3

Tables of Clinical Significance

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In this section can be found a variety of tables with importance to the clinician and nutrition scientist. There are no discussions of these tables because sections later in the book address key issues related to them. Rather, these tables represent a quick look at topics essential to an understanding of the health-related, nutrition-related human conditions.

TABLE 3.1

Proteins Involved in Lipid Transport

Protein	Function
apo A-II	Transport protein in HDL
apo B-48	Transport protein for chylomicrons; synthesized in the enterocyte in the human.
High density lipoprotein binding protein (HDLBP)	Binds HDL and functions in the removal of excess cellular cholesterol
apo D	Transport protein similar to retinol-binding protein
apo (a)	Abnormal transport protein for LDL
apo A-I	Transport protein for chylomicrons and HDL; synthesized in the liver and its synthesis is induced by retinoic acid
apo C-III	Transport protein for VLDL
apo A-IV	Transport protein for chylomicrons
CETP	Participates in the transport of cholesterol from peripheral tissue to liver; reduces HDL size
LCAT	Synthesized in the liver and is secreted into the plasma where it resides on the HDL. Participates in the reverse transport of cholesterol from peripheral tissues to the liver; esterifies the HDL cholesterol.
apo E	Mediates high affinity binding of LDL's to LDL receptor and the putative chylomicron receptor. Required for clearance of chylomicron remnant. Synthesized primarily in the liver.
apo C-I	Transport protein for VLDL
apo C-II	Chylomicron transport protein required cofactor for LPL activity
Apo B-100	Synthesized in the liver and is secreted into the circulation as part of the VLDL. Also serves as the ligand for the LDL receptor mediated hepatic endocytosis.
Lipoprotein lipase	Catalyzes the hydrolysis of plasma triglycerides into free fatty acids
Hepatic lipase	Catalyzes the hydrolysis of triglycerides and phospholipids of the LDL and HDL. It is bound to the surfaces of both hepatic and non hepatic tissues.

TABLE 3.2

Inherited Disorders of Carbohydrate Metabolism

	Disease	Mutation	Characteristics
Digestion	Lactose intolerance	Lactase	Chronic or intermittent diarrhea, flatulence, nausea, vomiting, growth failure in young children
	Sucrose intolerance	Sucrase	Diarrhea, flatulence, nausea, poor growth in infants
Intestinal transport	Glucose-galactose intolerance	Glucose-galactose carrier	Diarrhea, growth failure in infants, stools contain large quantities of glucose and lactic acid
Interconversion of sugars	Galactosemia	Galactose-1-P-uridyl transferase	Increased cellular content of galactose 1-phosphate, eye cataracts, mental retardation, increased cellular levels of galactitol; three mutations have been reported
		Galactokinase	Cataracts, cellular accumulation of galactose and galactitrol; two mutations have been reported
		Galactoepimerase	No severe symptoms; two mutations have been reported
	Fructosemia	Fructokinase	Fructosuria, fructosemia
		Fructose-1-P-aldolase	Hypoglycemia, vomiting after fructose load, fructosemia, fructosuria; in children: poor growth, jaundice, hyperbilirubinemia, albuminuria, amino-aciduria
		Fructose-1,6-diphosphatase	Hypoglycemia, hepatomegaly, poor muscle tone, increased blood lactate levels
	Pentosuria	NADP-lined xylitol dehydrogenase	Elevated levels of xylose in urine
Glucose catabolism	Hemolytic anemia	Glucose-6-phosphate dehydrogenase	Low erythrocyte levels of NADPH, hemolysis of the erythrocyte
		Pyruvate kinase	Nonspherocytic anemia, accumulation of phosphorylated glucose metabolites in the cell, jaundice in newborn
	Type VII glycogenosis	Phosphofructokinase	Intolerance to exercise, elevated muscle glycogen levels, accumulation of hexose monophosphates in muscle
Gluconeogenesis	Von Gierke's disease (Type I glycogenosis)	Glucose-6-phosphatase	Hypoglycemia, hyperlipemia, brain damage in some patients, excess liver glycogen levels, shortened lifespan, increased glycerol utilization
Glycogen synthesis	Amylopectinosis (Type IV glycogenosis)	Branching enzyme Liver amylo (1,4→1,6)-transglucosidase	Tissue accumulation of long-chain glycogen that is poorly branched, intolerance to exercise
Glycogenolysis	Pompe's disease (Type II glycogenosis)	Lysosomal a-1,4-glucosidase (acid maltase)	Generalized glycogen excess in viscera, muscles, and nervous system, extreme muscular weakness, hepatomegaly, enlarged heart
	Forbe's disease (Type III glycogenosis)	Amylo-1,6-glucosidase (debrancing enzyme)	Tissue accumulation of highly branched, short-chain glycogen, hypoglycemia, acidosis, muscular weakness, enlarged heart

TABLE 3.2 *(Continued)*

Inherited Disorders of Carbohydrate Metabolism

Disease	Mutation	Characteristics
McArdle's disease (Type V glycogenosis)	Muscle phosphorylase	Intolerance to exercise
Her's disease (Type VI glycogenosis)	Liver phosphorylase	Hepatomegaly, increased liver glycogen content, elevated serum lipids, growth retardation
(Type IX glycogenosis)	Phosphorylase kinase	Hepatomegaly, increased liver glycogen levels, decreasd phosphorylase activity in hepatocytes and leukocytes, elevated blood lipids, hypoglycemia after prolonged fasting, increased gluconeogenesis

TABLE 3.3

Genetic Diseases in Lipid Metabolism

Disease	Mutation	Characteristics
Tay-Sachs disease	Hexosaminidase A deficiency	Early death, CNS degeneration, ganglioside GM2 accumulates
Gaucher's disease	Glucocerebrosidase deficiency	Enlarged liver and spleen; erosion of long bones and pelvis; mental retardation; glucocerebroside accumulates
Fabry's disease	α Galactosidase A deficiency	Skin rash, kidney failure, pain in legs and feet, ceramide trihexoside accumulates
Niemann-Pick disease	Sphingomyelinase deficiency	Enlarged liver and spleen, mental retardation, sphingomyelin accumulates
Krabbe's disease (globoid leukodystrophy)	Galactocerebroside deficiency	Mental retardation, absence of myelin
Metachromatic leukodystrophy	Arylsulfatase A deficiency	Mental retardation, sulfatides accumulate
Generalized gangliosidosis	Gmi,Gandioside: β galactosidase deficiency	Mental retardation, enlarged liver
Sandhoff-Jatzkewitz disease	Hexosaminidase A and B deficiency	Same as Tay-Sachs but develops quicker
Fucosidosis	α-L-Fucosidase	Cerebral degeneration, spastic muscles, thick skin
Acetyl CoA carboxylase deficiency	Acetyl CoA carboxylase deficiency	No de novo fatty acid synthesis
Hypercholesterolemia	LDL receptor deficiency	Premature atherosclerosis and death from CVD
Refsum's disease	α hydroxylating enzyme	Neurological problems: deafness, blindness, cerebellar ataxia, phytanic acid accumulates

