Cambridge University Press & Assessment 978-1-009-10852-2 — Understanding Human Metabolism Keith N. Frayn Index <u>More Information</u>

Index

acetaldehyde, alcohol metabolism, 67 acetic acid, alcohol metabolism, 67 acetone, diabetic ketoacidosis and production of, 109-110 acetylcholine, muscles and, 114-115 acetyl-CoA alcohol metabolism, 67 amino acids and, 69 carbohydrate-fat balance and, 126-130 de novo lipogenesis, 130-132 fatty acid breakdown, 67-68 glucose conversion to, 104-106 ketone body formation and, 106-109 metabolic pathways, 40 metabolism and fate of, 69 acetyl-CoA carboxylase, 130-132 malonyl-CoA production, 138-139 Acheson, Kevin, 133 acquired metabolic disorders, 144-145, 148-149 actin, muscles and, 114 adaptation, human metabolism and, 98 adenosine triphosphate (ATP) brown fat and, 76 exercise and, 122-124 fast-twitch muscles and, 115-117 fatty acids and, 75-76 glycogen breakdown and, 54-56

metabolic pathways and, 34-38 metabolism and, 2-3 muscles and, 114-115 oxidative phosphorylation, 72-75 structure and function of, 60-62 synthesis of, 62-63 adipocytes, fat metabolism and, 84-85, 92-93 adipose tissue fat mobilisation and, 137-139 fat storage and, 24-27 adrenaline exercise and, 118-124 fight or flight response and, 124-125 glycogen breakdown and, 54-56 sympathetic nervous system activation, 45-46 aerobic glycolysis, 154–156 afferent nervous system, 45 alanine, glucose and fat metabolism and, 134 - 137alcohol metabolism, 67 amino acids acetyl-CoA and, 69 fasting and metabolism of, 110-111 fat metabolism and, 134-137 glucose metabolism and, 134-137 glucose production, 80-83 hormones and, 51-52

INDEX 173

models of, 29 oxidation of, 128-130 protein metabolism and, 85-86 proteins and, 27-30 starvation and breakdown of, 99-100 ammonia amino acid breakdown and, 69 nitrogen conversion to, 8 protein metabolism and, 110-111 starvation and, 103-104, 110-111 urea cycle and, 9-10 amylase, starch digestion and, 87-90 anaerobic muscle contraction, 115-117 arginine, creatine creation, 115-117 arterio-venous difference ketone body utilisation and, 108-109 atherosclerosis, human metabolism and, 153 - 154ATP synthase, structure of, 62-63, 73-74 autoimmune disease, 149-153 autonomic nervous system, 45 Banting, Frederick, 49-50 bariatric surgery, 151-153 Bayliss, William, 91 Benedict, Francis, 99-100 Bergmeyer, Hans, 39-40 Bergström, Jonas, 119-124 Bernard, Claude, 9 Best, Charles, 49-50 bile salts, fat metabolism and, 91 Biochemistry for the Medical Sciences (Newsholme & Leech), 124-125 The Biology of Human Starvation (Keys), 101-102 Black, Joseph, 5-11 blood, glucose concentration in, 80-83 blood plasma, fat storage and, 24-27 Bodily Changes in Pain, Hunger, Fear and Rage (Cannon), 124-125 Boussingault, Jean-Baptiste, 8-10

Boyer, Paul, 73-74 brain, ketone bodies and, 106–109 branched-chain amino acids, 136 Burkitt, Denis, 96-97 Cahill, George, 102-106, 108-109 calcium channels, muscles and, 114-115 calorimetry human starvation research and, 99-100 invention of, 7 lipogenesis research and, 133 principles of, 128-130 cancer, human metabolism and, 154–156 Cannon, Walter, 124-125 carbohydrate-burning exercise, 142-143 carbohydrate response element binding protein (ChREBP), 141-142 carbohydrates carbohydrate-fat balance and, 126 - 130common misunderstandings about, 160 digestion and absorption of, 87–90 fat and metabolism of, 106 fuel storage and, 20-22 glycogen storage and, 120-121 lipogenesis research on, 132-134 as metabolic fuel, 14-17 carbon dioxide production calorimetric measurement of, 128-130 physical activity measurement and, 112-113 cardiovascular disease, human metabolism and, 153-154 cellular metabolism, human metabolism vs., 3–5 chemical formulas, 29-30 chemiosmotic theory, 73-74 cholecystokinin (CCK), 91 cholesterol, 17-20 cardiovascular disease and, 153-154

