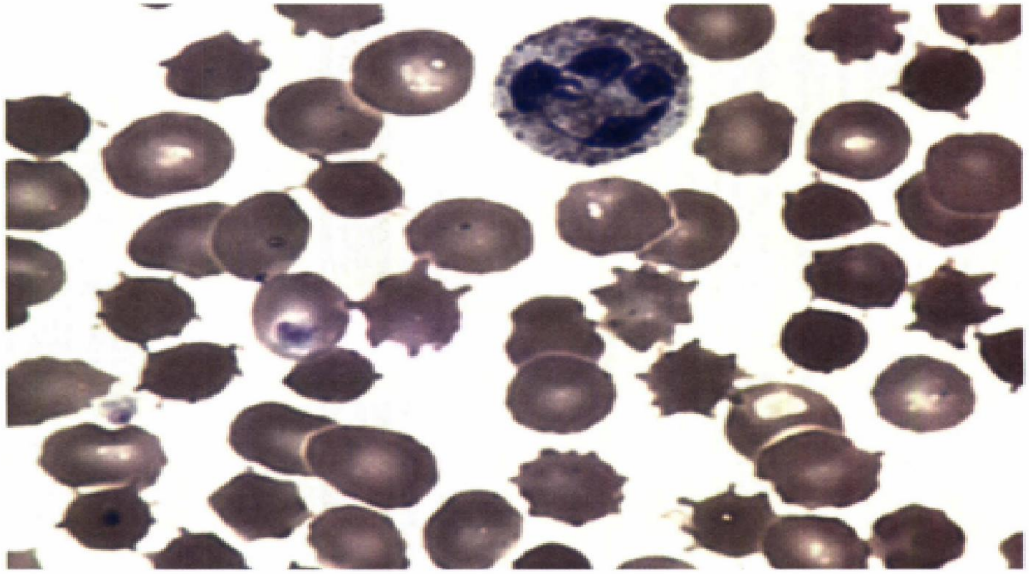

Figure IA1-24

Cell Type

Mature red blood cell

Description

Spherical and densely stained cell with 3–12 spicules of uneven length and width around the surface

Clinical Conditions

- Inherited lipid disorder (abetalipoproteinemia)
- Alcoholic cirrhosis
- Malabsorption states
- Neonatal hepatitis
- Pyruvate kinase deficiency

Codocyte (Target Cell)

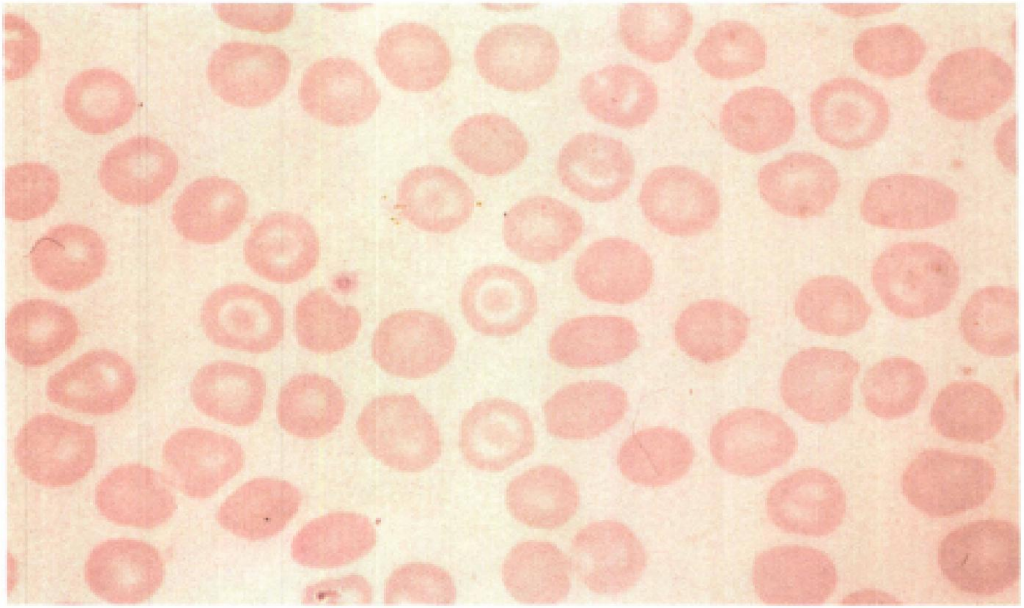

Figure IA1-25

Cell Type

Mature red blood cell

Description

Bell shaped, with a thin wall having a greater-than-normal surface membrane:volume ratio; central area of hemoglobin, a clear ring, and a peripheral ring of hemoglobin, giving an appearance of a bull's eye

Clinical Conditions

- Hemoglobinopathies
- Thalassemia
- Obstructive liver disease
- Iron deficiency anemia

Dacryocyte (Teardrop Cell)

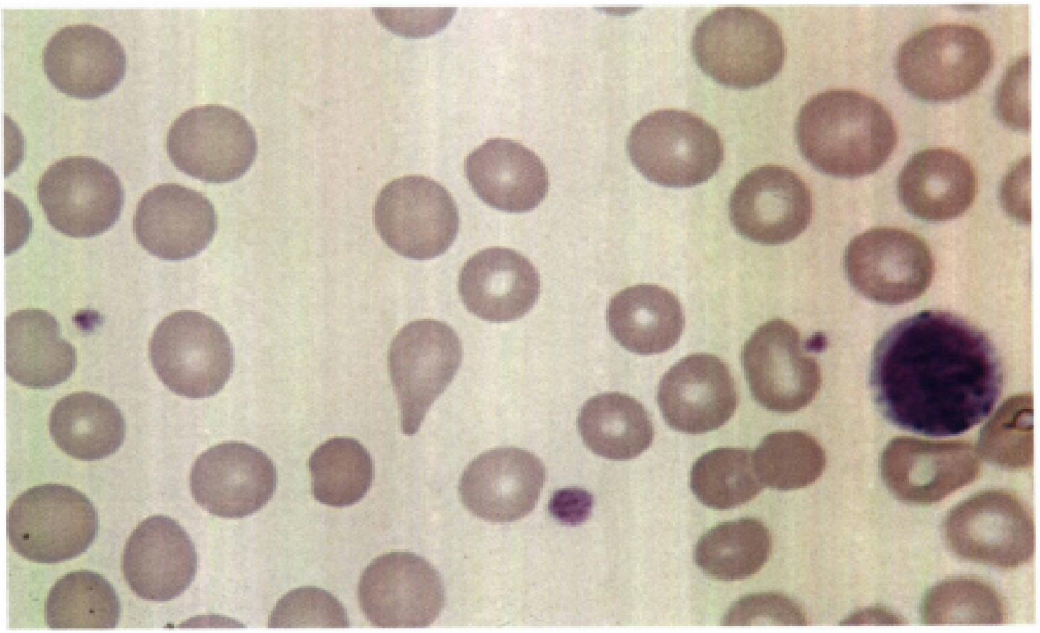

Figure IA1-26

Cell Type

Mature red blood cell

Description

Pear-shaped cell with a blunt pointed projection

Clinical Conditions

- Extramedullary hematopoiesis (myelofibrosis, myelophthisic anemia)
- Megaloblastic anemia
- Thalassemia
- Hypersplenism
- Renal disease

Degmacyte (Bite Cell)

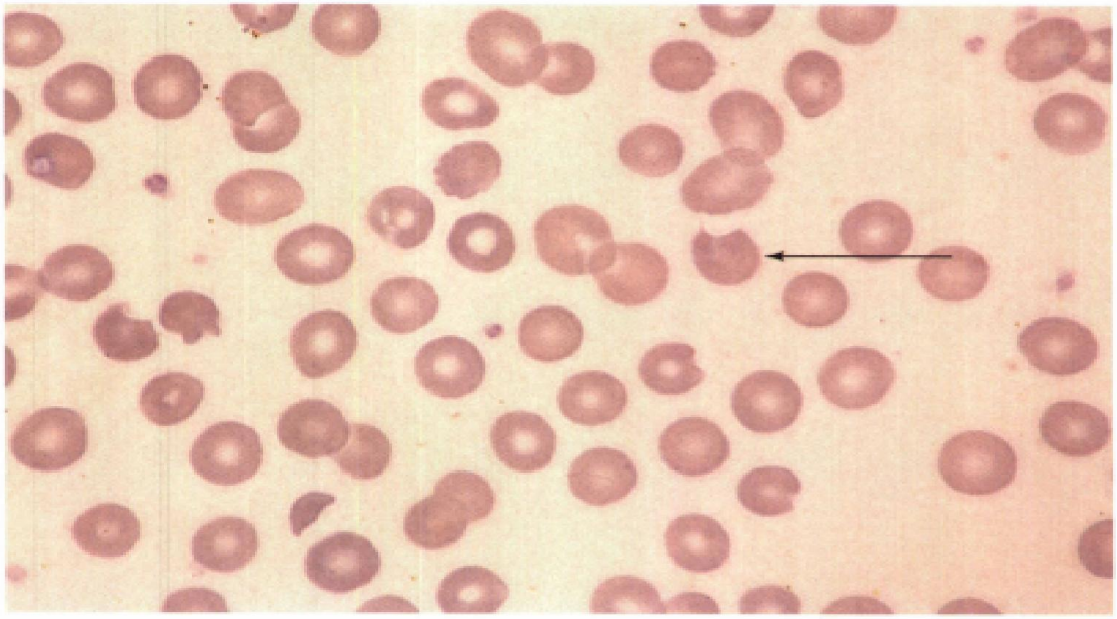

Figure IA1-27

Cell Type

Mature red blood cell

Description

Semicircular area (denatured and precipitated masses of hemoglobin) of cell removed by spleen; these cells may show multiple peripheral defects

