

Index

- acidemia 555–9
 - glutaric type I (GA1) 558–9
 - therapy 559
 - isovaleric 555–6
 - therapy 556
 - methylmalonic 556–7
 - diagnosis/presentation 557
 - therapy 557–8
 - propionic 556
 - diagnosis/presentation 557
 - therapy 557–8
- acrodermatitis enteropathica* 278
 - treatment 279
- acute respiratory disease *see* respiratory distress syndrome (RDS)
- adenosylcobalamin 174
 - see also* vitamin B12 (cobalamin)
- age
 - energy expenditure relationship 136
 - gestational age estimation 24, 48–9
 - protein accretion relationships 116–8
- air-displacement plethysmography (ADP) 603–4
- alanine 129
 - methylmalonic/propionic acidemia management 558
- albumin assessment 593
- aldosterone 107
- alkaline phosphatase (ALP) 198, 200, 201–2
 - bone mineral content and 250–1
 - screening for rickets of prematurity 250–1
 - laboratory assessment 589
 - smoking effects 202–3
- allantoic fluid 3–4
- allergies
 - postnatal nutrition influences 635
 - prevention 426
 - protein-hydrolysate formula use 425–6
- alpha-linolenic acid (ALA) 147–9
 - conversion to docosahexaenoic acid (DHA) 150
 - deficiency 148

- alpha-linolenic acid (ALA) (*cont.*)
 - dietary requirements 148–9
 - dietary supplements 428
- aluminum
 - metabolic bone disease and 248, 250
 - parenteral nutrition contamination 256
- amino acid transporters 7–8
 - alterations in IUGR 37–38
- amino acids
 - in human milk 333–5
 - metabolism 7–8, 27, 119, 335–6
 - accretion in specific tissues 118
 - age and feeding effects 116–8
 - following birth 617
 - placental 7, 8
 - protein–energy balance 139, 318–19
 - quantification 115–6
 - parenteral nutrition requirements 316–8, 573–4
 - acute respiratory disease and 512–3
 - complications 322–3
 - placental transfer 7–8
 - alterations in IUGR 37–38
 - in diabetic pregnancies 39
 - requirements 332, 333–5
 - responses to dietary protein 336
 - clinical implications 336–7
 - supplementation
 - amniotic 12
 - neonatal 117
 - tracers 624–5
 - see also* nitrogen balance; protein
- aminoacidopathies 548–55
 - hereditary tyrosinemias 550–2
 - homocystinuria (HCU) 554–5
 - maple syrup urine disease (MSUD) 552–4
 - nutritional support 547–8
 - phenylketonuria (PKU) 548–50
- ammonia production, placental 7
- amniotic fluid 11
 - growth factors 13
 - ingestion 11–13, 370
 - volume 11
- amniotic sac 3–4
- anemia 294
 - copper deficiency 282
 - iron deficiency 275
 - of prematurity 275, 294
- angiotensin 107
- anion-binding resins 499
- antacids 326, 499
- anthropometrics 595–7
 - growth charts 596–7
 - head circumference 596
 - length 596
 - skinfold measurements 597
 - weight 596
- antibiotics
 - methylmalonic/propionic acidemia management 558
 - short bowel syndrome management 499
- anticonvulsant therapy effects on bone 197
- antioxidants 577
 - bronchopulmonary dysplasia prevention 522–3
 - see also specific antioxidants*
- apical endocytic complex (AEC) 11–12
- apnea
 - of prematurity 510
 - reflux and 448
- apoptosis 98–99
 - hypoglycemia and 99–100
- arachidonic acid (ARA) 8, 27, 149–50, 157
 - adverse effects 155–7
 - in formulas
 - cow's milk-based term formula 416–7
 - preterm formulas 420
 - in human milk 352, 353, 354, 391
 - lung surfactant synthesis and 509–10
 - role in cognitive/behavioral development 153–4, 155
- arginase deficiency (arginemia) 560
- arginine 303–4, 335
 - antiatherogenic effects 304
 - necrotizing enterocolitis (NEC) and 304
 - pulmonary disease and 304
 - acute respiratory disease 513
 - role in immune function 72, 304
- arginine vasopressin (AVP) 107
- argininosuccinic acid lyase deficiency 560
- argininosuccinic acid synthetase deficiency 560
- ascorbic acid *see* vitamin C
- asphyxia 472
 - macrosomia and 472–3
- assisted reproductive technology (ART), genomic imprinting
 - relevance 25
- asthma, postnatal nutrition relationship 635
- atopy, postnatal nutrition relationship 635
- atrial natriuretic peptide (ANP) 107–8
- attention deficit-hyperactivity disorder (ADHD), hypoglycemia
 - relationship 459
- Bartter's syndrome 236–7
- Bayley Scales of Infant Development 152
- Beckwith-Weidemann syndrome 457
- behavioral development
 - hypoglycemia consequences 459–60
 - long chain polyunsaturated fatty acid role 152–5
- bethanechol 451
- bile acids 360
- bioelectrical impedance analysis (BIA) 603
- bioelectrical impedance spectroscopy (BIS) 603
- biotin 176–7
 - deficiency 177
 - in human milk 176

- neonatal requirements 176
- status assessment 177
- birth injury, macrosomia and 472–3
- birth weight
 - congenital heart disease and 533
 - fetal programming 23
 - folate relationships 2–3
 - importance of 23
 - intrauterine growth and 24
 - malaria and 3
 - maternal nutrition relationships 1–3
 - nutrient supplementation effects 1–2
 - plasma triglycerides and 470
 - preterm infants 49
 - see also* intrauterine growth; macrosomia
- blood flow
 - cerebral, hypoglycemia response 459–60
 - changes at birth 534
 - fetal 534
 - gastrointestinal blood flow regulation 485
- blood urea nitrogen 588–9
- blood–brain barrier 92–93
- body composition 569, 602, 607–8
 - bioelectrical techniques 603
 - body volume measurements 603–4
 - body water and electrolyte measurements 602–3
 - bone mineral measurements 604
 - infant studies using 606, 607
 - preterm infants 51–52
 - formula-fed infants 657
 - reference data for infancy 606–7
 - reference models 602
 - selection of assessment method 604–6
 - use of body composition data 604
- body mass index (BMI), bone mass and 193
- body temperature *see* thermal regulation
- body volume measurements 603–4
- body water measurements 602–3
- bone 188–206
 - biomechanics 189–91
 - loading 189–91
 - density 194
 - assessment 193–6
 - changes during lactation 207–8, 211–12
 - changes during pregnancy 211
 - postnatal changes 248
 - determinants of bone health 192–3
 - fetal bone physiology 213
 - fractures 194
 - rib fractures at birth in preterm infants 191
 - growth and development 189, 190, 193
 - fetal movement and 190–1, 248–9
 - mineral status postnatal development 194
 - postnatal adaptations 248
 - postnatal regulation of longitudinal growth 191–2
 - preterm infants 257
 - mass 192–3
 - bronchopulmonary dysplasia and 529
 - gastrointestinal disease effects 196–7
 - hormonal regulation 189, 193
 - peak bone mass 192, 205–6
 - metabolic bone disease of prematurity (MBDP) 248–54
 - biomechanical factors 249–50
 - bone resorption 249
 - characteristics 249
 - management 254
 - prevention 251–4
 - see also* osteopenia; rickets
 - metabolism disorders 244–8
 - see also specific disorders*
 - metabolism markers 198–203
 - correlations between 200, 201, 202
 - mineral content (BMC) 193–4
 - alkaline phosphatase and 250–1
 - assessment 193–6, 250, 604
 - diet and 258
 - infants of diabetic mothers 231
 - influencing factors 191
 - postnatal development 194
 - preterm infants 51, 250, 257–8, 657
 - mineralization 258–9
 - modeling 189, 190
 - quality 194
 - remodeling 189, 192, 204
 - hormonal regulation 203–6
 - influences on 203
 - risk factors for disease 196, 197
 - strength 194
 - assessment 194, 195
 - structure 188–9
 - turnover 199–200
 - biochemical measurements 198–203
 - during lactation 207–8, 211–12
 - during pregnancy 211
 - infants of diabetic mothers 199, 200–1, 210
 - preterm infants 201–2
- bone morphogenetic proteins (BMPs) 188
- bone sialoprotein (BSP) 199
- bradykinins 108
- brain
 - development
 - choline role 300
 - GLUT expression 92–93
 - hypoglycemia consequences 459–60
 - iron deficiency effects 295
 - long chain polyunsaturated fatty acid effects 155
 - maternal protein restriction effects 79, 80
 - taurine role 303
 - see also* cognitive development
 - hypoglycemia responses 96–98, 458–9
 - consequences 459–60

- brain (*cont.*)
 - neuronal apoptosis/necrosis when adaptive mechanisms fail 98–100
 - repeated hypoglycemia effects 98
- metabolism 91, 100
 - alternative substrates to glucose 93–94
 - glucose metabolism 91, 92, 100, 341, 617
 - glucose transport 92–93
 - metabolic coupling 95
 - monocarboxylate transporters (MCTs) 94–95
- branched-chain ketoaciduria *see* maple syrup urine disease (MSUD)
- breast anatomy 377
- breastfeeding 409
 - benefits for infant 336, 390, 393–5
 - body composition 393
 - chronic pediatric disease 394
 - gastrointestinal function 393
 - morbidity and mortality 393–4
 - necrotizing enterocolitis protection 394, 483
 - neurobehavioral aspects 394–5
- benefits for mother 395
- contraindications 395
- economic impact 395–6
- preterm infants 657–8, 659
 - supplementation 659
- see also* human milk; lactation
- bronchopulmonary dysplasia (BPD) 522, 530
 - growth and nutrition following hospital discharge 528–9
 - body composition 528–9
 - bone mass 529
 - long-term growth outcomes 529–30
 - weight and length growth 528
- growth failure in early life 522, 525–6, 530
 - dexamethasone therapy 526
 - energy needs 525–6
 - growth promotion 394, 526–8
- iron overload and 296
- nutrient supplementation therapy
 - lung function improvement 523–5
 - vitamin A 165, 524–5
 - vitamin E 169
- oxidative stress 522
- prevention 522–3, 524
 - antioxidant enzymes 523
 - inositol 523–4
 - N-acetylcysteine 523
 - selenium 523
 - vitamin E 523
- water balance abnormalities 108–9
- brush border membrane (BBM), fatty acid uptake 360
- butyric acid 345
- calbindins 213
 - fetal 213
 - placental 213–4
- calcitonin (CT) 208
 - fetal 214
- calcitonin gene-related peptide (CGRP) 208
 - during pregnancy 210
- calcitriol 209
 - during lactation 210
- calcium binding proteins (CaBP) 213
 - placental 213–4
- calcium (Ca) 185, 215–16
 - absorption 257
 - lactose effects 344–5, 422
 - deficiency, rickets and 246–7
 - see also* hypocalcemia
 - disorders of homeostasis 229–38
 - maternal hypercalcemia 234–5
 - maternal hypocalcemia 229–30
 - neonatal hypercalcemia 235–8
 - neonatal hypocalcemia 230–4
 - during lactation 211–2, 215–16
 - during pregnancy 209–10, 215–16
 - enteral nutrition requirements 255
 - human milk fortification 257, 403
 - fetal 212–3, 214
 - hormonal regulation
 - calcitonin 208
 - calcitonin gene-related peptide (CGRP) 208
 - parathyroid hormone 206
 - parathyroid hormone-related peptide 207–8
 - in formulas 252, 257, 258
 - preterm formula 420–1
 - in human milk 391–2
 - fortification for preterm infants 257, 403
 - laboratory assessment 589
 - parenteral nutrition requirements 254–6, 320–1
 - peak bone mass and 192, 193, 205–6
 - placental transport 213
 - serum concentrations 187
 - during pregnancy 209–10
 - total body content 185, 193–4
- calorimetry
 - direct 134, 610
 - doubly labeled water technique 135, 613–14, 627
 - indirect 134–5, 610–13
 - practical limitations 611–3
 - requirements for 611–2
 - theoretical limitations 610
 - infrared thermographic technique 135–6, 614–15
- capsases 99
- carbamoyl-phosphate synthetase (CPS) deficiency 560
- carbohydrates 340
 - assimilation 340
 - fetal development 342

