Blood Cell Identification – Graded

Case History

This peripheral blood smear is from a 64-year-old man without significant past medical history who presents for his annual routine physical with loss of appetite. Laboratory data include: WBC = 247.6 x 10^9/L; RBC = 4.23 x 10^{12}/L; HGB = 14.8 g/dL; HCT = 42.2%; MCV = 100 fL; RDW = 16%; and PLT = 111 x 10^9/L. Identify the arrowed object(s) on each image.

(PERIPHERAL BLOOD, WRIGHT-GIEMSA)

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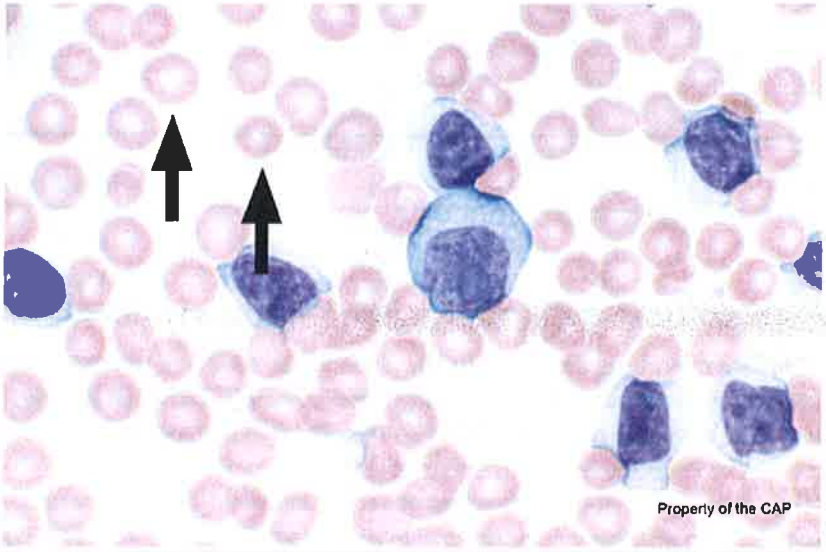
http://www.cap.org/ShowProperty?nodePath=/UCMCon/Contribution%20Folders/WebContent/pdf/hematology-glossary.pdf

BCP-01

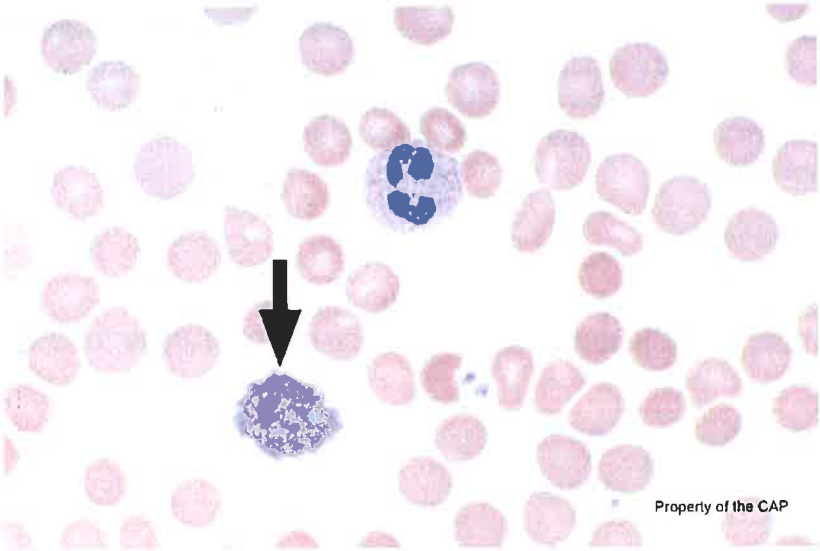


Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Erythrocyte, normal	78	94.0	5032	92.8	Good
Microcyte (with increased central pallor)	5	6.0	253	4.7	Unacceptable

The arrowed cells are normal erythrocytes, as correctly identified by 94.0% of referees and 92.8% of participants. These non-nucleated biconcave disc-shaped cells have a normal diameter of 6.7 to 7.8 µm and contain an area of central pallor that occupies one third of the cell diameter. Erythrocytes contain hemoglobin, which serves to carry oxygen to tissues. These cells stain pink-red with Wright-Giemsa stain. They circulate in the blood for approximately 120 days before undergoing catabolism or destruction in the spleen.