TABLE 3.4

Genetic Mutations in Enzymes of Amino Acid Metabolism

Disease	Mutation	Characteristics
Maple syrup urine disease	Branched chain keto acid dehydrogenase (Several variants)	Elevated levels of α ketoacids and their metabolites in blood and urine; mental retardation, ketoacidosis, early death
Methylmalonuria	Methylmalonyl CoA mutase (Several variants) Inability to use vitamin B_{12}	High blood levels of methylmalonate; pernicious anemia, early death
Nonketotic hyperglycinemia	Glycine cleavage enzyme	Severe mental retardation, early death, high blood glycine levels
Hypermethioninemia	Methionine adenosyltransferase (↑ Km not deficiency per se)	Accumulation of methionine in blood (condition is benign)
Homocysteinemia	Cystathionine synthase	Elevated blood levels of methionine, homocysteine; abnormal collagen (no cross linking); dislocated lenses and other ocular malformations; osteoporosis; mental retardation, thromboembolism and vascular occlusions; short lifespan
Cystathioninuria	Cystathionase	Elevated levels of cystathionine in urine (condition is benign)
Phenylketonuria	Phenylalanine hydroxylase (several variants)	Increased levels of phenylalanine and deaminated metabolites in blood and urine; mental retardation; decreased neurotransmitter synthesis; shortened lifespan
Tyrosinemia	Tyrosine transaminase	Eye and skin lesions, mental retardation
	Fumarylacetoacetate hydrolase	Liver failure, renal failure
	p-hydroxylphenylpyruvate oxidase	Increased need for ascorbic acid
Albinism	Tyrosinase	Lack of melanin (skin pigment) formation; increased sensitivity to sunlight; lack of eye pigment
Alcaptonuria	Homogentisate oxidase	Elevated urine levels of homogentisate; slow deposits of homogentisate in bones, connective tissue and internal organs resulting in gradual darkening of these structures. Increased susceptibility to arthritis
Histidenemia	Histidase	Elevated levels of histidine in blood and urine. Can give false positive result in test for phenylketonuria. Elevated urocanase levels in sweat. Decreased histamine formation.

TABLE 3.5

Mutations that Phenotype as Obesity

Genotype	Species	Phenotype
Estrogen receptor β		
Codons 238-244 — 21 bp deletion	human	obesity[1]
846G to A	human	obesity[1]
1421T to C	human	obesity[1]
1730A to G	human	obesity[1]
POMC (Proopiomelanocortin gene)		
codon 73-74 (btwn. 6997 and 6998)	human	extreme childhood and adolescent obesity[2]
within codon 176 (btwn. 7304 and 7305)	human	extreme childhood and adolescent obesity[2]
G7316T	human	extreme childhood and adolescent obesity[2]
G7341G	human	extreme childhood and adolescent obesity[2]
C6982T	human	extreme childhood and adolescent obesity[2]
C7111G	human	extreme childhood and adolescent obesity[2]
LEP (Leptin gene)		
G144A substitution in codon 48	human	extreme obesity and very low serum leptin levels[3]
G328A substitution in codon 110	human	extreme obesity and very low serum leptin levels[3]
c'some 6-10.5	mouse	obesity[4]
c'some 7-q32	human	obesity[4]
LEPR (Leptin receptor)		
c'some 4-46.7	mouse	obesity[4]
c'some 1-p31	human	obesity[4]
UCP1 (Uncoupling protein)		
Arg/Trp 40	human	juvenile onset obesity[5]
Ala/Thr 64	human	juvenile onset obesity[5]
Val/Met 137	human	juvenile onset obesity[5]
Met/Leu 229	human	juvenile onset obesity[5]
Lys/Asn 257	human	juvenile onset obesity[5]
UCP2 (11q13)	human	obesity[4]
UCP3 (11q13)	human	obesity[4]
MC3R (20q13)	human	obesity[4]
NPYR5 (4q31-q32)	human	obesity[4]
MSTN (2q32.1)	human	obesity[4]
Chromosome 2p12-13	human	Alstrom Syndrome (retinal pigment degeneration, neurogenic deafness, infantile obesity, hyperlipidemia, NIDDM[6]
fa mutation		
269Gln to Pro	Zucker rat	Obesity: Severe insulin resistance, hyperinsulinemia, hyperglycemia, hyperlipidemia, hypercortisolemia[7]
Ob-Rb (269Gln to Pro)	Zucker rat	Obesity: Decreased cell-surface expression and decreased leptin binding affinity[7]
C57 BLKS/J-Lepr^{db}/Lepr^{db}	mouse	hyperphagia, obesity, hyperinsulinemia, hyperglycemia[8]
Gsalpha		
R258W	human	Albright hereditary osteodystrophy: skeletal abnormalities and obesity[9]
R258A	human	Albright hereditary osteodystrophy: skeletal abnormalities and obesity[9]
PPARg2		
Pro115Gln	human	extreme obesity[10]
CPE (carboxypeptidase E)	mouse	hyperproinsulinemia, late onset obesity, diabetes[11]
IRS 1 (insulin receptor substrate) S13 and 972	human	NIDDM and obesity[12]
Beta3 AR 64 (Beta 3 adrenergic receptor)	human	NIDDM and obesity[12]
OB D75514 — D7S530	human	NIDDM, obesity, hypertension, and insulin resistance[13]