- digestion 69
 - fetal development 342
 - postnatal development 342
- fermentation
 - lactose 343–4
 - significance of 345
- in formulas
 - cow's milk-based term formula 415
 - dietary supplements 427
 - for short bowel syndrome 497
 - preterm infant formulas 342–3, 419
- in milk 341–2, 391
 - differences between cow's and human milk 413
- metabolism 620–4
 - development related to nutritional environment 76–78
 - disorders of *see* galactosemia; type I glycogen storage disease
 - glycogen 123–4
 - measurement 620–4
 - postnatal nutrition influence on subsequent health 633
 - see also* glucose; insulin; lactose
- cardiac physiology 534–5
- cardiovascular disorders, infants of diabetic mothers 471–2
 - see also* congenital heart disease (CHD)
- carnitine 592
 - isovaleric acidemia management 556
 - laboratory assessment 592
 - methylmalonic/propionic acidemia management 558
 - parenteral nutrition and 320, 573
 - urea cycle disorders and 562
- casein 412, 413–15
- catch-down growth 641
- catch-up growth 47–48, 641–2, 654
 - correlates of 644
 - health implications of 647–50
- cathepsins, role in bone resorption 204–5
- catheter related sepsis 372, 496, 575
- cell volume regulation 104
- cerebral blood flow (CBF), hypoglycemia response 459–60
 - see also* brain
- cholecystokinin 577
- cholestasis 303
 - parenteral nutrition and 324, 576–7
 - prevention 577
 - risk factors 576
 - short bowel syndrome and 502–3
- cholesterol 350
 - in human milk 352
 - postnatal nutrition influence on subsequent health 632–3
- cholestipol 499
- cholestyramine 499
- choline 299–300
 - biological functions 299
 - deficiency 300
 - in formulas 299–300
 - in human milk 299–300
 - role in brain development 300
- chromatin 636
 - structural alterations 636–7
- chromium 286–7
 - deficiency 286
- chylomicron assembly 362–4
- cisapride 451
- citrullinemia 560
- CLCN5 gene mutations 239
- clonal selection 635
- cobalamin *see* vitamin B12
- cognitive development
 - breastfeeding benefits 394
 - hypoglycemia consequences 459–60
 - infants of diabetic mothers 477–8
 - iron deficiency effects 295
 - long chain polyunsaturated fatty acid role 152–5, 416–17
- cold injury 60–61
 - clinical interventions 62–64
 - basic measures 62–63
 - rewarming strategy 63
 - clinical signs and sequelae 60–61
 - risk factors 60
- cold response, neonate 59, 60
- collagen pyridinoline cross-linking amino acids 199
- conditionally essential nutrients 299
 - see also specific nutrients*
- congenital anomalies, infants of diabetic mothers 470–2
 - pathogenesis 471
- congenital heart disease (CHD) 533–6
 - cellular and molecular changes 538
 - feeding difficulties 536–7
 - growth and 533–4, 541
 - etiology of growth failure 535, 536–7
 - management issues 540–1
 - metabolic alterations 536
 - nasogastric feeding benefits 540
 - necrotizing enterocolitis and 538–40
 - normal cardiac physiology 534–5
 - nutrient losses 537–8
 - nutritional assessment 540
 - nutritional regimen 541
 - pathophysiology 535
 - acyanotic CHD 535
 - cyanotic CHD 535
- cooling as cerebro-protective strategy 64
- copper 281–3
 - biological role 281
 - deficiency 282
 - diagnosis 283
 - metabolism 281–2
 - requirements 283
 - toxicity 283
- cortisol, role in milk production 386

- cow's milk-based preterm formula 417–8, 421
 carbohydrate 419
 indications for use 421
 lipids 419–20
 arachidonic acid 420
 docosahexaenoic acid 420
 minerals 420–1
 post-discharge formula 421–2
 indications for use 422
 protein 417–9
 see also formulas
 cow's milk-based term formula 413–7
 carbohydrate 415
 indications for use 417–21
 iron 417
 lipids 415
 arachidonic acid (ARA) 416–7
 docosahexaenoic acid (DHA) 416–7
 protein 406
 see also formulas
 cretinism, endemic 284
 critically ill infants 571
 glutamine and 574
 hypocalcemia 232
 lack of nutritional support 369–70
 see also neonatal surgical patients; parenteral nutrition
 crown-heel length (CHL) 49
 Cyclinex 1 561
 cysteine 317–8, 335–6, 418–19
 acute respiratory disease and 513
 cytokines 71
- dendritic cells 71
 dental caries 285
 Dent's disease 239
 deuterium oxide method 622–3
 dexamethasone, growth failure and 526
 diabetes
 breastfeeding benefits 394
 classification of diabetes in pregnancy 467
 early nutrition relationships 634
 cow's milk-based formulas 426, 634
 gestational 24
 bone metabolism and 200
 nutritional factors 25
 hypomagnesemia and 241
 permanent neonatal diabetes (PNDM) 461
 placental development and function 39
 amino acid transport 39
 glucose transport 39
 transient neonatal diabetes (TNDM) 461
 see also glucose; hyperglycemia; infants of diabetic mothers (IDM)
 diet-induced thermogenesis (DIT) 136
 dietary intake *see* feeding
- dietary supplements 427, 428
 carbohydrate 427
 fat 427–9
 protein 429
 see also nutrient supplementation
 digestion *see* gastrointestinal tract
 direct calorimetry 134, 610
 diuresis, in respiratory distress syndrome 108–9
 DNA methylation 637
 docosahexaenoic acid (DHA) 8, 27, 149–50, 157
 adverse effects 155–7
 in formulas
 cow's milk-based term formula 416–7
 preterm formula 420
 in human milk 352, 353, 354, 391
 lung surfactant synthesis and 509–10
 role in cognitive/behavioral development 153–5
 role in visual function 150–2, 416
 doubly labeled water technique 135, 613–14, 627
 dual energy X-ray absorptiometry (DEXA) 51–52, 194–5, 589
 use in body composition assessment 604, 605–6
 duodeno-gastric reflux (DGR) 445
 management 450
 see also gastrointestinal reflux (GIR)
 duodeno-gastroesophageal reflux (DGER) 445
 management 450
 see also gastrointestinal reflux (GIR)
- E-selectin 373
 early weight loss 47–48
 edema 105
 in respiratory distress syndrome 108
 electrolytes
 disturbances in extremely low birth weight infants 109–11
 avoidance strategy 111
 hyperosmolar state 109–10
 hyponatremia 110–1
 in parenteral nutrition 320
 laboratory assessment 588
 electroretinography 151
 endemic cretinism 284
 endoscopy, gastrointestinal reflux evaluation 450
 endotoxin, in necrotizing enterocolitis 485–7
 energy 134
 digestible energy 134
 metabolizable energy 134
 see also carbohydrates; glucose
 energy balance 134, 609
 measurement of 609
 direct calorimetry 610
 doubly labeled water technique 613–4
 energy expenditure 610
 energy intake 609–10
 heart rate variability 615
 indirect calorimetry 610–3

- infrared thermographic calorimetry 614–5
- labeled sodium bicarbonate 614
- parenteral nutrition and 513–4, 572–3
 - intravenous lipid emulsion effect 514–5
- protein–energy metabolism and balance 139, 318–19, 513–14
- see also* energy expenditure; energy intake; energy requirement
- energy expenditure 570
 - congenital heart disease effects 536
 - differences between term and preterm infants 441–2
 - influencing factors 136–8
 - age 136
 - clinical status 137
 - dietary intake 136
 - energy cost of growth 138
 - environmental temperature 137
 - physical activity 136–7
 - size for gestational age 137
 - measurement 134–6, 610, 627
 - direct calorimetry 610
 - doubly labeled water technique 613–4, 627
 - heart rate variability 615
 - indirect calorimetry 610–3
 - infrared thermographic calorimetry 614–5
 - labeled sodium bicarbonate 614
 - operative trauma effects 570–1
 - very low birth weight infants 511–2
- see also* energy balance
- energy intake 340
 - congenital heart disease and 536–7, 540, 541
 - effect on nitrogen balance 139–42
 - lung development and 508–9
 - measurement of 609–10
 - parenteral nutrition 318–9
 - with acute respiratory disease 511–2
 - preterm infants 52–53, 139
- see also* energy balance
- energy requirement 134
 - neonates 134, 569–70
 - term infants 138–9
 - with bronchopulmonary dysplasia 525–6
- preterm infants 139–42
- see also* energy balance
- enteral nutrition (EN) 255, 257–9
 - clinical perspectives 336–7
 - intake assessment 588
 - minimal enteral nutrition 373–5
 - composition 374
 - definition and purpose 373–4
 - methods of delivery 374
 - surgical patients 578–9
 - with parenteral nutrition 326, 578–9
 - preterm infants 336–7
 - lack of 369–70
 - problems with 370–1
 - necrotizing enterocolitis 369, 371, 482–3
 - transition to 370–1
 - problems with lack of 371–3
 - gastrointestinal hormone secretion 371–2
 - intestinal inflammation 372–3
 - loss of mucosal mass 371
 - sepsis 372
 - vascular inflammatory responses 373
 - reasons to withhold 369, 370
 - short bowel syndrome and 496–9
 - surgical patients 578–80
 - administration 579–80
 - benefits of 578
 - complications 580
 - feeding routes 579
 - selection of feeds 579
 - see also* feeding; formulas; human milk
- Enterobacter sakazakii* 429
- enteroglucagon 494
- epidermal growth factor (EGF), amniotic fluid 13
- epigenetic mechanisms 25
- epinephrine, in infants of diabetic mothers 477
- erythromycin 451
- essential fatty acids *see* fatty acids
- estrogen, bone mass regulation 189–91, 193
- exercise, bone mineral density and 193
- extracellular water (ECW) spaces 104
 - interstitial and plasma compartments 105
 - oncotic pressure 105
 - Starling's equilibrium 105
 - regulation in neonate 105–7
- extraembryonic coelom 3–4
- extremely low birth weight (ELBW) infants
 - bronchopulmonary dysplasia risk 522
 - see also* bronchopulmonary dysplasia (BPD)
- electrolyte disturbances
 - avoidance strategy 111
 - hyperosmolar state 109–10
 - hyponatremia 110–1
- see also* neonate; preterm infants; very low birth weight (VLBW) infants
- Fagan Test of Infant Intelligence 152–3
- familial hypocalciuric hypercalcemia (FHH) 236, 243
- fat necrosis 237
- fats *see* fatty acids; lipids
- fatty acid binding protein (FABP) 8, 360–1
- fatty acids 147, 350, 351
 - essential fatty acids 147–9
 - deficiency 148
 - dietary requirements 148–9
 - in formulas 148–9, 352–4
 - in milk 149, 350–4, 381, 391
 - differences between cow's and human milk 412