Blood Cell Identification – Graded

BCP-02

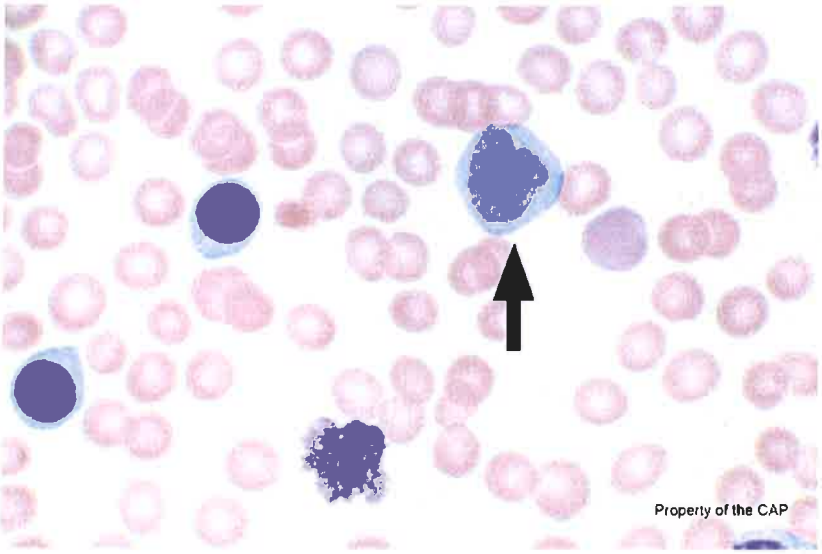


Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Basket cell/smudge cell	74	89.2	4794	88.4	Good
Platelet, giant	8	9.6	419	7.7	Unacceptable
Megakaryocytic cell	1	1.2	47	0.9	Unacceptable

The arrowed cell is a so-called basket or smudge cell, as correctly identified by 89.2% of referees and 88.4% of participants. This morphological appearance is commonly associated with cells that are fragile and easily damaged in the process of making a peripheral blood smear. The nucleus may either be a nondescript chromatin mass or the chromatin strands may spread out from a condensed nuclear remnant, giving the appearance of a basket. Cytoplasm is either absent or indistinct. Smudge cells are usually lymphocytes, but there is no recognizable cytoplasm to give a clue to the origin of the cell. They are seen most commonly in disorders characterized by lymphocyte fragility, such as infectious mononucleosis and (as in this case) chronic lymphocytic leukemia. Stabilizing the cells by adding albumin will allow a blood smear to be made in which the basket cells can be positively identified.

Blood Cell Identification – Graded

BCP-03

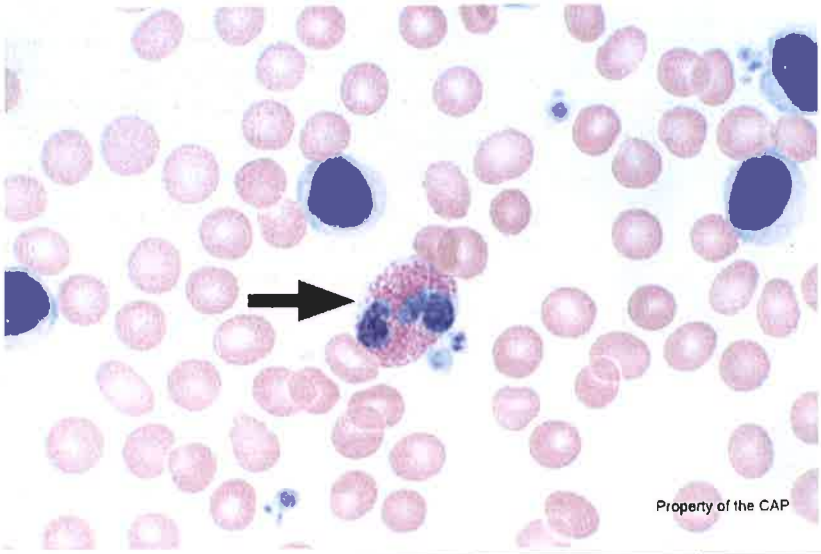


Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Monocyte	75	91.5	4731	87.3	Good
Monocyte, immature (promonocyte, monoblast)	3	3.7	213	4.0	Unacceptable
Neutrophil, myelocyte	2	2.4	30	0.6	Unacceptable
Malignant lymphoid cell (other than blast)	1	1.2	70	1.3	Unacceptable
Neutrophil, metamyelocyte	1	1.2	123	2.3	Unacceptable

The arrowed cell is a monocyte, as correctly identified by 91.5% of referees and 87.3% of participants. These cells are 12 to 20 µm in diameter with round, smooth edges or with pseudopod-like cytoplasmic extensions. The cytoplasm is abundant and gray to gray-blue and may contain fine, evenly distributed, azurophilic granules or vacuoles. The nucleus to cytoplasm ratio is 4:1 to 2:1. The nucleus is usually indented, often resembling a three-pointed hat, but it can also be folded or band-like. The chromatin is condensed, but less dense than that of a neutrophil or lymphocyte. Nucleoli are generally absent, but occasional monocytes may contain a small, inconspicuous nucleolus.