174 INDEX

citric acid cycle, 9-10 acetyl-CoA in, 69 carbohydrate-fat balance and, 126-130 fatty acids in, 84-85 metabolic pathways and, 32-34 oxidation and, 69-72 pyruvate in, 33-34 pyruvic acid breakdown barriers in, 81 - 82transamination and, 135-137 Cohen, Philip, 53 Collins, Jenny, 41-42 Collip James, 49-50 colon, human metabolism and, 96-97 combustion ATP synthesis and, 62-63 metabolism and, 62 communication systems human metabolism, 43-44 overview of, 44 compartmentation, metabolic pathways, 65-67 Cori, Carl, 83 Cori, Gerti, 83 Cori cycle, 83 in starvation research, 103-104 creatine, fast-twitch muscles and, 115 - 117creatine phosphate, fast-twitch muscles and, 115-117 cyclic AMP fat metabolism and, 93-95 hormone action, 55-56 daily life, metabolic interactions and, 142 - 143de Meyts, Pierre, 53 denaturation, protein metabolism, 95-96 de novo lipogenesis, 130-133 cancer and, 154-156 desaturation pathway, de novo

lipogenesis, 130-132

deuterium, metabolic research and, 78-79 diabetes insipidus, 149-150 diabetes mellitus. See type 1 and type 2 diabetes diabetic ketoacidosis, 109-110 starvation vs., 111 diacylglycerol, fat metabolism and, 93-95 2,4 dichlorophenoxyacetic acid, 76 dietary fibre, human metabolism and, 96-97 digestion and absorption carbohydrates, 87-90 fat metabolism and, 90-95 gastrointestinal tract (gut) and, 86-87 2,4 dinitrophenol (DNP), 76 DNA protein structure and, 29-30 protein synthesis and, 56-57 structure of, 60-62 dominant metabolic disorders, 145-146 electron transport, oxidative phosphorylation, 72-75 Embden, Gustav, 33 Embden-Meyerhof pathway, 33 emulsification, fat metabolism and, 91 endosymbiosis, 64-65 energy amino acids and, 30 exercise and consumption of, 122 fat vs. carbohydrate as source of, 22 - 23fuel use determined by, 126-130 human metabolism and energy balance, 97 physical activity and expenditure of, 112-113 starvation and expenditure decline, 103-104 energy balance units, 20-22 energy currency, overview of, 59-60

INDEX 175

energy storage, human metabolism and, 13 - 14enteric nervous system, 45 entero-endocrine cells, 91 environment, metabolic disorders and, 144-156 enzymatic analysis, metabolic pathways, 39-40 enzymes carbohydrate digestion and absorption, 87-90 fat metabolism and, 93-95 glucose-fatty acid cycle and, 141-142 metabolic pathways and, 34-38 epigenome, starvation effects of, 101-102 epinephrine. See adrenaline ester links, fatty acids, 18-19 evolution, metabolism in, 2-3 exercise ATP consumption during, 122-124 common misunderstandings about, 160 communication during, 118-119 energy consumption with, 122 fat-burning exercise, 122 fuel consumption during, 119-124 human metabolism and, 112-113 familial hypercholesterolaemia, 148 fasting state. See also starvation amino acids and protein metabolism, 85-86 fat metabolism, 84-85 fuel mobilisation in, 95-96 glucose metabolism and, 80-83, 88-90 insulin levels and, 88-90 protein and amino acid metabolism in, 110-111 fast-twitch muscles, 115-117 fat-burning exercise, 122, 142-143 common misunderstandings about, 160 fat cells GI UT4 in. 89 metabolism of, 41-42 fat depots, 84-85 fat metabolism, 3 amino acids and, 134-137 daily life vs. acute stress and, 80 disorders of, 147-148 fasting state and, 84-85 fight or flight response and, 124-125 insulin and, 137-139 lipogenesis and, 132-134 post-fast metabolism, 90-95 fat oxidation exercise and, 121-124 metabolic pathways, 65-67 fats carbohydrate-fat balance and, 126-130 common misunderstandings about, 159 - 160exercise and, 121-124 fuel storage and, 20-22 glucose interaction with, 130-132 lipogenesis and oxidation of, 132-134 as metabolic fuel, 17-20 oxidation of, 128-130 starvation and depletion of, 103-104 starvation and mobilisation of, 104-106 storage of, 21-22, 24-27 fatty acids ATP and oxidation of, 75-76 breakdown, 67-68 effect on insulin secretion/release, 137-139 exercise and, 121-124 fat metabolism and, 24-27, 84-85 fight or flight response and, 124-125 insulin effects on release of, 137-139 lipogenesis and, 130-132 metabolism and, 17-19