TABLE 3.5 *(Continued)*

Mutations that Phenotype as Obesity

Genotype	Species	Phenotype
Insulin receptor gene		
Ile1153Met	human	obesity, insulin resistance, hypoandrogenism, acanthosis nigricans[14]
ASIP (agouti signaling protein)		
2-88.8	mouse	obesity[4]
20q11.2-q12	human	obesity[4]
TUB (tubby)		
c'some 7-51.45	mouse	obesity[4]
c'some 11p15.4-p15.5	human	obesity[4]
TNFA (tumor necrosis factor)		
c'some 17-19.1	mouse	obesity[4]
c'some 6p21.3	human	obesity[4]
4p16.3 (autosomal dominant)	human	obesity — Achondroplasia[15]
20q11 (autosomal dominant)	human	obesity — Posterior Polymorphous Corneal Dystrophy[15]
15q11.2-q12(autosomal dominant)	human	obesity — Prader-Willi Syndrome[15]
12q23-q24.1(autosomal dominant)	human	obesity — Schinzel Syndrome[15]
11q13 (autosomal recessive)	human	obesity — BBS 1 (Bardet-Biedl Syn)[15]
16q21 (autosomal recessive)	human	obesity — BBS2[15]
3p13-p12 (autosomal recessive)	human	obesity — BBS3[15]
15q22.3-q23(autosomal recessive)	human	obesity — BBS4[15]
8q22-q23(autosomal recessive)	human	obesity — Cohen Syndrome (CHS1)[15]
Xq26-q27 (X linked)	human	obesity — Borjeson-Forssman-Lehman[15]
Xq21 **(X linked)**	human	obesity[15]
Xq21.1-q22 **(X linked)**	human	obesity — Wilson-Turner Syndrome[15]
Xq26 **(X linked)**	human	obesity — Simpson-Golabi Behmel [15]
HSD3B1 (1p13.1)	human	obesity[15]
ATP1A2 (1q21-q23)	human	obesity[15]
ACP1 (2p25)	human	obesity[15]
APOB (2p24-p23)	human	obesity[15]
APOD (3q27-qter)	human	obesity[15]
UCP (4q28-q31)	human	obesity[15]
TNFir24 (6p21.3)	human	obesity[15]
LPL (8p22)	human	obesity[15]
ADRB3 (8p12-p11.1)	human	obesity[15]
SUR (11p15.1)	human	obesity[15]
DRD2 (11q22.2-q22.3)	human	obesity[15]
APOA4 (11q23-qter)	human	obesity[15]
LDLR (19p13.2)	human	obesity[15]

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TABLE 3.6

Mutations that Phenotype as Heart Disease

Genotype	Species	Phenotype
LPL gene		
G188E (exon 5)	human	High plasma TG — heart disease[1]
P207L (exon 5)	human	High plasma TG — heart disease[1]
D250N (exon 6)	human	High plasma TG — heart disease[1]
Homocysteine gene		
373C/T = R125W(autosomal recessive)	human	Homocystinuria[2]
456C/G = I152M (autosomal recessive)	human	Homocystinuria[2]
494G/A = C165Y(autosomal recessive)	human	Homocystinuria[2]
539T/C = V180A(autosomal recessive)	human	Homocystinuria[2]
833T/C = I278T(autosomal recessive)	human	Homocystinuria[2]
1105C/T = R369C(autosomal recessive)	human	Homocystinuria[2]
1111G/A = V137M(autosomal recessive)	human	Homocystinuria[2]
1301 C/A = T434N(autosomal recessive)	human	Homocystinuria[2]
1330 G/A = D444N(autosomal recessive)	human	Homocystinuria[2]
1471 C/T = R491C(autosomal recessive)	human	Homocystinuria[2]
MTHR gene		
792+1G to A/?	human	Hyperhomocysteinemia/Hypomethioninemia[3]
G458T/G458T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
C692T/C692T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
C559T/C559T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
249-IG to T/G164C	human	Hyperhomocysteinemia/Hypomethioninemia[3]
G428A/?	human	Hyperhomocysteinemia/Hypomethioninemia[3]
C985T/C985T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
G167A/C1015T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
C559T/C559T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
C764T/C764T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
G167A/C1081T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
T980C/C1141T	human	Hyperhomocysteinemia/Hypomethioninemia[3]
C559T/N	human	Hyperhomocysteinemia/Hypomethioninemia[3]
833T to C = I278T	human	Mild hyperhomocysteinuria[2]
677C to T (A to V)	human	Mild hyperhomocysteinuria[2]
4p16.1 (btwn. D4S2957 and D4S827)	human	Ellis van Creveld Syn (cardiac malformations)[4]
9q31		
TD1 = G1764del to Stop (autosomal recessive)	human	Tangier disease — premature CAD[5]
TD2 = 3' del (autosomal recessive)	human	Tangier disease — premature CAD[5]
TD3 = N875S (autosomal recessive)	human	Tangier disease — premature CAD[5]
TD4 = A877V (autosomal recessive)	human	Tangier disease — premature CAD[5]
TD5 = W530S (autosomal recessive)	human	Tangier disease — premature CAD[5]
LDLR gene		
Missense C240 to F (Cys to Phe) Exon 5	human	Hypercholesterolemia/Premature CVD[6]
Missense G5218 to D (Gly to Asp) Exon 11	human	Hypercholesterolemia/Premature CVD[6]
Nonsense C122 to X (Cys to stop) Exon 4A	human	Hypercholesterolemia/Premature CVD[6]
Nonsense C122 to X (Cys to stop) Exon 4A	human	Hypercholesterolemia/Premature CVD[6]
Missense E187 to K (Glu to Lys) Exon 4B	human	Hypercholesterolemia/Premature CVD[6]
Missense C356 to Y (Cys to Tyr) Exon 8	human	Hypercholesterolemia/Premature CVD[6]
Nonsense C122 to X (Cys to stop) Exon 4A	human	Hypercholesterolemia/Premature CVD[6]
Nonsense C122 to X (Cys to stop) Exon 4A	human	Hypercholesterolemia/Premature CVD[6]
Missense w66 to G (Trp to Gly) Exon 3	human	Hypercholesterolemia/Premature CVD[6]
Missense W66 to G (Trp to Gly) Exon3	human	Hypercholesterolemia/Premature CVD[6]
Missense 187E to K (Glu to Lys) Exon 4B	human	Hypercholesterolemia/Premature CVD[6]
Missense W66 to G (Trp to Gly) exon 3	human	Hypercholesterolemia/Premature CVD[6]
Insertion 785insG (frameshift) Exon 17	human	Hypercholesterolemia/Premature CVD[6]
Missense W66 to G (Trp to Gly) Exon 3	human	Hypercholesterolemia/Premature CVD[6]
Deletion 165delG (frameshift) Exon 4A	human	Hypercholesterolemia/Premature CVD[6]
Missense D245 to E (Asp to Glu) Exon 5	human	Hypercholesterolemia/Premature CVD[6]