- fatty acids (*cont.*)
 long chain polyunsaturated fatty acids (LC-PUFA) 8, 147–8,
 149–57
 adverse effects 155–7
 role in cognitive/behavioral development 152–5
 role in visual function 150–2, 416
 metabolism 8–9, 626
 following birth 617
 measurement 626
 placental transfer 8–9
see also lipids
 naming 147
 parenteral nutrition requirements 319–20
 polyunsaturated fatty acids (PUFA) 8, 27
 antioxidant capacity and 26–27
 re-esterification 361–2
 pathways 361
 role in immune function 72–73
 short chain fatty acids (SCFA) 340–1, 345
 transport within enterocyte 360–1
 uptake at brush border membrane 360
see also lipids
 feces, measurement of energy losses 609–10
 feed thickeners 450
 feeding
 dietary intake effect on energy expenditure 136
 difficulties, with congenital heart disease 536–7
 preterm infants, complementary foods 54–55
 protein accretion relationships 116–8
 tolerance 371
 human milk fortifiers and 405
see also enteral nutrition; formulas; human milk; parenteral
 nutrition
 Fenton reaction 295
 fermentation, of carbohydrates
 lactose 343–4
 significance of 345
 ferritin assessment 593
 fetal growth *see* intrauterine growth
 fetal growth factors 9–10, 28
 amniotic fluid 13
 insulin-like growth factors (IGF) 9–10, 28
 IGF-I 9, 28
 IGF-II 9–10
see also hormones
 fetal nutrition 1, 27
 after placentaion is established 4–9
 amino acid metabolism 7–8, 27
 fatty acid metabolism 8–9
 glucose metabolism 6–7, 122–4, 342
 lactate metabolism 7
 oxygen consumption 4–6
 before placentaion 3–4
 significance of early nutritional factors 4
 fetal growth factors and 9–10
 maternal nutrition influence 1–3, 76–8, 79, 81–2
 global caloric restriction 80–81
 protein restriction 78–79
 metabolic capacity development and 76–77
 metabolic programming 76–78, 81–2
 animal models 78–81
 global caloric restriction 80–81
 maternal protein restriction 78–80
 mineral homeostasis 212–3
 paraplacental routes 11–13
 placenta and 10
 response to reduction in substrate supply 10–11
 fetal origins hypothesis 77–78
 fetal programming 23
 Fick principle 4
 flavin adenine dinucleotide (FAD) 173
 flavin mononucleotide (FMN) 173
 fluid balance *see* water balance
 fluoride 285
 fluoroscopy studies 449
 folate
 birth weight relationships 2–3, 175–6
 deficiency 175–6
 in human milk 175
 neonatal requirements 175
 status assessment 176
 follow-up formulas 426–7
 indications for use 427
 formulas 333, 336, 409, 655, 659
 amino acid supplementation 117
 arginine content 304
 bronchopulmonary dysplasia and 525, 526–8
 carbohydrate content 342–3, 415, 419
 choice of 413
 for short bowel syndrome 498
 form of formula 429
 choline content 299–300
 compositional differences between cow's and human milk 410,
 412–13
 carbohydrate 413
 lipid 412
 mineral 413
 protein 412
 congenital heart disease management 541
 evaporated milk formulas 411
 fatty acid content 148–9, 157
 adverse effects of supplementation 155–7
 cognitive/behavioral development and 152–5
 long chain polyunsaturated fatty acids 149–50
 visual acuity and 151–2, 416
 federal regulations 429–30
 follow-up formulas 426–7
 indications for use 427
 history of formula feeding 410–1
 inborn errors of metabolism management 544–8

- increasing the nutrient density 430
 - osmolality and 430
- inositol content 301
- lactose-free formulas 422–3
 - indications for use 423
- lipid content 352–4, 415, 419–20
 - arachidonic acid (ARA) 416–7, 420
 - docosahexaenoic acid (DHA) 416–7, 420
- mineral content 252, 257–9, 420–1
 - iron 417
- minimal enteral feeding 374
- models used in formula development 411–2
 - preterm infants 411–2
 - term infants 411
- modular formulations 427, 428
 - carbohydrate 427
 - fat 427–9
 - protein 429
- prebiotics 73
- preterm infant formulas 257–9, 411–12, 419, 655–7, 659
 - carbohydrate content 342–3, 419
 - cow's milk-based 417–8, 419, 421–2
 - growth and 52, 53–4, 55, 257, 655–6
 - iron content 276
 - lactose responses 342–3
 - lipid content 419–20
 - metabolic bone disease prevention 251–4
 - mineral content 420–1
 - post-discharge formula 421–2
 - small-for-gestational-age infants 658
 - studies of formula-fed infants 655–7
- protein content 413–5, 417–19
- protein hydrolysate-based formulas 423, 425–6
 - indications for use 425–6
- protein–energy balance 141–2
- rates of usage 409
- short bowel syndrome and 497–8
- soy-based formulas
 - indications for use 424
 - phytoestrogen concerns 424
- specialized formulations 427
- taurine content 302, 303
- vitamin content 163
 - biotin 176
 - folate 175
 - niacin 176
 - pantothenic acid 177
 - vitamin A 162–5
 - vitamin B1 (thiamine) 172
 - vitamin B2 (riboflavin) 173
 - vitamin B6 (pyridoxine) 174
 - vitamin B12 (cobalamin) 175
 - vitamin C 177
 - vitamin E 167–8
 - vitamin K 170
 - see also* feeding
- free radicals, parenteral nutrition and 577–8
- fructose metabolism disorders 462
- galactose 128, 345–6
- galactosemia 395, 461–2, 562–4
 - outcomes 562
 - presentation 562
 - therapy 562–4
- gas chromatography-combustion-mass spectrometry (GC-C-IRMS) 618
- gas chromatography-mass spectrometry (GCMS) 618
- gastric acid
 - gastroesophageal reflux and 446
 - secretion 70
- gastrin 495
- gastroenteritis, breastfeeding benefits 393
- gastroesophageal reflux (GER) *see* gastrointestinal reflux (GIR)
- gastrointestinal reflux (GIR) 445, 448
 - applied physiology 445–6
 - clinical presentation 448
 - differential diagnosis 448
 - evaluation 449–50
 - management 450–2
 - acid reduction strategies 451
 - avoidance of aggravating factors 450
 - dietary/feeding changes 450
 - posture 450
 - prokinetic agents 451
 - surgical treatment 451
 - thickening agents 450
- pathophysiology 446
- protective mechanisms 446
- significance of 445
- gastrointestinal tract
 - adaptation to small bowel resection 494–6
 - intestinal dilation and transit time 495–6
 - intestinal hypertrophy and hyperplasia 494–5
 - residual bowel length 496
- blood flow 534–5
 - regulation 485
- digestive function development 11–12, 67–70
 - breastfeeding benefits 393
 - carbohydrate digestion 69
 - gastrointestinal hormones and peptides 67–68, 371–2
 - lipid digestion 69
 - liver 68
 - milk components affecting 392
 - mucosal differentiation 67
 - pancreas 68
 - protein digestion 69
 - role of nutrients 69–70
- digestive function distribution 492–4
- diseases of, bone mass and 196–7

- gastrointestinal tract (*cont.*)
 see also gastrointestinal reflux (GIR); necrotizing enterocolitis (NEC); short bowel syndrome (SBS)
 glutamine effects 305
 immune function 70–73
 gut flora 70
 immune system 71
 innate immune system 70–71
 role of enteral nutrients 71–73, 372–3
 length of 492
 see also short bowel syndrome (SBS)
 malabsorption in congenital heart disease 537–8
 nucleotide role 306
 parenteral nutrition effects 323–4
 preterm infants
 bacterial colonization 484–5
 motility 484
 protein metabolism 118
 see also enteral nutrition
 genetic conflict hypothesis 25
 genetic factors in fetal growth 1, 25
 genomic imprinting 25
 relevance in ART pregnancies 25
 gestational age
 bone turnover and 200–1
 estimation 24, 48–9
 size for gestational age
 energy expenditure relationship 137
 gestational diabetes 24
 bone metabolism and 200
 nutritional factors 25
 see also diabetes; infants of diabetic mothers (IDM)
 ghrelin 10
 Gibbs-Donnan equilibrium 105
 Gitelman syndrome (GS) 241
 glomerular filtration development 106
 glucagon
 changes at birth 125–6
 enteroglucagon 494
 proglucagon
 glucocorticoids *see* steroids
 gluconeogenesis (GNG) 126–9
 differences between term and preterm infants 440–1
 glucose-6-phosphatase (G6P) 127–8
 measurement 620–4
 [2-¹³C]glycerol MIDA 622, 623–4
 deuterium oxide method 622–3
 [U-¹³]glucose MIDA 621–2, 623–4
 phosphoenol pyruvate carboxykinase (PEPCK) 126–7
 pyruvate carboxylase (PC) 126
 substrates 128
 alanine 129
 glycerol 128
 lactate 129
 pyruvate 128–9
 glucose 340, 590–2
 absorption 344
 amniotic supplementation 12
 disorders of homeostasis 454
 see also diabetes; hyperglycemia; hypoglycemia
 in parenteral nutrition 572, 573
 respiratory disease and 513–4
 in preterm infant formulas 419
 measurement 454–5, 590–2
 metabolism 6–7, 124–9, 340–1, 620–4
 brain 91, 92, 100, 341, 617
 differences between term and preterm infants 439–41
 during cold injury 61
 fetal 122–4
 gluconeogenesis development and regulation 126–9
 glycogen mobilization 125–6
 infants of diabetic mothers 469–70, 477
 measurement 620–4
 placental 6, 10
 postnatal nutrition influence on subsequent health 633
 regulation 96–97
 oligosaccharide digestion 342
 placental transfer 6–7, 122–3, 617
 alterations in IUGR 36–37
 in diabetic pregnancies 39
 tolerance
 maternal protein restriction effects 80
 parenteral nutrition 321–2
 see also diabetes; insulin
 transport
 across the placenta 6–7, 36–7, 122–3, 617
 alterations in IUGR 36–37
 glucose transporters (GLUT) 6–7, 36–7, 92–3, 122–3
 into brain 92–93
 see also carbohydrates; hyperglycemia; hypoglycemia
 glucose transporters (GLUT) 6–7, 36–7, 92–3, 122–3
 glucose-6-phosphatase (G6P) 123, 127–8
 deficiency *see* type I glycogen storage disease (GSD)
 glucosensing neurons 97
 glutamine 305–6, 574
 critical illness and sepsis effects 574
 gastrointestinal effects 305
 in human milk 333–5
 in parenteral nutrition 318, 574
 role in immune function 71–72, 305
 supplementation for preterm infants 305–6
 glutamine-glutamate placenta-hepatic shuttle 8
 glutaric acidemia type I (GA1) 558–9
 therapy 559
 glutaryl-CoA dehydrogenase deficiency 558
 glutathione peroxidase (GSHPx) 280
 selenium deficiency diagnosis 280–1
 glycerides 350
 glycerol 128, 617
 metabolism measurement 626

