Customer Information
Literature List – Red Blood Cells

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Note: Whether references are given in British or American English depends on the original.

General

Arneth B et al. *(2015): Technology and New Fluorescence Flow Cytometry Parameters in Hematological Analyzers. J Clin Lab Anal: 29(3): 175*
http://onlinelibrary.wiley.com/doi/10.1002/jcla.21747/abstract

> What we see as the essence: This paper gives a good overview of the technology behind the XE-Series and the benefits of flow cytometry and automatic cell counting. It shows that the XE-5000 delivers faster accurate results than older analysers.

RET / IRF / HFR / MFR

Yesmin S et al. *(2011): Immature reticulocyte fraction as a predictor of bone marrow recovery in children with acute lymphoblastic leukaemia on remission induction phase. Bangladesh Med Res Council Bull 37(2): 57-60*
http://www.banglajol.info/index.php/BMRCB/article/view/8435

> What we see as the essence: In 52% of paediatric ALL patients, IRF% values rose before NEUT# values during recovery after chemotherapy. Therefore, monitoring of both parameters may be beneficial.

Morkis IVC et al. *(2015): Assessment of immature platelet fraction and immature reticulocyte fraction as predictors of engraftment after hematopoietic stem cell transplantation. Int J Lab Hematol 37(2): 259.*
http://onlinelibrary.wiley.com/doi/10.1111/ijlh.12278/abstract

> What we see as the essence: Both IRF% and IPF% can be used to predict neutrophil and platelet recovery, respectively. Work was done on XE-5000.

Gonçalo AP et al. *(2011): Predictive value of immature reticulocyte and platelet fractions in hematopoietic recovery of allograft patients. Transplant Proc 43: 241–3.*
http://www.transplantation-proceedings.org/article/S0041-1345(10)01945-7/abstract

> What we see as the essence: The immaturity fractions IRF and IPF offer an easy and early evaluation method of posttransplantational recovery of the bone marrow.

Torres Gomez A et al. *(2003): Utility of reticulocyte maturation parameters in the differential diagnosis of macrocytic anemias. Clin Lab Haematol 25: 283–288.*
http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2257.2003.00536.x/abstract

What we see as the essence: Reticulocyte maturation parameters (measured here on ABX Pentra) can support differential diagnosis of macrocytic anaemias.

RET-H$_e$ / RET-Y / RBC-H$_e$

Peerschke E et al. *(2014): Using the Hemoglobin Content of Reticulocytes (RET-He) to Evaluate Anemia in Patients With Cancer. Am J Clin Pathol 142:506-512*
http://ajcp.ascpjournals.org/content/142/4/506.long

What we see as the essence: RET-He values above 31 or 32 pg could be used to rule out iron deficiency in cancer patients. In the present study the use of RET-He would have reduced the number of biochemical iron studies by 66% (from 209 to 70).

Schoorl M et al. *(2012): Effects of iron supplementation on red blood cell hemoglobin content in pregnancy. Hematology Reports 4: e24.*
Free online: http://www.pagepress.org/journals/index.php/hr/article/view/hr.2012.e24

What we see as the essence: Ret-H$_e$ and Ret-H$_e$/RBC-H$_e$ ratio are sensitive markers for screening when a decrease in red blood cell haemoglobin content is observed and for monitoring short-term effects of iron supplementation. The authors recommend integrating these parameters into the protocol for anaemia screening and monitoring during pregnancy.

Schoorl M et al. *(2012): Temporary impairment of reticulocyte haemoglobin content in subjects with community-acquired pneumonia. Int J Lab Hematol 34: 390–395.*
http://onlinelibrary.wiley.com/doi/10.1111/j.1751-553X.2012.01408.x/abstract

What we see as the essence: In patients with community-acquired pneumonia, acute inflammation results in decreased RET-H$_e$ values at an early stage, reflecting acute erythropoietic dysfunction.

Urrechaga E et al. *(2013): Erythrocyte and reticulocyte indices in the assesment of erythropoiesis activity and iron availability. Int J Lab Hematol 35: 144–149.*
http://onlinelibrary.wiley.com/doi/10.1111/ijlh.12013/abstract

What we see as the essence: RET-H$_e$ and %HYPO-H$_e$ are helpful in assessing erythropoiesis and iron status.