TABLE 3.6 *(Continued)*

Mutations that Phenotype as Heart Disease

Genotype	Species	Phenotype
C-45T in promoter	human	Hypercholesterolemia/Premature CAD[7]
Trp66Gly	human	Hypercholesterolemia/Premature CAD[7]
Cys68Tyr	human	Hypercholesterolemia/Premature CAD[7]
Cys88Tyr	human	Hypercholesterolemia/Premature CAD[7]
Glu387Lys	human	Hypercholesterolemia/Premature CAD[7]
Ala519Thr	human	Hypercholesterolemia/Premature CAD[7]
Ala585Ser	human	Hypercholesterolemia/Premature CAD[7]
Pro587Arg	human	Hypercholesterolemia/Premature CAD[7]
Phe598Leu	human	Hypercholesterolemia/Premature CAD[7]
Trp599Arg	human	Hypercholesterolemia/Premature CAD[7]
Arg723Gln	human	Hypercholesterolemia/Premature CAD[7]
Cys660stop	human	Hypercholesterolemia[8]
Asp206Glu	human	Hypercholesterolemia[8]
Val208Met	human	Hypercholesterolemia[8]
DelGly197	human	Hypercholesterolemia[8]
Glu80toLys	human	Hypercholesterolemia[8]
Asp206toGlu	human	Hypercholesterolemia[8]
Tyr807Lys	human	Hypercholesterolemia[8]
Glu207Lys	human	Hypercholesterolemia[8]
Pro664Leu	human	Hypercholesterolemia[8]
CBS gene		
G919 to A	human	Homocystinuria[9]
Elastin Gene		
7q11.23	human	Williams Syn (Supravalvular aortic stenosis)[10]
11p15.5	human	Long QT Syn (congenital heart & vascular disease)[10]
7q35-36	human	Long QT Syn (congenital heart & vascular disease)[10]
3p21-24	human	Long QT Syn (congenital heart & vascular disease)[10]
Paraoxonase gene		
Leu 54 to Met	human	CVD[11]
Troponin T gene		
Ile79Asn	human	Hypertrophic cardiomyopathy[12]
Arg92Gln	human	Hypertrophic cardiomyopathy[12]
Phe110Ile	human	Hypertrophic cardiomyopathy[12]
Glu163Lys	human	Hypertrophic cardiomyopathy[12]
Glu244Asp	human	Hypertrophic cardiomyopathy[12]
Arg278Cys	human	Hypertrophic cardiomyopathy[12]
Alpha Tropomyosin gene		
Asp175Asn	human	Hypertrophic cardiomyopathy[12]
Myosin gene		
Arg403Gln	human	Hypertrophic cardiomyopathy[12]
Arg453Gln	human	Hypertrophic cardiomyopathy[12]
Arg719Trp	human	Hypertrophic cardiomyopathy[12]
Val606Met	human	Hypertrophic cardiomyopathy[12]
Phe513Cys	human	Hypertrophic cardiomyopathy[12]
Leu908Val	human	Hypertrophic cardiomyopathy[12]
ApoB gene		
Arg3500 to Gln	human	hypercholesterolemia/peripheral vascular disease[13]
arg3531 to Cys	human	hypercholesterolemia/peripheral vascular disease[13]
Glu to Lys 4154	human	CAD[14]
Arg to Glu 3611	human	CAD[14]

TABLE 3.6 *(Continued)*

Mutations that Phenotype as Heart Disease

Genotype	Species	Phenotype
11 βHSD		
R208C	human	hypertension[15]
R213C	human	hypertension[15]
L250P	human	hypertension[15]
L251S	human	hypertension[15]
R337H	human	hypertension[15]
Y338	human	hypertension[15]
hBENaC		
C to T at Arg 564 (autosomal dominant)	human	Liddle's Syn (hypertension)[16]
Bradykinin receptor (14q32)		
845C/T	human	CVD[17]
704C/T	human	CVD[17]
649insG	human	CVD[17]
640T/C	human	CVD[17]
536T/C	human	CVD[17]
412C/G	human	CVD[17]
143C/T	human	CVD[17]
78C/T	human	CVD[17]
Transcription factor NKX2-5		
Thr178Met	human	Congenital heart disease[18]
Gln170ter	human	Congenital heart disease[18]
Gln198ter	human	Congenital heart disease[18]

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TABLE 3.7

Mutations that Phenotype as Diabetes

Genotype	Species	Phenotype
PC1 (prohormone convertase 1)		
Gly483Arg	human	Extreme childhood obesity, abnormal glucose homeostasis[1]
PC2 (prohormone convertase 2)	mouse	NIDDM: elevation of proinsulin level and/or proinsulin/insulin ratio[2]
PC3 (prohormone convertase 3)	mouse	NIDDM: elevation of proinsulin level and/or proinsulin/insulin ratio[2]

TABLE 3.7 *(Continued)*

Mutations that Phenotype as Diabetes

Genotype	Species	Phenotype
GCK (glucokinase)		NIDDM: low prevalence of micro-and macrovascular complications of diabetes[3]
A53S	human	MODY[4]
G80A	human	MODY[4]
H137R	human	MODY[4]
T168P	human	MODY[4]
M210T	human	MODY[4]
C213R	human	MODY[4]
V226M	human	MODY[4]
S336L	human	MODY[4]
V367M	human	MODY[4]
E248X	human	MODY[4]
S360X	human	MODY[4]
V401del1	human	MODY[4]
L1221G to T	human	MODY[4]
K161+2del10	human	MODY[4]
R186X	human	MODY[4]
G261R	human	MODY[4]
G279T	human	MODY[5]
Ala188Thr (autosomal dominant)	human	NIDDM[6]
7p (alleles z+4, z+2, Z22) (autosomal dominant)	human	NIDDM[7]
IRS 1 (insulin receptor substrate)		
S13 and 972	human	NIDDM and obesity[8]
Beta3 AR 64 (Beta 3 adrenergic receptor)	human	NIDDM and obesity[8]
OB D75514 — D7S530	human	NIDDM, obesity, hypertension, and insulin resistance[9]
Insulin receptor gene		
Codon 897 — nonsense mutation	human	Leprechaun/Minn 1:Leprechaunism-intrauterine growth retardation, extreme insulin resistance Death usually occurs before age 1.[10]
Glu460Lys	human	Leprechaun/Ark-1 Leprechaunism — intrauterine growth retardation, extreme insulin resistance Death usually occurs before age 1[10]
Leu233Pro	human	insulin resistance/NIDDM[10]
Phe382Val	human	insulin resistance/NIDDM[10]
Lys460Glu	human	insulin resistance/NIDDM[10]
Gln672stop	human	insulin resistance/NIDDM[10]
Arg735Ser	human	insulin resistance/NIDDM[10]
Arg897stop	human	insulin resistance/NIDDM[10]
Gly1008Val	human	insulin resistance/NIDDM[10]
Trp1200Ser	human	insulin resistance/NIDDM[10]
Val382Ser	human	Rabson-Mendenhall Syndrome — insulin resistance (NIDDM), abnormalities of teeth, nails, and pineal hyperplasia[10]
Amber133/Ser462	human	NIDDM, acanthosis nigricans, hypoandrogenism[11]
Ser735	human	NIDDM, acanthosis nigricans, hypoandrogenism[11]
Thr1134Ala	human	NIDDM, acanthosis nigricans, hypoandrogenism[11]
Arg209His	human	Leprechaun/Winnipeg — leprechaunism, extreme insulin resistance (NIDDM)[12]

