

# Index

Page numbers in *italics* denote Figures; those in **bold** denote Tables.

## A

- Abbott (Cell-Dyn) blood cell counters, 49–52, 49, 50
- abetalipoproteinaemia, 87, 88
- acanthocytosis, 86–9, 87, 88, **89**
- accessory cephalic vein, 2
- acid phosphatase, 288, 288
- ACT 5diff automated cell counter, 37–8, 38
- acute basophilic leukaemia, 438, 440, 440
- acute lymphoblastic leukaemia, 457–60, 458–60, **459**
- acute monoblastic leukaemia, 184
- acute myeloid leukaemia, 109, 113, 118, 432–40, **433**, 434–42
  - blood films, 432, 434–42
  - of Down syndrome, 443
  - FAB classification, **433**
  - WHO classification, **433**
- acute promyelocytic leukaemia, 52, 288, 292, **433**, 435, 438, 438
- adenosine deaminase excess, **355**
- adenylate kinase deficiency, **355**
- adult T-cell leukaemia/lymphoma, 474–5, 475
- Alder–Reilly anomaly, 110, **111**, 124
- aldolase deficiency, **354**
- alloimmune haemolytic anaemias, 365–7
- Alport syndrome, 114
- amegakaryocytic thrombocytopenia, **387**
- amniotic fluid cells, 146
- anaemia, 245–8, **246**, **247**
  - acquired haemolytic, 359–77
    - autoimmune, 359–62, 359, 360, 362–3
    - alloimmune, 365–7
    - bacterial and parasitic infections, 375
    - cold antibody-induced, 361–2, 362
    - combined cold/warm autoimmune, 363
    - diabetes mellitus, 375
    - drug-induced, 363–4, 364
    - familial autoimmune/lymphoproliferative syndrome, 366
    - haemolytic disease of newborn, 364–5, 365
    - liver disease, 373, 374
    - march haemoglobinuria, 375–6
    - neonatal glutathione peroxidase deficiency, 373
    - non-immune, 366–73, **366–7**
    - oxidant-induced, 371–3, 372, 373
    - paroxysmal cold haemoglobinuria, 362–3, 363
    - paroxysmal nocturnal haemoglobinuria, 376, 376
    - phosphate depletion, 375
    - renal disease, 373
    - snake and insect bites, 375, 375
    - vitamin E deficiency, 375
    - warm autoimmune, 359–61, 359, 360
    - Wilson disease, 373, 374, 375
  - aplastic, 381–2
  - blood film, 245, 247–8, **247**
  - causes, **246**
  - of chronic disease, 298–9, **298**, 299
  - congenital dyserythropoietic, 377–80, **377**, 378–80
  - congenital haemolytic, 330–359
    - cryohydrocytosis, 330–331
    - familial pseudohyperkalaemia, 345–6
    - hereditary elliptocytosis, 337–40, 338–40
    - hereditary pyropoikilocytosis, 340–342, 343
    - hereditary spherocytosis, 331–7, 332–6
    - hereditary stomatocytosis, 343–4, **343**, 344
    - hereditary xerocytosis, 344–5, 345
    - red cell enzyme abnormalities, 347–50, 348, 349
    - sitosterolaemia, 346–7
    - South-East Asian ovalocytosis, 342–3, 342
    - stomatin-deficient cryohydrocytosis, 346
  - congenital sideroblastic, 299–301, 300, 301
  - Diamond–Blackfan, 382
  - dyserythropoietic, 377–80, **377**, 378–80
  - Fanconi, 382, **387**
  - iron deficiency, 295–8, 296, **298**
  - lead poisoning, 301–2, 302
  - leucoerythroblastic, **247**
  - macrocytic, 323–30
    - associated with alcoholism and liver disease, 330
    - associated with myelodysplastic syndrome, 330
    - megaloblastic, 118, 323–9, **324**, 325–9
    - normocytic normochromic, **246**
    - sickle cell, 91, 312–16, 313–15
- anisochromasia, 75, 76, 117
- anisocytosis
  - platelets, 139
  - red cells, 73
- anticoagulants, blood sampling, 5–6
- aplastic anaemia, 381–2
- arthrogryphosis, renal dysfunction and cholestasis (ARC) syndrome, **388**
- Auer rods, 109–10, 112
- autoimmune haemolytic anaemia, 359–62, 359, 360, 362–3
- autoimmune thrombocytopenic purpura, 393–4, 393
- automated blood cell counters, 29–59
  - Abbott (Cell-Dyn), 49–52, 49, 50
  - Beckman–Coulter, 30–38, 30, 32, 33, **34**, 36–8
  - erroneous counts, 186, **187**, **188**, 198–205, **199**, 200–203, **204–5**
  - Horiba ABX, 52, 53
  - Mindray, 52–3