Blood Cell Identification – Graded

BCP-04

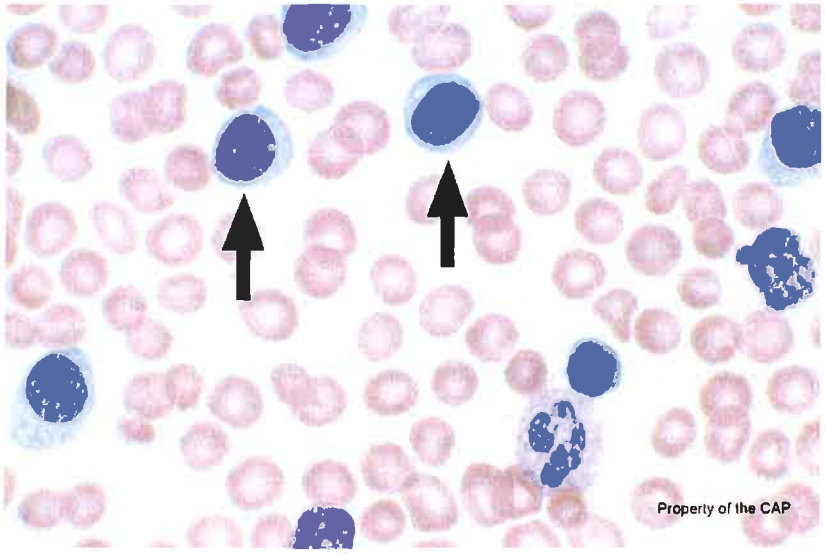


Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Eosinophil, any stage	83	100.0	5413	99.8	Good

The arrowed cell is an eosinophil, as correctly identified by 100.0% of referees and 99.8% of participants. These easily recognized cells are round to oval leukocytes and contain characteristic coarse, orange-red granulation. They are the same size as mature neutrophils (10 to 15 µm in diameter) with a typical nucleus to cytoplasm ratio of 1:3 for mature forms. The cytoplasm is filled by numerous coarse, orange-red granules of uniform size which exhibit a refractile appearance with light microscopy due to their crystalline structure. The coarse nature of eosinophilic granules differs from the smaller, finer granules of neutrophilic cells. In the most mature eosinophilic form, the nucleus segments into two or more lobes connected by a thin filament. About 80% of segmented eosinophils will have the classic two-lobed appearance with dense, compact chromatin. The remainder of segmented eosinophils will have three lobes, and an occasional cell will exhibit four to five lobes.

Blood Cell Identification – Graded

BCP-05



Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Lymphocyte	78	94.0	4905	90.5	Good
Malignant lymphoid cell (other than blast)	3	3.6	259	4.8	Good
Lymphocyte, large granular	1	1.2	97	1.8	Unacceptable

The arrowed cells are malignant lymphoid cells, more specifically lymphoma cells, as identified by 3.6% of referees and 4.8% of participants. In the context of chronic lymphocytic leukemia (CLL) the arrowed cells may also be identified as lymphocytes (see below) as reported by 94.0% of referees and 90.5% of participants. Lymphoma cells can exhibit a variety of appearances depending on the lymphoma subtype, and definitive diagnosis can be difficult based on smear morphology alone. These cells can exhibit a variety of sizes, shapes, and nuclear and cytoplasmic characteristics. Cell size ranges from 8 to 30 µm and the nucleus to cytoplasm (N:C) ratio varies from 7:1 to 3:1. It is critical to obtain an accurate clinical history, since knowledge of a previous diagnosis of lymphoma greatly aids in the identification of these cells. Supplemental studies, such as immunophenotyping, are often necessary to arrive at a diagnosis. In blood smears, it may be difficult to distinguish reactive lymphocytes from lymphoma cells. The most important distinction between these cells is the difference in their N:C ratios. The N:C ratio tends to be low in reactive lymphocytes, while it is usually high in lymphoma cells. In addition, reactive lymphocytes are characterized by their wide range of morphologic appearances within the same blood smear. In contrast, while lymphoma cells can exhibit a wide range of morphologic appearances, an individual case tends to show a monotonous population of the abnormal cells. In this older adult patient with a marked lymphocytosis, CLL is an appropriate consideration.

CLL cells may be the same size as normal lymphocytes, but are often slightly larger. The nucleus is typically round, although a small nuclear indentation may be present. The cells have clumped chromatin and a scant amount of pale blue cytoplasm. Nucleoli are inconspicuous. For the purposes of proficiency testing, a single CLL/SLL cell cannot be reliably distinguished from a normal lymphocyte by morphology alone. Occasional prolymphocytes are often seen. Prolymphocytes are larger cells with a round, centrally located nucleus, clumped chromatin, characteristic single prominent nucleolus, and a moderate amount of basophilic cytoplasm.

Case Presentation:

This peripheral blood smear is from a 64-year-old man without significant past medical history who presents for his annual routine physical with loss of appetite. Laboratory data include: WBC = 247.6 x 10^9/L; RBC = 4.23 x 10^{12}/L; HGB = 14.8 g/dL; HCT = 42.2%; MCV = 100 fL; RDW = 16%; and PLT = 111 x 10^9/L. Identify the arrowed object(s) on each image.