TABLE 3.7 *(Continued)*

Mutations that Phenotype as Diabetes

Genotype	Species	Phenotype
Asn15Lys	human	Rabson-Mendenhall Syndrome — insulin resistance (NIDDM), abnormalities of teeth, nails, and pineal hyperplasia[12]
Asn462Ser	human	NIDDM — extreme insulin resistance, acanthosis nigricans, Hyperandrogenism[12]
Trp133stop	human	NIDDM[12]
His209Arg	human	NIDDM[12]
Arg1000stop	human	NIDDM[12]
Gly996Val	human	NIDDM and acanthosis nigricans[13]
Glu 1135/WT	human	type A extreme insulin resistance[14]
Ile 1153	human	type A extreme insulin resistance[14]
Del exon 3/WT	human	type A extreme insulin resistance[14]
Del codon 1109/WT	human	type A extreme insulin resistance[14]
Glu993/Opal 1000	human	type A extreme insulin resistance[14]
Leu 1178/WT	human	type A extreme insulin resistance[14]
Ser 1200	human	type A extreme insulin resistance[14]
Lys15/Opal 1000	human	type A extreme insulin resistance[14]
AG to GG (intron4)	human	type A extreme insulin resistance[14]
Glu460/Amber 672	human	type A extreme insulin resistance[14]
Pro223	human	type A extreme insulin resistance[14]
Arg31	human	type A extreme insulin resistance[14]
Opal897	human	type A extreme insulin resistance[14]
Del codon 1109/Met910	human	type A extreme insulin resistance[14]
Ala28/Arg366	human	type A extreme insulin resistance[14]
KIR6.2		
E23R	human	NIDDM[15]
L270V	human	NIDDM[15]
I337V	human	NIDDM[15]
20q12-q13.1	human	MODY 1[16]
7p15-p13	human	MODY 2[16]
12q24.2	human	MODY 3[16]
13q12.1	human	MODY 4[16]
17cen-q21.3	human	MODY 5[16]
HNF1 alpha		
G31D	human	NIDDM- defective insulin secretion[17]
R159W	human	NIDDM- defective insulin secretion[17]
A161T	human	NIDDM- defective insulin secretion[17]
R200W	human	NIDDM- defective insulin secretion[17]
R271W	human	NIDDM- defective insulin secretion[17]
IVS5nt+2T to A	human	NIDDM- defective insulin secretion[17]
P379fsdelT	human	NIDDM- defective insulin secretion[17]
G292fsdelG	human	MODY[18]
Y122C	human	MODY[18]
R159Q	human	MODY[18]
S142F	human	MODY[18]
R55G56fsdelGACGG	human	MODY[18]
Q7X	human	MODY[18]
R171X	human	MODY[18]
P291fsdelC	human	MODY[18]
A443fsddCA	human	MODY[19]
P129T	human	MODY[19]

TABLE 3.7 *(Continued)*

Mutations that Phenotype as Diabetes

Genotype	Species	Phenotype
R131W	human	MODY[19]
R159W	human	MODY[19]
P519L	human	MODY[19]
T620I	human	MODY[19]
I128N	human	MODY[20]
H143Y	human	MODY[20]
P447L	human	MODY[20]
A559fsinsA	human	MODY[20]
CD38 gene		
Arg140Trp	human	Type II diabetes mellitus[21]
Insulin gene		
ValA3Leu (autosomal dominant)	human	mild diabetes or glucose intolerance[22]
PheB24Ser (autosomal dominant)	human	mild diabetes or glucose intolerance[22]
PheB25Leu (autosomal dominant)	human	mild diabetes or glucose intolerance[22]
His 65 (autosomal dominant)	human	mild diabetes or glucose intolerance[22]
Xaa 65 (autosomal dominant)	human	mild diabetes or glucose intolerance[23]
AspB10 (autosomal dominant)	human	mild diabetes or glucose intolerance[23]
mGPDH gene		
ACA:Thr243-ACG:Thr243	human	NIDDM[24]
CAT: His264-CGT: Arg264	human	NIDDM[24]
GCA:Ala305-GCC:Ala305	human	NIDDM[24]
GCA:Ala306-TCA:Ser306	human	NIDDM[24]
4p16 between D4S432 and D4S431	human	Wolfram Syn (DM, DI, optic atrophy, deafness)[25]
Mitochondrial DNA mutations(phenotype depends on % mutation in the heteroplasmic individual) [26,27]		
tRNA $^{Leu\ (UUR)}$		
A3423G,A3252G,C3256T, T3271C, T3290C, T3291C	human	NIDDM and deafness
ND 1		
G3316A, A3348G, T3394C, T3396C, G3423T,A3434G, G3438A, A3447G, A3480G G3483A, T4216	human	Diabetes with varying degrees of severity; CNS, Muscle, heart, and kidney involvement
ND2		
A4917	human	same as above
tRNA^{cys}		
C5780A	human	same as above
tRNA^{ser}		
C7476T	human	same as above
COX II		
A8245G,G8251A	human	same as above
tRNA^{lys}		
A8344G	human	same as above
ATPase 6,8 (genes overlap on the mt genome)		
T8993G or C, A8860G,G8894A	human	same as above
G8204A, C8289T	rat	same as above but milder
ND3		
C10398T, T11778C	human	same as above
ND4		
T11778C	human	same as above
tRNA ^{glu}		
T14709C	human	same as above

