3 classes of Anemias

- Macrocytic – Normochronic Anemias
- Microcytic – Hypochronic Anemias
- Normocytic – Normochronic Anemias

Ex. M-N Anemia – Pernicious Anemia
Folic acid deficiency anemia
typically result of malnutrition

In US, this type of anemia is seen in people on fad diets
low in green leafy vegetables

See macrocytic – normochronic RBCs, reduced in #, don’t see
neurologic effects seen in pernicious anemia.
Microcytic - Hypochromic Anemias

Small RBCs with reduced hemoglobin (Hb) content

Result from:
- Iron metabolism disorders
- Disorders of Hb synthesis

Ex. - Iron deficiency anemia (IDA)
- Sideroblastic anemia
  results from impaired heme synthesis
- Thalassemia
  results from impaired globin synthesis

IDA - most common type of anemia

Results from:
- Iron poor diet
- Chronic blood loss
  2-4ml of blood loss a day can produce IDA
- Pregnancy

Progression occurs in 3 stages:

- Stage I - Loss of iron exceeds the intake of iron, resulting in depletion of iron stores in the body

- Stage II - Depletion of iron stores results in RBCs with diminished Hb content and smaller RBCs

- Stage III - As normal RBCs die, and are removed from the circ. (≈120 days), as this stage progresses, normal RBCs are removed, the % of small, Hb deficient RBCs increases
As stage III progresses, the person begins developing clinical signs of anemia.

**Treatment -**

**If due to:**

- Iron poor diet, iron intake is increased
- If due to chronic blood loss, the site of blood loss has to be found and corrected
- As iron stores are replenished, the production of RBCs will return to normal
Normocytic - Normochromic Anemia

RBCs are normal in size and Hb content, but are reduced in 

Ex. Aplastic anemia
Hemolytic anemia
Sickle cell anemia

Aplastic anemia

Caused by:
- Exposure to radiation that kills the stem cells
- Exposure to chemicals that kill the stem cells (ex. Benzene)
- Autoimmune disease producing antibodies against the stem cells

Treatment:
- Regular blood transfusions
- Immunosuppression if due to autoimmune process
- Antibiotics to help prevent infections
- Hematopoietic growth factors can be given intravenously to stimulate stem cells that remain

None of these cure aplastic anemia. Only cure is bone marrow transplant.
Hemolytic anemia
results from premature destruction of RBCs.

Can be result of:
- Congenital defect in the membrane of the RBCs that causes them to be fragile and break more easily.
- Autoimmune disease against the RBCs
- Overactive spleen—spleen removes RBCs before full life span is completed.
- Can be caused by viral infection, bacterial infection, alcohol or drug abuse, etc.
Treatment: Depends on cause

- Overactive spleen → remove the spleen

- Autoimmune disease → immune suppression to reduce antibody production

- Fragile RBCs → spleen is removed to increase life span of RBCs

These can be accompanied by transfusions to increase RBCs in circulation.

Sickle Cell Anemia

Inherited type of anemia in which a valine residue is replaced by a glutamic acid residue in the β-globin subchain.
of the Hb molecule.

This causes the Hb to clump under hypoxic conditions→causes RBCs to take on a sickle shape.

The sickle-shaped RBCs get stuck in smaller blood vessels resulting in obstruction of blood flow & tissue hypoxia→pain, tissue damage, or stroke if it occurs in the brain.

Also, sickle shaped RBCs are removed from the circ. more readily than normal RBCs, so there are fewer RBCs in the circulation.
Treatment:
- Avoid situations that could lead to hypoxia.
- If hypoxic crises occurred it was managed with pain relievers, + O2 to reduce pain + increase O2 in the blood.

More recently bone marrow transplant has been successful in curing sickle cell anemia. Requires high dosage chemotherapy to kill person's RBC stem cells in their bone marrow. So, they have to be healthy to survive.

Hydroxyurea administration to stimulate production of fetal Hb.
Which is normal, but can cause leukemia.

Disorders where there is an excess of RBCs—Polycythemia

Ex. Polycythemia vera

Neoplastic disease of bone marrow stem cells resulting in excess production of RBCs, platelets, and granulocyte (basophils, eosinophils, and neutrophils)

Cause is not understood, but results in increased blood viscosity that can cause blockage of blood vessels, tissue hypoxia, and damage, strokes in the brain.
Treatment: Phlebotomy to reduce volume of blood in circulation.

Additional treatments are directed at reducing blood cell production.

Examples: Administration of hydroxyurea to inhibit bone marrow stem cell division, but has complication of predisposing individual to leukemia.

Leukocyte Disorders

Disorders involving the WBCs

Leukopenias - deficiency of WBCs

Leukocytoses - proliferation of WBCs
Infectious Mononucleosis (Mono)

Epstein-Barr virus infection of B cells.

Typically spread by saliva of infected individual and invades the body through the oral cavity and throat.

The infection causes an inflammatory response in which there is a proliferation of B and T cells, and monocytes.

These cells accumulate in the lymph nodes and tonsils causing them to swell.
Characterized by sore throat, and high fever, and swelling of tonsils + cervical lymph nodes.