- Nihon Kohden, 52  
 principles of operation, 29–30  
 reticulocyte and platelet counts, 53–9, 54–8, **59**  
 Siemens, 44–9, 45, 47, 48  
 Sysmex, 38–44, 39–41  
 automated image analysis, 29  
*see also individual blood cell counters*
- B**  
*Babesia divergens*, **154**, 165  
*Babesia equi*, **154**  
*Babesia microti*, **154**, 164  
 babesiosis, 164–5, 164, 165  
 bacterial infection, 148–50, 148–50  
   haemolytic anaemia, 375  
   white cell changes, 416–18, 416–18  
 bartonellosis, 150  
 basilic vein, 2  
 basket cells, 137  
 basopenia, 251, **251**  
 basophilia, 240–241, **241**  
 basophilic stippling, 95–6, 96  
 basophils, 122–3, 123  
   normal range  
     adults, **217**  
     infants and children, **222**  
     pregnancy, **223**  
 Batten disease, 124–5  
 Batten–Spielmeier–Vogt disease, 109, 125  
 Bayer blood cell counters  
   erroneous counts  
     differential white cell count, 199–200, **199**,  
       200–202  
     white blood cells, 190  
 Beckman–Coulter blood cell counters, 30–38, 30, 32, 33, **34**,  
 36–8  
   AcT 5diff, 37–8, 38  
   erroneous white cell count, 190  
   five-part differential, 31–5, 33, **34**  
   Hematoflow platform, 35, 37  
   Unicel DxH 800, 35, 36–7  
 Bernard–Soulier syndrome, **388**, 391  
 bilirubin crystals, 116  
 B-lineage lymphoproliferative disorders, 461–72  
   chronic lymphocytic leukaemia, 461–3, 462,  
     463  
   hairy cell leukaemia, 464–6, 465  
   monoclonal B-cell lymphocytosis, 463–4  
   prolymphocytic leukaemia, 464, 464  
 B-lineage prolymphocytic leukaemia, 464, 464  
 blood count, 17–66  
   automated blood cell counters, 29–59  
   automated image analysis, 29  
   differential white cell count, 23–5, 24, **25**  
     imprecision in, 25, **25**  
     inaccuracy in, 24–5  
     maldistribution of cells, 24, 24  
     misidentification of cells, 24–5  
     unidentifiable cells, 25  
   errors in, *see* erroneous blood counts  
   haemoglobin concentration, 17–19, 18  
     cyanmethaemoglobin method, 17–19, 18  
     recommended units, 19  
   hereditary spherocytosis, 333–5, 333–6  
   near-patient testing, 59–60  
   packed cell volume, 17, 19–21  
     microhaematocrit, 20, 20, **21**  
     plasma trapping, 20–21  
     reference method, 21  
   platelets, 22–3  
   red cell count, *see* red cell count  
   red cell indices, *see* red cell indices  
   reticulocytes, 26–9, 26, 27, **27**, 28, **28**  
   specimen storage, 60  
   units and approved abbreviations, 28–9, **29**  
   white cell count, *see* white cell count  
 blood film, 7–13, 7–10  
   automated spreading, 10  
   blood with high Hct, 10  
   buffy coat films, 10  
   ETDA-anticoagulated blood, 7  
   examination, 15, 67–71, 67–71  
   fixation, 10–11, 11  
   healthy subjects  
     adults, 142  
     hyposplenism, 143–4, **144**  
     infancy and childhood, 143  
     neonate, 143, 144  
     pregnancy, 143  
   micro-organisms in, 148–68  
   mounting, 12–13  
   non-anticoagulated blood, 8  
   staining, 11–12, **12**  
   storage artefacts, 7, 69–71, 69–71  
   storage of slides, 13  
   thick, 10, 11  
   unstained wet preparations, 10  
   wedge-spread, 8–10, 9, 10  
   *see also individual conditions*  
 blood sampling, 1–7  
   anticoagulant and specimen container, 5–6  
   capillary blood, 4–5, 4  
   cord blood, 5  
   effect on haematological variables, **212**  
   fetal blood, 5  
   guidelines, 6  
   needle-prick injury, 6–7  
   peripheral venous blood, 1–4, 2, 3, **4**  
   recommended order, **4**  
   specimen mixing, 7  
 bone marrow cells, necrotic, 137  
 Borrelia, 148  
 Brandalise syndrome, 112  
*Brugia malayi*, **154**, 169, 170  
 buffy coat films, 10  
 Burkitt lymphoma, 469  
 butterfly cannula, 2
- C**  
 Cabot rings, 96, 97  
*Candida parapsilosis*, 142  
 capillary blood, 4–5, 4  
*Capnocytophaga canimorsus*, 149  
 CD59 deficiency, inherited, **347**  
 cephalic vein, 2  
 Chédiak–Higashi anomaly, **111**, 112, 121, 123, 124, 131,  
 138  
 children, *see* infants and children

chronic eosinophilic leukaemia, 451, 457  
     not otherwise specified, 450–452, 451, 452  
 chronic lymphocytic leukaemia, 117, 129, 461–3, 462, 463  
 chronic lymphocytic leukaemia/lymphoma, 460–463, 460, 461  
 chronic myelogenous leukaemia, 446–50, 447–9, 449  
 chronic myeloid leukaemia, 114  
     atypical, 452–4, 453, 454  
     chronic myelomonocytic, 116, 454–5, 454  
     juvenile myelomonocytic, 455–6, 455, 456  
     *see also* chronic myelogenous leukaemia  
 chronic myelomonocytic leukaemia, 116, 454–5, 454  
 chronic neutrophilic leukaemia, 450, 450  
 Churg–Strauss syndrome, 239  
 cocaine-induced hyperthermia, 107  
 colchicine toxicity, 111–12  
 cold agglutinin, 67  
 cold antibody-induced haemolytic anaemia, 361–2, 362  
 combined cold/warm autoimmune haemolytic anaemia, 363  
 combined esterase, 287  
 congenital dyserythropoietic anaemia, 377–80, 377, 378–80  
 congenital erythropoietic porphyria, 97  
 congenital sideroblastic anaemia, 299–301, 300, 301  
 Coulter blood cell counters, erroneous differential white cell count, 200–203, 204–5  
 crenation, 69  
 cryoglobulin crystals, 70  
 cryoglobulinaemia, 115, 132  
 cryohydrocytosis, 346  
 cutaneous T-cell lymphoma, 473–4, 473  
 cyanmethaemoglobin method, 17–19, 18  
 cyclical neutropenia, 431–2  
 cytochemical techniques, 277–88, 277  
     diagnosis and classification of leukaemia, 280–288  
     glucose-6-phosphate dehydrogenase, 280  
     haemoglobin F-containing cells, 279, 279  
     haemoglobin H inclusions, 278–9, 278  
     Heinz bodies, 277–8, 277  
     Perls reaction for iron, 279–80, 280  
 cytogenetic analysis, 291–2  
 cytomegalovirus, 128