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Maier-Redelsperger M et al. *(2010): Strong association between a new marker of hemolysis and glomerulopathy in sickle cell anemia. Blood Cell Mol Dis 45: 289–92.*
http://www.sciencedirect.com/science/article/pii/S1079979610001993

What we see as the essence: A special algorithm combining RBC-H$_e$, RET-H$_e$ and lactate dehydrogenase bears the potential as a marker of haemolysis strongly correlated with albuminuria in sickle cell anaemia patients.

Jonckheere S et al. *(2010): Erythrocyte indices in the assessment of iron status in dialysis-dependent patients with end-stage renal disease on continuous erythropoietin receptor activator versus epoetin beta therapy. Acta Haematol 124: 27–33.*
http://www.karger.com/Article/FullText/313785

What we see as the essence: Due to fluctuations of iron status parameters, a fixed time point should be used for iron status monitoring during erythropoietin therapy.

Leers MP et al. *(2010): The value of the Thomas-plot in the diagnostic work up of anemic patients referred by general practitioners. Int J Lab Hematol 32: 572–81.*
http://onlinelibrary.wiley.com/doi/10.1111/j.1751-553X.2010.01221.x/abstract

What we see as the essence: The Thomas plot is helpful in diagnosing patients referred from general practitioners and differentiating functional iron deficiency from classical iron deficiency.

Schoorl M et al. *(2010): Changes in red blood cell hemoglobinization during pregnancy. Ned Tijdschr Klin Chem Labgeneesk 35: 206–208.*
Free online: http://www.nvkc.nl/publicaties/documents/2010-3-p206-208.pdf,
Reprinted in Sysmex J Int 20(1): 12–14.

What we see as the essence: RET-H$_e$ is a useful sensitive and early indicator of iron status in the second half of pregnancy and should ideally be measured in combination with zinc protoporphyrin (ZPP) and IRF.

Van Wyck DB et al. *(2010): Analytical and biological variation in measures of anemia and iron status in patients treated with maintenance hemodialysis. Am J Kidney Diseases 56: 540–546.*
http://www.ajkd.org/article/S0272-6386(10)00918-2/abstract

What we see as the essence: RET-H$_e$ could prove superior to transferrin saturation (TSAT) and ferritin in monitoring iron status of haemodialysis patients due to a lower biological variation.

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Maconi M et al. *(2009): Erythrocyte and reticulocyte indices in iron deficiency in chronic kidney disease: comparison of two methods. Scand J Clin Lab Invest 69: 365–370.*
http://informahealthcare.com/doi/abs/10.1080/00365510802657673

What we see as the essence: RET-H_e and CHr correlate and agree well in evaluating CKD patients needing iron support.

Miwa N et al. *(2009): Usefulness of measuring reticulocyte hemoglobin equivalent in the management of haemodialysis patients with iron deficiency. Int J Lab Hematol 32: 248–255.*
http://onlinelibrary.wiley.com/doi/10.1111/j.1751-553X.2009.01179.x/abstract

What we see as the essence: RET-H_e is equivalent to CHr and useful in managing haemodialysis patients with iron deficiency as it responds more rapidly than HGB.

Mast A et al. *(2008): Reticulocyte hemoglobin content. Am J Hematol 83: 307–310.*
Free online: http://onlinelibrary.wiley.com/doi/10.1002/ajh.21090/pdf

What we see as the essence: Reticulocyte haemoglobin can be used to differentiate iron deficiency from other causes of anaemia and as an early marker to monitor the therapy.

Thomas C et al. *(2006): The diagnostic plot: a concept for identifying different states of iron deficiency and monitoring the response to epoetin therapy. Med Oncol 23: 23–36.*
http://link.springer.com/article/10.1385%2FMO%3A23%3A1%3A23

What we see as the essence: The Thomas plot incl. RET-H_e can be used for the differential diagnosis of anaemia and also gives therapy options.

Brugnara C et al. *(2006): Reticulocyte hemoglobin equivalent (Ret He) and assessment of iron-deficient states. Clin Lab Haematol 28: 303–308.*
Free online: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1618805/pdf/clh0028-0303.pdf

What we see as the essence: RET-H_e is a reliable marker of cellular haemoglobin content and can be used to identify iron-deficient states, particularly in dialysis patients. RET-H_e and CHr are in good agreement.