176 INDEX

fatty acids (cont.) in starvation studies, 104-106 volatile (short-chain) fatty acids, 96-97 fatty acid synthase, 130-132 Felig, Philip, 134-137 fibrils, 114 fight or flight response, metabolism and, 124-125 fluorodeoxyglucose, cancer and, 154-156 Forbes, Gilbert, 103–104 Foster, Daniel, 138-139 free fatty acids (FFA), 26-27 fuels calorimetric measurement of, 128-130 carbohydrates and fats as, 20-22, 125 energy determinants of utilisation, 126-130 exercise and utilisation of, 119-124 fasting and mobilisation of, 95-96 lipids as, 17-20 metabolism and storage of, 31 gall bladder, bile salts storage in, 91 Garland, Peter, 138-139 gastrointestinal tract (gut), 86-87 genetics Mendelian inheritance disorders and, 146-148 metabolic disorders and, 145-146 obesity and, 148-149 Gilbert, Walter, 51 glucagon, 51 glucocorticoid receptor, 56-57 gluconeogenesis pathway for, 82-83 starting point for, 131-132 in starvation studies, 104-106 glucose amino acids and metabolism of, 134-137 brain function and, 21 fat interaction with, 130-132

fight or flight response and, 124-125 insulin and metabolism of, 137-139 lipogenesis and, 132-134 liver storage of, 88-89 metabolic pathways and, 32-34 metabolism of, 80-83 oxidation of, 128-130 starvation and loss of, 104-106 storage of reserves and, 23-27 in type 1 diabetes, 151-152 glucose-6-phosphatase, glycogen breakdown and, 83 glucose-6-phosphate, 38-42 glycogen synthesis and, 83 glycolysis and, 115-117 glucose-6-phosphate dehydrogenase, 38-42 genetic deficiency in, 145-146 glucose clamp technique, fatty acid release, 137-139 'The glucose fatty-acid cycle: its role in insulin sensitivity and the metabolic disturbances of diabetes mellitus' (Randle, Newsholme, Hales & Garland), 138-139 glucose-fatty acid cycle, 138-139 glucose transporters (GLUTs), carbohydrate digestion and absorption, 88 glutaminase, 110-111 glutamine glucose and fat metabolism and, 134-137 metabolism of, 110-111 glycerol, 18-19 fat metabolism and, 93-95 glucose production and, 104-106 glycogen breakdown of, 83 carbohydrates and, 14-17 exercise and breakdown of, 118-124 fight or flight response and breakdown of. 124-125

Cambridge University Press & Assessment 978-1-009-10852-2 — Understanding Human Metabolism Keith N. Frayn Index <u>More Information</u>

INDEX 177

fuel storage and, 20-22 in muscle, 83 muscle storage of, 115-117 starvation and depletion of, 103-104 glycogen loading, 120-121 glycogen phosphorylase, 55-56, 115-117 glycogen storage diseases, 146-148 glycogen synthase, 53 glycolysis ATP synthesis and, 62-63 cancer and, 154-156 fast-twitch muscles and, 115-117 insulin stimulation, 131-132 metabolic pathways, 65-67 muscles and, 114-115 in starvation research, 104–106 glyoxylate cycle, 131-132 GPR109A receptor, 58 G protein-coupled receptors, 54-56 signalling with, 57 guanosine triphosphate (GTP), G proteins and, 54-56 Gurr, Mike, 37-38 Haber-Bosch process, 8 Hales, Nick, 138-139 hexokinase, metabolic pathways and, 38-42 hormones common misunderstandings about, 159-160 exercise and, 119-124 fat metabolism and, 91 G protein-coupled receptors, 54-56 metabolic communication and, 44 metabolism and, 57-58 protein synthesis, receptors and, 56-57 receptors and, 50-53 release, metabolic modulation, 47 signalling molecules, 47-50