TABLE 3.7 *(Continued)*

Mutations that Phenotype as Diabetes

Genotype	Species	Phenotype
TRNAthr		
C15904T, A15924G, G15927A G15928A	human	same as above
D-loop		
C16069T,T16093C,C16126T	human	same as above

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TABLE 3.8

Normal Values for Micronutrients in Blood

Ascorbic acid, plasma	0.6–1.6 mg/dl	Phosphorus	3.4–4.5 mg/dl
Calcium, serum	4.5–5.3 meq/l	Potassium	3.5–5.0 meq/l
β-Carotene, serum	40–200 μg/dl	Riboflavin, red cell	>14.9 μg/dl cells
Chloride, serum	95–103 meq/l	Folate, plasma	>6 ng/ml
Lead, whole blood	0–50 μg/dl	Pantothenic acid, plasma	≥6 μg/dl
Magnesium, serum	1.5–2.5 meq/l	Pantothenic acid, whole blood	≥80 μg/dl
Sodium, plasma	136–142 meq/l	Biotin, whole blood	>25 ng/ml
Sulfate, serum	0.2–1.3 meq/l	B_{12}, plasma	>150 pg/ml
Vitamin A, serum	15–60 μg/dl	Vitamin D 25(OH)–D_3, plasma	>10 ng/ml
Retinol, plasma	>20 μg/dl	α-Tocopherol, plasma	>0.80 mg/dl

Note: For more information on blood analysis see: NHANES Manual for Nutrition Assessment, CDC, Atlanta, GA (contact Elaine Gunter); ICNND Manual for Nutrition Surveys, 2nd ed., 1963, U.S. Government Printing Office, Washington, D.C.; Sauberlich et al., 1974, *Laboratory Tests for the Assessment of Nutritional Status,* CRC Press, Boca Raton, FL.

TABLE 3.9

Normal Clinical Values for Constituents of Blood

	Common Units or SI Units
Ammonia	22-39 umol/L
Calcium	8.5-10.5 mg/dl or 2.25-2.65 mmol/L
Carbon dioxide	24-30 meq/l or 24-29 mmol/L
Chloride	100-106 meq/L or mmol/L
Copper	100-200 µg/dl or 16-31 µmol/L
Iron	50-150 µg/dl or 11.6-31.3 µmol/L
Lead	50 µg/dl or less
Magnesium	1.5-2.0 meq/L or 0.75-1.25 mmol/L
P CO_2	35-40 mm Hg
pH	7.35-7.45
Phosphorus	3.0-4.5 mg/dl or 1-1.5 mmol/L
PO_2	75-100 mm Hg
Potassium	3.5-5.0 meq/L or 2.5-5.0 mmol/L
Sodium	135-145 meq/L or 135-145 mmol/L
Acetoaetate	less than 2 mmol
Ascorbic adic	0.4-15 mg/dl or 23-85 µmol/L
Bilirubin	0.4-0.6 mg/dl or 1.71-6.84 µmol/L
Carotinoids	0.8-4.0 µg/ml
Creatinine	0.6-1.5 mg/dl or 60-130 µmol/L
Lactic acid	0.6-1.8 meq/L or 0.44-1.28 µmol/L
Cholesterol	120-220 mg/dl or 3.9-7.3 mmol/L
Triglycerides	40-150 mg/dl or 6-18 mmol/L
Pyruvic acid	0-0.11 meq/L or 79.8-228 µmol/L
Urea nitrogen	8-25 mg/dl or 2.86-7.14 mmol/L
Uric acid	3.0-7.0 mg/dl or 0.18-0.29 mmol/L
Albumin	3.5-5.0 g/dl
Insulin	6-20 µU/dl
Glucose	70-100 mg/dl or 4-6 mmol/L

TABLE 3.10

Normal Values for Micronutrients in Urine

Calcium, mg/24 hr	100–250
Chloride, meq/24 hr	110–250
Copper, µg/24 hr	0–100
Lead, µg/24 hr	< 100
Phosphorus, g/24 hr	0.9–1.3
Potassium, meq/24 hr	25–100
Sodium, meq/24 hr	130–260
Zinc, mg/24 hr	0.15–1.2
Creatinine, mg/kg bodyweight	15–25
Riboflavin, µg/g creatinine	> 80
Niacin metabolite,[a] µg/g creatinine	> 1.6
Pyridoxine, µg/g creatinine	≥ 20
Biotin, µg/24 hr	> 25
Pantothenic acid, mg/24 hr	≥ 1
Folate, FIGLU[b] after histidine load	< 5 mg/8 hr
B_{12}, methylmalonic acid after a valine load	≤ 2 mg/24 hr

Note: For more information on urine analyses see: ICNNO, 1963, *Manual for Nutrition Surveys,* 2nd ed., U.S. Government Printing Office, Washington, D.C.; Sauberlich et al., 1974, *Laboratory Tests for the Assessment of Nutritional Status,* CRC Press, Boca Raton, FL; NHANES Manual for Nutrition Assessment, CDC, Atlanta, GA; Gibson, R.S., 1990. *Principles of Nutrition Assessment,* Oxford University Press, New York.

[a] N^1-methylnicotinamide.

[b] Formiminoglutamic acid.

TABLE 3.11

Normal Clinical Values for Constituents of Human Urine

Constituent	Content
Aldosterone	2–26 µg/24 hr; 5.5–72 nmol/d
Catecholamines (total)	< 100 µg/24 hr
Epinephrine	< 10 µg/24 hr; <100 nmol/d
Norepinephrine	< 100 µg/24 hr; <590 nmol/d
Cortisol, free	20–100 µg/24 hr; 0.55–2.76 µmol/d
11,17-Hydroxycorticoids	men: 4–12 µg/24 hr; women, 4–8 µg/24 hr
17-Ketosteroids	<8 yrs: 0–2 mg/24 hr; 9–20 yrs: 2–20 mg/24
Metanephrine	< 1.3 mg/24 hr; 6.6 umol/d
Vanillylmandilic acid	< 7 mg/24 hr; < 35 µmol/d
Lead	< 80 µg/24 hr; 0.4 µmol/d
Sodium	190 mmol/l
Potassium	70 mol/l
Chloride	200 mmol/l
Phosphate (PO_4)	35 mmol/l
Phosphorus	22.5 mmol/g creatinine/l urine
Sulfate (SO_4)	21–34 mmol/l
Calcium	204 ± 73 mg/24 hr; 1.25–12.5 mmol/24 hr
Iodine	>50 µg/g creatinine
Chromium	3.27–3.85 nmol/l
Manganese	7–10.6 nmol/24 hr
Urea	330–580 mmol/l (depends on diet)
Uric acid	0.4–5.8 mmol/l
Amino nitrogen	19–31 mmol/l (depends on diet)
Ammonia	29–72 mmol/l (depends on diet)
Creatinine	9.5–28.5 mmol/l
Porphyrins	
D aminolevulinic acid	1.5–7.5 mg/24 hr; 11–57 umol/d
Coproporphyrin	< 230 µg/24 hr; < 350 nmol/d
Uroporphyrin	< 50 µg/24 hr; < 60 nmol/d
Porphobilinogen	< 2 mg/24 hr; 8.8 µmol/d
Urobilinogen	< 2.5 mg/24 hr; 70–470 µmol/d
Vitamins (well nourished adult subjects)	
Riboflavin	> 120 µg/24 hr
Niacin	> 66 µg/g creatinine
B_6	> 20 µg/g creatinine
Methylmalonic acid (B_{12} deficient)	>5.0 ug/mg creatinine
Gla:creatinine (K deficient)	Men: 3.16 ± 0.06; women 3.83±0.08
Specific gravity of urine	1.003–1.030
pH	5.5–7.0