## D

dacrocytes, 84, 84  
 diabetes mellitus, 375  
 Diamond–Blackfan anaemia, 382  
 differential white cell count, 23–5, 24, 25  
     imprecision in, 25, 25  
     inaccuracy in, 24–5  
     maldistribution of cells, 24, 24  
     misidentification of cells, 24–5  
     unidentifiable cells, 25  
 DiGeorge syndrome, 388  
 dimorphism, 76, 76  
 2,3-diphosphoglycerate deficiency, 355  
 discocytes, 80  
 disintegrated cells, 136–7, 136  
 Döhle bodies, 106, 113–14, 113  
 Dorfman–Chanarin syndrome, 112  
 Down syndrome, 142  
     acute myeloid leukaemia, 443  
     transient abnormal myelopoiesis, 441, 442–3  
 drug-induced haemolytic anaemia, 363–4, 364

dyserythropoietic anaemia, 377–80, 377, 378–80  
     acquired, 380–381  
     congenital, 377–80, 377, 378–80  
 dysmegakaryopoietic thrombocytopenia, 387

## E

echinocytosis, 69, 84–6, 85, 85, 86  
 ehrlichiosis, 150  
 elliptocytosis, 82–3, 83  
     hereditary, 337–40, 338–40  
     blood film and count, 338–40, 338–40  
     differential diagnosis, 340  
     further tests, 340  
 endothelial cells, 145, 145  
 enolase deficiency, 339  
 eosinopenia, 251, 251  
 eosinophilia, 236–40, 236–40  
     idiopathic hypereosinophilic syndrome, 426–8, 427  
     parasitic infections, 237–8  
     with pulmonary infiltration, 240  
     reactive, 425–6, 425, 426  
     T-cell mediated hypereosinophilia, 426  
 eosinophils, 112–15, 112–15  
     normal range  
     adults, 217  
     infants and children, 222  
     neonate, 219  
     pregnancy, 223  
 epithelial cells, 145, 146  
 Epstein–Barr virus 127, 241, 242, 257, 381, 394, 418–9  
 Epstein syndrome, 114, 389  
 erroneous blood counts, 186–210  
     automated blood counts, 186–8  
     automated differential counts, 198–205, 199, 200–203, 204–5  
     haemoglobin concentration, 191–4, 191–3  
     MHC, MCHC, and RDW, 192, 195  
     platelet count, 195–7, 195, 196, 198  
     red cells, MCV and haematocrit, 178, 192, 194–5  
     reticulocyte count, 205–6, 205  
     sources of error, 187, 188  
     white cell count, 188–91, 189, 190  
 erythrocytes, *see* red cells  
*Escherichia coli*, 152  
 essential thrombocythaemia, 395–7, 396  
 evacuated containers, 3

## F

familial autoimmune/lymphoproliferative syndrome, 366  
 familial pseudohyperkalaemia, 345–6  
 familial thrombocytosis, 395  
 Fanconi anaemia, 382, 387  
 fat cells, 146, 146  
 Fechtner syndrome, 389  
 fetal blood sampling, 5  
 fetus  
     normal ranges, 218–20, 220  
     thrombocytopenia, 256  
 fibrin strands, 69  
 filariasis, 168–9, 169–71  
 five-part differential automated cell counters, 31–5, 33, 34  
 fixation of blood films, 10–11, 11  
 flow cytometry, 288–9, 289, 290–291, 291, 292  
 fluorescence *in situ* hybridization, 292  
 follicular lymphoma, 468–9, 468  
 fungal infection, 151, 153

**G**

- G6PD, *see* glucose-6-phosphate dehydrogenase  
ghost cells, 82  
giant platelets, **390**  
glucose phosphate isomerase deficiency, **354**, 357  
glucose-6-phosphate dehydrogenase, 280  
  deficiency, 350–352, 350, 351, **356**  
    blood film and count, 350–352, 350, 351  
    differential diagnosis, 352  
    further tests, 352  
 $\gamma$ -glutamate cysteine synthase deficiency, **356**  
glutathione peroxidase deficiency, **356**, 358  
glutathione reductase deficiency, **356**  
glutathione synthetase deficiency, **356**  
granulocyte precursors, 133–5, 134, 135  
  metamyelocytes, 135, 135  
  myeloblasts, 134  
  myelocytes, 134, 135  
  promyelocytes, 134, 134  
granulocytes  
  morphology, 99–123  
    basophils, 122–3, 123  
    eosinophils, 119–22, 119–22  
    neutrophils, 99–118, 99  
  normal range in adults, **217**  
grape cells, 127  
grey platelet syndrome, **388**, 392  
GrisCELLI syndrome, 138

**H**

- haematocrit  
  errors in, **192**  
  high, 10  
haemoflagellates, 165–7, 166, 167  
haemoglobin Bart's hydrops fetalis, 311–12, 311  
haemoglobin C disease, 82, 318–19, 319  
haemoglobin C trait, 319–20, 320  
haemoglobin C/ $\beta$ -thalassaemia, 320, 320  
haemoglobin concentration, 17–19, 18, **29**  
  cyanmethaemoglobin method, 17–19, 18  
  errors in, 191–4, **191–3**  
  normal range  
    adults, **216**  
    fetus, 220  
    infants and children, **221**  
    neonate, **218**  
    pregnancy, **223**  
    preterm infants, **223**  
recommended units, 19  
haemoglobin Constant Spring, 95  
haemoglobin distribution width, **216**  
haemoglobin E disease, 320–321, 321  
haemoglobin E trait, 321–2, 321  
haemoglobin E/ $\beta$ -thalassaemia, 322, 322  
haemoglobin F-containing cells, 279, 279  
haemoglobin H disease, 309–11, 310, 311  
haemoglobin H inclusions, **27**  
  cytochemical techniques, 278–9, 278  
haemoglobin S, 317  
haemoglobin S-Oman, 95  
haemoglobinopathies, 312–23  
  *see also individual conditions*  
haemoglobin, unstable, 322–3, 323  
haemolysis, 377