Houssay, Bernardo, 83 Hultman, Eric, 21, 119-124 human metabolism adaptability of, 98 cancer and, 154-156 cardiovascular disease and, 153-154 colon and, 96-97 common misunderstandings about, 159-160 communication in, 43-44 current and future research challenges in, 157-158 daily life and, 80, 142-143 diabetes-starvation comparisons, 109-110 energy balance and, 97 energy storage and, 11-12 exercise and physical activity and, 112 - 113fight or flight response and, 124-125 gastrointestinal tract (gut) and, 86-87 interconnectivity of carbohydrate, fat and amino acid metabolism, 126 pathways for, 3-5 starvation and changes to, 103-104 stress and, 80, 124-125 study of, 77-79 hunger, ketosis and, 109–110 hunger strikes, starvation research and, 101 - 1043-hydroxybutyrate, 58 inborn errors of metabolism, 146-148 insulin chemical structure, 51 desaturation pathway and, 131-132 fat metabolism and, 94 gene expression and, 141-142 glucose and fat metabolism and, 137-139 glycogen breakdown and, 54-56 ketone body formation and, 106-109

178 INDEX

insulin (cont.) pancreatic β-cells, 52-53 pre- and post-fast concentrations, 88-90 starvation and loss of, 104-106 structure and function, 49-50 in type 1 diabetes, 109-110, 149-153 in type 2 diabetes, 149-153 insulin resistance, 151-153 integrative physiology, 4-5 intestinal cells, fat metabolism, 92 intestinal microflora, colon and, 96-97 intravenous feeding, lipogenesis and, 132-134 islets of Langerhans, 52-53 isotopic tracers, metabolic research and, 78-79 James, Tony, 37-38 Jequiér, Eric, 133 Jewell, Derek, 92 Karpe, Fredrik, 21-22 ketone bodies common misunderstandings about, 160 diabetes and, 109-110 metabolic pathways and, 57-58 protein and amino acid metabolism and, 110–111 in starvation studies, 104-109 ketosis, 109-110 Keys, Ancel, 101-102 kidneys hormone production by, 57 protein and amino acid metabolism and, 110-111 King, Rod, 132-134 Koch Light, 35-37 Krebs, Hans, 4-5, 9-10, 40 Krebs Cycle, 9-10 metabolic pathways and, 32-34 oxidation and, 69-72

lactate. See lactic acid lacteals, fat storage and, 24-27 lactic acid anaerobic muscle contraction, 115-117 common misunderstandings about, 159-160 glucose metabolism and, 82-83 in starvation research, 103-104 Langerhans, Paul, 52-53 Laplace, Pierre-Simon, 7 Lavoisier, Antoine, 5-11, 62, 99-100, 128-130 LDL receptor cardiovascular disease and, 153-154 fat metabolism disorders and, 148 Leech, Tony, 124-125 leptin, 50-53, 57-58 Levanzin, Agostino, 99-100 lipases, fat metabolism and, 90-91 Lipid Biochemistry (James & Gurr), 37-38 lipids atherosclerosis and accumulation of, 153-154 carbohydrate digestion and absorption, 88 as metabolic fuel, 17-20 Lipmann, Fritz, 40 lipogenesis fatty acid production and, 130-132 importance of, 132-134 liver bile salts production and, 91 glucose production, 80-83 glycogen storage and fatty acid oxidation in, 138-139 starch digestion and absorption and, 88-89 Macleod, John, 49-50

magnetic resonance spectroscopy (MRS), enzymatic analysis, 39–40

Cambridge University Press & Assessment 978-1-009-10852-2 — Understanding Human Metabolism Keith N. Frayn Index <u>More Information</u>