Note: Values were from: Sauberlich, HE *Assessment of Nutritional Status,* 2nd Edition CRC Press, Boca Raton, 1999; Banks, P, Bartley, W, Birt, LM, *The Biochemistry of Tissues* 2nd Edition John Wiley 1976; and Murray, RK, Granner, DK, Mayes, PA, Rodwell, *VW Harper's Biochemistry* 24th Edition Appleton & Lange, 1996.

TABLE 3.12

Retinol Binding Proteins

Acronym	Protein	Molecular Weight	Location	Function
RBP	Retinol binding protein	21,000	Plasma	Transports all-*trans* retinol from intestinal absorption site to target tissues
CRBP	Cellular retinol binding protein	14,600	Cells of target tissue	Transports all-*trans* retinol from plasma membrane to organelles within the cell
CRBP II	Cellular retinol binding protein Type II	16,000	Absorptive cells of small intestine	Transports all-*trans* retinol from absorptive sites on plasma membrane of mucosal cells
CRABP	Cellular retinoic acid binding protein	14,600	Cells of target tissue	Transports all-*trans* retinoic acid to the nucleus
CRALBP	Cellular retinal binding protein	33,000	Specific cells in the eye	Transports 11-*cis* retinal and 11-*cis* retinol as part of the visual cycle
IRBP	Interphotoreceptor or interstitial retinol binding protein	144,000	Retina	Transports all-*trans* retinol and 11-*cis* retinal in the retina extracellular space
RAR	Nuclear retinoic acid receptor, 3 main forms (α, β, γ)		All cells α-liver β-brain γ-liver, kidney, lung	Binds retinoic acid and regions of DNA having the GGTCA sequence
RXR	Nuclear retinoic acid receptors, multiple forms			

TABLE 3.13

Drugs that Alter Nutritional State

Drug	Effect
Spironolactone	Increases need for vitamin A
Thiazides	Increases potassium excretion
Cholestyramine	Increases fecal excretion of cholesterol, vitamin A, B_{12}, folacin
Colestipol	Increases fecal excretion of bile acids, cholesterol, Vitamin A, K, & D
Phenolphthalein	Increases fecal excretion of ingesta (laxative effect) also affects availability of vitamins A, D, K and increases potassium loss
Phenytoin, dilantin	Impairs use of folate
Coumarin, dicoumarol	Interferes with vitamin K in its role in coagulation
Cyclosporin	Interferes with vitamin K metabolism
Isoniazid	Increases need for niacin and B_6
Sulfasalazine	Increases need for folacin
p-aminosalicylic acid	Increases need for vitamin B_{12}
Neomycin	Increases need for vitamin B_{12}
Tetracycline	Interferes with uptake of calcium, magnesium, iron, and zinc
EDTA	Binds divalent ions in the intestine thus decreasing availability
Phenylbutazone	Increases niacin need
Penicillamine	Binds copper and B_6 thus increasing need
Thiosemicarbazide	Binds vitamin B_6
L-DOPA	Increases need for vitamin B_6
Hydralazine	Increases need for vitamin B_6
Pyrimethane	Increases need for folacin
Methotrexate	Increases need for folacin
Theophylline	Increases protein turnover, increases calcium mobilization in cells
Ametine	Interferes with vitamin B_{12}
Aluminum hydroxide	Reduces folate availability as well as phosphate use
Magnesium hydroxide	Counteracts phosphate in intestine
Sodium bicarbonate	Reduces folate availability
Ethanol	Drives up need for niacin, riboflavin, B_6 and folacin
Mineral oil	Impairs absorption of vitamin A & β carotene
Azulfidine	Impairs absorption of folacin, B_{12} and fat soluble vitamins
Oral contraceptives	Increases folacin turnover
Amphetamine	Anorexia
Phenethylamine & related compounds	Anorexia
Colchicine	Promotes peristalsis thus reducing the absorption of all nutrients
Biguanides	Promotes glucose use; decreases absorption of B_{12}

Note: The information in this table provided by the *Physicians' Desk Reference*; *The Merck Index*; Sauberlich, HE, *Assessment of Nutritional Status,* 2nd ed., CRC Press, 1999; and Murray, RK, Granner, DK, Mayes, PA, Rodwell, VW, *Harper's Biochemistry* 24 ed. Appleton & Lange, Stamford, CN, 1997.

TABLE 3.14

Drugs that May Have Anti-Obesity Properties

Drug	Example	Effect
a) Anti Nutrition Drugs		
1. Gastric emptying inhibitors	(--) threochlorocitric acid	Delays gastric emptying, induces satiety
2. Glucosidase inhibitors	Acarbose, miglitol	Inhibits carbohydrate digestion
3. Inhibitors of lipid uptake	Cholestyramine	Binds bile acids, disrupts micelle formation
4. Pseudonutrients	Olestra	Fat substitute with less energy
	Artificial sweeteners	Sugar substitute, no energy
	Bulking agents, fibers	Induce satiety at lower energy intake
5. Lipase inhibitor	Xenecal	Inhibits hydrolysis of triacylglycides
b) Drugs that Affect Nutrient Partitioning		
1. Growth hormone		Stimulates protein synthesis
2. Testosterone		Stimulates protein synthesis in males only
3. α_2 adrenergic antagonists		Enhances lipolysis
4. Thermogenic drugs		
β_2 and β_3 adrenergic	BRL-26830A, terbutaline	Stimulates protein synthesis and lipolysis; can have serious side effects
Dinitrophenol		Metabolic poison; not recommended
c) Appetite Suppressors		
1. β phenethylamine derivatives	Fastin, Dexatrim	Interferes with hunger signaling via norepinephrine
2. Serotonergic agents	Fenfluramine, fluoxetine	Increases serotonin release and signals satiety
3. Amine reuptake inhibitor	Sibutramine	Blocks reuptake of norepinephrine and 5-HT and suppresses appetite