Schoorl M et al. *(2006): Erythropoiesis activity, iron availability and reticulocyte hemoglobinization during treatment with hemodialysis and in subjects with uremia. Clin Lab 52: 621–629.*
http://www.clin-lab-publications.com/abstracts/160.html

What we see as the essence: Biochemical parameters reflecting functional iron availability and haematological parameters reflecting haemoglobinisation are interdependent.

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Thomas L et al. *(2005): Reticulocyte hemoglobin measurement -- comparison of two methods in the diagnosis of iron-restricted erythropoiesis. Clin Chem Lab Med 43: 1193–1202.*
http://www.degruyter.com/view/j/cclm.2005.43.issue-11/cclm.2005.207/cclm.2005.207.xml

What we see as the essence: RET-H_e can replace CHr in the diagnostic Thomas plot without loss of sensitivity or specificity.

Canals C et al. *(2005): Clinical utility of the new Sysmex XE 2100 parameter - reticulocyte hemoglobin equivalent - in the diagnosis of anemia. Haematologica 90: 1133–1134.*
Free online: http://www.haematologica.org/content/90/8/1133.long

What we see as the essence: RET-H_e is useful for the differential diagnosis of iron deficiency anaemia vs anaemia of chronic disease and could also be helpful in the identification of thalassaemia patients.

Buttarello M et al. *(2004): The new reticulocyte parameter (RET-Y) of the Sysmex XE 2100: its use in the diagnosis and monitoring of posttreatment sideropenic anemia. Am J Clin Pathol 121: 489–495.*
Free online: http://ajcp.ascpjournals.org/content/121/4/489.long

What we see as the essence: RET-Y closely correlates with CHr and can be used for diagnosis and early monitoring after the administration of intravenous iron.

%HYPO-H_e / %HYPER-H_e / %MicroR / %MacroR

Schoorl M et al. *(2012): Efficacy of Advanced Discriminating Algorithms for Screening on Iron-Deficiency Anemia and ß-Thalassemia Trait. Am J Clin Pathol 138: 300–304.*
http://ajcp.ascpjournals.org/content/138/2/300.abstract

What we see as the essence: The authors conclude that the advanced algorithms, derived from extended RBC parameters provided by the Sysmex XE-5000 analyzer, are useful as laboratory devices for anaemia screening.

Persijn L et al. *(2012): Screening for hereditary spherocytosis in routine practice: evaluation of a diagnostic algorithm with focus on non-splenectomised patients. Ann Hematol 91: 301–302.*
http://link.springer.com/article/10.1007%2Fs00277-011-1243-y

What we see as the essence: The hereditary spherocytosis diagnostic tool by Mullier *et al.* is useful and works, but needs fine-tuning to the local patient population.

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Mullier F et al. *(2011): Additional erythrocytic and reticulocytic parameters helpful for diagnosis of hereditary spherocytosis: results of a multicentre study. Ann Hematol 90: 759–768.*
http://link.springer.com/article/10.1007%2Fs00277-010-1138-3

What we see as the essence: Combining several RBC parameters allows to efficiently screen for hereditary spherocytosis even in mild cases.

Urrechaga E et al. *(2011): The role of automated measurement of RBC subpopulations in differential diagnosis of microcytic anemia and β-thalassemia screening. Am J Clin Pathol 135: 374-379.*
Free online: http://ajcp.ascpjournals.org/content/135/3/374.full.pdf+html

What we see as the essence: Because of high sensitivity and specificity, the new index %MicroR-%HYPO-He was the most reliable index in the differential diagnosis of microcytic anaemias.

Urrechaga E. et al. *(2011): Erythrocyte and reticulocyte parameters in iron deficiency and thalassemia. J Clin Lab Anal 25: 223–228.*
http://onlinelibrary.wiley.com/doi/10.1002/jcla.20462/abstract

What we see as the essence: Beta-thalassaemia can be recognised through high RBC, small MCV, high %MicroR and moderately increased IRF, whereas iron deficiency shows high RDW and %HYPO-H$_e$.