INDEX 179

malonyl-CoA, 130-132 fatty acid synthesis and, 138-139 Marks, Vincent, 94 McGarry, Denis, 58, 138-139 Mendelian inheritance, metabolic disorders and, 146-148 metabolic disorders, 144-156 acquired disorders, 144-145, 148-149 diabetes, 149-153 inherited disorders, 144-145 Mendelian inheritance and, 146-148 patterns of inherited disorders, 145-146 polygenic disorders, 148-149 metabolic pathways cellular location, 65-67 chart of. 35-37 current research on, 38-42 discovery of, 9-10, 37-38 enzymes and, 34-38 fat cells metabolism, 41-42 properties of, 32 steps in, 32-34 storage of reserves and, 23-27 metabolic regulation, 3 starvation and, 99-100 metabolism alcohol, 67 ATP synthesis and, 62-63 carbohydrates and, 14-17 combustion and, 62 defined, 1-2 early theories of, 5-11 evolution and, 2-3 fuel storage and, 31 of glucose, 80-83 hormones and, 57-58 in humans, 3-5 proteins, 27-30 metabolites exercise and, 121-122 isotopic tracers and measurement of, 79 metabolic pathways, 40

metformin, 154-156 Methods of Enzymatic Analysis (Bergmeyer), 39-40 Meyerhof, Otto Fritz, 33 Mitchell, Peter, 73-74 mitochondria (mitochondrion) fatty acid breakdown, 67-68 metabolic pathways, 65-67 in slow-twitch muscles, 117-118 structure and function, 64-65 molar units, 48-49 for insulin, 50 monoacylglycerols, fat metabolism and, 91, 93-95 motor neurons, 114-115, 118-119 muscles contraction, somatic nervous system and, 46 fast-twitch muscles, 115-117 fibres in, 114-117 GLUT4 in, 89 glycogen in, 83, 103-104 physical activity and, 113-115 protein synthesis in, 85-86, 95-96 slow-twitch muscles, 117-118 myosin, muscles and, 114 NADP/NADH, metabolic pathways and, 38-42 nervous system exercise and, 118-119 metabolic communication and, 44 structure and function of, 44-47 Newsholme, Eric, 37, 124-125, 138-139 Nicholson, Donald, 35-37 Nilsson, Lars, 21 non-esterified fatty acids (NEFA), 26-27 noradrenaline (norepinephrine), 45, 54-56,80

Cambridge University Press & Assessment 978-1-009-10852-2 — Understanding Human Metabolism Keith N. Frayn Index More Information

180 INDEX

obesity cancer and, 154-156 metabolic disorders and, 148-149 type 2 diabetes and, 151-153 oleic acid, 41-42 Online Mendelian Inheritance in Man (OMIM) database, 146-148 The Online Metabolic & Molecular Bases of Inherited Disease (Scriver), 146-148 Owen, Oliver, 102-106, 108-109 Oxford BioBank (OBB), 21-22 oxidation amino acids, 128-130 citric acid cycle, 69-72 fats, 128-130 fatty acids, 106-109 glucose, 128-130 metabolic pathways, 32-34, 65-67 metabolism and, 5 slow-twitch muscles and, 117-118 oxidative phosphorylation, ATP and, 72-75 oxygen consumption calorimetric measurement of, 128-130 exercise and, 121-122 physical activity measurement and, 112-113 palmitic acid, 41-42 de novo lipogenesis, 130-132 pancreatic amylase, carbohydrate digestion and absorption, 87-90 pancreatic β-cells, insulin and, 52-53,

149–153 pantothenic acid, metabolic pathways, 40 parasympathetic nervous system, hormone release and, 47