(PERIPHERAL BLOOD, WRIGHT-GIEMSA)

Case Discussion: Chronic Lymphocytic Leukemia

Chronic lymphocytic leukemia/small lymphocytic lymphoma (CLL/SLL) is a neoplasm of mature small B-lymphocytes with a frequent leukemic presentation defined as ≥5.0 x 10^9/L mature monoclonal B-cells in the peripheral blood. Alternatively, a diagnosis of CLL can be made in the setting of lower monoclonal B-cell counts if the patient has cytopenias resulting from their disease. When lymph nodes are involved in the absence of leukemia, the designation of small lymphocytic lymphoma (SLL) is used. Patients with isolated low level blood involvement by monoclonal B-cells (<5.0 x 10^9/L) without systemic evidence of disease may be classified as monoclonal B-cell lymphocytosis with a small but definite risk or progression to CLL (estimated at 1-2%/year).

CLL is the most common type of leukemia in adults in Western populations with an estimated annual incidence of 4.1 per 100,000 person-years in the United States. The disease affects older adults with a median age of 65 years at presentation. It is more common in Caucasians than in African Americans and is least common in Asians. There is a male predominance, with a 1.4-2:1 male to female ratio. Patients may be asymptomatic at presentation or exhibit effects of cytopenias, lymphadenopathy, or organ involvement. The peripheral blood and bone marrow are usually involved, and the spleen and liver are typically infiltrated. Patients presenting with SLL often have generalized lymph node involvement. Peripheral blood cytopenias may be due to immune-mediated mechanisms related to the leukemic clone or to bone marrow replacement by a leukemic infiltrate. Fever, night sweats, or unexplained weight loss (so-called B symptoms) are uncommon.

Examination of the peripheral blood in patients with CLL shows a lymphocytosis composed of small, mature appearing lymphocytes with dense, hyperchromatic chromatin imparting a "cracked" appearance and a high nuclear-to-cytoplasmic ratio. Frequent smudge cells occur due to the fragility of CLL cells, and may be minimized by the use of albumin in the preparation of the peripheral blood smear. Prolymphocytes are usually less than 2 to 3% of the lymphocytes and are larger than prototypic CLL cells, with slightly more open chromatin and a prominent central nucleolus. When >55% of lymphocytes are prolymphocytes at the time of initial presentation, a diagnosis of B-prolymphocytic leukemia (B-PLL) is appropriate. Bone marrow examination is not required to establish a diagnosis of CLL and is usually only performed when it is unclear whether cytopenias are due to extensive marrow infiltration by CLL or other reasons. The bone marrow can show a range of involvement including interstitial, nodular, or diffuse patterns.

Immunophenotyping by flow cytometry is relied upon to confirm the diagnosis. CLL cells typically express CD5, CD19, CD20 (dim), CD23, CD22 (dim or absent), FMC7 (dim or absent), CD79b (dim or absent) and dim monotypic surface immunoglobulin. The cells lack expression of CD10 and cyclin D1, typical of follicular lymphoma and mantle cell lymphoma, respectively. CD38 and ZAP70 expression have been shown to correlate with *IGHV* hypermutation (>2% mutated from nearest germline sequence) status and adverse outcome.

Molecular genetic analysis has become common place with the realization that certain chromosome abnormalities are associated with prognosis. Because standard karyotyping often fails in CLL, fluorescent in situ hybridization (FISH) studies for trisomy 12, deletion 13q, deletion 11q, deletion 6q, and deletion 17p have become routine. 13q deletion is the most common abnormality (55%) and is associated with a favorable prognosis. Trisomy 12

(16% of cases) and lack of karyotypic abnormalities have an intermediate prognosis while 11q deletion and deletion 17p have an unfavorable prognosis. In particular, loss of 17p (*TP53*) has a relatively poor outcome with lack of response to standard therapies. Next generation sequencing studies have been performed in CLL and have defined the most common mutations in CLL, providing insight into how therapy affects the mutation profile and clonal architecture. Recurrently mutated genes that have been recently reported include *TP53*, *NOTCH1*, *SF3B1*, *BIRC3*, *MYD88*, *XPO1* and *KLHL6*. Although more validation studies and further integration with existing prognostic models is needed, some associations have been observed. *SF3B1* and *TP53* mutations have shown an adverse impact on prognosis independent of *IGHV* mutational status. In a whole-genome study of mutated and unmutated CLL, mutations in *MYD88* and *KLHL6* are predominant in CLL with mutated immunoglobulin genes, while *NOTCH1* and *XPO1* are more common in patients with unmutated immunoglobulins. *MYD88* mutations, though uncommon in CLL/SLL, have been linked to other favorable biologic factors. *NOTCH1* mutations are fairly prevalent among fludarabine-refractory patients, which could help to inform treatment selection if this trend is validated in future clinical trials.

