Figure 1: Normal blood smear

Figure 2: RETICULOCYTE stain

Figure 3: Thin area of smear

Figure 4: Thick area, plus drying artifacts

Figure 5: (for comparison) TRUE ROULEAUX- when protein concentration in the blood is high (e.g. multiple myeloma) red cells are coated and their normal electrostatic repulsion is lost. This leads to the "stacked coin" appearance seen in the slide.

Figure 6: Drying Artifacts
Figure 7: Drying Artifacts

Figure 8: Normal NEUTROPHIL and LYMPHOCYTE

Figure 9: Normal MONOCYTES and LYMPHOCYTE

Figure 10: MONOCYTE

Figure 11: EOSINOPHIL

Figure 12: BASOPHILS
Figure 13: Peripheral blood- MYELOCYTES and METAMYELOCYTE are not normal findings in peripheral blood but may be seen in conditions such as myelophthisis (invasion of the bone marrow), hemolytic anemias, and other stressful states.

Figure 14: Nucleated RBC (orthochromic normoblast)- similarly not seen normally but seen with myelophthisis, hemolysis, and other stresses.
HEMATOLOGY
*Morphological Abnormalities of Red Blood Cells*

Lab 1- Kodachrome: 1 Peripheral blood: normal; 525x

Lab 1- Kodachrome: 2 Bone marrow: normal; 525x

Lab 1- Kodachrome: 3 Peripheral blood: iron deficiency anemia 525x

Lab 1- Kodachrome: 4 Peripheral blood: Lead poisoning- basophilic stippling 1250x

Lab 1- Kodachrome: 5 Peripheral blood: Sideroblastic anemia- one classically sees dimorphic red cells: a hypochromic/microcytic population and larger cells that are not hypochromic. This type of picture could also be seen after blood transfusion and with partially treated iron-deficiency anemia. 525x
Lab 1- Kodachrome: 6 Bone marrow: Sideroblastic anemia; Prussian blue stain; in pathognomonic ringed SIDEROBLASTS, the iron appears to surround the nucleus because it is trapped in mitochondria. Ringed SIDEROBLASTS can be idiopathic (e.g. myelodysplastic syndrome), hereditary, and can occur with drugs and toxins (especially alcohol). 1250x

Lab 1- Kodachrome: 7 Peripheral blood: megaloblastic anemia- The earliest morphologic abnormality in B12/Folate deficiency is hypersegmentation of the NEUTROPHILS (greater than 5 lobes). There is pancytopenia, oval MACROCYTES, and extreme anisocytosis; 640x

Lab 1- Kodachrome: 8 Bone marrow: megaloblastic anemia- the hallmark of megaloblastic change is nuclear/cytoplasmic asynchrony or dissociation. Most of the cells in this field are red cell precursors with cytoplasmic maturation but large nuclei with non-condensed chromatin. 525x

Lab 1- Kodachrome: 9 Peripheral blood: myelofibrosis- TEARDROPS and ELLIPTOCYTES are characteristic of myelophththic processes and are most extreme in myelofibrosis. Leukoerythroblastosis (immature myeloid cells and nucleated red blood cells in the blood) are also most characteristic of myelophththic processes and is always seen in myelofibrosis. 640x
Lab 1- Kodachrome: 10 Peripheral blood: macroglobulinemia, ROULEAUX 525x

Lab 1- Kodachrome: 11 Peripheral blood: ECHINOCYTES and TARGET CELLS; 1250x

Lab 1- Kodachrome: 12 Peripheral blood: spur cell anemia (ACANTHOCYTES with liver disease) 1250x

Lab 1- Kodachrome: 13 Peripheral blood: STOMATOCYTES - most often artifacts, but true stomatocytes can be seen after alcohol binges and with rare hereditary conditions; 640x

Lab 1- Kodachrome: 14 Peripheral blood: autoimmune hemolytic anemia; SPHEROCYTES, small cells lacking central pallor, are formed when red blood cells lose some of their membrane and must maximize surface: volume ratio. SPHEROCYTES is the predominant abnormality in the blood smear in autoimmune hemolytic anemia and hereditary spherocytosis. Note also in this slide the large bluish cells, which represent RETICULOCYTES. 640x
Lab 1- Kodachrome: 15 Peripheral blood: hereditary spherocytosis cannot be distinguished from autoimmune hemolytic anemia on the blood film. The disorders can be distinguished by history, physical exam (splenomegaly), and DIRECT Coombs' test. 1250x

Lab 1- Kodachrome: 16 Peripheral blood: iron deficiency anemia complicated by hemolytic transfusion. There is underlying hypochromic/microcytic red cells. SPHEROCYTES are a result of the immune hemolytic reaction to mismatched blood. 640x