Clinical Conditions

- Drug-induced anemias
- Glucose-6-phosphate dehydrogenase deficiency
- Thalassemia
- Unstable hemoglobinopathies

Drepanocyte (Sickle Cell)

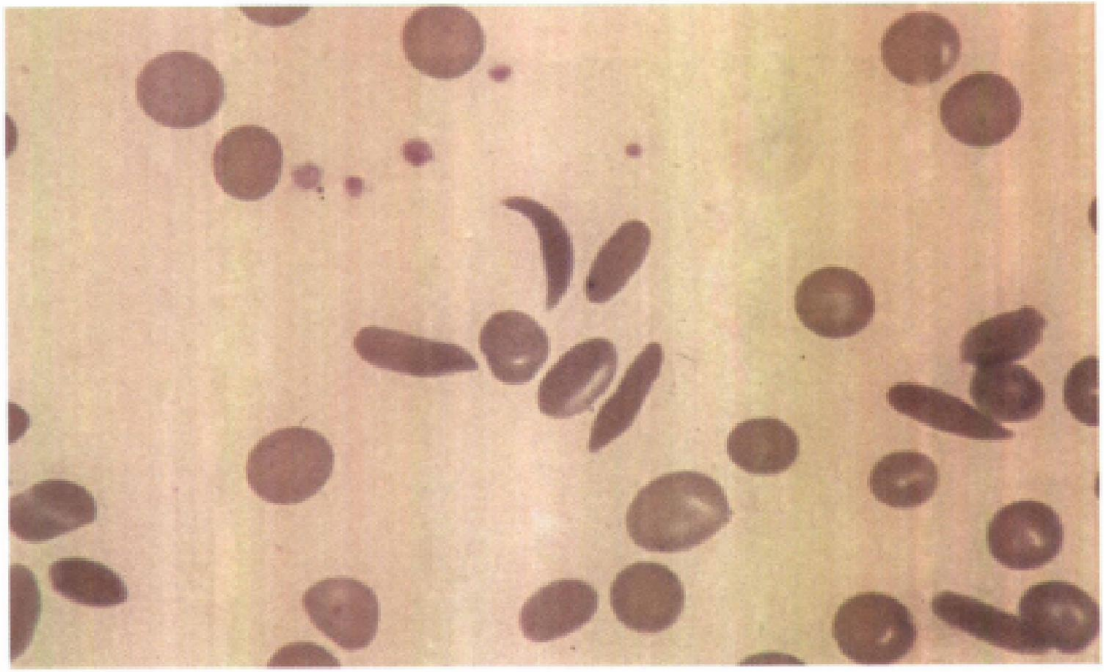

Figure IA1-28

Cell Type

Mature red blood cell

Description

Elongated cell due to polymers of abnormal hemoglobin; terminal projections, causing the cell to take on an irregular shape; usually lacks a central pallor

Clinical Conditions

- Hemoglobinopathies (SS, SC, SD, S-β thalassemia)

Echinocyte (Burr Cell)

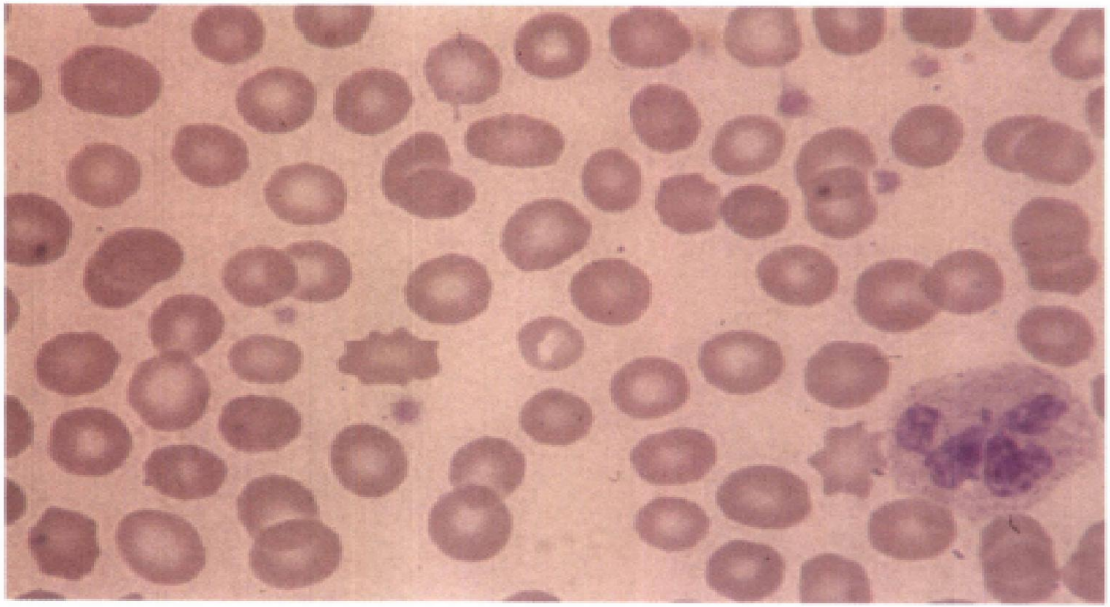

Figure IA1-29

Cell Type

Mature red blood cell

Description

Cell with evenly distributed, short spicules; the spicules have a blunt end; retains central pallor

Clinical Conditions

- Slow drying in high humidity
- Renal insufficiency
- Pyruvate kinase deficiency
- Stored blood
- Severe dehydration
- Burns

Keratocyte (Horn Cell)

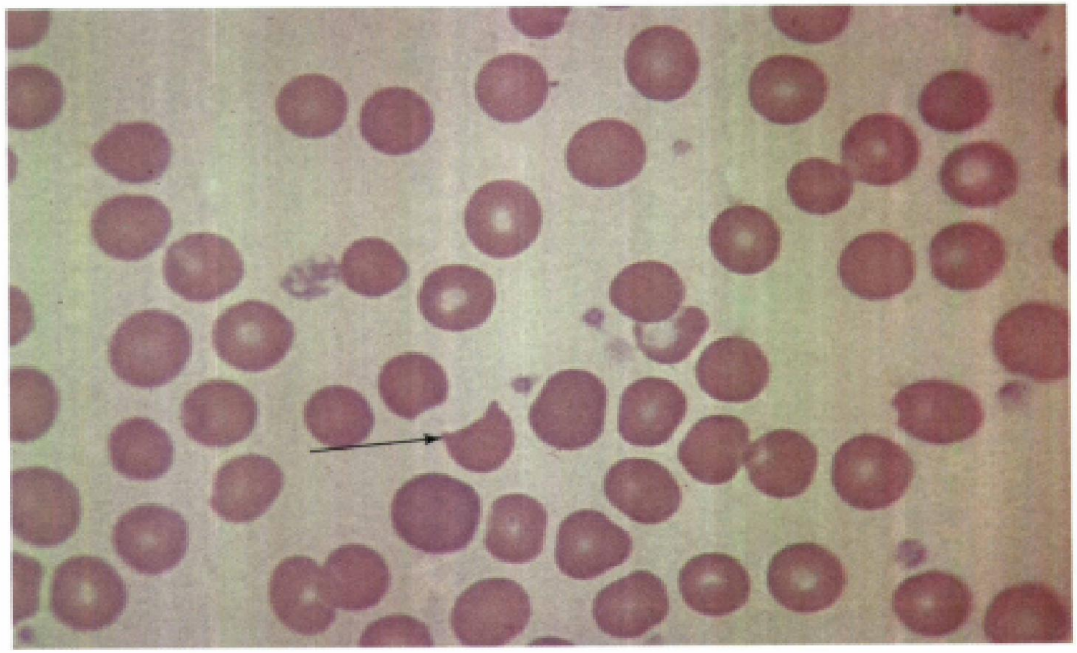

Figure IA1-30

Cell Type

Mature red blood cell

Description

Cell with projections (usually two) that resemble horns

Clinical Conditions

- Microangiopathic hemolytic anemia
- Glomerulonephritis
- Waring Blender syndrome
- Pyruvate kinase deficiency