- glycine
 deficiency 2, 3
 isovaleric acidemia management 556
 glycine-serine placenta-hepatic shuttle 8
 glycogen metabolism
 fetus 123–4
 hormonal regulation 124
 mobilization 124
 glycogen stores at birth 124–5
 mobilization 125–6
 see also type I glycogen storage disease (GSD)
 glycogen phosphorylase (GP) 124, 125
 glycogen synthase (GS) 125
 glycogenin 123–4
 goblet cells 70–71
 growth *see* intrauterine growth; neonate; preterm infants
 growth charts/curves 596–7, 641
 intrauterine growth curves 23–24, 33, 48–9
 growth factors
 intestinal resection and 495
 see also fetal growth factors
 growth hormone 10
 bone mass and 193
 congenital heart disease management 538
 intestinal resection and 495
 gut atresia 12
 gut flora 70
 necrotizing enterocolitis and 484–5
 preterm infants 484–5
 gut-associated lymphoid tissue (GALT) 372
- H2 blockers 451, 499
 head circumference 596
 heart rate variability 615
 heat response, neonate 60
 see also hyperthermia
 hemochromatosis 293
 hemolytic anemia of prematurity 168
 hemorrhage, iron deficiency and 293
 heparin, effects on bone 197
 hepatic development *see* liver
 hepatic rickets 245
 histone modification 636–7
 HIV, breastfeeding and 395
 homocystinuria (HCU) 554–5
 pyridoxine responsiveness 554–5
 screening 554
 therapy 554–5
 hormones
 bone mass regulation 189, 193
 bone remodeling regulation 203–6
 fetal growth regulation 28
 bone growth 192
 growth hormone 28
 insulin 9
 leptin 10, 28
 placental growth hormone (PGH) 28
 thyroid hormones 10
 see also fetal growth factors
 gastrointestinal 67–68
 effects of lack of enteral feeding 371–2
 glucose metabolism regulation 96
 glycogen synthesis 124
 hypoglycemia responses 458
 lactation initiation 385–6
 mineral metabolism regulation 206–16
 calcitonin (CT) 208
 calcitonin gene-related peptide (CGRP) 208
 parathyroid hormone (PTH) 206
 parathyroid hormone-related peptide (PTHrP) 206–8
 water balance regulation 107
 arginine vasopressin (AVP) 107
 atrial natriuretic peptide (ANP) 107–8
 kallikrein and bradykinins 108
 prostaglandin-E 108
 renin, angiotensin and aldosterone 107
 see also specific hormones
 host defense *see* immune function
 human milk 332, 333
 amino acid content 333–5
 bile salt-dependent lipase (BSDL) 356, 359–60
 carbohydrate content 341–2, 391
 choline content 299–300
 composition 377–8, 390–3, 655, 659
 changes at initiation of lactation 384–5
 components affecting gastrointestinal function 392
 components affecting host defense 392–3
 differences from cow's milk 410, 412–13
 nutritional aspects 390
 preterm milk 401, 402
 variability 402–3
 deficiencies for preterm infants 249, 257, 401, 403
 growth and 52, 403
 metabolic bone disease and 249, 251
 mineral status 403
 protein status 403
 ejection 383–4
 ‘let down reflex’ 377, 382
 fortification for preterm infants 251–4, 257, 403–4
 fortifier compositions 404
 in-hospital feeding practices 406
 methods 406
 non-nutritional outcomes 405–6
 reformulations of human milk fortifiers 404–5
 inositol content 301
 lipid content 149, 350–4, 381, 391
 formula comparison 352–4
 influences 354
 lipid synthesis 379–80
 long chain polyunsaturated fatty acids 149–50

- human milk (*cont.*)
 - mineral content 391–2
 - minimal enteral feeding 374
 - nucleotide content 306, 392
 - parathyroid hormone-related peptide 207
 - preterm availability 401–2
 - protein (nitrogen) content 390–1
 - secretion of *see* lactation
 - superiority of 336
 - vitamin content 162, 392
 - biotin 176
 - folate 175
 - niacin 176
 - pantothenic acid 177
 - vitamin A 162
 - vitamin B1 (thiamine) 172
 - vitamin B2 (riboflavin) 173
 - vitamin B6 (pyridoxine) 174
 - vitamin B12 (cobalamin) 175
 - vitamin C (ascorbic acid) 177
 - vitamin D 392
 - vitamin E 166–7
 - vitamin K 170, 392
 - see also specific vitamins*
 - volume production 382–3
 - local regulation 383
 - see also* breastfeeding; feeding; formulas; lactation
- hydroxyproline 199, 200
- hyperammonemia *see* urea cycle disorders
- hyperbilirubinemia, infants of diabetic mothers 475–6
- hypercalcemia
 - causes 234, 235
 - maternal 234–5
 - neonatal 235–8
 - familial hypocalciuric hypercalcemia (FHH) 236, 243
 - hyperparathyroidism and 235–6
 - treatment 237–8
 - see also* calcium
- hyperglycemia 454, 460–1
 - consequences 461
 - macrosomia and 38, 39
 - management 461
 - parenteral nutrition and 575
 - placental effects 39
 - see also* diabetes; glucose
- hyperinsulinemia 456
 - fetal 468
 - macrosomia and 39–40, 468
 - hypoglycemia and 456–7
 - hyperinsulinemic hypoglycemia (HIHG) 457, 459–60
 - transient hyperinsulinemia 456–7
 - infants of diabetic mothers 468
 - see also* hypoglycemia; insulin
- hypermagnesemia 242–4
 - treatment 243–4
 - see also* magnesium
- hybern timers, extremely low birth weight infants 109
 - avoidance strategy 111
 - see also* sodium balance
- hyperosmolar state, extremely low birth weight infants 109–10
- hyperparathyroidism
 - maternal
 - hypercalcemia and 232, 234
 - magnesium balance and 242
 - neonatal 235–6
 - secondary 235
- hyperphosphatemia 239
 - see also* phosphorus
- hyperprostaglandin E syndrome (HPS) 236
- hypertension, maternal protein restriction effects 80
- hyperthermia 61–62
 - fetal 61
 - neonatal 61–62
- hypertrophic cardiomyopathy, infants of diabetic mothers 472
- hypocalcemia
 - causes 229, 230
 - maternal 229–30
 - neonatal 230–4
 - critically ill infants 232
 - early-onset 231–2, 233
 - identification of 233
 - infants of diabetic mothers 231, 474–5
 - late-onset 232–3
 - preterm infants 231
 - treatment 233–4, 475
 - vitamin D deficiency and 232
 - see also* calcium
- hypoglycemia 454–60
 - brain responses to 96–98, 458–9
 - consequences 459–60
 - neuronal apoptosis/necrosis when adaptation fails 98–100
 - repeated hypoglycemia effects 98
 - synaptic adaptation 98
 - clinical presentation 454
 - definition 91–92, 455
 - etiology 455–6, 458
 - hyperinsulinemia and 456–7
 - hyperinsulinemic hypoglycemia (HIHG) 457, 459–60
 - transient hyperinsulinemia 456–7
 - identification of 454–5
 - incidence 454, 455
 - increased metabolic demand 457–8
 - infants of diabetic mothers 456–7, 468, 473–4
 - management 460, 475
 - physiological responses to 458
 - unusual causes 458
 - see also* glucose
- hypomagnesemia
 - diabetes and 241

- maternal, causes 240–1
- neonatal 240–2
 - familial 241
 - infants of diabetic mothers 475
 - management 242, 475
 - wasting diseases 241–2
- see also* magnesium
- hyponatremia, very/extremely low birth weight infants 110–1
 - avoidance strategy 111
 - see also* sodium balance
- hypoparathyroidism, neonatal 232
 - neonatal
 - hypomagnesemia and 242
- hypophosphatasia 236
- hypophosphatemia 238–9
 - causes 238
 - renal hypophosphatemic rickets 229, 232, 247
 - treatment 247
 - see also* phosphorus
- hypothermia *see* cold injury
- hypothyroidism, neonatal 236, 284–5
- hypoxia
 - during hypothermia 61
 - IUGR and
 - post placental hypoxia 35–36
 - pre-placental hypoxia 35
 - utero-placental hypoxia 35
- immune function
 - gastrointestinal tract 70–73
 - gut flora 70
 - immune system 71
 - innate immune system 70–71
 - role of enteral nutrients 71–73, 372–3
- human milk fortifiers and 405–6
- milk components affecting 392–3
- necrotizing enterocolitis and 484
- nucleotide role 306–7
- preterm infants 70, 484
- inborn errors of metabolism 544
 - effects of 546
 - nutrition management 544
 - nutritional support 545, 546–7, 548
 - pathophysiology 546
 - symptoms 546
 - see also specific disorders*
- incubators 62–63
 - humidity requirements 63
- indirect calorimetry 134–5, 610–13
 - practical limitations 611–3
 - requirements for 611–2
 - theoretical limitations 610
- indomethacin 108, 516
- infant formulas *see* formulas
- infants of diabetic mothers (IDM) 81, 466
 - bone properties 199, 200–1, 210, 231
 - cognitive development 477–8
 - congenital anomalies 470–2
 - cardiovascular malformations 471–2
 - pathogenesis 471
 - hyperbilirubinemia 475–6
 - hypocalcemia 231, 474–5
 - hypoglycemia 456–7, 468, 473–4
 - hypomagnesemia 475
 - ineffective erythropoiesis 476
 - iron deficiency 292–3
 - long-term prognosis 477–8
 - macrosomia 38, 468, 472–3
 - birth injury and asphyxia 472–3
 - fetal hyperinsulinemia and 468
 - hormonal environment 39–40
 - insulin prophylaxis 467
 - management 474
 - metabolic analyses 469–70, 477
 - pathogenesis of maternal diabetes effects on fetus 468
 - perinatal mortality and morbidity 466–8
 - polycythemia 476
 - renal vein thrombosis 476–7
 - respiratory distress syndrome 473
 - symptoms 474
 - see also* diabetes
- inflammation
 - in necrotizing enterocolitis 485–6
 - lack of enteral feeding and 372–3
 - intestinal 372–3
 - vascular 373
- infrared thermographic calorimetry 135–6, 614–15
- innate immune system, gastrointestinal tract 70–71
- inositol 300–1
 - bronchopulmonary dysplasia prevention 523–4
 - in formulas 301
 - in human milk 301
 - lung surfactant biosynthesis and 510
 - supplementation in preterm infants 301, 302
- insulin
 - changes at birth 125–6
 - fetal growth and 9
 - fetal response to glucose 38–39
 - glucose regulation 96
 - glycogen synthesis regulation 124
 - macrosomia prevention 467
 - metabolic programming effects
 - caloric redistribution during suckling period and 82, 83–4
 - consequences of diabetes during pregnancy 81
 - litter size manipulation studies 82, 633
 - maternal protein restriction effects 78, 79–80
 - potential mechanisms 86
 - parenteral nutrition and 321–2
 - see also* hyperinsulinemia
- insulin dependent diabetes mellitus (IDDM) *see* diabetes