## haemolytic anaemia

- acquired, 359–77  
    alloimmune, 365–7  
    bacterial and parasitic infections, 375  
    cold antibody-induced, 361–2, 362  
    combined cold/warm autoimmune, 363  
    diabetes mellitus, 375  
    drug-induced, 363–4, 364  
    familial autoimmune/lymphoproliferative syndrome, 366  
    haemolytic disease of newborn, 364–5, 365  
    liver disease, 373, 374  
    march haemoglobinuria, 375–6  
    neonatal glutathione peroxidase deficiency, 373  
    non-immune, 366–73, **366–7**  
    oxidant-induced, 371–3, 372, 373  
    paroxysmal cold haemoglobinuria, 362–3, 363  
    paroxysmal nocturnal haemoglobinuria, 376, 376  
    phosphate depletion, 375  
    renal disease, 373  
    snake and insect bites, 375, 375  
    vitamin E deficiency, 375  
    warm autoimmune, 359–61, 359, 360  
    Wilson disease, 373, 374, 375  
  congenital, 330–359  
    cryohydrocytosis, 346  
    familial pseudohyperkalaemia, 345–6  
    hereditary elliptocytosis, 337–40, 338–40  
    hereditary pyropoikilocytosis, 340–342, 343  
    hereditary spherocytosis, 331–7, 332–6  
    hereditary stomatocytosis, 343–4, **343**, 344  
    hereditary xerocytosis, 344–5, 345  
    red cell enzyme abnormalities, 347–50, 348, 349  
    South-East Asian ovalocytosis, 342–3, 342  
    stomatin-deficient cryohydrocytosis, 346  
    congenital non-spherocytic, **339**, 354–9, **354–6**, 357, 358  
    congenital sitosterolaemia, 346–7  
    microangiopathic, 90, 366–71, **367–8**, 368–71  
    *see also specific types*  
  haemolytic disease of newborn, 364–5, 365  
  haemolytic-uraemic syndrome, 89, 369  
  hairy cell leukaemia, 464–6, 465  
    variant, 466, 466  
  heel puncture, 4  
  Heinz bodies, **27**, 82, 373  
    cytochemical techniques, 277–8, 277  
  Hematoflow platform, 35, 37  
  hereditary stomatocytosis, 343–4, **343**, 344  
  hereditary xerocytosis, 344–5, 345  
  Hermansky-Pudlak syndrome, 124, 138  
  hexokinase deficiency, **354**  
  *Histoplasma capsulatum*, 153  
  HIV/AIDS, 422–3, 422, 423  
  Hodgkin lymphoma, 476–7  
  Horiba ABX blood cell counter, 49  
  Howell-Jolly bodies, **27**, 91, 94–5, 150  
  human T-cell lymphotropic virus, 424  
  hyperchromia, 76  
  hypercoagulability, 69  
  hyperlipidaemia, 71  
  hyperthermia, cocaine-induced, 107  
  hypochromia, 75–6, 75  
  hyposplenism, 143–4, **144**

**I**

idiopathic hypereosinophilic syndrome, 110, 119, 426–8, 427  
immunocytochemistry, 289, 292  
immunophenotyping, 288–9, 289, 291, 292  
  applications, **290–291**  
infantile pyknocytosis, 88  
infants and children  
  blood film, 143  
  normal ranges, 220–223, **221–3**  
    basophils, **222**  
    eosinophils, **222**  
    haemoglobin, **221, 223**  
    large unstained cells, **222**  
    lymphocytes, **222**  
    mean cell haemoglobin, **221**  
    mean cell volume, **221**  
    monocytes, **222**  
    neutrophils, **222**  
    packed cell volume, **221**  
    red cell count, **221**  
    white cell count, **222**  
infectious mononucleosis, 418–22, 419, 420, **421**  
insect bites, 375  
iron deficiency anaemia, 295–8, 296, **298**  
irregularly contracted red cells, 81, 82, **83**

**J**

Jordans anomaly, 112, 124  
juvenile myelomonocytic leukaemia, 455–6, 455, **456**

**K**

keratocytes, 89, 90  
*Klebsiella oxytoca*, 151  
Kleihauer test, 248  
knizocytes, 92

**L**

lactate dehydrogenase deficiency, **355**  
large granular lymphocyte leukaemia, 475, 475  
large unstained cells  
  normal range  
    adults, **217**  
    infants and children, **222**  
lead poisoning, 301–2, 302  
*Leishmania donovani*, **154**, 166, 167, 168  
leptocytes, 76  
leucocytes, *see* white cells  
leucocytosis, 234–41, **235**  
  basophilia, 240–241, **241**  
  eosinophilia, 236–40, **236–40**  
  neutrophilia, 234, 236, **236**  
leucoerythroblastic anaemia, **247**  
leucoerythroblastic blood films, 135–6  
leucopenia, 248  
leukaemia  
  acute basophilic, 438, 440, 440  
  acute lymphoblastic, 457–60, 458–60, **459**  
  acute monoblastic, 184  
  acute myeloid, 109, 118, 432–40, **433**, 434–42  
    of Down syndrome, 443  
  adult T-cell leukaemia/lymphoma, 474–5, 475

  chronic eosinophilic, 451, 457  
    not otherwise specified, 450–452, 451, 452  
  chronic lymphocytic, 117, 129, 461–3, 462, 463  
  chronic myelogenous, 446–8, 447, **448**  
    accelerated phase, 448–50, 449, **449**  
  chronic myeloid, 114  
    atypical, 452–4, 453, **454**  
  chronic myelomonocytic, 116, 454–5, 454  
  chronic neutrophilic, 450, 450  
  classification and diagnosis, 280–288  
    acid phosphatase, 88, 288  
    combined esterase, 287  
    myeloperoxidase, 282–4, 285  
    naphthol AS-D chloroacetate esterase, 286, 286, 287  
    neutrophil alkaline phosphatase, 281–2, **281**, 282, **283**, 284  
    non-specific esterases, 286–7, 287  
    periodic acid-Schiff reaction, 273, 287–8, 287  
    Sudan black B, 272, 284–5, 285  
  hairy cell, 464–6, 465, 466  
  juvenile myelomonocytic, 455–6, 455, **456**  
  large granular lymphocyte, 475, 475  
  mast cell, 440–442, 442, **442**  
  plasma cell, 470–472, 471  
  prolymphocytic  
    B-lineage, 464, 464  
    T-lineage, 472–3, 472  
  leukaemoid reactions, 428–31  
    lymphoid, 430–431, 430, 431  
    myeloid, 428–9, 429, 430  
  liver disease, 373, 374  
*Loa loa*, **154**, 169, 171  
lupus erythematosus, 116  
lymphocytes, 123–30, 123–30  
  morphological abnormalities, 124–5, 124, 125, **126**  
  in lymphoproliferative disorders, 129–30, 129, 130  
  reactive changes, 125–8, 126–9  
  normal range  
    adults, **217**  
    infants and children, **222**  
    neonate, **219**  
    pregnancy, **209**  
  lymphocytopenia (lymphopenia), 251–2, **252**  
  lymphocytosis, 241–2, **242**  
  lymphoid cells, apoptotic, 129, 129  
  lymphoid leukaemoid reactions, 430–431, 430, 431  
  lymphoid/myeloid neoplasms with abnormalities of *PDGFRA*, *PDGFRB* or *FGFR1*, 457  
  lymphoma  
    adult T-cell leukaemia/lymphoma, 474–5, 475  
    Burkitt, 469  
    cutaneous T-cell, 473–4, 473  
    follicular, 468–9, 468  
    Hodgkin, 476–7  
    lymphoplasmacytic, 467–8, 467  
    mantle cell, 469, 469  
    splenic with villous lymphocytes, 466–7, 467  
    T-cell, 475–6, 476  
  lymphoplasmacytic lymphoma, 467–8, 467  
  lymphoproliferative disorders, 129–30, 129, 130