Knizocyte (Pinch Cell)

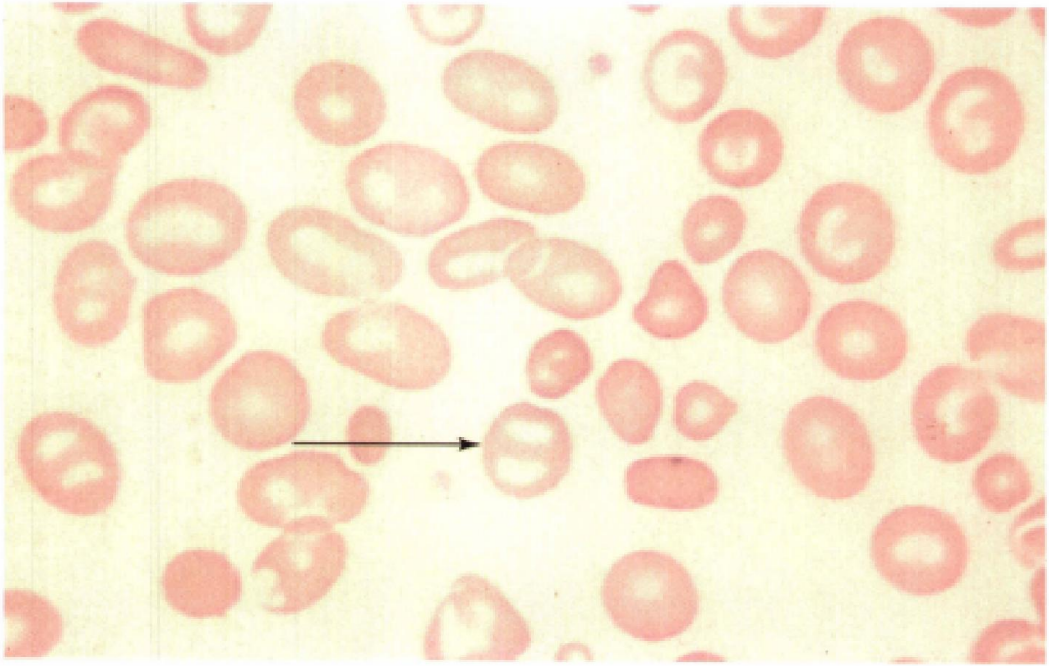

Figure IA1-31

Cell Type

Mature red blood cell

Description

Cell with triconcave shape having two central pallors

Clinical Conditions

- Hemolytic anemia
- Hemoglobinopathies
- Pancreatitis

Ovalocyte (Elliptocyte)

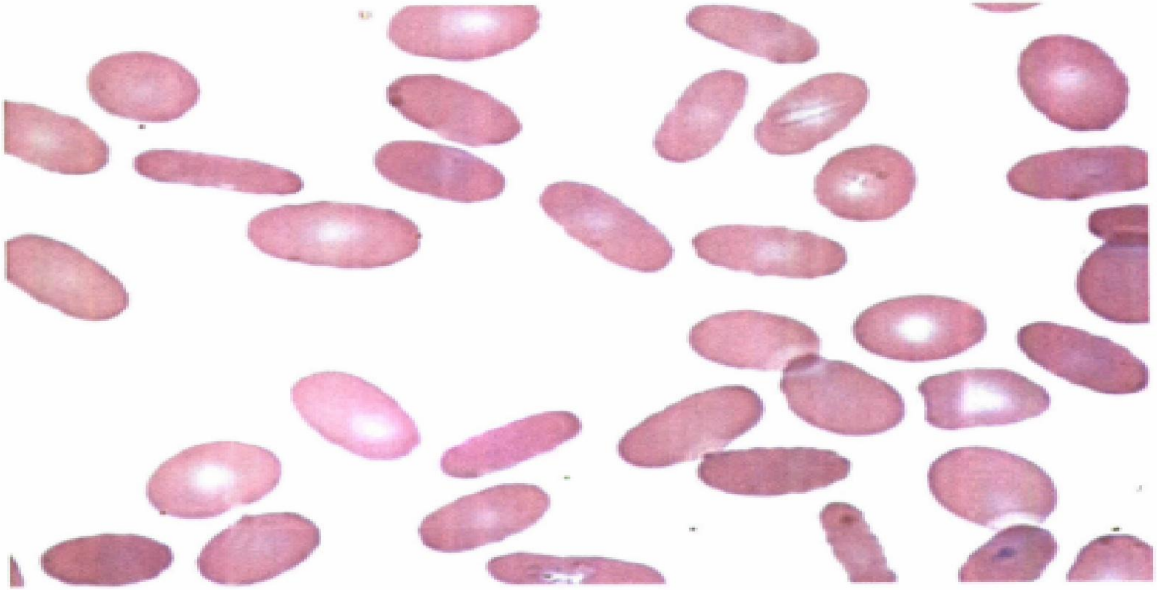

Figure IA1-32

Cell Type

Mature red blood cell

Description

Oval-shaped cell (may be slightly egg, rod, or pencil shaped); hemoglobin is concentrated at two ends; normal central pallor

Clinical Conditions

- Hereditary elliptocytosis
- Iron deficiency anemia
- Myelophthisic anemia
- Megaloblastic anemia
- Thalassemia
- Sideroblastic anemia
- Congenital dyserythropoietic anemia

Pyknocyte (Blister Cell)

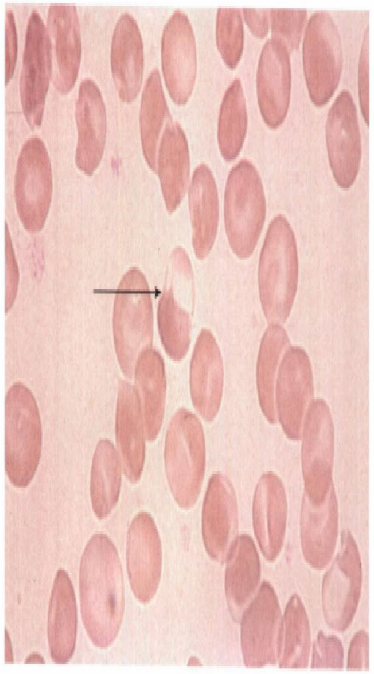

Figure IA1-33

Cell Type

Mature red blood cell

Description

Cell with a clearing on one side and a concentrated area of hemoglobin on the other side

Clinical Conditions

- Infantile pyknocytosis
- Infantile viremia

Schistocyte (Schizocyte)

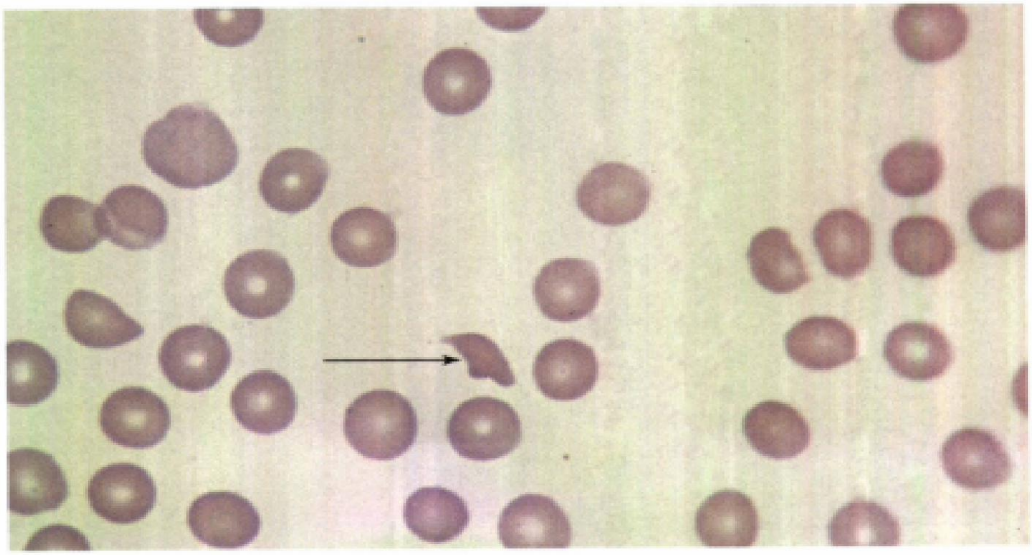

Figure IA1-34

Cell Type

Mature red blood cell

Description

Irregular shape or fragment of cell; results from damaged membrane

Clinical Conditions

- Microangiopathic hemolytic anemias
- Traumatic hemolytic anemias
- Waring Blender syndrome