- insulin-like growth factors (IGF) 9–10, 28, 595
 - amniotic fluid 13
 - congenital heart disease and 538
 - glycogen synthesis regulation 124
 - IGF-I 9, 28, 595
 - laboratory assessment 594–7
 - role in bone regulation 188, 193, 203
 - IGF-II 9–10
 - intestinal resection and 495
 - laboratory assessment 595
 - macrosomia and 40
- intestine *see* gastrointestinal tract
- intracellular water (ICW) spaces 104
 - cell volume regulation 104
- intrauterine growth 1, 23–4, 28
 - bone 190–1
 - fetal movement and 190–1, 248–9
 - congenital heart disease and 533
 - definitions of normal and abnormal growth 23–24
 - determinants of 24–28
 - genetic factors 1, 25
 - hormones 28
 - excess intrauterine growth 24
 - growth rates 33–34
 - macrosomia and 39
 - nutritional factors 25–27
 - fetal nutrition 27
 - maternal nutrition 1–3, 26–7
 - placental function 5, 27
 - response to maternal fasting 10–11
 - preterm infants 49
 - reference standards 48–51
 - significance of early nutritional factors 4
 - twin pregnancies 4
 - see also* birth weight; intrauterine growth restriction (IUGR)
- intrauterine growth curves 23–24, 33, 48–9
- intrauterine growth restriction (IUGR) 24, 32–8
 - cold injury risk 60
 - definition 24
 - hypoglycemia and 455–6
 - nutritional factors 25
 - placental nutrient transfer alterations 36–38
 - glucose transporters and 36–37
 - placental vasculature development 34–36
 - oxygen and angiogenic development 34–35
 - post-placental hypoxia 35–36
 - pre-placental hypoxia 35
 - utero-placental hypoxia and preeclampsia 35
 - significance for later life 77–78
 - symmetrical and asymmetrical IUGR 34
 - see also* intrauterine growth
- intravenous feeding *see* parenteral nutrition
- iodide 284–5
 - biological role 284
 - deficiency 284
- cretinism 284
 - maternal 284
 - neonatal hypothyroidism 284–5
- metabolism 284
- requirements 285
- toxicity 285
- iron 275–6, 291
 - balance 291–3
 - overload 293, 294, 295–6
 - postnatal 292, 293–4
 - preterm infants 293–4
 - biological role 275
 - deficiency 26, 275, 291–3
 - anemia 275
 - assessment 592–3, 594
 - maternal 291–2
 - potential consequences 294–5
 - preterm infants 295
 - in cow's milk-based term formula 417
 - in human milk 392
 - laboratory assessment 592–3
 - metabolism 275
 - requirements 276, 296
 - preterm infants 276, 296
 - short bowel syndrome and 498
 - supplementation in preterm infants 294
 - toxicity 275–6, 294, 296
- isoflavones 424
- isotope ratio mass spectrometry (IRMS) 619
- isovaleric acidemia 555–6
 - therapy 556
- kallikrein 108
- kangaroo care 63
- Keshan disease 280
- ketone bodies 93–94
 - metabolism measurement 626
 - monocarboxylate transporters (MCTs) 94
- ketotic hyperglycinemia *see* methylmalonic acidemia; propionic acidemia
- kidney, neonatal 106–7
 - distal tubule and collecting system development 106
 - extracellular water regulation 105–7
 - glomerular filtration development 106
 - potassium balance 107
 - proximal tubular development 106
 - sodium balance 106–7
- knee-heel length (KHL) 49
- lactate metabolism 7, 94, 129
 - lipid synthesis 379–80
 - monocarboxylate transporters (MCTs) 94–95
 - see also* lactose
- lactate transporters 7
- lactation 377

- bone loss and 207–8, 211–12
- calcitriol concentrations 210
- initiation of 384–6
 - changes in milk composition 384–5
 - hormonal requirements 385–6
 - milk transfer to infant during secretory activation 384
- milk secretion 377, 379–84
 - delay in onset 386
 - exocytosis 379
 - lipids 379, 380
 - paracellular pathway role 381
 - regulation 382–4
 - secretory activation 384, 386
 - secretory differentiation 384
 - transcytosis of interstitial molecules 380–1
 - transport across apical membrane 380
- milk volume production 382–3
 - local regulation 383
- parathyroid hormone-related peptide and 207–8
- prolactin secretion 383
 - see also* breastfeeding; human milk
- lactic acidosis 566
 - during hypothermia 61
- lactoferrin 392
- lactose
 - calcium absorption and 344–5, 422
 - digestion 69, 343–4
 - versus fermentation 343–4
 - in human milk 341–2, 391
 - intolerance 419, 423, 461
 - preterm infant formulas 419
 - preterm infant responses to 342–3
 - see also* lactate metabolism
- lactose-free formulas 422–3
 - indications for use 423
 - see also* soy-based formulas
- large for gestational age (LGA) 24
- length 596
- leptin 10, 28
 - bone metabolism relationships 202, 203, 205
 - macrosomia and 40
- leucine
 - placental transfer in IUGR 38
 - tracer 624
- linoleic acid (LA) 147–9
 - conversion to arachidonic acid 150
 - deficiency 148
 - dietary requirements 148–9
 - parenteral nutrition 320
 - dietary supplements 428
- linolenic acid *see* alpha-linolenic acid (ALA)
- lipases 69, 355
 - carboxylester (CEL) 358
 - gastric 355–7
 - ontogeny 356–7
 - lingual 355, 356
 - milk bile salt-dependent (BSDL) 356, 359–60
 - genetic organization 359
 - pancreatic colipase-dependent (CDL) 356, 357–8
 - pancreatic lipase-related proteins (PLRP1/PLRP2) 358–9
- lipid-binding proteins 361
- lipids 350, 589–90
 - absorption 360
 - digestion 69, 354–64
 - intestine 357–60
 - luminal phase 355
 - stomach 355–7
 - function 352
 - in formulas
 - cow's milk-based term formula 415
 - dietary supplements 427–9
 - for short bowel syndrome 497
 - preterm formulas 419–20
 - in milk 149, 350–4, 381, 391
 - comparison with formula 352–4
 - differences between cow's and human milk 412
 - influences 354
 - secretion 379, 380
 - variability 402–3
 - in parenteral nutrition 572
 - complications 323, 575–6
 - effect on energy metabolism 514–5
 - effect on lung function 515–6
 - improving tolerance 322
 - monitoring 325–6
 - requirements 319–20
 - tolerance 572–3
- laboratory assessment 589–90
- major lipids in infant nutrition 350
- metabolism 8–9, 626
 - development related to nutritional environment 76–78
 - following birth 617
 - measurement 626
 - placental transfer 8–9
- postnatal nutrition influence on subsequent health 632–3
- synthesis during lactation 379–80
 - see also* fatty acids
- lipolysis, intragastric 355–7
- lipoproteins 9
- liver
 - development 68
 - caloric redistribution during suckling period effects 84
 - maternal protein restriction effects 80
 - disease, short bowel syndrome and 502–3
 - glycogen store mobilization 124, 125–6
 - hepatic rickets 245
 - vitamin turnover
 - vitamin A 162
 - vitamin E 166–7

- long chain polyunsaturated fatty acids (LC-PUFA) 8, 147–8, 149–57
 - adverse effects 155–7
 - lung surfactant synthesis 509–10
 - role in cognitive/behavioral development 152–5
 - role in visual function 150–2, 416
- loperamide hydrochloride 499
- low-density lipoprotein (LDL) 9
- lower esophageal sphincter (LES) 446
 - gastroesophageal reflux and 446
 - LES pressure 446
- lung
 - defense mechanisms 510
 - development, nutritional status effects 508–9
 - connective tissue composition 509–10
 - surfactant synthesis 509–10
 - intravenous lipid emulsion effect on function 515–6
 - see also* bronchopulmonary dysplasia (BPD)
- M cells 70–71
- macrosomia 24, 32, 40, 468, 472–3
 - birth injury and asphyxia 472–3
 - fetal hyperinsulinemia and 39–40, 468
 - growth patterns 39
 - hormonal environment 39–40
 - insulin prophylaxis 467
- magnesium (Mg)
 - disorders of homeostasis 239–44
 - management 242, 243–4
 - maternal hypomagnesemia 240–1
 - neonatal hypermagnesemia 242–4
 - neonatal hypomagnesemia 240–2
 - enteral nutrition requirements 255
 - formula supplementation 252, 258
 - fetal 212–3
 - laboratory assessment 589
 - maternal supplementation 240
 - metabolism 185
 - parenteral nutrition requirements 254, 255, 256, 320
 - serum concentrations 187–8
 - total body content 185–7
- malabsorption, in congenital heart disease 537–8
- malaria, birth weight and 3
- malignant infantile osteopetrosis 232–3
- malnutrition, respiratory consequences
 - impact on lung development 508–9
 - respiratory muscles 510–1
 - surfactant synthesis 509–10
- mammary gland *see* breast anatomy; human milk; lactation
- manganese 285–6
 - deficiency 285, 286
 - metabolism 285–6
 - physiologic role 285
 - requirements 286
- manometry
 - esophageal 449–50
 - gastroduodenal 450
- maple syrup urine disease (MSUD) 552–4
 - therapy 552–4
 - variants 552
- mass isotope distribution analysis (MIDA)
 - [2-¹³C] glycerol MIDA 622, 623–4
 - [U-¹³] glucose MIDA 621–2, 623–4
- mast cells 71
- mastitis 381
- maternal nutrition 1
 - birth weight relationships 1–3
 - nutrient supplementation effects 1–2
 - fetal growth and 1–3, 26–7
 - response to maternal fasting 10–11
 - fetal nutrient supply and 1–3
 - glucose 122, 123
 - vitamin D 215
 - maternal immunity relationship 27
 - metabolic programming 76–78, 79
 - animal models 78–81, 82–5
 - global caloric restriction 80–81
 - maternal protein restriction 78–80
 - persistent effects in adult life 79
 - relevance to obesity and metabolic syndrome epidemic 86–87
 - mineral homeostasis disorders
 - hypercalcemia 234–5
 - hypocalcemia 229–30
 - hypomagnesemia 240–1
 - iron deficiency 275–6
- medical record review 586
- menaquinones 169, 170
 - see also* vitamin K
- Menke's Steely Hair Syndrome 282
- metabolic bone disease of prematurity (MBDP) 248–54
 - biomechanical factors 249–50
 - bone resorption 249
 - characteristics 249
 - management 254
 - prevention 251–4
 - see also* osteopenia; rickets
- metabolic coupling, brain 95
- metabolic differentiation 635–6
- metabolic programming 76–78, 79, 81–2
 - animal models 78–81, 82–5
 - caloric redistribution during suckling period 82–85
 - litter size manipulation 82, 633
 - diabetic pregnancies 81
 - maternal global caloric restriction 80–81
 - maternal protein restriction 78–80
 - immediate effects on fetus and neonate 78–79
 - persistent effects in adult life 79
 - postnatal period 82–83, 85, 631, 638
 - caloric redistribution during suckling period 82–85
 - see also* postnatal nutrition influence on subsequent health
 - potential mechanisms 86, 635
 - alterations in cell number 635