The differential diagnosis for CLL/SLL is broad, and can include other small mature B-cell leukemias that are characteristically CD5 positive (such as leukemic mantle cell lymphoma), or occasionally CD5 positive (such as splenic marginal zone lymphoma). Mantle cell lymphoma cells are often intermediately-sized with slight nuclear irregularities, bright CD20 and surface immunoglobulin expression, expression of CD79b and FMC7, and usually a t(11;14)(q13;q32) involving *IGH* and *CCND1*. Splenic marginal zone lymphomas and other B-cell lymphoma/leukemias, unclassifiable typically have brighter CD20 expression and lack CD5. The cells may have slightly eccentric nuclei with abundant cytoplasm or cytoplasmic villous projections. It can be more difficult to establish a diagnosis of CLL/SLL with atypical features such as larger irregular nuclei or a divergent immunophenotype from prototypic CLL/SLL, but careful exclusion of other B-cell chronic lymphoproliferative disorders and an assessment of clinical presentation and genetic features can be useful in making this distinction. Persistent polyclonal B-cell lymphocytosis, an unusual disorder that typically affects female smokers with an associated HLA-DRB1*07 haplotype, is easily distinguished with flow cytometric analysis that reveals CD5 negative, CD27+IgM+IgD+ polytypic B-cells in those cases and often increased serum IgM levels. As was discussed above, monoclonal B-cell lymphocytosis with a CLL-immunophenotype detected by peripheral blood flow cytometry should be separated from overt CLL/SLL and requires knowledge of potential lymph node and extramedullary disease sites in addition to absolute abnormal B-cell count in order to confidently establish this diagnosis.

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Hematology and Clinical Microscopy Committee

References:

1. Chiorazzi, N, Kanti RR, and Ferrarini M. Chronic Lymphocytic Leukemia. *N Eng J Med* 2005;352:804 15.
2. Hallek M, Cheson BD, Catovsky D, et al. Guidelines for the diagnosis and treatment of chronic lymphocytic leukemia: a report from the International Workshop on Chronic Lymphocytic Leukemia updating the National Cancer Institute - Working Group 1996 guidelines. *Blood* 2008;111:5446-5456.
3. Krober A, Seiler T, Benner A, et al. VH mutation status, CD38 expression level, genomic aberrations, and survival in chronic lymphocytic leukemia. *Blood* 2002;100:1410-1416.
4. Dohner H, Stilgenbauer S, Benner A, et al. Genomic aberrations and survival in chronic lymphocytic leukemia. *N Eng J Med.* 2000;343(26):1910-1916).
5. Puente XS, Pinyol M, Quesada V, et al. Whole-genome sequencing identifies recurrent mutations in chronic lymphocytic leukemia. *Nature* 2011;475:101-105.

Blood Cell Identification – Ungraded

Case History

This peripheral blood smear is from a 42-year-old man with a past medical history significant for hypertension who presents with progressive fatigue and weakness over the past month. He indicates generalized abdominal fullness. Laboratory data include: WBC = 129.7 x 10^9/L; RBC = 4.43 x 10^{12}/L; HGB = 13.0 g/dL; HCT = 40.3%; MCV = 91 fL; RDW = 15%; and PLT = 309 x 10^9/L. Identify the arrowed object(s) on each image.

(PERIPHERAL BLOOD, WRIGHT-GIEMSA)

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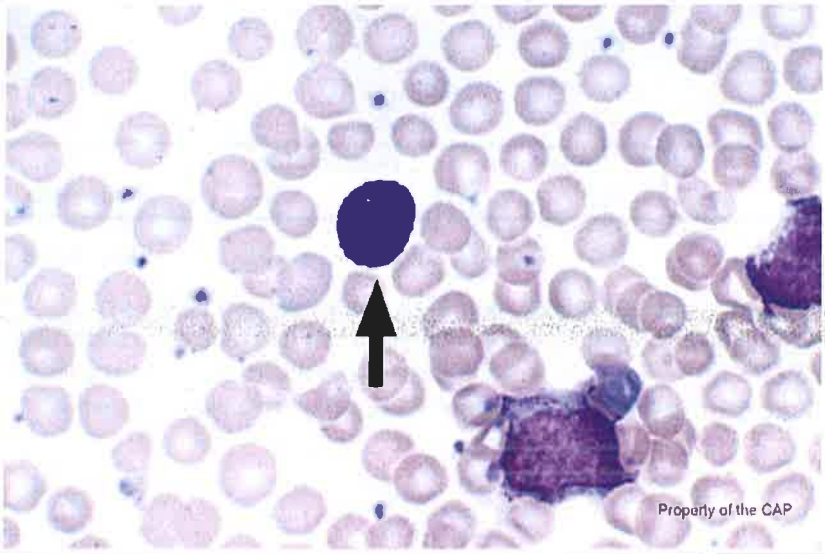
BCP-06