Lab 1- Kodachrome: 17 Peripheral blood: hereditary elliptocytosis- usually a mild hereditary hemolytic anemia. 525x

Lab 1- Kodachrome: 18 Peripheral blood: thalassemia minor- there is always substantial MICROCYTOSIS. TARGET CELLS, basophilic stippling, and hypochromia may or may not be prominent. 640x
Lab 1- Kodachrome: 19 Peripheral blood: thalassemia major 640x

Lab 1- Kodachrome: 20 Peripheral blood: sickle cell anemia- TARGET CELLS are seen in hemoglobinopathies, thalassemias, in liver disease, and asplenia. 640x

Lab 1- Kodachrome: 21 Peripheral blood: hemoglobin SC disease- SC patients frequently have compensated hemolysis (they are not anemic). SICKLE CELLS tend to be few, TARGET CELLS prominent, and there are a number of unusual forms (BOAT CELLS). 800x

Lab 1- Kodachrome: 22 Peripheral blood: S-thalassemia- In Sickle-thalassemia, the anemia tends to be milder than in SS disease, there are few SICKLE CELLS, and there is MICROCYTOSIS. 640x
Morphological Abnormalities of Red Blood Cells

Lab 1- Kodachrome: 23 Peripheral blood: red cell fragmentation due to artificial valve- In contrast to microangiopathic hemolysis, the platelet count is not low. 640x

Lab 1- Kodachrome: 24 Peripheral blood: thrombotic thrombocytopenic purpura- Causes of microangiopathic hemolytic anemia include: TTP, hemolytic-uremic syndrome, disseminated intravascular coagulation, disseminated carcinomatosis, malignant hypertension, and renal vasculitis. Conditions other than TTP would rarely, if ever, produce a blood smear picture this severe. In the proper clinical context (neurologic symptoms), this smear would be diagnostic of TTP. 525x

Lab 1- Kodachrome: 25 Peripheral blood: microangiopathic hemolytic anemia- In microangiopathic hemolytic anemias, there are SCHISTOCYTES, SPHEROCYTES, polychromasia, and thrombocytopenia. 800x

Lab 1- Kodachrome: 26 Kidney: microangiopathic hemolytic anemia 200x
Lab 1- Kodachrome: 27 Peripheral blood: microangiopathic hemolytic anemia associated with disseminated cancer 800x

Lab 1- Kodachrome: 28 Lung: intravascular tumor 125x

Lab 1- Kodachrome: 29 Peripheral blood: malaria parasite- this slide illustrates a ringed form MEROZOITE. 1250x

Lab 1- Kodachrome: 30 Review abnormal red cell shapes:
Lab 3- Kodachrome: 1 Case A: Iron deficiency anemia, 640x

Lab 3- Kodachrome: 2 Case B: Pernicious anemia, 640x

Lab 3- Kodachrome: 3 Case B: Pernicious anemia, 1225x

Lab 3- Kodachrome: 4 Case B: Pernicious anemia, 640x
Lab 3- Kodachrome: 9 Case E: **Postsplenectomy state**, 800x

Lab 3- Kodachrome: 10 Case E: **Postsplenectomy state**, 1225x
Lab 7- Kodachrome: 1 Hodgkin's disease, nodular sclerosing

Lab 7- Kodachrome: 2 Follicular lymphoma, low power

Lab 7- Kodachrome: 4 Follicular lymphoma ("BUT-TOCK" CELL)

Lab 7- Kodachrome: 3 Follicular lymphoma, small cleaved (high power)
HEMATOLOGY

Pancytopenia and Thrombocytopenia

Lab 8- Kodachrome: 1 Peripheral blood

Lab 8- Kodachrome: 2 Peripheral blood

Lab 8- Kodachrome: 3 Bone marrow aspirate

Lab 8- Kodachrome: 4 Bone marrow biopsy

Lab 8- Kodachrome: 5 Reticulin Stain

Lab 8- Kodachrome: 6 Tartrate-resistant acid phosphatase
HEMATOLOGY
Pancytopenia and Thrombocytopenia

Lab 8- Kodachrome: 7 Peripheral Blood- thrombocytopenia

Lab 8- Kodachrome: 8 Peripheral Blood- MEGATHROMBOCYTE

Lab 8- Kodachrome: 9 Bone marrow/increased MEGAKARYOCYTES

Lab 8- Kodachrome: 10 Bone marrow/vacuolated MEGAKARYOCYTE
Lab 9- Kodachrome: 1 Peripheral blood: chronic myeloid leukemia; The full spectrum of myeloid maturation visible from immature MYELOCYTES to NEUTROPHILS. There are usually peaks in the differential at the myeloid and neutrophil stages. A LAP (Leukocyte Alkaline Phosphatase) score is useful to differentiate CML (low) from a leukemoid reaction (high). 525x