- chromatin structure alterations 636–7
 clonal selection 635
 DNA methylation 637
 metabolic differentiation 635–6
 regulatory pattern of DNA binding proteins 636
 relevance to obesity and metabolic syndrome epidemic 86–87
 metabolic rate *see* energy balance; energy expenditure
 metabolic research 617–20
 analytical principles 619–20
 carbohydrate metabolism 620–4
 lipid metabolism 626
 protein metabolism 624–5
 stable isotopes 618–9
 gas chromatography-combustion-mass spectrometry (GC-C-IRMS) 618
 gas chromatography-mass spectrometry (GCMS) 618
 isotope ratio mass spectrometry (IRMS) 619
 see also energy balance; energy expenditure
 metabolic syndrome, metabolic programming relevance 86–87
 metabolism 544–6
 see also inborn errors of metabolism
 methionine 2
 methylcobalamin 174
 see also vitamin B12 (cobalamin)
 3-methylhistidine (3-MH), urinary excretion quantification 115–6, 594
 methylmalonic acidemia 556–7
 diagnosis/presentation 557
 therapy 557–8
 metoclopramide 451
 microsomal triglyceride transfer protein (MTP) 361
 milk *see* formulas; human milk
 minerals
 bone mineral content (BMC) *see* bone
 disorders of homeostasis 229–44
 calcium 229–38
 magnesium 239–44
 phosphate 238–9
 see also specific minerals
 fetal 212–3
 vitamin D role 215
 hormonal regulation 206–16
 calcitonin (CT) 208
 calcitonin gene-related peptide (CGRP) 208
 parathyroid hormone (PTH) 206
 parathyroid hormone-related peptide (PTHrP) 206–8
 in formulas 252, 257–9
 preterm formula 420–1
 in milk 391–2
 differences between cow's and human milk 413
 fortification for preterm infants 403
 in parenteral nutrition 254–6, 315, 317, 320–1
 maternal 209–11
 metabolism 185
 short bowel syndrome and 498
 see also specific minerals
 minimal enteral nutrition 373–5
 composition 374
 definition and purpose 373–4
 methods of delivery 374
 surgical patients 578–9
 with parenteral nutrition 326, 578–9
 modular formulations 427, 428
 carbohydrate 427
 fat 427–9
 protein 429
 molybdenum 287
 monocarboxylate transporters (MCTs) 94–95
 mortality
 breastfeeding benefits 393–4
 infants of diabetic mothers 466–8
 short bowel syndrome 501
 mucosal addressin adhesion molecule-1 (MadCAM-1) 372
 mucus, protective function in gut 70
 myelination, long chain polyunsaturated fatty acid effects 155
 N-acetylcysteine (NAC), bronchopulmonary dysplasia prevention 523
 N-acetylglutamate synthetase (NAGS) deficiency 560
 N-telopeptides 199, 200–2
 nasogastric feeding, with congenital heart disease 540
 necrosis 98–99
 hypoglycemia and 100
 necrotizing enterocolitis (NEC) 482, 487
 arginine and 304
 breastfeeding benefits 394, 483
 clinical presentation 482
 congenital heart disease and 538–40
 inflammatory cascade 485–6
 intestinal fermentation and 345
 pathophysiology 482
 bacterial colonization 484–5
 enteral feeding 369, 371, 482–3
 host defense 484
 intestinal blood flow regulation 485
 motility 484
 prematurity 484
 short bowel syndrome and 492
 neonatal short bowel syndrome *see* short bowel syndrome (SBS)
 neonatal surgical patients
 critical illness effects 571
 enteral nutrition 578–80
 administration 579–80
 benefits of 578
 complications 580
 feeding routes 579
 selection of feeds 579
 nutritional management 569
 operative trauma effect on energy expenditure 570–1
 parenteral nutrition 571–8
 complications 575–8

- neonatal surgical patients (*cont.*)
 - composition 571–5
 - indications 571
- neonate 569
 - bone growth and development
 - mineral status 194
 - regulation 191–2
 - see also* bone
 - energy expenditure 570
 - influencing factors 136–8
 - measurement 134–6
 - operative trauma effects 570–1
 - energy requirement 134, 569–70
 - glucose metabolism 124–9
 - gluconeogenesis development and regulation 126–9
 - mobilization of liver glycogen stores 125–6
 - growth
 - bronchopulmonary dysplasia effects 522, 525–6, 528–30
 - congenital heart disease effects 533–4, 535, 536–7, 541
 - energy cost of 138
 - fatty acid supplementation effects 155–6
 - VLBW infants 115, 595
 - gut flora 70
 - hyperparathyroidism 235–6
 - secondary 235
 - hypothyroidism 284–5
 - innate immune system 70–71
 - iron balance 292, 293–4
 - consequences of early deficiency 294–5
 - consequences of overload 295–6
 - requirements 296
 - see also* iron
 - kidney 106–7
 - distal tubule and collecting system development 106
 - extracellular water (ECW) regulation 105–7
 - glomerular filtration development 106
 - proximal tubular development 106
 - metabolic capacity development 76–77
 - metabolic programming 76–78, 82–3, 85
 - animal models 82–85
 - maternal protein restriction 78–79
 - metabolic research 617–20
 - carbohydrate metabolism 620–4
 - lipid metabolism 626
 - protein metabolism 624–5
 - mineral content
 - calcium 185, 187
 - magnesium 185–8
 - phosphorus 185, 187
 - serum concentrations 187–8
 - mineral homeostasis disorders
 - hypercalcemia 235–8
 - hypermagnesemia 242–4
 - hyperphosphatemia 239
 - hypocalcemia 230–4
 - hypomagnesemia 240–2
 - hypophosphatemia 238–9
 - potassium balance 107
 - protein metabolism 119
 - accretion of specific tissues 118
 - age and feeding effects 116–8
 - quantification 115–6
 - sodium balance 106–7
 - surgical treatment *see* neonatal surgical patients
 - thermal regulation 59–64
 - clinical interventions 62–64
 - cold injury 60–61
 - cold response 59
 - heat response 60
 - hyperthermia 61–62
 - neutral thermal environment 58–59, 137
 - vitamin deficiency *see specific vitamins*
 - vitamin requirements 167, 168
 - see also specific vitamins*
 - water balance
 - extracellular water (ECW) regulation 105–7
 - hormone regulation 107–8
 - water spaces 104
 - see also* neonatal surgical patients; postnatal nutrition influence on subsequent health; preterm infants
- neurodevelopment, postnatal nutrition relationship 635
 - see also* brain
- neutral thermal environment 137
- niacin 176
 - deficiency 176
 - in human milk 176
 - neonatal requirements 176
 - status assessment 176
- nitric oxide (NO) 304
 - acute respiratory disease and 513
- 2-(2-nitro-4-trifluoro-methylbenzoyl)-1, 3-cyclohexanedione (NTBC) 550
- nitrogen balance 573
 - acute respiratory disease and 512–3
 - amino acid metabolism quantification 115
 - effect of energy and protein intakes 139–42
 - effect of other nutrient intakes 142
 - nitrogen content of milk 390–1
 - see also* amino acids; protein
- norepinephrine, in infants of diabetic mothers 477–8
- nucleotides (NT) 306–7
 - gastrointestinal role 306
 - immune responsiveness and 306–7
 - in human milk 306, 392
- nutrient supplementation
 - amniotic glucose supplementation 12
 - dietary supplements 427
 - long chain polyunsaturated fatty acids (LC-PUFA) 150, 157
 - adverse effects 155–7

- cognitive/behavioral development and 152–5
- lung surfactant biosynthesis and 509–10
- visual acuity and 151–2
- maternal
 - birth weight relationships 1–2
 - calcium 212
 - magnesium 240
 - vitamin D 215
 - vitamin K 170, 171
- neonates
 - amino acids 117
 - calcium 233–4
 - fatty acids 155–6
 - magnesium 242
 - short bowel syndrome and 498
 - zinc 278, 279
- preterm infants
 - fatty acids 155–6
 - glutamine 305–6
 - inositol 301, 302
 - iron 294
 - metabolic bone disease prevention
 - 251–4
 - milk fortification 251–4, 257, 403–4
 - minerals 257, 403
 - vitamin A 162–5
 - vitamin E 167–8
- see also* formulas; *specific nutrients*
- nutritional assessment 586
 - anthropometrics 595–7
 - growth charts 596–7
 - head circumference 596
 - length
 - skinfold measurements 597
 - weight 596
- laboratory assessment 588–95
 - albumin 593
 - blood urea nitrogen 588–9
 - carnitine 592
 - electrolytes 588
 - glucose 590–2
 - insulin-like growth factor (IGF) axis 595
 - iron 592–3
 - lipids 589–90
 - minerals 589
 - transferrin 594
 - transthyretin (prealbumin) 594
 - urinary 3-methylhistidine 594
 - visceral proteins 593
 - vitamin A 592
 - vitamin E 592
- medical record review 586
- nutritional intake 586–8
 - enteral intake 588
 - parenteral intake 586–8
- obesity
 - breastfeeding benefits 393
 - early postnatal nutrition influence 631–2
 - infants of diabetic mothers 478
 - metabolic programming relevance 86–87
- oncotic pressure 105
- ornithine transcarbamoylase (OTC) deficiency
 - 560
- osmotic pressure 104
- osteoblasts 188
 - differentiation 188
- osteocalcin 198–9, 200, 201, 203
 - during pregnancy 210–1
 - fetal 213
- osteoclasts 188, 205
- osteocytes 188
- osteogenesis imperfecta 202
- osteomalacia 244, 248
- osteopenia 248, 249
 - parenteral hyperalimentation-induced 247–8
 - soy-based formulas and 238, 249
- osteoporosis 194
 - copper deficiency and 282
- otitis media, breastfeeding benefits 393–4
- over-heating *see* hyperthermia
- oxidative stress
 - in bronchopulmonary dysplasia (BPD) 522
 - parenteral nutrition and 577–8
- oxygen consumption 4–6
 - congenital heart disease and 536
- oxytocin 382, 383–4
- P-selectin 373
- palmitic acid 147, 415–16
- pancreas development 68
 - consequences of diabetes during pregnancy 81
 - maternal protein restriction effects 78–79, 80
 - see also* insulin
- pancreatic colipase-dependent lipase (CDL) 356, 357–8
- pancreatic lipase-related proteins (PLRP1/PLRP2) 358–9
- pantothenic acid 177
 - deficiency 177
 - in human milk 177
 - neonatal requirements 177
 - status assessment 177
- parathyroid hormone (PTH) 206
 - during pregnancy 210, 211
 - fetal 214
 - mineral metabolism regulation 206
 - hypocalcemia and 229
 - role in bone remodeling 203–4
 - vitamin D metabolism regulation 209
 - calcitriol and 209