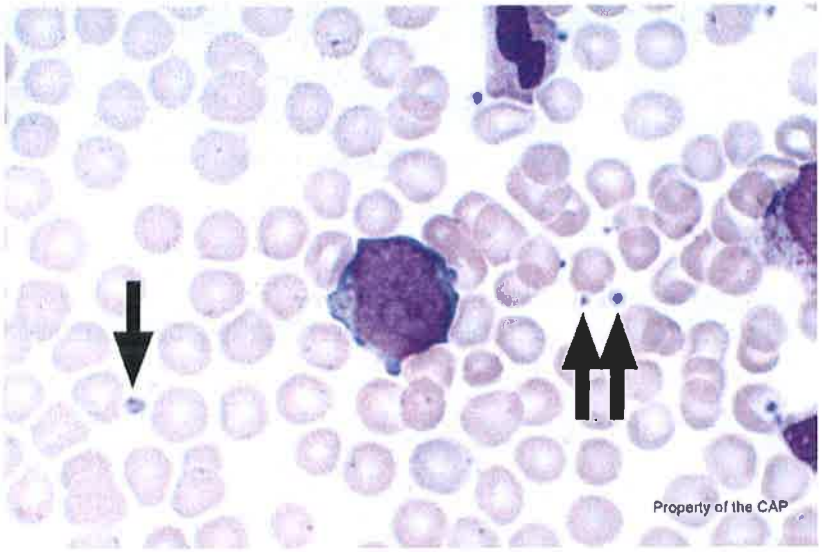


Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Basophil, any stage	70	84.3	4781	89.4	Educational
Mast cell	10	12.1	362	6.8	Educational
Basophilic stippling (coarse)	1	1.2	16	0.3	Educational

The arrowed cell is a basophil, as correctly identified by 84.3% of referees and 89.4% of participants. Basophils are the least common circulating granulocyte, rarely identified in the normal peripheral blood smear. Unlike neutrophils with 3 to 5 lobed nuclei and fine eosinophilic granules, basophils typically have only two prominent nuclear lobes and cytoplasm with numerous dense basophilic granules, often obscuring the nuclear detail. Basophils are an important part of the allergic immune response, and infrequently circulate in appreciable number (typically representing less than 0.3% of peripheral leukocytes). Chronic myelogenous leukemia (CML) is associated with a peripheral blood basophilia, as seen in this case.

Blood Cell Identification – Ungraded

BCP-07

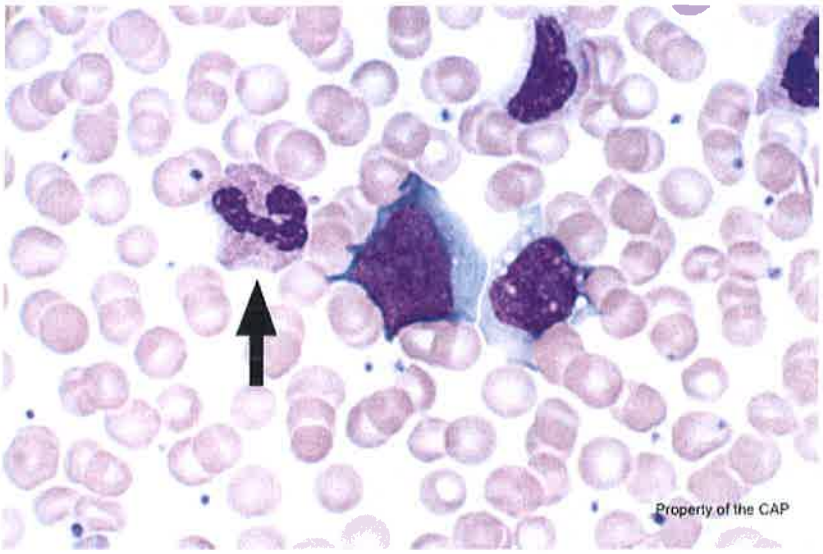


Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Platelet, normal	83	100.0	5217	99.6	Educational

The arrowed objects are platelets, as correctly identified by 100.0% of referees and 99.6% of participants. Platelets are circulating megakaryocyte cytoplasmic fragments that function in blood clot formation and hemostasis. They are a normal constituent of the peripheral blood, occurring at a level of ~150,000 to 400,000/µL. They are normally small, ranging from 1.5 to 3 µm in diameter and lack a nucleus.

Blood Cell Identification – Ungraded

BCP-08

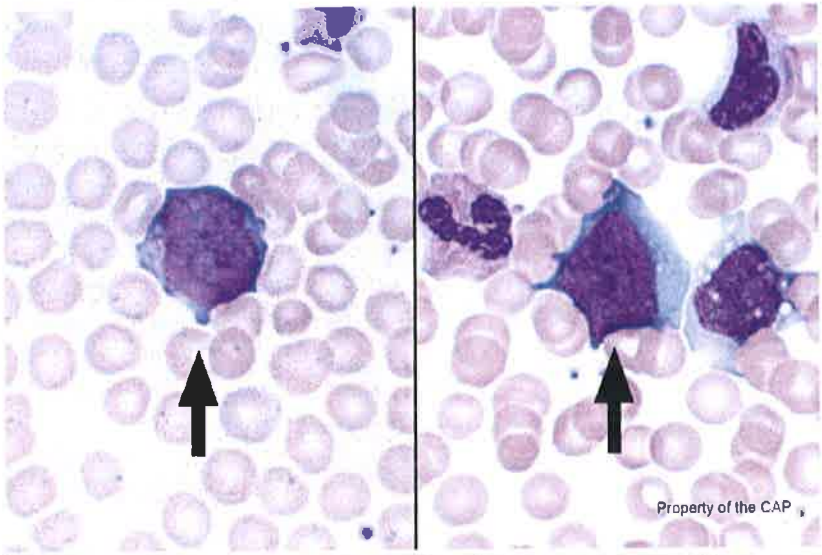


Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Neutrophil. segmented or band	81	97.6	5084	97.1	Educational
Neutrophil, toxic	2	2.4	115	2.2	Educational