Spherocyte

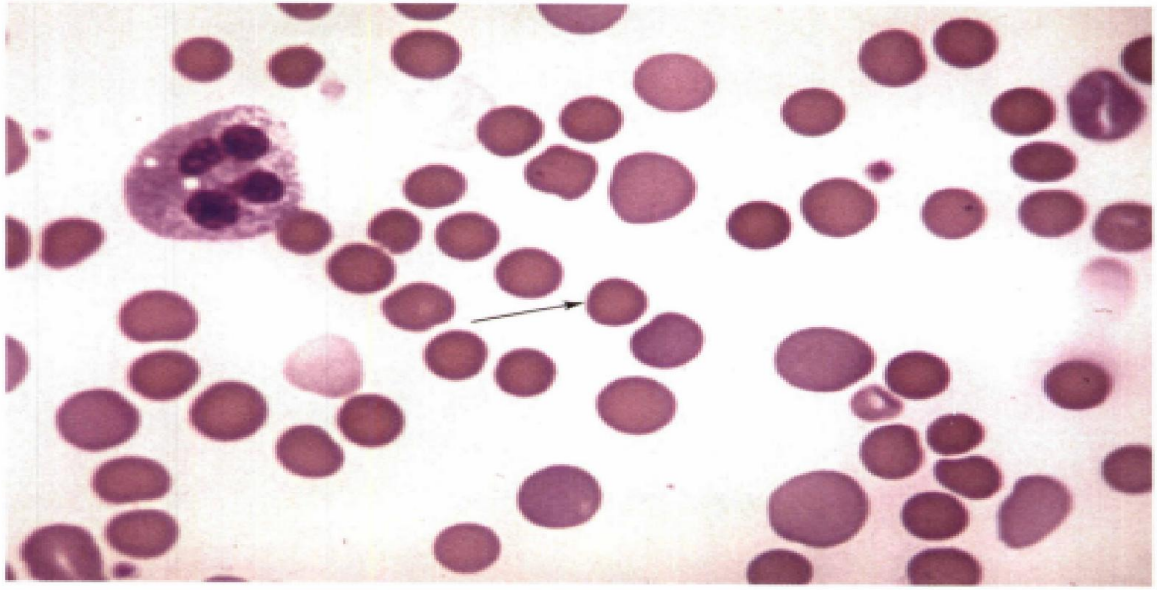

Figure IA1-35

Cell Type

Mature red blood cell

Size: 6.1–7.0 μ

Description

Round cells; increased staining intensity with no central pallor; smaller volume than a normal cell (decreased surface:volume ratio)

Clinical Conditions

- Hereditary spherocytosis
- Immunohemolytic anemias
- Heinz body hemolytic anemia
- Severe burns (microspherocytes seen); microspherocytes are <4.0 μ
- Hypersplenism

Stomatocyte

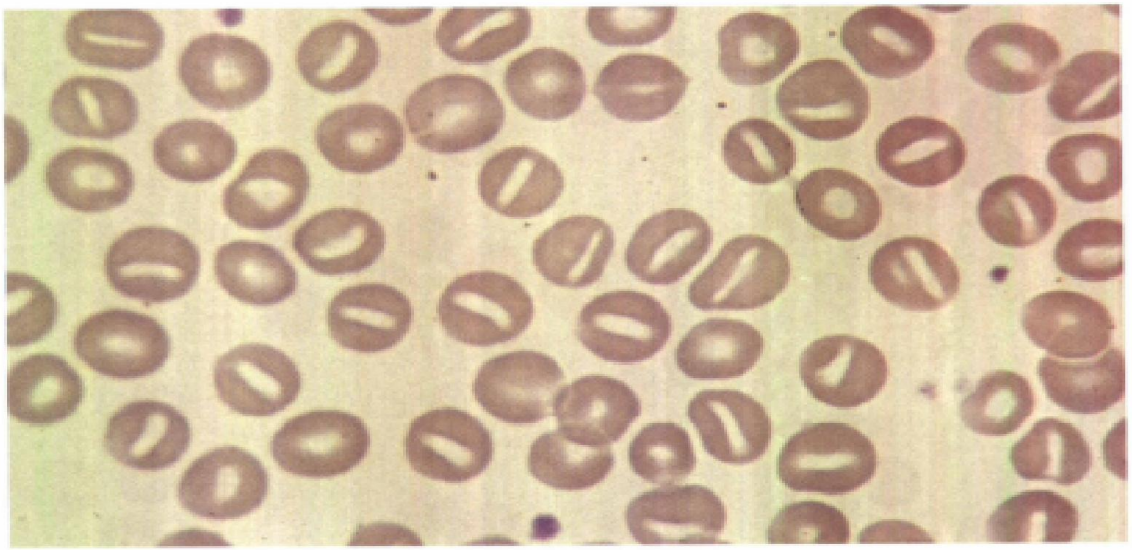

Figure IA1-36

Cell Type

Mature red blood cell

Description

Cell having a slitlike area of central pallor

Clinical Conditions

- Hereditary stomatocytosis
- Alcoholism
- Obstructive liver disease
- Cirrhosis
- Rh-null disease

SIZE

Macrocyte

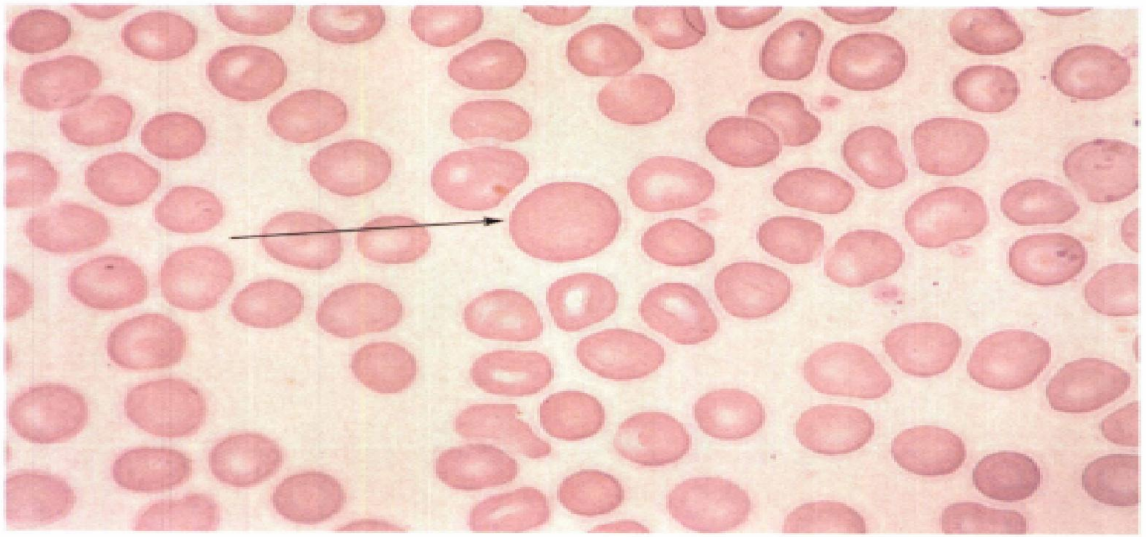

Figure IA1-37

Size: $>7.8\ \mu$

Cell Type

Mature red blood cell

Description

Large cell, mean corpuscular volume usually >100 fL; usually normochromic; may be round or oval; cytoplasm is pink-red

Clinical Conditions

- Liver disease (round macrocytes seen)
- Megaloblastic anemias (oval macrocytes seen)
- Myelodysplastic syndrome
- Acute blood loss
- Chemotherapy

