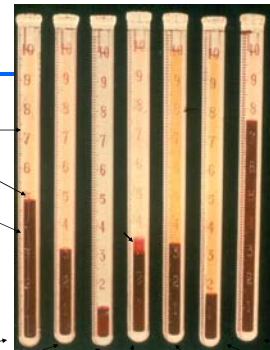


Hematology 101

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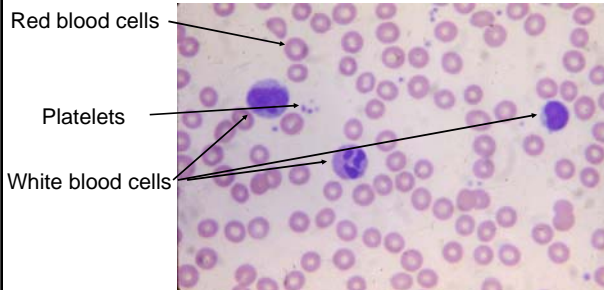
Hematocrits

Plasma
 White cells
 Red cells

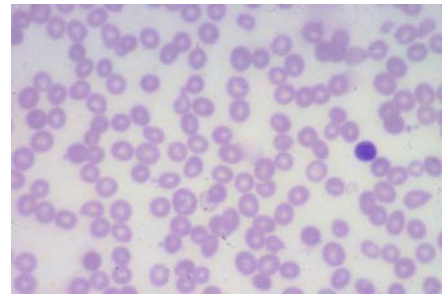


Normal, Hemorrhage, IDA, Leukemia, Hemolysis, B12, P Vera

Normal Peripheral Blood

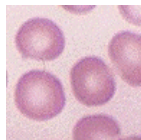


Aplastic Anemia Peripheral Blood



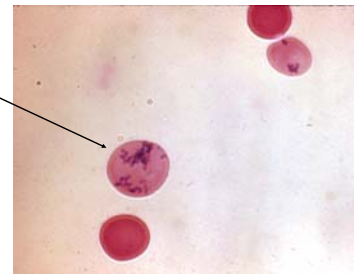
Red Cells

- Contain a red pigment, hemoglobin
- Carry oxygen from the lung to other tissues that need it
 - Muscles, liver, kidney, heart, brain
- Normally live 4 months



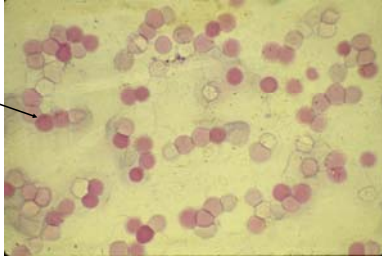
Reticulocytes

Red cells newly released from bone marrow



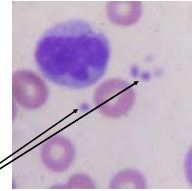
Fetal Hemoglobin

Kleihauer-Betke stain



Platelets

- Help blood clot
- Live 7-10 days
- Low numbers can lead to:
 - Bruising
 - Petechiae (tiny red dots)
 - Nosebleeds
 - Internal bleeding



Platelets

Types of White Cells (Leukocytes)

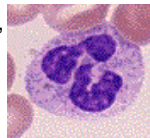
Type	Life Span
Phagocytes (eaters):	
Neutrophil	hours
Monocyte	days
Eosinophil	hours
Basophil	hours
Lymphocytes	months-years

White Blood Cell Functions

- Neutrophils - eat bacteria and fungus
- Lymphocytes - direct the other cells and make antibodies
- Monocytes - eat particles coated with antibody
- Eosinophils - allergies and fight parasites
- Basophils - allergies

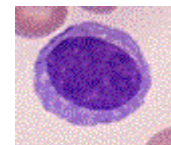
Neutrophils (Phagocytes)

- Polymorphonuclear (PMN), segmented, granulocytes
- Bands, juveniles = early forms
- First line of defense against bacterial infection is intact skin and lining of the mouth, throat and intestines
- Second line of defense is neutrophils, which eat bacteria and kill them
- Low neutrophil number increases susceptibility to bacterial and fungal infections