**M**

- McLeod phenotype, **349**
- macrocytic anaemias, 323–30  
     associated with alcoholism and liver disease, 330  
     associated with myelodysplastic syndrome, 330  
     megaloblastic anaemia, 323–9, **324**, 325–9
- macrocytosis, 74–5, 74  
     causes, **75**
- macrophages, 132–3, 133
- macropolycytes, 116–17, 117
- malaria, 114, 115, 132, 140, 152–64, **153**, 154–63
- malaria parasites, staining for, 12
- malignant melanoma, 116
- Mansonella ozzardi*, **154**, 169
- Mansonella perstans*, **154**, 169, 171
- mantle cell lymphoma, 469, 469
- march haemoglobinuria, 375–6
- Maroteaux–Lamy syndrome, 110, 131
- mast cell leukaemia, 440–442, 442, **442**
- mast cells, 136, 136
- mastocytosis, 452, 453
- May–Hegglin anomaly, **111**, 114, **389**
- mean cell haemoglobin (MCH), 17, **29**  
     errors in, **193**, 195  
     normal range  
         adults, **216**  
         infants and children, **221**
- mean cell haemoglobin concentration (MCHC), 17, **29**  
     errors in, **193**, 195  
     normal range in adults, **216**
- mean cell volume (MCV), 17, **29**  
     errors in, **192**, **193**, 194–5  
     normal range  
         adults, **216**  
         infants and children, **221**  
         neonate, **218**  
         pregnancy, **223**
- mean platelet volume (MPV), **29**
- median cubital vein, 2
- Medich giant platelet syndrome, **389**
- Mediterranean stomatocytosis/macrophthrombocytopenia, 93, **138**, 344, **388**
- megakaryocytes, 140–142, 141, 142
- megaloblastic anaemia, 118, 323–9, **324**, 325–9  
     blood film and count, 324–8, 324–8  
     causes, **324**  
     differential diagnosis, 328–9
- micro-organisms in blood films, 148–68  
     babesiosis, 164–5, 164, 165  
     bacteria, 148–50, 148–50  
     filariasis, 168–9, 169–71  
     fungi, 151, 153  
     haemoflagellates, 165–7, 166, 167  
     parasites, 152–65, **154**, 156–65  
     toxoplasmosis, 165
- microangiopathic haemolytic anaemia, 90, 366–71, **367–8**, 368–71
- microcytosis, 73–4, 73, **73–4**
- microscopes, setting up and using, 13–15, 14
- Miller ocular micrometer, 28, **28**
- Mindray blood cell counters, 52–3
- molecular genetic analysis, 292
- monoclonal B-cell lymphocytosis, 463–4
- monocyte precursors, 131–2
- monocytes, 130–131, 131, 132  
     normal range  
         adults, **217**  
         infants and children, **222**  
         neonate, **229**  
         pregnancy, **223**
- monocytopenia, 251
- monocytosis, 242–3, **243**
- mononuclear cells, **217**
- Montreal platelet syndrome, **390**
- morphology of blood cells, 67–185  
     blood film in healthy subjects, 142–5, 144, **144**  
     megakaryocytes, 140–142, 141, 142  
     micro-organisms in blood films, 148–68  
     non-haemopoietic cells, 145–8  
     platelets, 137–40, 138–40, **138**  
     red cells, 72–98  
     white cells, 98–123  
     *see also individual conditions*
- Morquio syndrome, 124
- morular cells, 127
- Mott cells, 127
- multiple myeloma, 67, 68, 470–472, 471
- myeloblasts, 134
- myelocytes, 134, 135
- myelodysplasia, 106
- myelodysplastic syndromes, 443–6, 444–6, **444**  
     FAB classification, **444**  
     macrocytic anaemia associated with, 330  
     WHO classification, **444**
- myelodysplastic/myeloproliferative neoplasms, 452–7  
     unclassifiable, 456–7
- myelofibrosis, primary, 397–8, 398
- myeloid leukaemoid reactions, 428–9, 429, 430
- myeloperoxidase, 282–4, 285
- myeloproliferative neoplasms, 446–8, **446**, 447, 448

**N**

- naphthol AS-D chloroacetate esterase, 286, 286, 287
- Napoleon hat cells, 95
- near-patient testing, 59–60  
     non-invasive methods, 59–60
- needle-prick injury, 6–7
- Neisseria meningitidis*, 149
- neonate  
     blood film, 143, 144  
     glutathione peroxidase deficiency, 373  
     haemolytic disease of newborn, 364–5, 365  
     normal ranges, 218–20, **218**, **219**  
         eosinophils, **219**  
         haemoglobin, **218**, **221**  
         lymphocytes, **219**  
         mean cell volume, **218**  
         monocytes, **219**  
         neutrophils, **219**  
         nucleated red blood cells, **219**  
         packed cell volume, **218**  
         red cell count, **218**  
         white cell count, **219**  
     thrombocytopenia, **256**
- neuroacanthocytosis, **349**