Microcyte

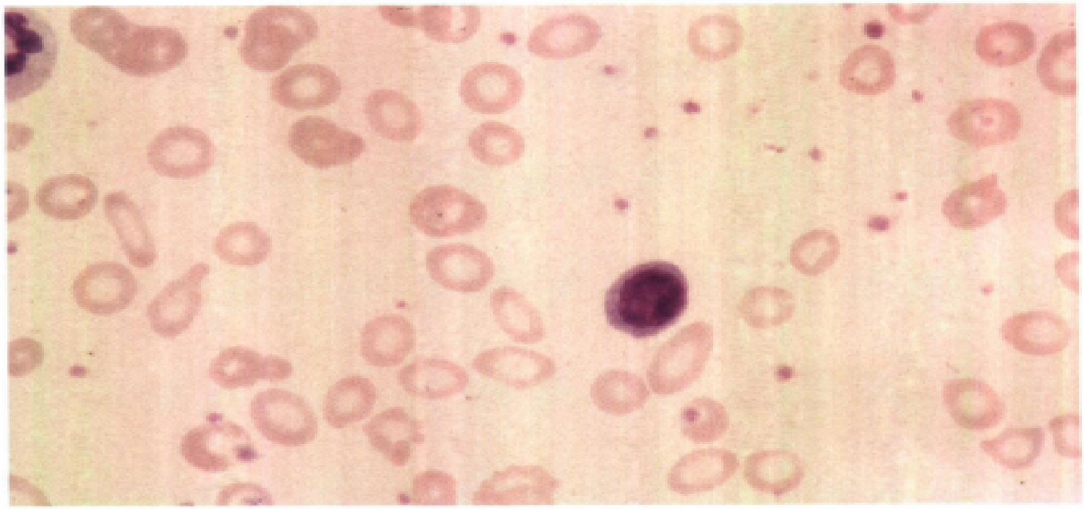

Figure IA1-38

Size: $< 6.5\ \mu$

Cell Type

Mature red blood cell

Description

Smaller than a normal cell; mean corpuscular volume usually <80 fL; has a central pallor; normochromic or hypochromic

Clinical Conditions

- Iron deficiency anemia
- Thalassemias
- Lead poisoning
- Anemia of chronic disease
- Sideroblastic anemia

COLORING

Dimorphic

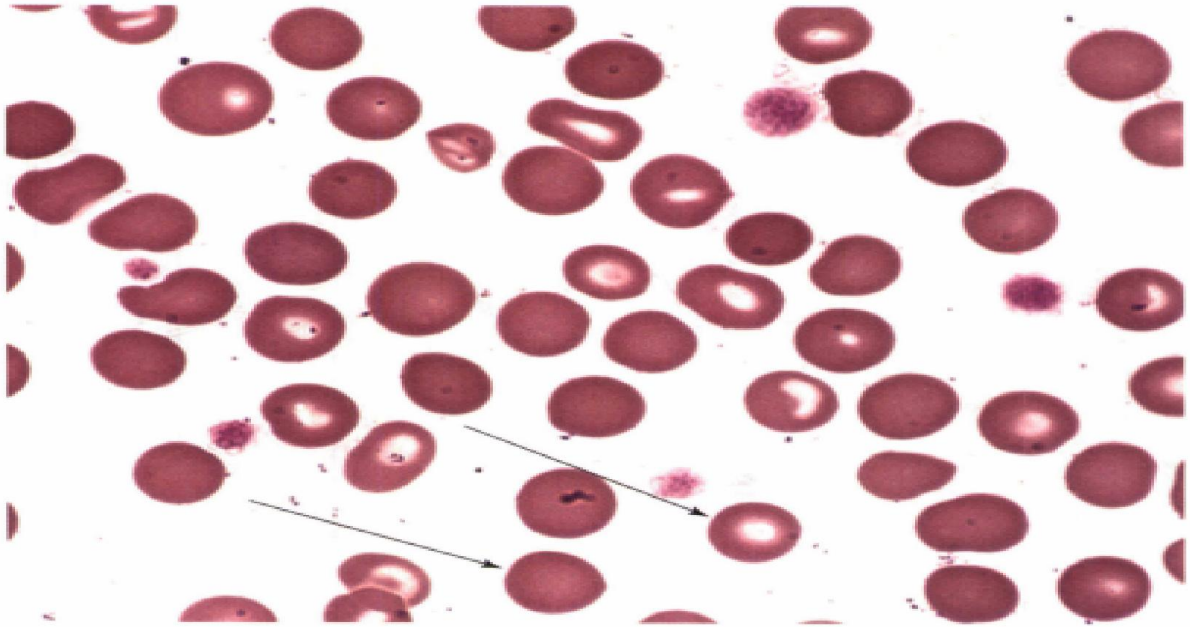

Figure IA1-39

Cell Type

Mature erythrocytes

Size: 6–11 μ

Description

Dual population of cells, normocytic and microcytic; normocytic and macrocytic; may also exhibit normochromia and hypochromia

Clinical Conditions

- Sideroblastic anemia
- Myelodysplastic syndromes

Hypochromic

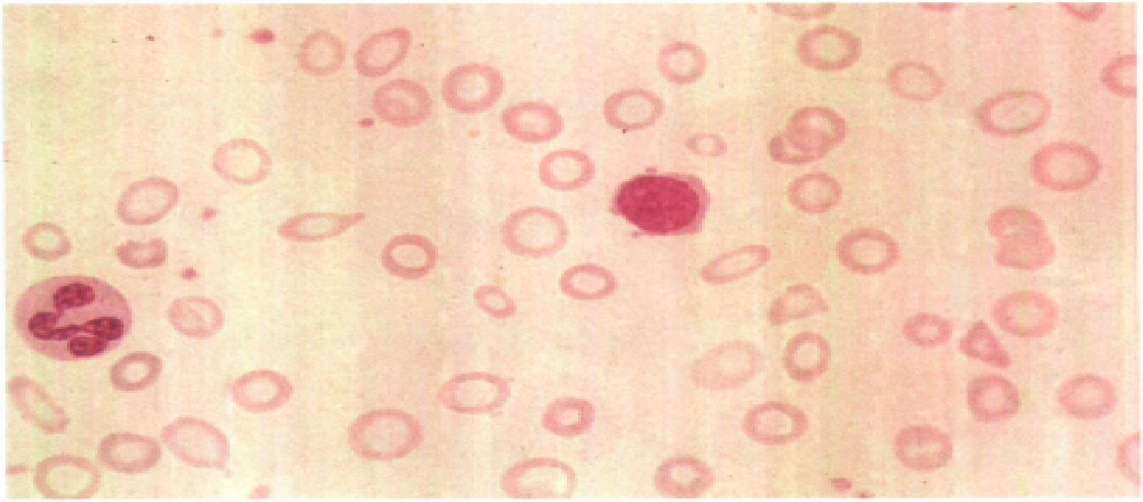

Figure IA1-40

Cell Type

Mature red blood cell

Description

Cells possess a greater central pallor than normal (greater than one-third); may lack hemoglobin and have a decreased mean corpuscular hemoglobin concentration or may be abnormally thin

Clinical Conditions

- Iron deficiency anemia
- Thalassemia
- Anemia of chronic disease
- Sideroblastic anemia
- Myelodysplastic syndromes

Polychromatophilic

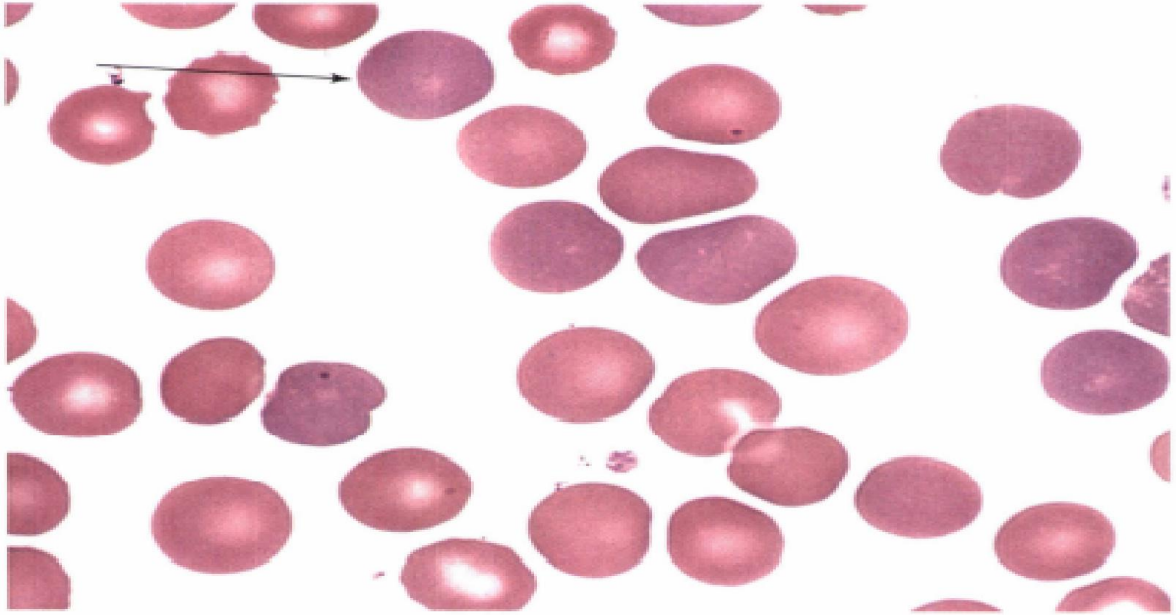

Figure IA1-41

Cell Type

Young red blood cell with no nucleus

Size: 8–11 μ

Description

Contains residual RNA, which stains diffusely blue; identified as reticulocyte when stained with a supravital dye