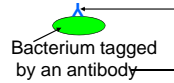
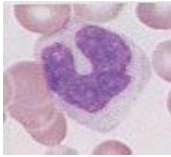
Lymphocytes

- Regulate other white cells
- Make antibodies
 - Proteins that act as flags to stick to bacteria and viruses
 - Tell other cells to eat things



Monocytes

- Phagocytes
- Become tissue macrophages
 - Cells in the tissues that eat particles tagged with antibodies



CBC Machine

- Draw blood from the tube into an electronic counter
- Result is called the complete blood count (CBC)



Blood Counts

	OP CODES	RESULTS	UNITS
WBC	6.1	WBC	# 7.8 x 10 ⁹
RBC	4.48	RBC	# 4.4 x 10 ¹²
Hb	13.6	HGB	g/dl 13.6
Hct	41.5	HCT	% 41.5
MCV	92.7	MCV	fL 92.7
MCH	30.4	MCH	pg 30.4
MCHC	32.7	MCHC	g/dl 32.7
RDW	13.3	RDW	% 13.3
Plat	336	PLT	# 336 x 10 ⁹
MPV	8.4	MPV	fL 8.4

Red Cells

- Hemoglobin (Hb, Hgb)
 - 12-15 grams/100 ml (g/dl) [lower for children]
- Hematocrit (Hct)
 - 35 to 45%

Anemia = Low Hb/Hct (H/H)

Platelets

- Platelet count (Plt)
 - 150,000 to 400,000/ μ l

Thrombocytopenia = low platelets

White Blood Cells (Leukocytes)

- WBC = white blood cell count
 - 5000–10,000/ μ l, 5 – 10 thousand/ μ l
- WBC differential
 - % Neutrophils, bands, lymphocytes, monocytes, eosinophils, basophils

Leukopenia = low WBC

Absolute Neutrophil Count (ANC)

- **ANC** = $WBC \times \% \text{ Neutrophils}$
 - e.g. $WBC = 5000/\mu\text{l}$, 30% neutrophils
 - $ANC = 5000 \times 0.30 = 1500/\mu\text{l}$
- Normal: above 1500/ μl
- OK: above 500
- Low: 200-500
- Very low: below 200

Neutropenia = low neutrophils

CBC Summary

- Quick and easy assessment of numbers of blood cells
- Relatively inexpensive
- No single test tells us more about a blood disorder
- Measures all three cell types (RBC, WBC, platelets)
- Provides other valuable details

Causes of Anemia

- Decreased production
 - Decreased reticulocytes
- Increased destruction
 - Increased reticulocytes
- Blood loss
 - Increased reticulocytes

Definitions

- **Aplastic Anemia (AA):**
 - Pancytopenia due to decreased production
 - Hypocellular bone marrow
- **Leukemia:**
 - Malignant proliferation of immature cells
- **Myelodysplastic syndrome (MDS):**
 - Cytopenia with hypercellular bone marrow

Bone Marrow Equipment



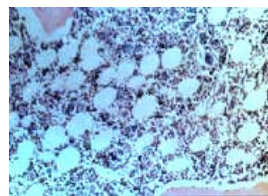
Aspirate



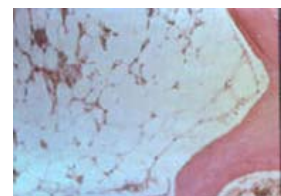
Biopsy

Bone Marrow Biopsy

Normal

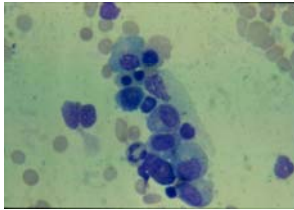


Aplastic

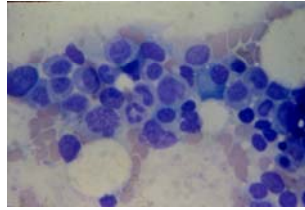


Normal Bone Marrow Aspirate

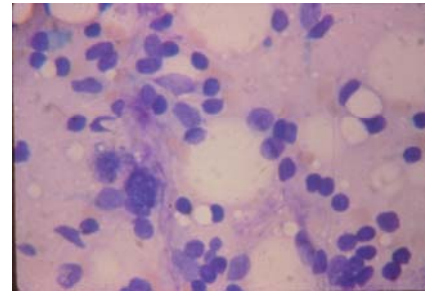
Erythroid (red cells)