Urrechaga E et al. *(2011): The role of automated measurement of red cell subpopulations on the Sysmex XE-5000 analyzer in the differential diagnosis of microcytic anemia. Int J Lab Hematol 33: 30–36.*
http://onlinelibrary.wiley.com/doi/10.1111/j.1751-553X.2010.01238.x/abstract

What we see as the essence: Because of high sensitivity and specificity, the new index %MicroR-%HYPO-H$_e$ was the most reliable index in the differential diagnosis of microcytic anaemias.

Urrechaga E et al. *(2009): Potential utility of the new Sysmex XE 5000 red blood cell extended parameters in the study of disorders of iron metabolism. Clin Chem Lab Med 47: 1411–1416.*
http://www.degruyter.com/view/j/cclm.2009.47.issue-11/cclm.2009.301/cclm.2009.301.xml?format=INT

What we see as the essence: The new parameters %HYPO-H$_e$/%HYPER-H$_e$ and %MicroR/%MacroR appear to be sensitive for detecting small changes in the number of red cells with inadequate haemoglobinisation and volume in order to distinguish beta-thalassaemia from iron deficiency anaemia.

FRC

Hervent AS et al. *(2015): This performance evaluation showed that the CELLAVISION Advanced RBC Software Application is easy to use and provides a sensitive and reproducible measurement of schistocytes in peripheral blood.. Int J Lab Hematol 37(5):588*
http://onlinelibrary.wiley.com/doi/10.1111/ijlh.12363/abstract

> What we see as the essence: This performance evaluation showed that the CELLAVISION Advanced RBC Software Application is easy to use and provides a sensitive and reproducible measurement of schistocytes in peripheral blood.

Lesesve JF et al. *(2015): Fragmented red cells reference range for the Sysmex XN® - series of automated blood cell counters. Int J Lab Hematol (early online).*
http://onlinelibrary.wiley.com/doi/10.1111/ijlh.12364/abstract

> What we see as the essence: Normal values were determined on the XN-Series for the percentage fragmented red blood cells, FRC%: 0.14 +/- 0.35% (mean 0%). It was also found that HYPO-He correlates with FRC%; so samples with both a high HYPO-He and FRC% should be interpreted with care.

Lesesve JF et al. *(2012): Fragmented red blood cells automated measurement is a useful parameter to exclude schistocytes on the blood film. Int J Lab Hematol 34(6):566.*
http://onlinelibrary.wiley.com/doi/10.1111/j.1751-553X.2012.01434.x/abstract

> What we see as the essence: The automated FRC count offers a better degree of certainty than microscopy to exclude the presence of fragmented RBC.

Abe Y et al. *(2009): The effectiveness of measuring for fragmented red cells using an automated hematology analyzer in patients with thrombotic microangiopathy. Clin Appl Thromb Hemost 15: 257–262.*
http://cat.sagepub.com/content/15/3/257.abstract

> What we see as the essence: In conclusion, the FRC level is a simple and useful marker for thrombotic microangiopathy (TMA), and an FRC level of 1.2% is recommended as the cutoff value for the diagnosis of TMA.

Imoto S et al. *(2005): Usefulness of sequential automated analysis of fragmented red blood cells for the differential diagnosis of TTP-hemolytic uremic syndrome following allogeneic hematopoietic cell transplantation. Lab Hematol 11: 131–136.*
http://cardenjennings.metapress.com/app/home/contribution.asp?referrer=parent&backto=issue,8,11;journal,32,52;linkingpublicationresults,1:104952,1

> What we see as the essence: Sequential monitoring of FRC% may be a reliable marker for a specific type of complication (TTP-HUS; thrombotic thrombocytopenic pupura haemolytic uraemic syndrome) after allogeneic haematopoietic precursor cell transplantation.

Banno S et al. (2005): *Quantification of red blood cell fragmentation by the automated hematology analyzer XE-2100 in patients with living donor liver transplantation. Clin Lab Haematol 27: 292–296.*
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2257.2005.00704.x/abstract

> What we see as the essence: The determination of FRC% by the XE-2100 enables early diagnoses and monitoring of TTP (thrombotic thrombocytopenic pupura) or TMA (thrombotic microangiopathy) and will be useful in the clinical field.