Clinical Conditions

- Increased erythrocyte production
- Hemolytic anemias
- Membrane disorders
- Hemolytic disease of the newborn

INCLUSIONS

Basophilic Stippling (Punctuate Basophilia)

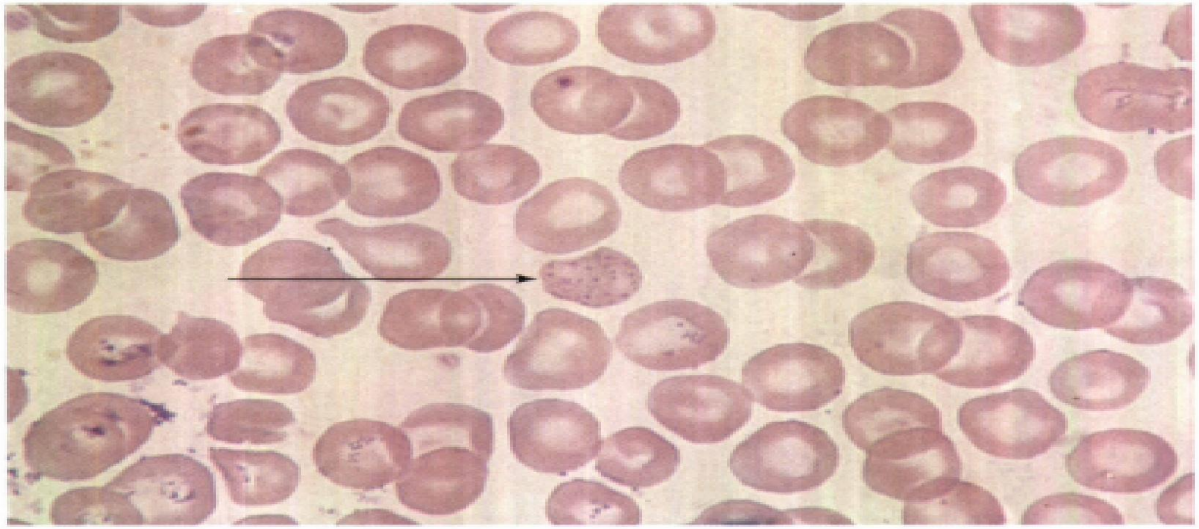

Figure IA1-42

Cell Type

Mature red blood cell

Description

Coarse, deep blue inclusions; irregularly aggregated or clumped ribosomes throughout the cell; mitochondria and siderosomes may also aggregate

Clinical Conditions

- Altered hemoglobin biosynthesis
- Lead intoxication
- Thalassemia
- Megaloblastic anemia
- Alcoholism
- Sideroblastic anemia
- Pyrimidine-5′-nucleotidase deficiency

Cabot Ring

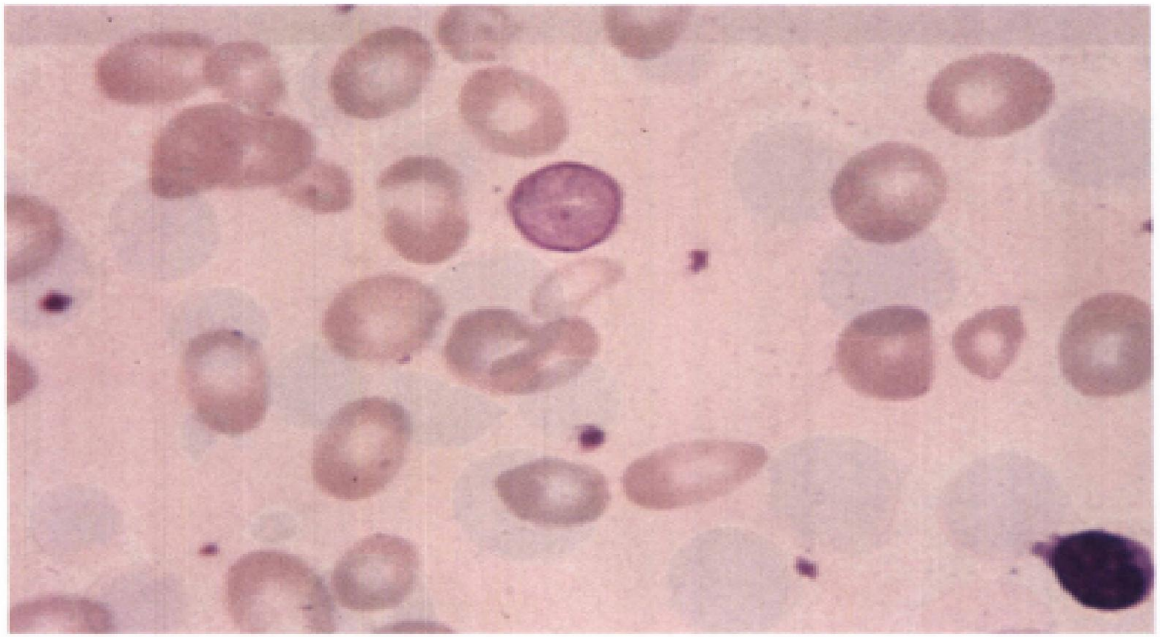

Figure IA1-43

Cell Type

Mature red blood cell

Description

Oval or figure eight–shaped inclusion; red-violet; usually one per cell; consists of nuclear remnants or part of the mitotic spindle

Clinical Conditions

- Severe anemias
- Dyserythropoiesis

Heinz Bodies

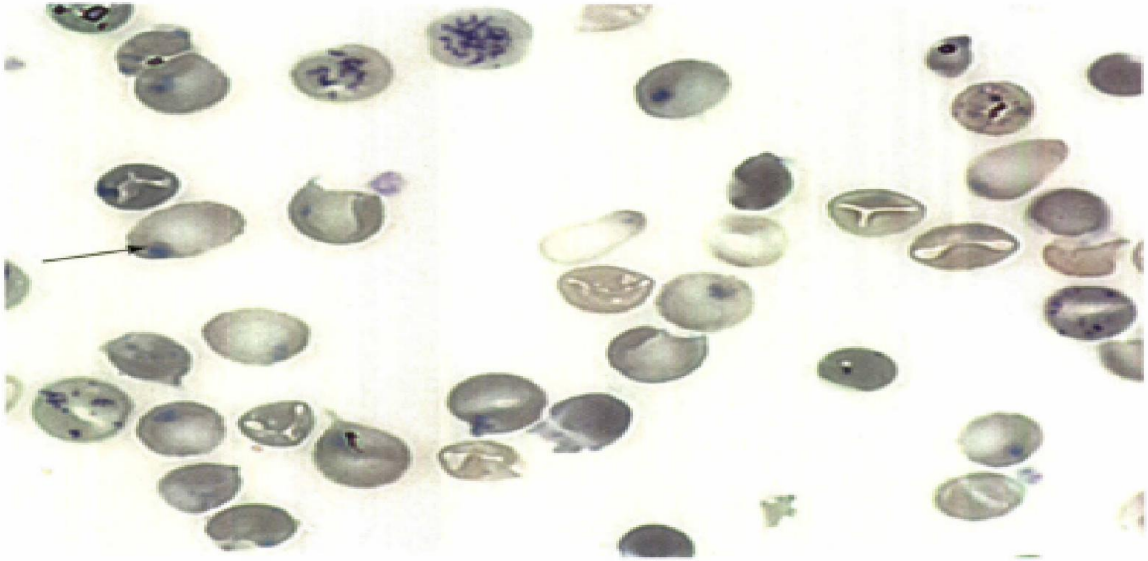

Figure IA1-44

Cell Type

Young and mature red blood cells

Size: 1–2 μ

Description

Round, refractile inclusions found on the periphery of the cell when stained with a supravital dye; consists of denatured globin produced by the destruction of hemoglobin; they may occur in multiple numbers

Clinical Conditions

- Drug-induced anemias
- Thalassemia
- Glucose-6-phosphate dehydrogenase deficiency and other red blood cell enzymopathies
- Unstable hemoglobinopathies