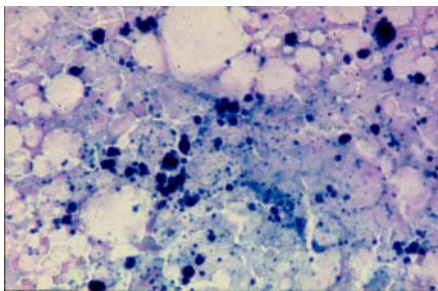
Myeloid (white cells)



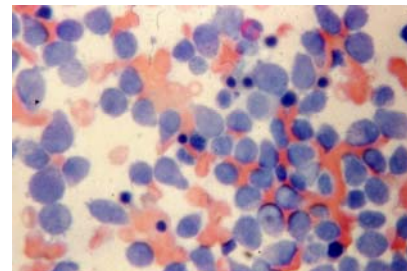
Aplastic Anemia Bone Marrow Aspirate



Bone Marrow Iron

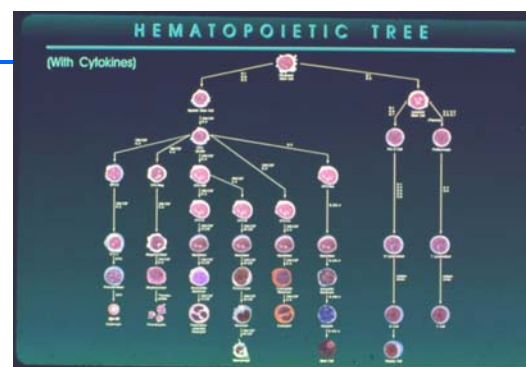


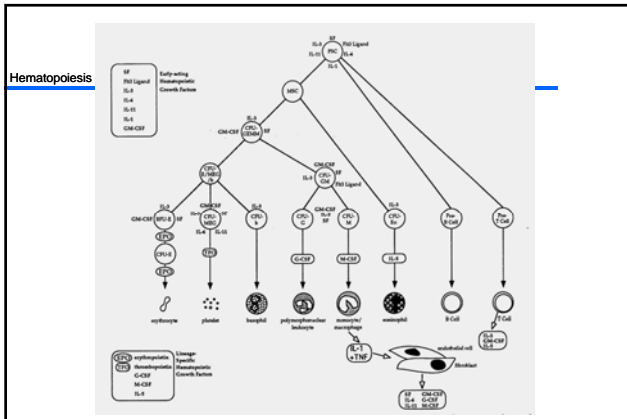
Leukemia Bone Marrow



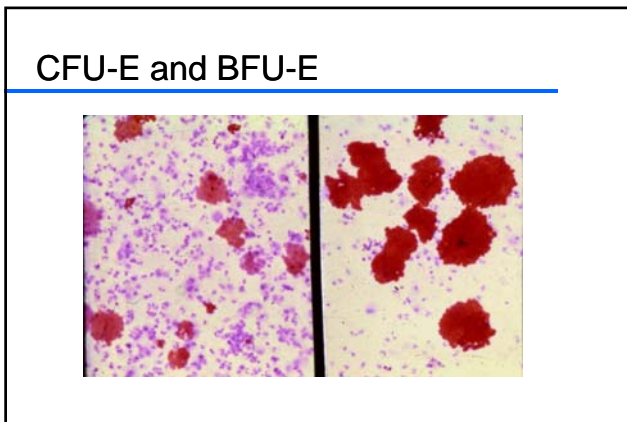
Hematopoiesis

- Formation and development of blood cells
- Takes place in the bone marrow
- Involves "stem cells"