Mono is self-limiting, i.e. runs its course in 2-3 wks so treatment is palliative (directed at reducing the symptoms).

Leukemia
"White Blood"

A disorder of the WBCs and WBC forming tissues caused by loss of regulation of WBC stem cell division resulting in accumulation of dysfunctional WBCs in the circulation.
Proliferation of WBCs causes accumulation of WBCs in the bone marrow that can also affect production of RBCs and platelets.

Acute Leukemias—characterized by:
- disruption of normal WBC production early in WBC development process.
Results in production of "Blast cells"—immature WBCs that are not able to function normally.
- Also has abrupt onset and is fast progressing.
Chronic leukemias -
  - WBCs appear mature but don't function normally
  - Have gradual onset and progression

Lymphoblastic (lymphocytic) leukemia
  usually involve B-cells

Myelocytic leukemia
  involve more than one of the WBC types.

Putting these together:

Acute lymphoblastic (lymphocytic)
  leukemia = abrupt onset
  = fast progressing
- involves a proliferation of immature WBCs

**ALL** - most common type of leukemia in children

**Chronic lymphocytic leukemia (CLL)**
- gradual onset
- slow progressing
- involves an proliferation of WBCs that appear mature, but don't function normally

**CLL** - most common leukemia in adults

**Acute myeloblastic leukemia (AML)**
- abrupt onset
- fast progressing
- involves proliferation of immature WBCs that are non-functional

**Chronic myelocytic Leukemia (CML)**
- Gradual onset
- Slow progression
- Proliferation of more than one type of WBC which appear mature but are non-functional

CML and AML are sometimes called myelogenous leukemia

Primary symptoms of leukemia are:
- Anemia - results from low RBC production due to accumulation of WBCs in bone marrow
- Increased bruising and bleeding as a result of increased platelet production due to accumulation of WBCs in bone marrow

- Increased incidents of infections due to production of non-functioning WBCs

- Bone pain due to accumulation of WBCs in the bone marrow

- Liver, spleen, and lymph node enlargement due to accumulation of WBCs in these organs.

Treatment: Chemotherapy and Radiation to try to reduce proliferation of WBCs
High dosage chemotherapy plus bone marrow transplant if a compatible donor can be found.

**Myceloma**

B cell cancer in which an abnormal B cell returns to the bone marrow and begins proliferating to form a B cell tumor (myeloma).

The myeloma may spread to other parts of the skeletal system resulting in multiple myelomas.

Mycelomas secrete osteoclast activating factor that stimulates the osteoclasts to breakdown bone matrix.
This can lead to bone pain, lesions, and weakening of the bones predisposing to bone fractures.

Fast spreading and if left untreated will usually kill within 6 months of diagnosis.

Until recently only treatment was aggressive radiation & chemotherapy. Poor prognosis - death usually occurring within 3 yrs of diagnosis.

More recently peripher/blood stem cell transplant has increased survival to up to 5 yrs.
Lymphomas

A group of malignant cancers that result from proliferation of lymphocytes and macrophages in the lymph nodes.

The proliferation of these cells causes the lymph nodes involved to swell.

Two types of lymphomas:
- Hodgkin’s lymphoma (HL)
- Non-Hodgkin’s Lymphoma

HL

Characterized by enlargement of a single lymph node or localized group of lymph nodes.
Biopsy of the involved lymph nodes reveals the presence of Reed-Sternberg cells—large, multi lobed, multinucleated cells.

RS cells are believed to be malignant macrophages and/or lymphocytes (depending on the type of HL).

The RS cells secrete cytokines that attract other RBCs to the lymph node(s) causing them to swell.

HL spreads from node to node through the lymphatic system, eventually disrupting the system and its normal immune
functions.

Treatment for HL:
Localized radiation + chemotherapy
directed at the lymph nodes involved.

Prognosis - 75% survive 5 yrs, depending on how early
diagnosis is made & treatment started.

\[ \text{NHL} \]

characterized by:
- Enlargement of dispersed lymph nodes
- Lack of presence of R-S cells in nodes involved.
Malignant cells in NHL are believed to be derived from B cells.

Treatment for NHL: Similar to HL. Depending on how early diagnosis is made and treatment started, 5-year survival rate is 30-40%.

Cardiovascular System
Diagram of the human circulatory system, showing the heart, lungs, veins, and arteries. Key parts labeled include:

- **Pulmonary Valve**
- **Right Atrium**
- **Right AV Valve**
- **Right Ventricle**
- **Pulmonary SL Valve**
- **Vena Cava**
- **Pulmonary Artery**
- **Arterioles**
- **Capillaries**
- **Venules**
- **Veins**
- **Arteries of Each Organ**
- **Arteries**
- **Pulmonary Veins**
- **Aorta**
- **Left Atrium**
- **Left AV Valve**
- **Left Ventricle**
- **Aortic SL Valve**
- **Capillaries of Each Organ**
- **Waste Products CO₂**
- **Nutrients**

3 types of Blood Vessels:

Arteries — carry blood away from heart to the various organs

Veins — carry blood from the various organs to the heart

Capillaries — form capillary beds (networks) in the tissues

All exchange of gases + nutrients + wastes occurs across the walls of the capillaries.