Hemoglobin C Crystals

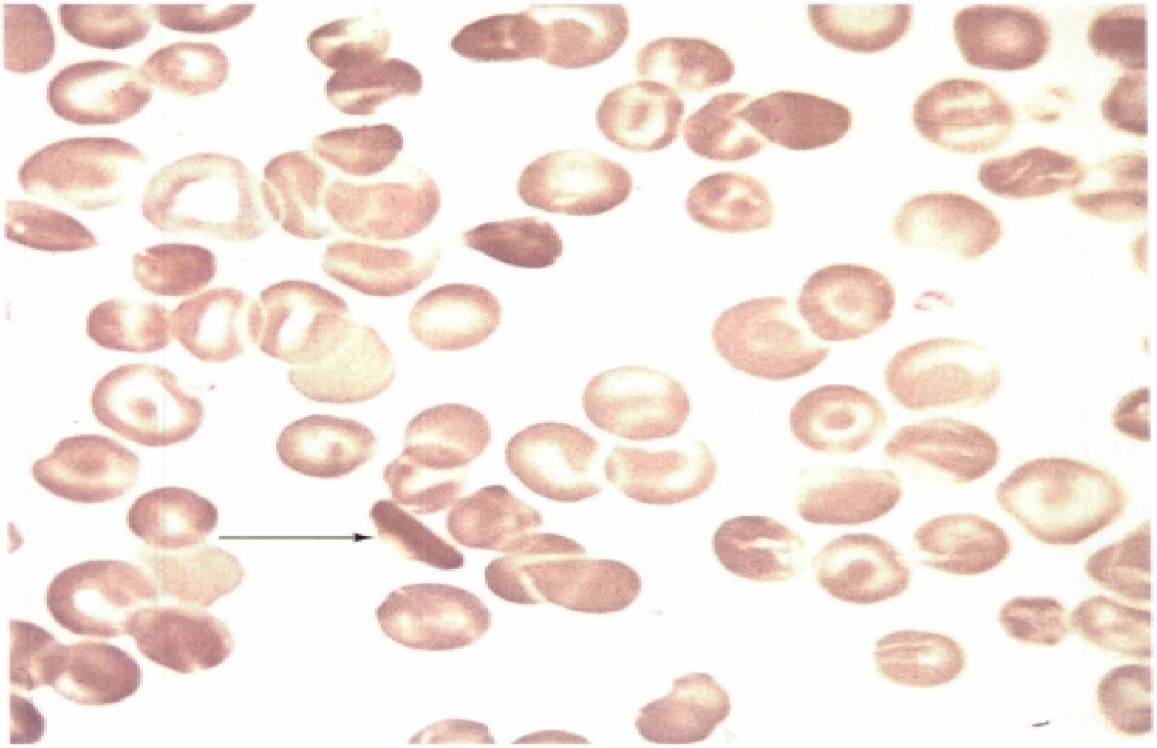

Figure IA1-45

Cell Type

Mature red blood cells

Description

Hexagonal, rod-shaped inclusions with blunt ends that stain very dark; formed within the cell membrane; remainder of cell has a clear area

Clinical Condition

- Hemoglobin CC disease

Hemoglobin H Inclusions

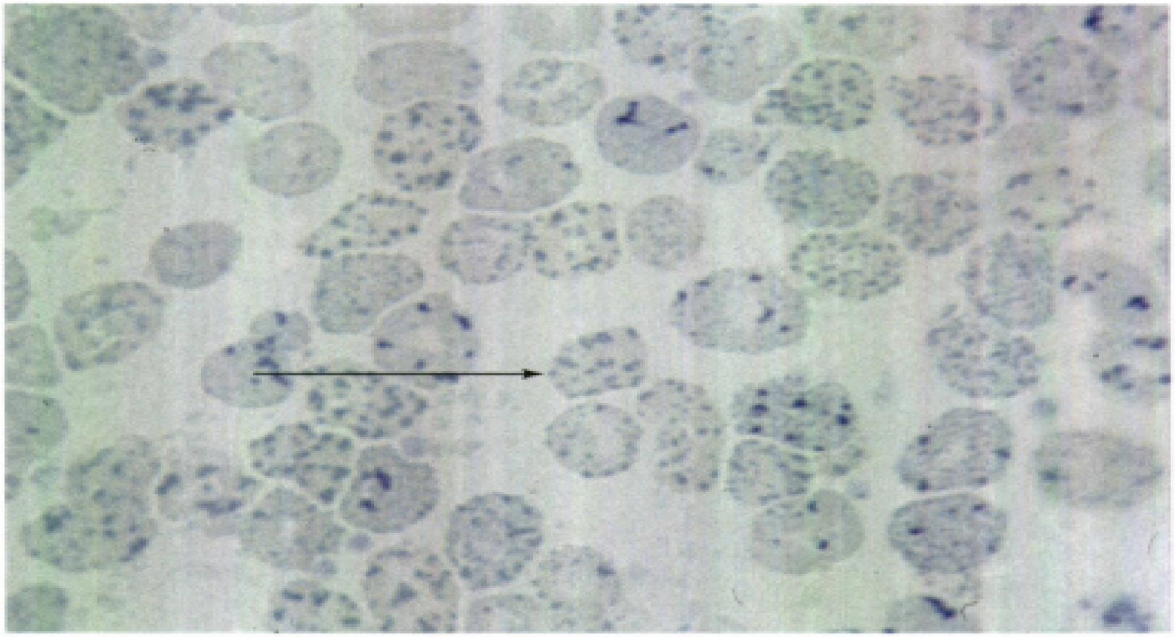

Figure IA1-46

Cell Type

Nucleated and nonnucleated red blood cells

Description

Unpaired beta-chains form small, greenish-blue inclusions when stained with brilliant cresyl blue; uniformly dispersed throughout the cell; when present in multiple numbers, they give the cell a "golf ball" appearance

Clinical Condition

- Hemoglobin H disease

Hemoglobin SC Crystals

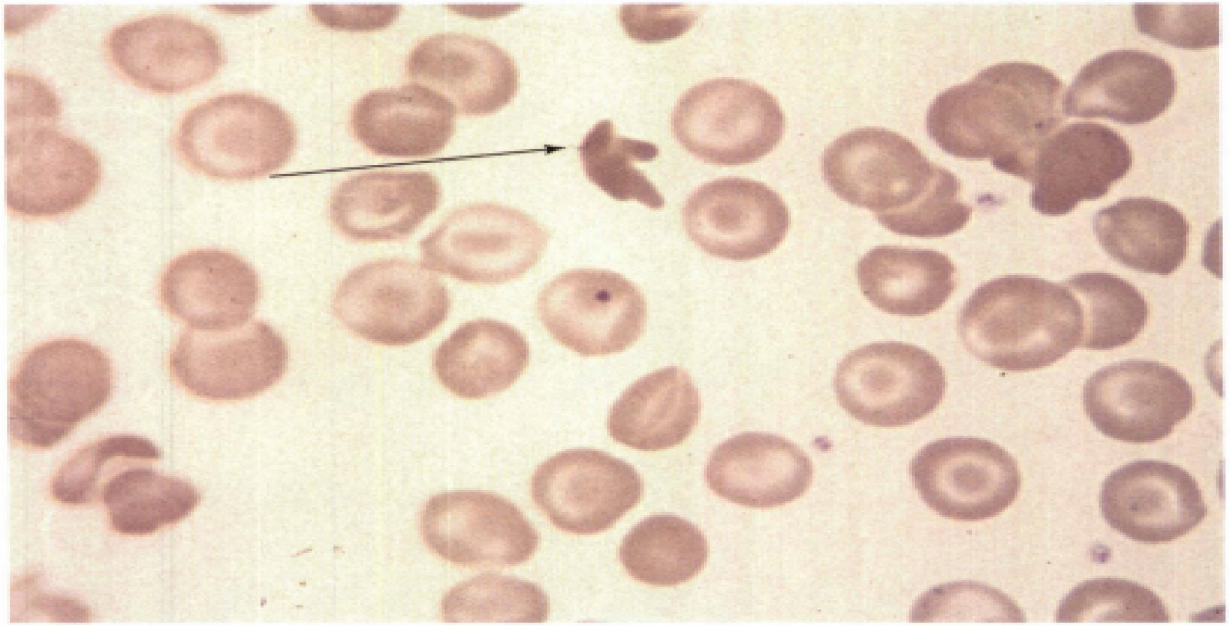

Figure IA1-47

Cell Type

Mature red blood cell

Description

Darkly stained condensed hemoglobin; crystals may be straight with parallel sides and a blunt protruding end or have several fingerlike projections from the center; crystals may protrude from the cell membrane; remainder of cell has pallor or distorted membrane