Jiang M et al. (2001): *Quantification of red blood cell fragmentation by automated haematology analyser XE-2100. Clin Lab Haematol 23: 167–172.*
http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2257.2001.00386.x/abstract

> Initial study showing that the automated FRC% measurement is promising.

NRBC

Cremer M et al. (2015): *Nucleated red blood cells as marker for an increased risk of unfavorable outcome and mortality in very low birth weight infants. Early Hum Dev. 2015; 91(10):559-563*
http://www.earlyhumandevelopment.com/article/S0378-3782(15)00123-1/abstract

> What we see as the essence: This study of 438 low birth weight infants indicates that an NRBC count obtained 24-120 h after birth can serve as a surrogate marker for later severe morbidity and mortality. The optimal cut-off value was $2x10^9/L$ with 83% sensitivity and 75% specifity.

Hebbar S et al. (2014): *Significance of maternal and cord blood nucleated red blood cell count in pregnancies complicated by preeclampsia. J Pregnancy. 2014; 496416*
Free online: http://www. hindawi.com/journals/jp/2014/496416

> What we see as the essence: Cord blood NRBCs are significantly raised in preeclampsia and are associated with adverse early neonatal outcome. Neonates are more likely to have IUGR and low birth weight. Below the count of 13/100 WBC adverse neonatal outcomes are less likely.

Tantanate C et al. (2014): *Performance evaluation of the automated nucleated red blood cell enumeration on Sysmex XN analyser. Int J Lab Hematol. 2015;37(3):341.*
http://onlinelibrary.wiley.com/doi/10.1111/ijlh.12291/abstract

> What we see as the essence: NRBC counts from the XN-Series could replace manual counts: the precision of the XN-Series was superior and a small bias (manual counts slightly higher than NRBC counts from the XN-Series) was only observed for NRBC counts above 200/100 WBC.

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Hotton J et al. (2013): *Performance and Abnormal Cell Flagging Comparisons of Three Automated Blood Cell Counters -Cell-Dyn Sapphire, DxH-800, and XN-2000. Am J Clin Pathol 140:845–852.*
http://ajcp.ascpjournals.org/content/140/6/845.abstract

> What we see as the essence: Repeatability, linearity and carryover was good for all tested analysers, and correlation between the analysers was good for HGB, MCV, PLT and WBC.
>
> Quotes: "The XN showed a higher sensitivity than the SAPH and DxH for all flags of interest." "For the first time, we have decreased the slide review for our laboratory from 20% with the SAPH to 9.3% with the XN."

Parco S et al. (2013): *Public banking of umbilical cord blood or storage in a private bank: testing social and ethical policy in northeastern Italy. J Blood Med 4: 23–29.*
Free online: http://www.dovepress.com/getfile.php?fileID=15732

> What we see as the essence: An excellent correlation was found between manual NRBC counts and NRBC counts from the XE-2100 (r^2 = 0.94) in umbilical cord blood. This number may be used to correct the WBC count and thereby guarantee an adequate WBC concentration for blood banking of umbilical cord blood.

Gasparović V et al. (2012): *Nucleated red blood cells count as first prognostic marker for adverse neonatal outcome in severe preeclamptic pregnancies.Coll Antropol 36: 853–857.*
Free online: http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=133776

> What we see as the essence: An increased count of nucleated red blood cells in preterm newborns born from pregnancies with severe preeclampsia seems to be the first significant marker for detecting adverse neonatal outcome.

Pipitone S et al. (2012): *Evaluation of automated nucleated red blood cells counting on Sysmex XE-5000 and Siemens ADVIA 2120. Clin Chem Lab Med 50: 1857–1859.*
http://www.degruyter.com/view/j/cclm.2012.50.issue-10/cclm-2012-0148/cclm-2012-0148.xml

> What we see as the essence: The results show excellent analytical performances for the XE-5000, with high accuracy and precision. In agreement with previous studies, the authors also showed that despite similar performance in terms of analytical imprecision, the overall correlation with microscopy is higher for XE-5000 than for ADVIA 2120, i.e., correlation coefficient 0.97 vs. 0.67 and AUC 0.97 vs. 0.73, respectively.