- neutropenia, 248–9, **249**, **250**  
 acquired disorders, **250**  
 cyclical, 431–2  
 inherited disorders, **249**  
 severe congenital, 431
- neutrophil alkaline phosphatase, 281–2, **281**, 282, **283**, 284
- neutrophilia, 234, 236, **236**
- neutrophils, 99–118, 99  
 aggregation, 118, 118, 119  
 cytoplasmic abnormalities, 107–14, **108**  
 Auer rods, 109–10, 112  
 Döhle bodies, 113–14, 113  
 exogenous inclusions, 114–16, 115, 116  
 increased granulation, 109, 109, 110  
 reduced granulation, 107, 109  
 vacuolation, 111–13, 113
- fragments, 112
- necrobiotic, 117, 118
- normal range  
 adults, **217**  
 infants and children, **222**  
 neonate, **219**  
 pregnancy, **223**
- nuclear abnormalities  
 band form and left shift, 99–100, 100, **103**  
 botryoid nucleus, **103**  
 dense chromatin clumping, **103**  
 detached nuclear fragments, **103**  
 drumsticks, 100, 101–2, 102  
 hypersegmentation, **103**  
 hyposegmentation, **103**  
 lobe count and right shift, 100–101, 101  
 Pelger–Huët anomaly, 104, 104, 105, 120, 122  
 ring nuclei, **103**, 106  
 sessile nodules, 102, 102
- Niemann–Pick disease, 124
- Nihon Kohden blood cell counter, 52–3
- non-haemopoietic malignant cells, 146–8, 147, 148
- non-Hodgkin lymphoma, 130
- non-specific esterases, 286–7, 287
- normal ranges, 211–32  
 adults, 216–18, **216**, **217**  
 haematological variables affecting, **212**, **214**, **215**  
 infants and children, 220–223, **221–3**  
 neonate and fetus, 218–20, **218**, **219**, 220  
 pregnancy, 223, **223**  
 reticulocyte count, 225–6, **226**
- nucleated red blood cells, 69  
 normal range in neonates, **219**
- O**
- Onchocerca volvulus*, **154**
- Oroya fever, 150
- ovalocytosis, 82–3, 83  
 South-East Asian, 342–3, 342
- oxidant-induced haemolytic anaemia, 371–3, 372, 373
- P**
- packed cell volume (PCV), 17, 19–21, **29**  
 microhaematocrit, 20, 20, **21**  
 normal range  
 infants and children, **221**  
 neonate, **218**  
 pregnancy, **223**  
 plasma trapping, 20–21  
 reference method, 21
- pancytopenia, 184, 256–8, **257**  
 blood film, 257–8
- Pappenheimer bodies, 27, 96, 96
- parasitic infections, 152–65, **154**, 156–65  
 eosinophilia, **237–8**  
 haemolytic anaemia, 375  
 malaria, 152–64, **153**, 154–63
- Paris–Trousseau thrombocytopenia, 140, **387**
- paroxysmal cold haemoglobinuria, 362–3, 363
- paroxysmal nocturnal haemoglobinuria, 376, 376
- pattern-recognition automated differential counters, 29
- Pelger–Huët anomaly, **103**, 104, 104, 105, 120, 122, **389**
- Penicillium marneffei*, 142
- periodic acid–Schiff reaction, 287–8, 287
- Perls reaction for iron, 279–80, 280
- persistent polyclonal B-cell lymphocytosis, 424–5, 425
- phosphate depletion, 375
- phosphofructokinase deficiency, **354**
- phosphoglycerate deficiency, **355**
- pincer cells, 94, 94
- plasma cells, 130
- plasma cell leukaemia, 470–472, 471
- plasmacytosis, 243, **243**
- Plasmodium falciparum*, 114, 115, 132, 140, **154**, 156–7, 160
- Plasmodium knowlesi*, 151–2, **154**, 162–3
- Plasmodium malariae*, **154**, 156–7, 161
- Plasmodium ovale*, **154**, 156–7, 159
- Plasmodium vivax*, **154**, 156–7, 158–9
- platelet count, 22–3, **29**  
 automated, 57–9  
 errors in, 195–7, **195**, **196**, 198  
 normal range, 224–5, **224**, **225**  
 pregnancy, **223**
- plateletcrit, **29**
- platelet disorders, 386–98  
 thrombocytopenia, 252–6, **253–6**, 386–93, **386–90**, 391, 392  
 thrombocytosis, 243–5, **244**, **245**
- platelets, 137–40, 138–40, **138**  
 abnormal distribution, 137–40, 139, 140  
 abnormalities of size, 137, 138, **138**, 139  
 aggregation, 68  
 reticulated, 57–9  
 satellitism, 140, 140  
 volume, **29**
- poikilocytosis, 78–97, 78, 79  
 see also individual types
- polychromasia, 76–8, 77
- polycythaemia, 232, **233**, **234**, 383–6  
 relative, 383, 386  
 secondary, 385–6  
 true, 383  
 vera, 383, 384
- Pompe disease, 124
- post-infection immune thrombocytopenic purpura, 394
- pregnancy  
 blood film, 143  
 normal ranges, 223, **223**
- promyelocytes, 134, 134
- pyrimidine nucleotidase deficiency, **355**, 358
- pyropoikilocytosis, hereditary, 78, 340–342, 343
- pyruvate kinase deficiency, 352–4, 353, **355**

## Q

quantitative changes in blood cells, 232–76  
 anaemia, 245–8, **246**, **247**  
 basopenia, 251, **251**  
 eosinopenia, 251, **251**  
 leucocytosis, 234–41, **235**  
 leucopenia, 248  
 lymphocytopenia (lymphopenia), 251–2, **252**  
 lymphocytosis, 241–2, **242**  
 monocytopenia, 251  
 monocytosis, 242–3, **243**  
 neutropenia, 248–9, **249**, **250**  
 pancytopenia, 256–8, **257**  
 plasmacytosis, 243, **243**  
 polycythaemia, 232, **233**, **234**  
 reticulocytopenia, 248, **248**  
 reticulocytosis, 232, **234**  
 thrombocytopenia, 252–6, **253–6**  
 thrombocytosis, 243–5, **244**, **245**  
 Quebec platelet disorder, **387**