- parathyroid hormone-related peptide (PTHrP) 206–8
 during pregnancy 210
 fetal 212, 214
 lactation and 207–8
- parenteral nutrition (PN) 571–8
 acute respiratory disease and 511–4, 516–17
 energy 511–2
 glucose 513–4
 lipid emulsions 514–6
 protein and amino acids 512–3
 complications 248, 256–7, 322–4, 575–8
 aluminum contamination 256
 free radicals 577–8
 hepatic complications 576–7
 infections/sepsis 372, 496, 575
 infusion-related complications 322, 576
 metabolic complications 322–4, 575–6
 minimization of 324–6
 vascular inflammatory responses 373
 composition 315–6, 571–5
 amino acids 316–8, 573–4
 electrolyte content 320
 energy 318–9, 572–3
 fluid requirements 572
 lipids 319–20, 572–3
 minerals 254–6, 315, 317, 320–1, 574–5
 recommended nutrient intakes 315, 316–21
 trace elements 317, 321, 574–5
 vitamins 255, 256–7, 317, 321, 574–5
 history of 312–3
 improving tolerance 321–2
 indications 314, 571
 infusate delivery 315–6
 intake assessment 586–8
 intravenous lipid emulsions 514–6, 572, 573
 effects on energy metabolism 514–5
 effects on lung function 515–6
 management strategies 326–7
 minimal enteral feeding and 326, 578–9
 monitoring 324–6
 osteopenia and 247–8
 research needs 327
 short bowel syndrome and 496, 498–9
 surgical patients 569, 571–8
 techniques 313–4
 when to start 326
 when to stop 326
- pepsin 356–7
- periventricular-intraventricular hemorrhage (PIVH) 171
- Peyer's patches 71, 372
- pH studies, esophageal 449
- phenylalanine metabolic pathway 335, 548–9
- phenylalanine tracer 624–5
- phenylketonuria (PKU) 2, 548–50
 therapy 549–50
- phosphatidylcholine (PC), lung surfactant 509, 510
- phosphatidylglycerol (PG), lung surfactant 509
- phosphoenolpyruvate carboxykinase (PEPCK) 123, 126–7
- phospholipids 350
 in human milk 352
- phosphorus (P) 185
 deficiency 236
 phosphorus deficiency syndrome 250
 disorders of homeostasis 238–9
 neonatal hyperphosphatemia 239
 neonatal hypophosphatemia 238–9
 enteral nutrition requirements 255
 human milk fortification 257, 403
 fetal 212–3
 hormonal regulation
 calcitonin 208
 parathyroid hormone 206
 in formulas 252, 258
 preterm formula 420–1
 in human milk 391–2
 fortification for preterm infants 257, 403
 laboratory assessment 589
 parenteral nutrition requirements 254–6, 320–1
 serum concentrations 187
 total body content 185
- phyloquinone 169, 170
see also vitamin K
- physical activity, energy expenditure relationship 136–7
- phytoestrogens 424
- placenta 10, 27, 213–16
 amino acid uptake and metabolism 7, 8
 ammonia production 7
 glucose uptake 6, 10
 in diabetic pregnancies 39
 lactate production 7
 nutrient demands of 1
 nutrient transfer 5, 27, 617
 alterations in IUGR 36–38
 amino acids 7–8, 37–8, 39
 fatty acids 8–9
 glucose 6–7, 36–7, 39, 122–3, 617
 in diabetic pregnancies 39
 minerals 213
 vitamin D 215
 vasculature development in IUGR 34–36
 oxygen and angiogenic development 34–35
 post-placental hypoxia 35–36
 pre-placental hypoxia 35
 uteroplacental hypoxia and preeclampsia 35
- placental growth hormone (PGH) 28
- plasma 105
 oncotic pressure 105
 Starling's equilibrium 105
- polycythemia, infants of diabetic mothers 476

- polymorphonuclear neutrophils (PMNs) 373
 polythene bags 64
 polyunsaturated fatty acids (PUFA) 8, 27
 antioxidant capacity and 26–27
 postnatal growth *see* neonate; preterm infant; very low birth weight (VLBW) infants
 postnatal nutrition influence on subsequent health 631, 638
 atopy, allergy and asthma 635
 carbohydrates 633
 feeding volume and energy density 631–2
 lipids 632–3
 mechanisms 635
 alterations in cell number 635
 chromatin structure alterations 636–7
 clonal selection 635
 DNA methylation 637
 metabolic differentiation 635–6
 regulatory patterns of DNA binding proteins 636
 neurodevelopment 635
 protein restriction 632
 type I diabetes 634
 see also metabolic programming
 postnatal period *see* neonate
 potassium balance 107
 parenteral nutrition 320
 total body potassium (TBK) 603
 Potential Renal Solute Load (PRSL) calculation 430
 prealbumin (transthyretin) assessment 594
 prebiotics 73
 short bowel syndrome management 499
 preeclampsia, IUGR and 35
 pregnancy
 diabetes in, consequences for progeny 81
 bone metabolism 199, 200–1
 see also diabetes; gestational diabetes; infants of diabetic mothers (IDM)
 maternal physiology 209–11
 PreKUnil tablets 550
 preterm infants 47, 437
 anemia of prematurity 275, 294
 body composition 51–52
 diet effects 52
 bone characteristics
 accretion 257
 mineral content 51, 250, 257–8
 strength assessment 195
 turnover 201–2
 see also metabolic bone disease of prematurity (MBDP)
 breastfeeding 657–8, 659
 supplementation 659
 bronchopulmonary dysplasia *see* bronchopulmonary dysplasia (BPD)
 copper requirements 283
 early weight loss 47–48
 energy expenditure 441–2
 energy intake 52–53, 139
 energy requirement 139–42
 enteral feeding 336–7
 fetal growth and 49
 reference standards 48–51
 formulas 257–9, 411–12, 419, 655–7, 659
 carbohydrate content 342–3, 419
 cow's milk-based 417–8, 421–2
 growth and 52, 53–4, 55, 257, 655–6
 iron content 276
 lactose responses 342–3
 lipid content 419–20
 metabolic bone disease prevention 251–4
 mineral content 420–1
 post-discharge formula 421–2
 protein content 417–9
 small-for-gestational-age infants 658
 studies of formula-fed infants 655–7
 gastrointestinal tract
 bacterial colonization 484–5
 motility 484
 glucose absorption 344
 glucose metabolism 439–41
 endogenous glucose production 439–40
 gluconeogenesis 440–1
 regulation of endogenous glucose production 440
 glutamine supplementation 305–6
 growth 49–51, 52–5, 640, 654–5, 660
 adolescent outcomes 643–4
 adult growth outcomes 644–7
 breastfed infants 657–8
 catch-down growth 641
 catch-up growth 47–48, 641–2, 654
 complementary food (CF) effects 54–55
 correlates of growth and catch-up 644, 648, 649
 crown-heel length (CHL) 49
 diet effects 52, 53–5
 early childhood outcomes 642–3
 fatty acid supplementation effects 155–6
 formula-fed infants 655–6
 growth failure 640
 health implications of growth failure 647–50
 monitoring 659–60
 post-discharge growth 53–55
 pre-discharge growth 52–53
 study methodology 640–1
 weight gain 49–51
 hospital discharge goals 658
 human milk deficiencies 249, 257, 401, 403
 growth and 52, 403
 metabolic bone disease and 249, 251
 mineral status 403
 protein status 403
 requirements 402

- preterm infants (*cont.*)
 human milk fortification 251–4, 257, 403–4
 fortifier compositions 404
 in-hospital feeding practices 406
 methods 406
 non-nutritional outcomes 405–6
 reformulations of human milk fortifiers 404–5
 hypocalcemia 231
 hypoglycemia 455
 immune function 484
 innate immune system 70
 inborn errors of metabolism 544
 inositol supplementation 301, 302
 iron balance 293–4
 deficiency 295
 overload 294
 requirements 276, 296
 supplementation 294
 toxicity 294
 kidney development and function 106, 107
 lack of nutritional support 369–70
 lactose digestion 343–4
 lactose responses 342–3
 metabolic differences from term infants 437, 442–3
 necrotizing enterocolitis 484, 486–7
 post-hospital nutrition 654, 660
 breastfeeding 657–8, 659
 discharge goals 658
 duration of feeding post-discharge diets 659
 formula-feeding 655–7, 659
 monitoring 659–60
 small-for-gestational-age infants 658
 suggested approach 658–60
 protein metabolism 119
 accretion of specific tissues 118
 age and feeding effects 116–8
 differences from term infants 437–9
 proteolysis 437–9
 quantification 115–6
 respiratory distress syndrome (RDS) 108–9
 rib fractures at birth 191
 sodium balance 107
 taurine levels 302–3
 thermal regulation
 clinical interventions 62–64
 cold injury risk 60
 vitamin deficiency
 vitamin A 165
 vitamin E 168, 169
 vitamin supplementation
 vitamin A 165
 vitamin E 167–8
 water balance 47, 107
 abnormalities 108–9
 hormonal regulation 107, 108
 see also extremely low birth weight (ELBW) infants; neonate;
 very low birth weight (VLBW) infants
 probiotics 73
 short bowel syndrome management 499
 procollagen 199
 type I C-terminal propeptide (PICP) 199, 200–2
 progesterone, milk production inhibition 385–6
 proglucagon
 proglycogen 123–4
 Prognostically Bad Signs in Pregnancy (PBSP) 466, 467
 prokinetic agents 451
 prolactin 382
 secretion 383
 propionic acidemia 556
 diagnosis/presentation 557
 therapy 557–8
 prostaglandins, water balance and 108
 protein 332, 337
 accretion
 age and feeding effects 116–8
 protein–energy metabolism and balance 139, 318–19
 quantification 115–6
 specific tissues 118
 digestibility 332–3
 digestion 69
 in formulas
 cow's milk-based preterm formula 417–9
 cow's milk-based term formula 413–5
 dietary supplements 429
 for short bowel syndrome 497–8
 in milk 390–1
 differences between cow's and human milk 412
 fortification for preterm infants 403
 infant responses to 336
 clinical implications 336–7
 intake
 effect on nitrogen balance 139–42
 preterm infants 257–8
 metabolism 573–4, 624–5
 diabetic pregnancies 470
 differences between term and preterm infants 437–9
 measurement 624–5
 postnatal protein restriction influence on subsequent
 health 632
 requirements 332, 573
 supplementation
 maternal, birth weight relationships 1–2
 neonatal 117
 visceral protein assessment 593
 see also amino acids; nitrogen balance
 protein hydrolysate-based formulas 423, 425–6
 indications for use 425–6
 protein induced by vitamin K absence or antagonism (PIVKA-II)
 171–2
 proteolysis, differences between term and preterm infants 437–9