Clinical Condition

- Hemoglobin SC disease

Howell-Jolly Body

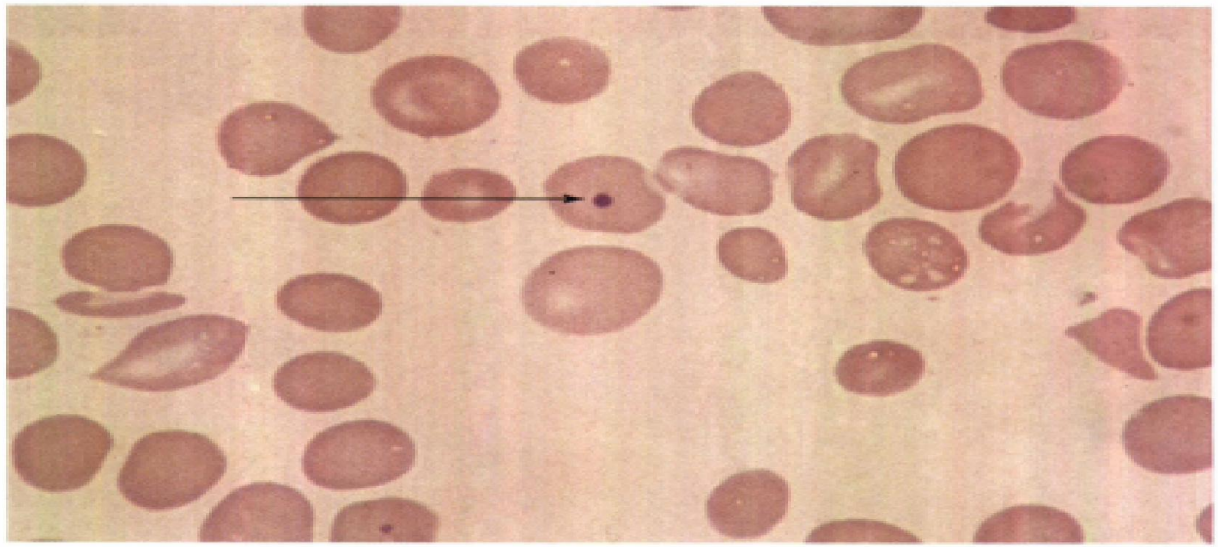

Figure IA1-48

Size: 0.5–1.0 μ

Cell Type

Nucleated and nonnucleated red blood cells

Description

Round fragments of nucleus (DNA); reddish-blue to deep purple; usually one per cell but occasionally may be two or more; represents chromosomes that have been separated from the mitotic spindle during abnormal mitosis; may also appear to arise from nuclear fragmentation or abnormal expulsion of the nucleus

Clinical Conditions

- Megaloblastic anemia
- Hemolytic anemias
- Hyposplenism
- Splenectomized persons
- Alcoholism
- Sickle cell anemia

Malaria

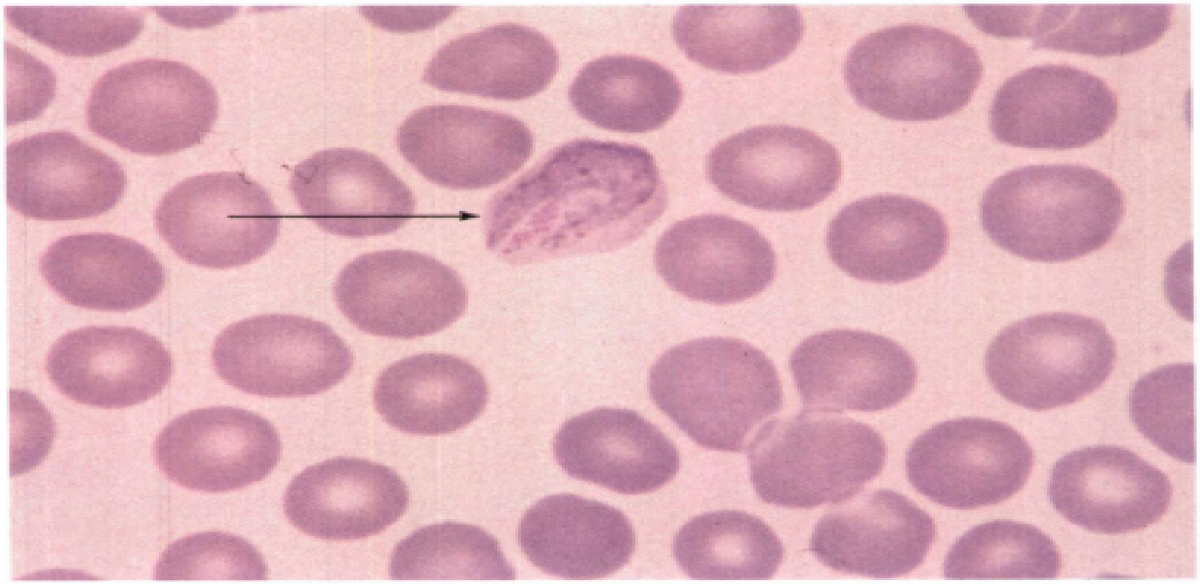

Figure IA1-49

Cell Type

Red blood cell

Description

Depends on the species of *Plasmodium* that infects the cells:

Plasmodium vivax infection enlarges the cell; Schüffner's granules may be present
Plasmodium malariae infection does not enlarge the cell
Plasmodium falciparum infection produces delicate ring forms; cells are not enlarged; Schüffner's granules are not present
Plasmodium ovale infection produces large, oval cells; Schüffner's granules are present

Clinical Conditions

- *Plasmodium* infections

Pappenheimer Body

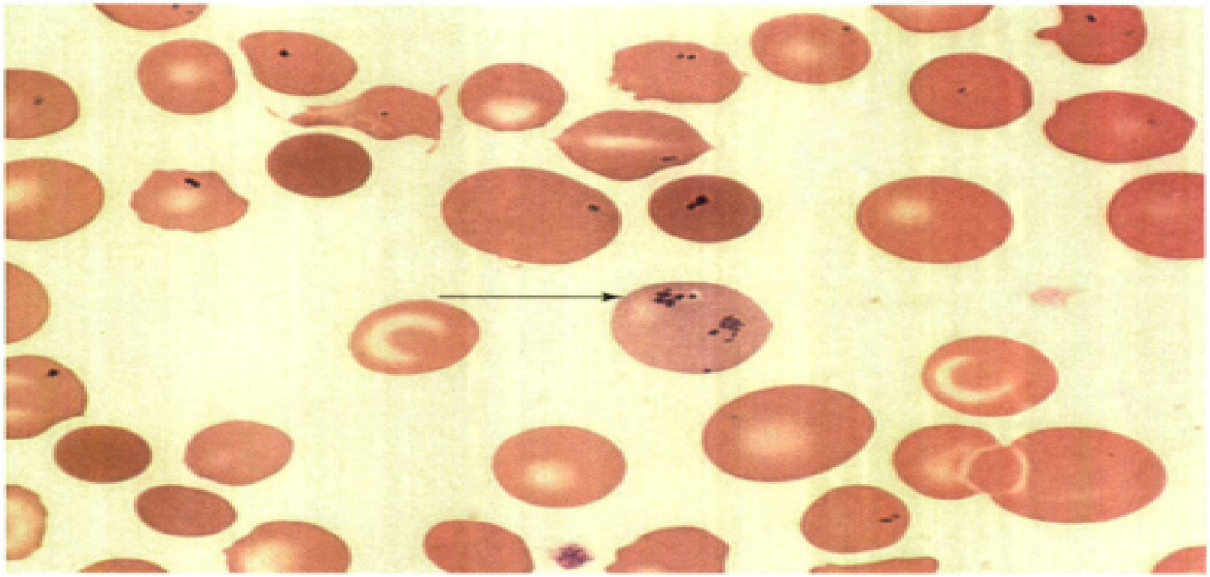

Figure IA1-50

Cell Type

Mature red blood cells, reticulocytes, metarubricytes

Description

Small, irregular, pale blue– to dark-staining granules; usually found on the periphery of the cell and in groups; smaller than Howell-Jolly bodies; represent siderosomes, which stain positive with Perls' Prussian blue stain and indicate iron content

Clinical Conditions

- Disturbed hemoglobin synthesis
- Sideroblastic anemia
- Dyserythropoietic anemias
- Thalassemia
- Myelodysplastic syndromes

ABNORMAL MATURATION

Dyserythropoiesis

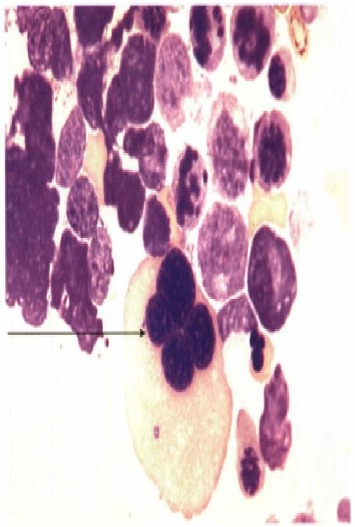

Figure IA1-51

Cell Type

Red blood cell precursors

Description

Abnormal findings in red blood cell precursors, including abnormal nuclear shapes, more than one nucleus, nuclear fragments, megaloblastoid and/or megaloblastic maturation, and vacuolated cytoplasm

Clinical Conditions

- Myelodysplastic syndromes
- Megaloblastic anemias
- Erythroleukemia (M6a)
- Pure erythroid leukemia (M6b)
- Arsenic poisoning