The arrowed cell is a segmented neutrophil/toxic neutrophil, as correctly identified by 97.6% of referees and 97.1% of participants. Segmented neutrophils are the most mature granulocytic form and are usually the most predominant white cell in adult blood. Neutrophils range in diameter from 10 to 15µm, with moderate amounts of pale pink cytoplasm containing fine, eosinophilic granules. The nucleus usually has three or four segments (or "lobes") connected by a thin filament that contains no internal chromatin, giving it the appearance of a solid, thread-like dark line. Toxic neutrophils, like the one arrowed here, have more defined and more basophilic appearing granules.

Blood Cell Identification – Ungraded

BCP-09

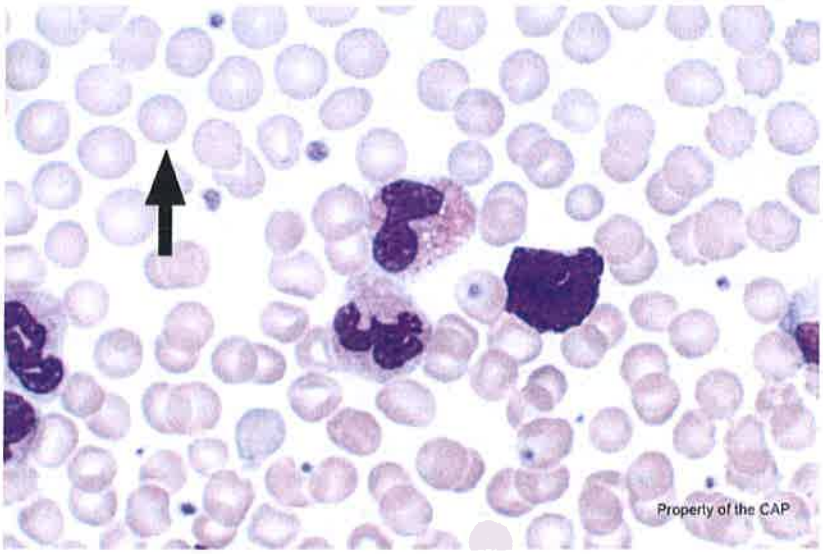


Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Blast cell	56	67.5	3755	71.8	Educational
Lymphocyte, reactive	12	14.5	946	18.1	Educational
Malignant lymphoid cell (other than blast)	6	7.2	56	1.1	Educational
Myeloblast with Auer rod	4	4.8	138	2.6	Educational

The arrowed cell is a blast, as correctly identified by 67.5% of referees and 71.8% of participants. Blasts are precursor cells of either the myeloid or lymphoid lineage. Most blasts are larger than mature leukocytes, have a smooth nuclear chromatin pattern, occasionally prominent nucleoli, and scant cytoplasm. However, they can have a broad range of morphology related to the degree of differentiation, with monocytic blasts having relatively more cytoplasm and nuclear convolutions, in part resembling their mature counterparts. In adults, blasts represent less than 5% of cells in a normal bone marrow, and they are uncommonly seen in the peripheral circulation unless there is a neoplastic process or infection/inflammation. Blasts and reactive lymphocytes may sometimes be challenging to distinguish from one another. In such instances, careful examination of the chromatin quality of the cell(s) in question is often helpful. Blasts characteristically demonstrate finely dispersed or powdery chromatin (exemplified by the arrowed cells) while reactive lymphocytes typically show a condensed or clumped chromatin pattern.

Blood Cell Identification – Ungraded

BCP-10



Identification	Referees No.	Referees %	Participants No.	Participants %	Evaluation
Erythrocyte, normal	82	98.8	5034	96.1	Educational
Microcyte (with increased central pallor)	1	1.2	126	2.4	Educational

The arrowed cell is a normal erythrocyte, as correctly identified by 98.8% of referees and 96.1% of participants. These non-nucleated biconcave disc-shaped cells measure approximately 7µm in diameter and contain an area of central pallor that occupies one third of the cell width. Erythrocytes primarily function to transport oxygen via hemoglobin. These cells stain pink-red with Wright-Giemsa stain.

Case Presentation:

This peripheral blood smear is from a 42-year-old man with a past medical history significant for hypertension who presents with progressive fatigue and weakness over the past month. He indicates generalized abdominal fullness. Laboratory data include: WBC = 129.7 x 10^9/L; RBC = 4.43 x 10^{12}/L; HGB = 13.0 g/dL; HCT = 40.3%; MCV = 91 fL; RDW = 15%; and PLT = 309 x 10^9/L. Identify the arrowed object(s) on each image.

