- Chronic anemia
  - >2 months
  - No hepatosplenomegaly
    ✓ No petichiae and purpura → Iron-deficiency Anemia, anemia of chronic disease, folate deficiency
    ✓ Petichiae & purpura → ITP (Idiopathic thrombocytopenic purpura) + iron deficiency, Acute leukemia (Blast cell), Aplastic anemia
    ✓ Chronic diseases → Chronic renal failure, rheumatoid arthritis, infective endocarditis, hypothyroidism, etc.
    ✓ Tumours → CA stomach and colon
  - With hepatosplenomegaly
    ✓ Mongoloid face → Thalassemia
      • α-thalassemia cannot use hemoglobin electrophoresis
      • β-thalassemia can use hemoglobin electrophoresis for diagnosis
    ✓ No Mongoloid face with lymphadenopathy → Acute leukemia, lymphoma, TB lymph node
    ✓ Liver disease

- Iron studies in iron deficiency anemia and anemia of chronic disease

<table>
<thead>
<tr>
<th>Test</th>
<th>IDA</th>
<th>ACD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum iron</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>TIBC (total iron binding capacity)</td>
<td>High</td>
<td>Normal or low</td>
</tr>
<tr>
<td>Transferrin saturation</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Serum ferritin</td>
<td>Low</td>
<td>Normal or increased</td>
</tr>
<tr>
<td>Marrow Iron</td>
<td>Absent</td>
<td>Normal or increased</td>
</tr>
<tr>
<td>Transferrin receptor</td>
<td>High</td>
<td>Normal or increased</td>
</tr>
</tbody>
</table>

- In children, check for nutritional status
- In puberty and post-pubertal women, check for hyper-menorrhagea
- Decreased haptoglobin
- Increased unconjugated bilirubin
- Increased LDH

- Blood smear
  - With Prussian blue: Heinz bodies
  - With Wright stain: Bite cells

Disorders of WBCs

- Pancytopenia
  - All CBC parameters below normal ranges
    - Anemia
    - Leukopenia
    - Thrombocytopenia
  - It is a finding, not a diagnostic endpoint
  - Possible causes of pancytopenia
    - Constitutional bone marrow failure
      - Genetic defects in DNA repair
      - Fanconi anemia
        - Autosomal recessive disease
        - Presents at late childhood/early adulthood
      - Shwachman-Diamond syndrome
        - Gene defect in chromosome 7
    - Acquired BM failure
      - Aplastic anemia
      - Radiation, chemotherapy
      - Paroxysmal nocturnal hemoglobinuria
    - Acquired ineffective hematopoiesis due to nutritional deficiency
      - Vitamin B₁₂, folate
    - Acquired disorders characterized by BM effacement
      - Acute myeloid leukemia
      - Hairy cell leukemia
      - Metastatic carcinoma
    - Drugs that could cause aplastic anemia
      - Nonsteroidal anti-inflammatory drugs (NSAIDs)
      - Benzene
      - Chloramphenicol
  - Blood smear of pancytopenia
    - Shows less of everything, including red blood cells
  - Symptoms
    - Fatigue
    - Pallor
    - Mucosal bleeding
    - Petechiae as a result of thrombocytopenia
    - Neutropenia occurs, leading to frequent infections
  - Pathology of bone marrow
    - Marrow is hypocellular, with fat infiltration

- Leukocytosis
  - Characterized by an increase in the total number of leukocytes in the blood more than $11 \times 10^9/L$
  - Leukocytosis is usually due to increase in the neutrophils, but may be also due to increased lymphocytes

- Leukopenia
  - Leukopenia is a condition in which the total leukocyte count is less than $4 \times 10^9/L$
## Increased Destruction (Normal–High Reticulocyte Count)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood loss</td>
<td>Loss rather than destruction. Clinical features depend on rate and severity of blood loss. Chronic loss better tolerated, regenerate by increasing erythropoiesis. Acute blood loss: possible hypovolemia may lead to shock and death. Hematocrit may be initially normal because of equal plasma and RBC loss; will decrease as interstitial fluid equilibrates.</td>
</tr>
<tr>
<td>Warm hemolytic anemia</td>
<td>IgG</td>
</tr>
<tr>
<td>Cold hemolytic anemia</td>
<td>IgM</td>
</tr>
<tr>
<td>Paroxysmal hemolytic anemia</td>
<td>IgG</td>
</tr>
<tr>
<td>Prespleenectomy smear: spherical cells lacking central pallor and reticulocytosis.</td>
<td></td>
</tr>
<tr>
<td>Postspleenectomy smear: more spherocytes and Howell-Jolly bodies.</td>
<td></td>
</tr>
<tr>
<td>G6PD deficiency</td>
<td>X-linked deficiency of the enzyme (hexose monophosphate shunt). Decreased regeneration of NADPH, therefore glutathione. Older cells unable to tolerate oxidative stress. Associated with drugs (e.g., sulfa, quinine, nitrofurantoin), infections (particularly viral), or certain foods (fava beans).</td>
</tr>
<tr>
<td>Smear: reticulocytosis and Heinz bodies (Hb degradation products).</td>
<td></td>
</tr>
<tr>
<td>Paroxysmal nocturnal hemoglobinuria</td>
<td>Acquired deficiency of membrane proteins: decay accelerating factor (CD55) and membrane inhibitor of reactive lysis (CD59). Chronic intravascular hemolysis. Predisposes to stem cell disorders (e.g., aplastic anemia, acute leukemia). Most frequently die of infection or venous thrombosis. Diagnosis: flow cytometry, absence of CD55 and CD59.</td>
</tr>
</tbody>
</table>
Summary of lab findings in hematopoietic disorders

- Lab investigations
  - Evaluation of microcytic anemia
    - PBS, iron study, HGB electrophoresis
  - Evaluation of macrocytic anemia
    - PBS, serum vitamin B₁₂ level, serum & RBC folate levels, LFT, s-TSH level, bone marrow (BM) examination & cytogenetics
  - Evaluation of normocytic anemia
    - PBS, s-bilirubin, s-LDH (if hemolysis suspected), iron studies, RFT, Epo level, BM examination