Lab 9- Kodachrome: 2 Peripheral blood: BASOPHILS in a patient with chronic myeloid leukemia; Basophilia is found in all myeloproliferative disorders and is sign of acceleration in CML. 800x

Lab 9- Kodachrome: 3 Peripheral blood: Myelophthisis. There are numerous TEARDROPS and ELIPTOCYTES. Leukoerythroblastosis (immature myeloid cells and nucleated RBCs in the blood) is also consistent with myelophthisis but especially myelofibrosis. 525x

Lab 9- Kodachrome: 4 Bone marrow biopsy: Myelofibrosis; Wright’s stain. The bone marrow aspirate is usually dry, and one sees a swirling pattern H/E. 160x
Lab 9- Kodachrome: 5 Bone marrow biopsy: myelofibrosis; Reticulin stain 160x

Lab 9- Kodachrome: 6 Bone marrow biopsy: myelofibrosis; Masson stain 525x

Lab 9- Kodachrome: 7 Peripheral blood: acute myeloblastic leukemia. There are numerous BLASTS with pale, blue cytoplasm, an increased N/C ratio, fine uncondensed chromatin, and +/- nucleoli.

Lab 9- Kodachrome: 8 Peripheral blood: acute myeloblastic leukemia- note the abundance of immature GRANULOCYTES; Sudan black stain 640x
Lab 9- Kodachrome: 9 Peripheral blood: acute myeloblastic leukemia; Peroxidase stain 1225x

Lab 9- Kodachrome: 10 Peripheral blood: acute myeloblastic leukemia; Approximately 20% of myeloid/monocytic leukemic cells have Auer Rod - linear condensations of abnormal primary granules.; Wright's stain; 640x

Lab 9- Kodachrome: 11 Bone Marrow: acute promyelocytic leukemia; The cells are not only morphologically distinguishable due to the hypergranularity, but this variant of AML also has a number of distinguishing characteristics including: association with DIC, a specific chromosomal abnormality (t15;17), and a high response rate to congenors of retinoic acid.

Lab 9- Kodachrome: 12 Peripheral blood: acute lymphoblastic leukemia; Wright's stain, 1225x
Lab 9- Kodachrome: 13 Peripheral blood: **acute lymphoblastic leukemia**; PAS stain. Both **LYMPHOBLASTS** and **RED CELL BLASTS** in erythroleukemia stain PAS +. 1225x

Lab 9- Kodachrome: 14 Peripheral blood: **acute monocytic leukemia**; The malignant cells have the same characteristics as **MONOCYTES** with blue-gray cytoplasm and folded nuclei. There is also a propensity to involve extramedullary sites, including the gums. 1225x

Lab 9- Kodachrome: 15 Bone marrow: **acute monocytic leukemia**; non specific esterase; NSE stains cells of the monocytic lineage. 1225x

Lab 9- Kodachrome: 16 Peripheral blood: **Erythroleukemia**- the bizarre red cell precursors indicate erythroleukemia; 525x
HEMATOLOGY

Morphological Abnormalities of Leukocytes and Platelets

Lab 9- Kodachrome: 17 Peripheral blood: **Chronic lymphocytic leukemia**; There are a number of small, mature lymphocytes c/w CLL. The diagnosis is usually confirmed with a bone marrow biopsy or flow cytometry which shows **MONOCLONAL B CELL** proliferation (classically CD5+) 1225x

Lab 9- Kodachrome: 18 Peripheral blood: **Follicular B Cell Lymphoma** - The clefted lymphoid cell with a nucleolus ("BUTTOCK" CELL) is characteristic of this type of lymphoma; 1225x

Lab 9- Kodachrome: 19 Bone marrow: **Burkitt’s lymphoma** - The Burkitt’s lymphoma/leukemia cells are immature, deeply basophilic, and highly vacuolated. This lymphoma is associated with the t8;21, the Epstein-Barr Virus in the African variant, and has shown an increased incidence in patients with AIDS and immunosuppression. In addition, it is the fastest growing cancer known to man with a doubling time of 24 hours. Wright stain.