- proton pump inhibitors 499
 pseudohypoparathyroidism, neonatal 239
 'pup in a cup' model 82–85
 adaptation during period of dietary intervention 83–85
 generational effects 85
 programmed effects in adulthood 85
 pyridoxine *see* vitamin B6
 pyruvate 128–9
 pyruvate carboxylase (PC) 126
 pyruvate dehydrogenase complex (PDHC) 95–96
 pyruvate dehydrogenase deficiency 566
- receptor to activated NfκB (RANK) 196, 205
 regurgitation *see* gastrointestinal reflux (GIR)
 renal development *see* kidney, neonatal
 renal hypophosphatemic rickets 229, 232, 247
 treatment 247
 renal magnesium wasting diseases 241–2
 renal solute load calculation 430
 renal vein thrombosis 476–7
 renin 107
 respiratory disorders
 breastfeeding benefits 394
 malnutrition consequences 508–11
 respiratory failure 508
 see also respiratory distress syndrome (RDS)
 respiratory distress syndrome (RDS)
 infants of diabetic mothers 473
 total parenteral nutrition 511–4, 516–17
 energy 511–2
 glucose 513–4
 lipid emulsions 514–6
 protein and amino acids 512–3
 water balance abnormalities 108–9
 respiratory system
 lung defense mechanisms 510
 nutritional status effects
 lung development 508–9
 respiratory muscles 510–1
 surfactant synthesis 509–10
 ventilatory drive 511
 retinal function, long chain polyunsaturated fatty acid role 150–2
 retinol 161
 see also vitamin A
 retinopathy of prematurity (ROP) 168–9
 breastfeeding benefits 394–5
 inositol supplementation benefits 301
 iron overload and 296
 rib fractures, preterm birth and 191
 riboflavin *see* vitamin B2
 rickets 229, 244, 248, 250–1
 calcium deficiency 246–7
 hepatic 245
 of prematurity 249, 250–1
 etiology 249
- management 254
 phosphorus deficiency 249
 presentation 250
 screening 250–1
 renal hypophosphatemic 229, 232, 247
 treatment 247
 vitamin D deficiency 244–5
 treatment 245
 vitamin D-dependent (VDDR) 229, 232, 245–6
- salt balance *see* sodium balance
 scintigraphy, gastroesophageal 450
 scurvy 177–8
 secondary yolk sac 3–4
 selenium 280–1
 biological role 280
 bronchopulmonary dysplasia prevention 523
 deficiency 280
 diagnosis 280–1
 metabolism/homeostasis 280
 requirements 281
 toxicity 281
 sepsis 571
 glutamine and 574
 in short bowel syndrome 496
 metabolic response to 571
 parenteral nutrition-related 372, 496, 575
 serum alkaline phosphatase *see* alkaline phosphatase
 short bowel syndrome (SBS) 492
 adaptation to small bowel resection 494–6
 intestinal dilation and transit time 495–6
 intestinal hypertrophy and hyperplasia 494–5
 residual bowel length 496
 causes 492, 493
 complications 502–3
 hospital discharge 499–500
 medical management 496–500
 enteral nutrition 496–9
 medications 499
 parenteral nutrition 496, 498–9
 prebiotics 499
 probiotics 499
 outcomes 501–3
 pathophysiology 492–4
 probiotics 499
 sepsis and 496
 surgical management 500–1
 transplantation 501
 short gut colitis 499
 SIgA, in human milk 392
 Silver-Russell Syndrome 25
 single-photon absorptiometry (SPA) 194, 250
 size at birth 23
 see also birth weight
 size for gestational age, energy expenditure relationship 137

- skinfold measurements 597
- small left colon syndrome 471
- smoking, fetal bone metabolism and 202–3
- sodium balance 106–7
 - hyponatremia extremely low birth weight infants 109
 - hyperosmolar state in extremely low birth weight infants 109–10
 - hyponatremia in very/extremely low birth weight infants 110–1
 - parenteral nutrition 320
 - preterm formula 421
- sodium benzoate 561–2
- sodium bicarbonate, labeled 614
- sodium phenylbutyrate 562
- somatostatin 499
- soy-based formulas 238, 247, 249, 422, 423–4
 - indications for use 424
 - galactosemia 562–3
 - phytoestrogen concerns 424
- stable isotopes 618–9
 - analytical principles 619–20
 - gas chromatography-combustion-mass spectrometry (GC-C-IRMS) 618
 - gas chromatography-mass spectrometry (GCMS) 618
 - isotope ratio mass spectrometry (IRMS) 619
- starch digestion 342
- Starling's equilibrium 105
- steroids
 - effects on bone 196, 197
 - growth failure and 526
- sterols 350
- subaortic stenosis, infants of diabetic mothers 472
- sulfasalazine 499
- sulfur amino acid pathway 335–6
- superoxide dismutase (SOD), bronchopulmonary dysplasia
 - prevention 523
- surgical patients *see* neonatal surgical patients
- tartrate-resistant acid phosphatase (TRAP), serum 199
- taurine 302–3, 336
 - deficiency 3
 - cholestasis and 303
 - in formulas 302, 303
 - in preterm infants 302–3
 - placental transfer in IUGR 38
 - role in brain development 303
- Teller Acuity Card test 151
- telopeptide of type I collagen (ICTP) 199, 200–1
- temperature, environmental
 - energy expenditure relationship 137
 - see also* thermal regulation
- testosterone, bone mass regulation 189–91, 193
- therapeutic cooling 64
- thermal regulation 58, 64
 - clinical interventions 62–64
 - basic measures 62–63
 - cooling as cerebro-protective strategy 64
 - kangaroo care 63
 - polythene bags 64
- fetal hyperthermia 61
- neonatal 59–64
 - changes in thermal environment at birth 58–59
 - cold injury 60–61, 62
 - cold response 59, 60
 - heat response 60
 - hyperthermia 61–62
 - neutral thermal environment 58–59, 137
 - temperature monitoring 62
- thiamine *see* vitamin B1
- thickening agents 450
- thyroid hormones 10, 284
 - effects on bone metabolism 204
- thyrotropic hormone (TSH) 284
- tocopherol *see* vitamin E
- Total Body Electrical Conductivity (TOBEC) 594–7, 603
- total body potassium (TBK) 603
- total body water (TBW) 603
- total fat mass (TFM) 597
- total parenteral nutrition (TPN) *see* parenteral nutrition (PN)
- trace elements 273–5
 - deficiencies 273
 - genetic defects in metabolism 274
 - in human milk 391–2
 - in parenteral nutrition 317, 321, 574–5
 - see also specific elements*
- transcription factors 636
- transferrin assessment 594
- transthyretin (prealbumin) assessment 594
- Trial to Reduce Type I Diabetes in the Genetically at Risk (TRIGR) 634
- triglycerides (TG)
 - birth weight relationship 470
 - in parenteral nutrition 573
 - placental transfer 9
 - release of 361–4
 - synthesis during lactation 379–80
 - see also* lipids
- twin pregnancies, fetal growth 4
- type I glycogen storage disease (GSD) 564–6
 - presentation 564
 - therapy 564–6
- tyrosine 317, 318, 335, 419
- tyrosinemia
 - neonatal 551–2
 - type I 550–1
 - therapy 295
 - type II 552
 - therapy 552
 - type III 552
- ultrasound, bone strength assessment 195
- umbilical cord

- mineral concentrations 212–3
- nutrient absorption 12
- uniparental disomies (UPD) 25, 26
- urea 588–9
 - blood urea nitrogen 588–9
- urea cycle disorders 559–62
 - therapy 560–2
 - acute therapy 561
 - chronic therapy 561–2
- urea tracer 625
- urinary tract infection, breastfeeding benefits 394
- ursodeoxycholic acid 577
- uterine gland secretions 3–4
- ventilatory drive 511
- very low birth weight (VLBW) infants 47
 - early weight loss 47–48
 - electrolyte disturbance
 - avoidance strategy 111
 - hyponatremia 110
 - energy expenditure 511–2
 - growth 115, 595
 - adolescent outcomes 643–4
 - adult growth outcomes 644–7
 - correlates of growth and catch-up 644, 648, 649
 - early childhood outcomes 642–3
 - health implications of growth failure 647–50
 - study methodology 640–1
 - hyperglycemia 460–1
 - see also* neonate; preterm infants
- very low-density lipoprotein (VLDL) 9
- visual evoked potentials (VEPs) 151
- visual function
 - assessment 151
 - breastfeeding benefits 394–5
 - long chain polyunsaturated fatty acid role 150–2, 416
- vitamins 161
 - biotin 176–7
 - deficiency 177
 - in human milk 176
 - neonatal requirements 176
 - status assessment 177
 - folate
 - birth weight relationships 2–3, 175–6
 - deficiency 175–6
 - in human milk 175
 - neonatal requirements 175
 - status assessment 176
 - in human milk 392
 - in parenteral nutrition 315, 317, 321, 574–5
 - niacin 176
 - deficiency 176
 - in human milk 176
 - neonatal requirements 176
 - status assessment 176
 - pantothenic acid 177
 - deficiency 177
 - in human milk 177
 - neonatal requirements 177
 - status assessment 177
 - short bowel syndrome and 498
 - vitamin A 161–6, 592
 - bone metabolism and 204
 - bronchopulmonary dysplasia and 165, 524–5
 - deficiency 165
 - delivery to fetus 161–2
 - in human milk 162
 - in liver 162
 - metabolism 162
 - neonatal requirements 162–5
 - status assessment 166, 592
 - supplementation for preterm infants 165
 - toxicity 165–6
 - vitamin B1 (thiamine) 173
 - deficiency 172–3
 - neonatal requirements 172
 - status assessment 173
 - toxicity 172–3
 - vitamin B2 (riboflavin) 173
 - deficiency 173
 - in human milk 173
 - neonatal requirements 173
 - status assessment 173
 - vitamin B6 (pyridoxine) 173–4
 - deficiency 174
 - delivery to fetus 174
 - in human milk 174
 - neonatal requirements 174
 - status assessment 174
 - vitamin B12 (cobalamin) 174–5
 - absorption and storage 174–5
 - deficiency 175
 - in human milk 175
 - neonatal requirements 175
 - short bowel syndrome and 498
 - status assessment 175
 - vitamin C (ascorbic acid) 177–8
 - birth weight relationship 2
 - deficiency 177–8
 - in human milk 177
 - neonatal requirements 177
 - status assessment 178
 - vitamin D
 - bone mineralization and 191, 193, 259
 - calcium absorption and 257
 - deficiency 215, 229–30, 232, 244, 258
 - diabetes prevention 634
 - during pregnancy 210, 211
 - enteral nutrition 255, 257, 258
 - fetal mineral homeostasis and 215

- vitamins (*cont.*)
 - hypocalcemia and 232
 - in human milk 392
 - metabolism 208–9
 - parenteral nutrition 255, 256–7
 - placental transfer 215
 - rickets and 229, 232, 244–6
 - sources 208–9
 - supplementation 215
 - synthesis 209
 - toxicity 244
- vitamin E 166–9, 592
 - absorption 166, 168
 - bronchopulmonary dysplasia and 169, 523
 - deficiency 168, 169
 - delivery to fetus 166
 - in human milk 166–7
 - in liver 166–7
 - neonatal requirements 167–8
 - status assessment 169, 592
 - storage 166
 - supplementation therapy 168–9
 - toxicity 169
- vitamin K 172, 392
 - absorption 170
 - deficiency 171–2
 - delivery to fetus 170
 - function 169–70
 - in human milk 170, 392
 - maternal supplementation 170, 171
 - neonatal requirements 170–1
 - status assessment 171–2
 - toxicity 171
- water soluble vitamins 172
- von Gierke's disease *see* type I glycogen storage disease (GSD)
- water balance
 - abnormalities 108–11
 - bronchopulmonary dysplasia (BPD) 108–9
 - hyperosmolar state in extremely low birth weight infants 109–10
 - respiratory distress syndrome 108–9
- body water measurements 602–3
- cell volume regulation 104
- hormonal regulation 107–8
 - arginine vasopressin (AVP) 107
 - atrial natriuretic peptide (ANP) 107–8
 - kallikrein and bradykinins 108
 - prostaglandin-E 108
 - renin, angiotensin and aldosterone 107
- oncotic pressure 105
- osmotic pressure 104
- preterm infant 47
- Starling's equilibrium 105
- surgical neonatal patients 572
- water spaces 104
- weight 596
 - see also* birth weight
- weight gain
 - fetal *see* intrauterine growth
 - preterm infants 49–51
- whey proteins 391, 412, 413–15
 - preterm formulas 418–9
- Williams syndrome 237
- X-linked recessive nephrolithiasis 238–9
- z-scores 641
- zinc 276–9
 - biological roles 276–7
 - deficiency 277–8
 - diagnosis 278–9
 - short bowel syndrome and 498
 - treatment 279
- metabolism 277
- requirements 279
- supplementation 278
- toxicity 279