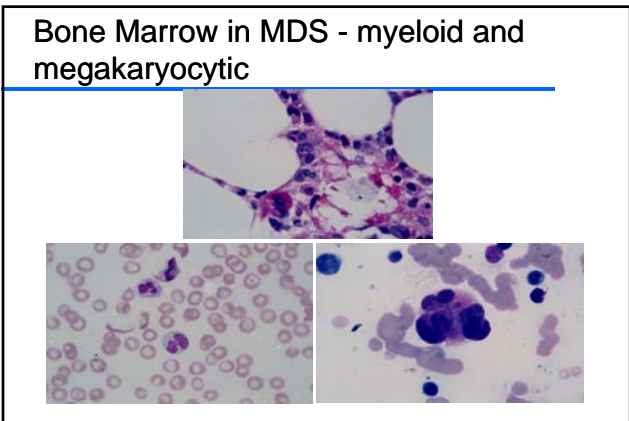
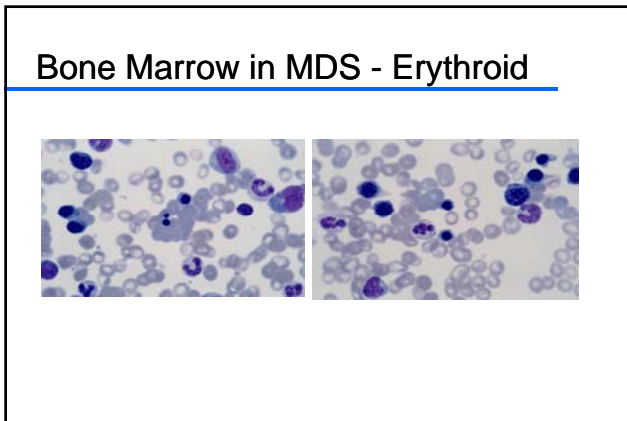




- BM Cultures**
- CFU-E: colony-forming unit, erythroid
 - BFU-E: burst-forming unit, erythroid
 - CFU-C: colony-forming unit in culture
 - CFU-GM: colony-forming unit, granulocyte-macrophage



- Dysplastic Marrow in MDS**
- **Erythroid:** megaloblastic, multinucleation, nuclear fragments, increased immature forms, ring sideroblasts
 - **Myeloid:** increased immature forms, hypo/hyper-granulation
 - **Megakaryocytes:** hypo-/hyper-lobulated, small forms, increased nuclear-cytoplasmic ratio



FAB CLASSIFICATION

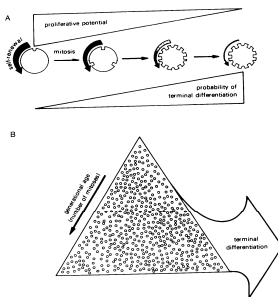
- No MDS
- RA = refractory anemia
- RARS = ring sideroblasts
- RAEB = RA with excess blasts (5-20%)
- CMML = chronic myelomonocytic leukemia, PB monocytes >1000/ μ L
- RAEBT = RA in transformation

French-American-British

WHO Classification

- ◆ RCUD: refractory cytopenia with unilineage dysplasia ($\geq 10\%$ cells in one lineage)
 - RA, RN, RT: anemia, neutropenia, thrombocytopenia
- ◆ RARS: ring sideroblasts
- ◆ RCMD: multilineage dysplasia (≥ 2 lineages)
- ◆ RAEB-1: 5-9% blasts
- ◆ RAEB-2: 10-19% blasts
- ◆ MDS-U: unclassified: dysplasia <10% cells, + clone
- ◆ MDS del(5q): anemia with isolated del(5q)

Hematopoiesis



Blood and Marrow MDS Study

- Aspirate: Morphology
- Biopsy: Cellularity
- Cytochemistry: PAS, MPO, dual esterase, iron
- Flow cytometry: Lymphocytes, granulocytes
- Oncogenes: p53, p21
- Cytogenetics:
 - Classical G banding,
 - FISH (fluorescence in situ hybridization),
 - CGH (comparative genomic hybridization)

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The End