Lab 9- Kodachrome: 20 Peripheral blood: **Pelger-huet anomaly**; PELGER-HUET CELLS are mature NEUTRO-PHILS with 2 symmetric round/oval nuclear lobes with a thin strand of chromatin in between. These cells are associated with a benign hereditary condition and an acquired pseudo-Pelger-Huet abnormality in myeloproliferative disorders, myelodysplastic syndromes, in addition to reactive processes. 1225x
Lab 9- Kodachrome: 21 Peripheral blood: Pelger-huet anomaly; Stodtmeister cell. This is a uninuclear variant of the Pelger-Huet anomaly.; 1225x

Lab 9- Kodachrome: 22 Peripheral blood: Hairy cell leukemia classically presents with splenomegaly, pancytopenia with lymphadenopathy. There is an excellent prognosis with certain treatments including 2-CDA or IFN.; 1225x

Lab 9- Kodachrome: 23 Peripheral blood: Atypical lymphocytes: excessive cytoplasm, eccentric nuclei, +/- nucleoli, and the chromatin ay not be completely clumped. The DDx includes: Infectious mononucleosis, CMV, Toxoplasmosis, and reactive processes. N.B. In mononucleosis, the B cells are infected, but it is the T cells which appear atypical; 1225x

Lab 9- Kodachrome: 24 Peripheral blood: There are several reactive LYMPHOCYTES suggestive of infectious mononucleosis; 1225x
Lab 9- Kodachrome: 25 Peripheral blood: **Reactive Lymphocytosis** (influenza)

Lab 9- Kodachrome: 26 Bone Marrow: **PLASMA CELLS** characterized by deeply basophilic cytoplasm, eccentric nuclei, perinuclear clear zone. These cells are diagnostic of a variant of **multiple myeloma** (1% of all cases) called **plasma cell leukemia**.; 525x

Lab 9- Kodachrome: 27 Bone Marrow: Tumor clumps of **metastatic adenocarcinoma of the prostate** in the bone marrow.; 640x

Lab 9- Kodachrome: 28 Bone Marrow: Lipid laden **MACROPHAGES** consistent with **Gaucher’s disease**, in which the glucocerebroside enzyme is deficient. 800x
Lab 9- Kodachrome: 29 Peripheral blood: Extreme thrombocytosis. Platelet counts this high (1.5 to 2,000,000) are only seen in myeloproliferative disorders, including essential thrombocytopenia, which is characterized by both hemorrhagic and thrombotic tendencies.; 800x

Lab 9- Kodachrome: 30 Peripheral blood: MEGATHROMBOCYTE (giant platelet)- these are seen in a reactive processes but also myeloproliferative disorders. These platelets are often functionally abnormal.; 1225x

Lab 9- Kodachrome: 31 Toxic Granulation of NEUTROPHIL- a non-specific sign of infection.

Lab 9- Kodachrome: 32 Dohle Body. These areas in the cytoplasm of NEUTROPHILS stain blue with Wright’s stain due to the increase in RNA present in the RER of the cells. Dohle bodies are seen in a number of conditions, including: sepsis, burns, myelodysplastic conditions, and hereditary conditions.
Lab 9- Kodachrome:  33 Vacuolization of NEUTROPHILS

Lab 9- Kodachrome:  34 LAP stain of NEUTROPHILS; In this case, the LAP is high, consistent with reactive neutrophilia. A low LAP score would be consistent with CML.
Lab 10- Kodachrome: 1 Case H: Chronic myelogenous leukemia- many mature white cells; low LAP score (high in reactive leukocytosis)

Lab 10- Kodachrome: 2 Case H: Chronic myelogenous leukemia

Lab 10- Kodachrome: 3 Case I: Hodgkin's disease

Lab 10- Kodachrome: 4 Case I: Hodgkin's disease

Lab 10- Kodachrome: 5 Case J:

Lab 10- Kodachrome: 6 Case K: Hereditary Pelger-Huet anomaly
Lab 10- Kodachrome: 7 Case K: Hereditary Pelger-Huet anomaly

Lab 10- Kodachrome: 8 Case K: Hereditary Pelger-Huet anomaly

Lab 10- Kodachrome: 9 Case K: Hereditary Pelger-Huet anomaly

Lab 10- Kodachrome: 10 Case L: Thrombotic thrombocytopenic purpura- marked SCHISTOCYTES, occasional SPHEROCYTES, moderate polychromasia, thrombocytopenia

Lab 10- Kodachrome: 11 Case L: Thrombotic thrombocytopenic purpura- SCHISTOCYTES, thrombocytopenia

Lab 10- Kodachrome: 11 Case L: Thrombotic thrombocytopenic purpura- SCHISTOCYTES, thrombocytopenia

Lab 10- Kodachrome: 12 Case M: Acute leukemia, probably lymphoblastic
Lab 10- Kodachrome: 13 Case M: Acute leukemia, probably lymphoblastic