(PERIPHERAL BLOOD, WRIGHT-GIEMSA)

Case discussion: Chronic Myelogenous Leukemia

Chronic myelogenous leukemia (CML) is a myeloproliferative neoplasm characterized by the expansion of granulocytic precursors in the peripheral blood and bone marrow. Most patients are identified in the "chronic phase" of disease, with an elevated leukocyte count, and many are entirely asymptomatic at the time of diagnosis. If the disease remains untreated, patients progress through an "accelerated phase" to a terminal "blast phase", representing progression to an acute leukemia. Unlike most cancers that arise as a consequence of multiple "hits" or mutations of the genetic sequence, CML in the chronic phase harbors a single, balanced translocation between the long arms of chromosomes 9 and 22 in an early hematopoietic precursor. The t(9;22) fuses the *BCR* and *ABL1* genes, ultimately resulting in a BCR-ABL1 fusion protein with enhanced tyrosine kinase activity that is responsible for the proliferation of primarily the granulocytic lineage in the bone marrow and peripheral blood. Most often, the translocation can be identified by routine karyotype, producing a shortened chromosome 22, referred to as the Philadelphia chromosome. In some patients, the translocation is not seen by routine karyotype, but can be identified molecular testing, such as fluorescent in-situ hybridization (FISH).

The peripheral blood smear from a patient with CML typically shows a leukocytosis, with a median of approximately 100,000 cells/μL. The full spectrum of granulocytic maturation is present, including neutrophils, bands, metamyelocytes, myelocytes, promyelocytes, and rare blasts. Myelocytes, however, are typically overrepresented, a feature referred to as a "myelocyte bulge". Eosinophils are often increased. Basophilia is a classic and invariable feature of CML, which makes it a helpful diagnostic finding. While not universal, thrombocytosis is also common. The accelerated phase of disease is associated with, amongst other findings, increased numbers of blast cells, or either thrombocytosis or thrombocytopenia despite therapy. Finally, the blast phase represents progression of the disease to acute myeloid leukemia (AML) or, less frequently, acute lymphoblastic leukemia (ALL).

While the morphologic features seen in the peripheral smear are often telling, cytogenetic and FISH studies are necessary to confirm the diagnosis of CML. Other myeloid neoplasms, including chronic myelomonocytic leukemia (CMML) and the prefibrotic stages of primary myelofibrosis (PMF) can also be associated with overlapping peripheral blood findings. However, CMML is characterized by peripheral blood monocytosis and PMF with a leukoerythroblastic smear. Neither CMML nor PMF are associated with the basophilia that is typical of CML. While benign neutrophilia associated with significant infection or systemic inflammatory states is a diagnostic consideration, this can often be excluded by clinical history, physical exam, and other laboratory findings. The peripheral smear in reactive neutrophilia typically shows a predominance of mature granulocytes followed by progressively fewer band forms, metamyelocytes, and myelocytes. In a reactive neutrophilia, promyelocytes and blasts are often not prominent. The lack of increased basophils and eosinophils is also a useful morphologic finding suggesting a reactive neutrophilia. In contrast, CML typically demonstrates a more pronounced left-shift which includes a myelocyte bulge as well as occasional blasts and promyelocytes in addition to basophilia and eosinophilia.

Patients with chronic phase CML can be effectively treated with inhibitors of the BCR-ABL fusion protein, referred to as tyrosine kinase inhibitors. This class of drugs inhibits the function of the abnormal fusion protein created by the disease causing translocation. This will lead to resolution of the peripheral blood and bone marrow findings as well as eventual loss of the cytogenetic abnormality. The laboratory plays a key role in patient follow-up, as quantitative assessment of the disease-associated *BCR-ABL1* transcript levels by real-time polymerase chain reaction (RT-PCR) is regularly performed to monitor disease status and response to therapy. Nonetheless, the peripheral blood smear morphology is key to the initial diagnosis and can be one of the first signs of disease progression.

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Hematology and Clinical Microscopy Resource Committee

References:

1. Glassy EF, Agosti SJ, College of American Pathologists. Atlas Subcommittee., College of American Pathologists. *Color atlas of hematology : An Illustrated Field Guide Based on Proficiency Testing.* Northfield, Illinois: College of American Patholgists; 1998.
2. Swerdlow SH, International Agency for Research on Cancer., World Health Organization. *WHO classification of tumours of haematopoietic and lymphoid tissues.* 4th ed. Lyon, France: International Agency for Research on Cancer; 2008.
3. Vardiman JW. Chronic Myelogenous Leukemia, *BCR-ABL1+. American Journal of Clinical Pathology.* 2009; 132:250-260.

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Participant	Date	Participant	Date

Director (or Designee) Signature - I have verified that the individuals listed above have successfully participated in this activity.

Date

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