## R

reactive eosinophilia, 425–6, 425, **426**  
 red cell aplasia, 382–3  
 red cell count, 22–3, **29**  
   errors in, **192**, 194–5  
   normal range  
     adults, **216**  
     infants and children, **221**  
     neonate, **218**  
     pregnancy, **223**  
 red cell disorders, 295–415  
   anaemia, 245–8, **246**, **247**  
     acquired haemolytic, 359–77  
     aplastic, 381–2  
     of chronic disease, 298–9, **298**, **299**  
     congenital haemolytic, 330–350  
     congenital sideroblastic, 299–301, **300**, **301**  
     dyserythropoietic, 377–80, **377**, 378–80  
     iron deficiency, 295–8, 296, **298**  
     lead poisoning, 301–2, **302**  
     leucoerythroblastic, **247**  
     macrocytic, 323–30  
   aplasia, 382–3  
   haemoglobin Bart's hydrops fetalis, 311–12, **311**  
   haemoglobin H disease, 309–11, **310**, **311**  
   haemoglobinopathies, 312–23  
   polycythaemia, 218, **219**, **220**, 383–6  
    $\alpha$  thalassaemia trait, 308–9, **309**  
    $\beta$  thalassaemia intermedia, 307, **307**, **308**  
    $\beta$  thalassaemia major, 305–7, **306**  
    $\beta$  thalassaemia trait, 302–5, **303**, **304**  
   *see also individual conditions*  
 red cell distribution width  
   errors in, **193**, 195  
   normal range, adults, **216**  
 red cell enzyme abnormalities, 347–50, **348**, **349**  
   congenital non-spherocytic haemolytic anaemia, 354–9, **354–6**,  
     357, **358**  
   glucose-6-phosphate dehydrogenase deficiency, 350–352, **350**, **351**  
   pyruvate kinase deficiency, 352–4, **353**  
 red cell indices, 23  
 red cell sedimentation rate, **29**

## red cells

agglutination, 72, 97–8, **98**  
 aplasia, **247**  
 budding, **70**  
 circulating nucleated, 97  
 crystals, 97, **97**  
 fragmentation, **70**, **366–7**  
 inclusions, 94–5  
 membrane, **332**  
 membrane defects, 347–59, **347**  
 micro-organisms in, 97  
 morphology, 72–98  
   *see also various types*  
 nucleated, **69**  
 rosetting, 97–8, **98**  
 rouleaux formation, 97–8, **98**  
 Reed–Sternberg cells, **148**  
 renal disease, **373**  
 reticulocyte count, 26–9, 26, 27, **27**, **28**, **28**, **29**  
   automated, 53–5, **54–8**, **59**  
   errors in, 205–6, **205**  
   normal range, 225–6, **226**  
 reticulocyte immaturity, 55–7  
 reticulocyte index, **28**  
 reticulocytopenia, 248, **248**  
 reticulocytosis, 232, **234**  
 Rh deficiency syndrome, **349**  
 rheumatoid arthritis, **119**

## S

Sanfilippo syndrome, **125**  
 schistocytes, 89–91, **90**  
 Sebastian syndrome, **389**  
 severe congenital neutropenia, **431**  
 Sézary syndrome, 473–4, **473**  
 sickle cells, 93–4, **94**, **95**  
 sickle cell anaemia, 312–15, **313–15**  
   blood film and count, 312–14, **313–15**  
   differential diagnosis, 314–15  
   further tests, **315**  
 sickle cell/haemoglobin C disease, 317–18, **318**  
 sickle cell/ $\beta$  thalassaemia, 316–17, **317**  
 sickle cell trait, **316**  
 sideroblastic anaemia  
   acquired, **331**  
   congenital, 299–301, **300**, **301**  
 Siemens Advia blood cell counters, erroneous counts, 199–200,  
   **199**, **202**, **203**  
 Siemens blood cell counters, 44–9, **45**, **47**, **48**  
 sitosterolaemia, 346–7  
 slides, storage of, **13**  
 snake bites, 375, **375**  
 South-East Asian ovalocytosis, 342–3, **342**  
 specimen containers, 5–6  
   evacuated, **3**  
 specimen mixing, **7**  
 spherocytosis, 79–81, **80**, **80**, **81**  
   hereditary, 331–7, **332–6**  
     blood film and count, 333–5, **333–6**  
     differential diagnosis, **336**  
     further tests, **337**  
 spherocytinocytes, **84**, **86**  
 spiculated cells, **84**

splenic lymphoma with villous lymphocytes, 466–7, 467  
 staining of blood films, 11–12, **12**  
   malaria parasites, 12  
 stomatin-deficient cryohydrocytosis, 346  
 stomatocytosis, 92–3, 93  
   hereditary, 343–4, **343**, 344  
 storage  
   of slides, 13  
   of specimens, 60  
 storage artefacts, 7, 69–71, 69–71  
 Sudan black B, 284–5, 285  
 supplementary tests, 277–94  
   cytochemical techniques, 277–88, **277**  
   cytogenetic analysis, 291–2  
   fluorescence *in situ* hybridization, 292  
   immunophenotyping, 288–9, 289  
   molecular genetic analysis, 292  
   ultrastructural examination, 292–3, 293  
 Sysmex blood cell counters, 38–44, 39–41  
   erroneous counts, 200–203, **204–5**  
   SE-9000, 38–40, 39  
   XE-2100, 40–43, 40, 41  
   XE-2100D, 43  
   XE-5000, 43–4  
   XN series, 44  
   XT-2000i, 44