peptide bonds, proteins and, 27-30 phenylketonuria, 146-148

phosphate groups anaerobic muscle contraction, 115-117 ATP structure, 60-62 enzyme activity regulation, 54-56 phosphorylase kinase, 55–56 physical activity human metabolism and, 112-113 intensity of, 112-113 muscles during, 113-115 starvation vs., 98 'Physiological roles of ketone bodies as substrates and signals in mammalian tissues' (Williamson & Robinson), 58 polygenic metabolic disorders, 148-149 polymers carbohydrates and, 14-17 proteins as, 27-30 polypeptides, proteins as, 27-30 Pond, Caroline, 84-85 postabsorptive metabolism carbohydrate-fat balance and, 126-130 of fats, 90-95 postabsorptive state, glucose metabolism and, 80-83 Priestley, Joseph, 5-11 protein channels, nervous system and, 44-47 proteins fasting and metabolism of, 110-111 glucose and fat metabolism and, 134-137 metabolism of, 27-30, 85-86, 95-96 in muscle fibres, 114 starvation and breakdown of, 99-100, 103-104 pyruvate. See pyruvic acid pyruvate dehydrogenase, 66-67 pyruvic acid alanine conversion and, 135-137 ATP synthesis, 75-76

Cambridge University Press & Assessment 978-1-009-10852-2 — Understanding Human Metabolism Keith N. Frayn Index <u>More Information</u>

INDEX 181

glucose breakdown and, 81-82 metabolic pathways and, 33 starvation and, 104-106 Randle, Philip, 138-139 receptors hormone receptors, 50-53 protein synthesis, 56-57 recessive metabolic disorders, 145-146 respiratory exchange ratio (RER), 129-130 respiratory quotient (RQ), 129-130 resting metabolic rate physical activity measurement and, 112 - 113starvation and fall in, 103-104 reverse cholesterol transport, 153-154 reverse glucose fatty-acid cycle, 138-139 **RNA** ATP and structure of, 60-62 protein synthesis and, 56-57 Robertson, Denise, 92 Robinson, Alison, 58 Sands, Bobby, 101-104 Sanger, Fred, 51 saturated fats, metabolism and, 41-42 Schoenheimer, Rudolf, 77-78 Schutz, Yves, 133 secretin, 91 Séguin, Armand, 7-8 sex-linked mutations, metabolic disorders, 145-146 skeletal muscles, physical activity and, 113-115 Skou, Jens, 73-74 slow-twitch muscles, 117-118 smooth muscles, 113-115 somatic nervous system, 45 muscle contraction and, 46 Stallknecht, Bente, 45-46

starch carbohydrates and, 14-17 digestion and absorption of, 87-90 Starling, Ernest, 91 starvation. See also fasting state Dutch famine study, 101-102 fat metabolism and, 84-85 glucose metabolism and, 80-83 glycogen storage and, 21 human metabolism and, 4-5 human studies of, 99-103 ketone bodies and, 106-109 metabolic changes during, 103-104 physical activity vs., 98 protein and amino acid metabolism and, 110-111 protein storage and, 30 Second World War studies of, 101-102 therapeutic starvation, 102-103 type 1 diabetes compared to, 109-110 voluntary starvation, 101-102 statin drugs, 153-154 stress, fat metabolism and, 80, 124-125 substrate-level phosphorylation, 62-63, 72-75, 115-118 sugars carbohydrates and, 14-17 common misunderstandings about, 159 - 160sulfonylurea drugs, 151–153 supercompensation, exercise and, 119-124 sympathetic nervous system exercise and, 118–119 hormone release and, 47 synapses, 44-47 Thompson, Dylan, 112-113 Thompson, Leonard, 49-50 thyroid hormone secretion, starvation and

decrease in, 103-104

Cambridge University Press & Assessment 978-1-009-10852-2 — Understanding Human Metabolism Keith N. Frayn Index <u>More Information</u>

182 INDEX

titin (protein), 27-30 transamination, metabolite formation and, 135-137 trauma, metabolic response to, 124-125 triacylglycerol cardiovascular disease and, 153-154 fat metabolism, 84-85, 90-95 fuel storage, 22-23 insulin resistance and, 151-153 storage of reserves, 24-27 type 1 diabetes, 149-153 glucose-fatty acid cycle and, 138-139 starvation compared to, 109-110 type 2 diabetes, 151-153

urea cycle, 9–10, 103–104 alanine conversion and, 135–137 urine, nitrogen excretion during starvation in, 103–104

Von Gierke disease, 146–148 von Leibig, Justus, 8

Wahren, John, 121–122 Walker, John, 73–74 Warburg, Otto, 9–10, 154–156 Warburg effect, 154–156 Whitley, Helen, 126–130 Williamson, Derek, 57–58

Zammit, Victor, 138-139