Kuert S et al. (2011): Association of nucleated red blood cells in blood and arterial oxygen partial tension. Clin Chem Lab Med 49: 257–263.
http://www.degruyter.com/view/j/cclm.2011.49.issue-2/cclm.2011.041/cclm.2011.041.xml?format=INT

What we see as the essence: The NRBC count is an independent risk indicator of poor prognosis and mortality, NRBC-positive patients required a longer stay in the intensive care unit.

Danise P et al. (2011): Evaluation of nucleated red blood cells in the peripheral blood of hematological diseases. Clin Chem Lab Med 50: 357–360.
http://www.degruyter.com/view/j/cclm.2012.50.issue-2/cclm.2011.766/cclm.2011.766.xml?format=INT

What we see as the essence: NRBC are found in nearly all onco-haematological diseases at diagnosis and frequently during therapy. They are absent at remission.

Danise P et al. (2009): Nucleated red blood cells and soluble transferrin receptor in thalassemia syndromes: relationship with global and ineffective erythropoiesis. Clin Chem Lab Med 47: 1539–1542.
http://www.degruyter.com/view/j/cclm.2009.47.issue-12/cclm.2009.340/cclm.2009.340.xml?format=INT

What we see as the essence: The NRBC count helps defining ineffective erythropoiesis in thalassaemia patients and supporting transfusion management.

Stachon A et al. (2007): Nucleated red blood cells in the blood of medical intensive care patients indicate increased mortality risk: a prospective cohort study. Crit Care 11: R62.
Free online: http://ccforum.com/content/pdf/cc5932.pdf

What we see as the essence: The NRBC count is one indicator of mortality — persistence (observed in daily screenings) and high concentration are both indicators for poor prognosis.

Stachon A et al. (2006): Poor prognosis indicated by nucleated red blood cells in peripheral blood is not associated with organ failure of the liver or kidney. Clin Chem Lab Med 44: 955–961.
http://www.degruyter.com/view/j/cclm.2006.44.issue-8/cclm.2006.183/cclm.2006.183.xml?format=INT

What we see as the essence: The NRBC count is one indicator of mortality independent of other factors such as kidney or liver failure.

Stachon A et al. *(2006): Daily monitoring of nucleated red blood cells in the blood of surgical intensive care patients. Clin Chim Acta 366: 329–335.*
http://www.sciencedirect.com/science/article/pii/S0009898105006923

> What we see as the essence: NRBC count is an early indicator of mortality - daily screening is recommended.

Otsubo H et al. *(2005): Persistent nucleated red blood cells in peripheral blood is a poor prognostic factor in patients undergoing stem cell transplantation. Clin Lab Haematol 27: 242–246.*
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2257.2005.00687.x/abstract

> What we see as the essence: Monitoring NRBC in stem cell transplantation patients provides useful clinical information - NRBC can be observed persistently in non-survivors.

Stachon A et al. *(2004): High in-hospital mortality of intensive care patients with nucleated red blood cells in blood. Clin Chem Lab Med 42: 933–938.*
http://www.degruyter.com/view/j/cclm.2004.42.issue-8/cclm.2004.151/cclm.2004.151.xml

> What we see as the essence: The NRBC count is of high prognostic power regarding in-hospital mortality.

Wang FS et al. *(2003): Development and clinical application of nucleated red blood cell counting and staging on the automated haematology analyser XE-2100. Clin Lab Haematol 25: 17–23.*
http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2257.2003.00476.x/abstract

> What we see as the essence: The NRBC count correlates well with flow cytometry.

Stachon A et al. *(2002): Nucleated red blood cells indicate high risk of in-hospital mortality. J Lab Clin Med 140: 407–412.*
http://www.journals.elsevierhealth.com/periodicals/ymlc/article/S0022-2143(02)00104-X/abstract

> What we see as the essence: NRBC are often an only transient observation, but they indicate a poor prognosis, whether transient or persistent.

Briggs C et al. *(2000): New quantitative parameters on a recently introduced automated blood cell counter - the XE 2100. Clin Lab Haematol 22: 345–350.*
http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2257.2000.00330.x/abstract

> What we see as the essence: The automated NRBC count was highly correlated with the manual reference count (r^2=0.97) and thus eliminates the need for manual NRBC counts.