## T

target cells, 91–2, 91, **92**  
 Tay–Sachs disease, 124, 125  
 T-cell lymphoma, 475–6, 476  
 T-cell mediated hypereosinophilia, 426  
 T-lineage lymphoproliferative disorders, 472–7  
 T-lineage prolymphocytic leukaemia, 472–3, 472  
 teardrop cells, *see* dacryocytosis  
 $\alpha$  thalassaemia trait, 308–9, 309  
 $\beta$  thalassaemia intermedia, 307, 307, 308  
 $\beta$  thalassaemia major, 305–7, 306  
 $\beta$  thalassaemia trait, 302–5, 303, 304  
   blood film and count, 302–4, 303  
   differential diagnosis, 304–5  
   further tests, 305  
 thick films, 10, 11  
 thrombocytopenia, 252–6, **253–6**, 386–93, **386–90**,  
   391, 392  
   amegakaryocytic, **387**  
   autoimmune thrombocytopenic purpura, 393–4, 393  
   blood film, 255–6  
   causes, **253–6**  
     fetal, **256**  
     neonatal, **256**  
   congenital, 386–93, **386–90**  
   dysmegakaryopoietic, **387**  
   Paris–Trousseau, 140, **387**  
   post-infection immune thrombocytopenic purpura, 394  
   thrombotic thrombocytopenic purpura, 394–5  
   X-linked, **386**, **389**  
 thrombocytosis, 243–5, **244**, **245**  
   blood film, 244–5  
 thrombotic thrombocytopenic purpura, 394–5  
 tourniquet, 2  
 toxoplasmosis, 165  
 triose phosphate isomerase deficiency, **355**, 357  
*Tropheryma whipplei*, 150

*Trypanosoma brucei gambiense*, **154**, 166–7  
*Trypanosoma brucei rhodesiense*, **154**, 166  
*Trypanosoma cruzi*, **154**, 166, 167, 167  
*Trypanosoma evansi*, 167  
*Trypanosoma gambiense*, **154**, 166–7  
*Trypanosoma rangeli*, **154**, 166  
*Trypanosoma rhodesiense*, **154**, 166  
 tuberculosis, white cell changes, 418  
 tumour cell aggregates, 68

## U

ultrastructural examination, 292–3, 293  
 Unicel DxH 800 automated cell counter, 35, 36–7  
 unstable haemoglobins, 322–3, 323

## V

vein patency, 2  
 velocardiofacial syndrome, **388**  
 venepuncture, 1–4, 2, 3, **4**  
   evacuated container, 3  
   needle and syringe, 2, 3  
 viral infections, white cell disorders, 418–24  
 vitamin E deficiency, 375  
 von Willebrand disease, **390**

## W

warm autoimmune haemolytic anaemia, 359–61, 359, 360  
 wedge-spread films, 8–10, 9, 10  
   problems with, 10  
 Whipple disease, 150  
 white cell count, **29**, 222  
   differential, 23–5, 24, **25**  
     errors in, 198–205, **199**, 200–203, **204–5**  
     errors in, 188–91, **189**, 190  
   normal range  
     adults, **217**  
     ethnic differences, **217**  
     infants and children, **222**  
     neonate, **219**  
     pregnancy, **223**  
 white cell disorders, 416–81  
   adult T-cell leukaemia/lymphoma, 454, 474–5, 475  
   bacterial infection, 416–18, 416–18  
   B-lineage lymphoproliferative disorders, 461–72  
     monoclonal B-cell lymphocytosis, 463–4  
   chronic lymphocytic leukaemia/lymphoma, 460–463, **460**,  
     **461**  
   Hodgkin lymphoma, 476–7  
   idiopathic hypereosinophilic syndrome, 426–8, 427  
   leukaemia  
     acute basophil, 438, 440, 440  
     acute lymphoblastic, 457–60, 458–60, **459**  
     acute myeloid, 432–40, **433**, 434–42  
     acute myeloid of Down syndrome, 443  
     chronic eosinophilic, not otherwise specified, 450–452, 451,  
       452  
     chronic lymphocytic, 117, 461–3, 462, 463  
     chronic myelogenous, 446–50, 447–9, **449**  
     chronic myeloid, atypical, 452–4, 453, **454**  
     chronic myelomonocytic, 116  
     chronic neutrophilic, 450, 450  
     hairy cell, 464–6, 465, 466  
     large granular lymphocyte, 475, 475  
     mast cell, 440–442, 442, **442**

- plasma cell, 470–472, 471
  - prolymphocytic, 441–3
  - T-lineage prolymphocytic, 472–3, 472
  - leukaemoid reactions, 428–31, **428**
  - lymphoid/myeloid neoplasms with abnormalities of *PDGFRA*, *PDGFRB* or *FGFR1*, 457
  - lymphoma, 469–70, 469
    - cutaneous T-cell, 472–3, 472
    - follicular, 468–9, 468
    - lymphoplasmacytic, 467–8, 467
    - mantle cell, 469, 469
    - splenic with villous lymphocytes, 466–7, 467
    - T-cell, 475–6, 476
  - mastocytosis, 452, 453
  - multiple myeloma, 67, 68, 470–472, 471
  - myelodysplastic/myeloproliferative neoplasms, 452–7
    - unclassifiable, 456–7
  - myelodysplastic syndromes, 443–6, 444–6, **444**
  - myeloproliferative neoplasms, 446–8, **446**, 447, 448
  - neutropenia
    - cyclical, 431–2
    - severe congenital, 431
  - persistent polyclonal B-cell lymphocytosis, 424–5, 425
  - reactive eosinophilia, 425–6, 425, **426**
  - splenic lymphoma with villous lymphocytes, 466–7, 467
  - T-cell mediated hypereosinophilia, 426
  - T-lineage lymphoproliferative disorders, 472–7
  - transient abnormal myelopoiesis of Down syndrome, 441, 442–3
  - viral infection, 418–24
  - white cells
    - morphology, 98–123
    - see also different types*
  - white platelet syndrome, **388**
  - Wilson disease, 373, 374, 375
  - Wiskott–Aldrich syndrome, 138, 139, **386**
  - Wuchereria bancrofti*, **154**, 169, 170
- X**
- X-linked thrombocytopenia, **386**, **389**
- Y**
- Yersinia pestis*, 151
  - York platelet syndrome, **389**
- Z**
- Zieve syndrome, 374