TABLE 3.15

Micronutrient Interactions

	Calcium	Phosphorus	Potassium	Sodium	Magnesium	Zinc	Iron	Copper	Iodine	Fluorine	Vitamin A	Vitamin D	Vitamin E	B_{12}	Vitamin K	Riboflavin	Niacin	Thiamin	Ascorbic acid	B_6	Folacin
Calcium	X	↑a	↓a	↓a↑m	↑m↓a						↑a	↑a, m							↑m		
Phosphorus	↑a	X	↑m	↑m	↓a							↑a				↑m	↑m	↑m			
Potassium	↑↓m	↑a	X	↑a	↓a, ↑m							↑a								↑↓m	
Sodium	↑↓m	↑a		X	↓a, ↑m							↑m								↑↓m	
Magnesium	↓a	↑m		↓a, ↑m	X				↑m			↑a						↑m	↑m	↑m	
Zinc						X		↓a, ↑m			↑m	↑a	↑m				↑m			↑m	
Iron	↑m	↓a				↓a	X	↓a, ↑m						↑m		↑m	↑m		↑a	↓a	↑m
Copper						↓a	↓a, ↑m	X			↑m					↑m				↑m	
Iodine									X			↓a		↑a			↑m		↑m		
Fluorine	↓a									X											
Cobalt							↓a														
Chromium						↓a															
Manganese					↓a		↓a														
Molybdenum							↑m	↓a													
Selenium								↑m													

Note: ↑ increase; ↓ decrease; a, absorption; m, metabolism.

TABLE 3.16

Preferred Ligand Binding Groups for Metal Ions

Metal	Ligand Groups
K^+	Singly charged oxygen donors or neutral oxygen ligands
Mg^{2+}	Carboxylase, phosphate, nitrogen donors
Ca^{2+}	$=Mg^{2+}$, but less affinity for nitrogen donors, phosphate, and other multidentate anions
Mn^{2+}	Similar to Mg^{2+}
Fe^{2+}	–SH, NH_2 > carboxylates
Fe^{3+}	Carboxylate, tyrosine, $–NH_2$, porphyrin (four 'hard' nitrogen donors)
Co^{3+}	Similar to Fe^{3+}
Cu^+	–SH (cysteine)
Cu^{2+}	Amines >> carboxylates
Zn^{2+}	Imidazole, cysteine
Mo^{2+}	–SH
Cd^{2+}	–SH

TABLE 3.17

Food Components That Affect Calcium Absorption

Component	Effect
Alcohol	↓
Ascorbic acid	↓↑
Cellulose	↓
Fat[a]	↑↓
Fiber	↓
Lactose	↑
Medium-chain triglycerides	↑
Oxalates	↓
Pectin	↑↓
Phytate	↓
Protein[b]	↑↓
Sodium alginate	↓
Uronic acid	↓

[a] In cases of steatorrhea, calcium absorption is reduced.

[b] Certain proteins, e.g., those in milk, enhance calcium availability while others, e.g., those in plants, reduce it.

TABLE 3.18

Calcium Binding Proteins

Protein	Function
α-Lactalbumin	Carries calcium in milk
Casein	Carries calcium in milk
Calmodulin	Serves as major intracellular calcium receptor; activates cyclic nucleotidephosphodiesterase
Calbindin D_{9k} and D_{28k}	Facilitates intracellular Ca^{2+} translocation
Osteocalcin	Essential for calcium deposition in bone
$Ca^{2+}Mg^{2+}$ ATPase	Essential to movement of calcium across membranes
Prothrombin	Essential to blood clot formation
Calcitonin	Inhibits osteoclast-mediated bone resorption Regulates blood calcium levels by preventing hypercalcemia
Parathyroid hormone	Stimulates calcitonin synthesis, bone Ca resorption, renal Ca conservation
Albumin	Carries calcium in the blood
Globulin	Carries calcium in the blood
Osteopontin	Essential for calcium mobilization from bone
Troponin C	Muscle contraction
Alkaline phosphatase	Mineralization of bone
Sialoprotein	Embryonic bone growth
GLA-rich clotting proteins	Binds calcium in the coagulation cascade (see vitamin K)
Villin, gelsolin	Cytoskeleton stabilization

TABLE 3.19

The Body Content of Iron

Types of Iron	Male (70 kg)	Female (60 kg)
Essential Iron	3.100 g	2.100 g
Hemoglobin	2.700	1.800
Myoglobin, cytochromes, and other enzymes	0.400	0.300
Storage and transport iron	0.900	0.500
Ferritin, Hemosiderin	0.897	0.407
Transferrin	0.003	0.003
Total iron	4.000	2.600

TABLE 3.20

Body Mass Index Calculated as Body Mass Index = Body Weight/Height.^{2} BMI for a given height

wt/lb	wt/kg													
Height		56	57	58	59	60	61	62	63	64	65	66	67	68
		142.2	144.8	147.3	149.9	152.4	154.9	157.5	160.0	162.6	165.1	167.6	170.2	172.7
100	45.5	22.5	21.7	20.9	20.2	19.6	18.9	18.3	17.8	17.2	16.7	16.2	15.7	15.2
110	50.0	24.7	23.8	23.0	22.3	21.5	20.8	20.2	19.5	18.9	18.3	17.8	17.3	16.8
120	54.5	27.0	26.0	25.1	24.3	23.5	22.7	22.0	21.3	20.6	20.0	19.4	18.8	18.3
130	59.1	29.2	28.2	27.2	26.3	25.4	24.6	23.8	23.1	22.4	21.7	21.0	20.4	19.8
140	63.6	31.5	30.4	29.3	28.3	27.4	26.5	25.7	24.9	24.1	23.3	22.7	22.0	21.3
150	68.2	33.7	32.5	31.4	30.3	29.4	28.4	27.5	26.6	25.8	25.0	24.3	23.5	22.9
160	72.7	36.0	34.7	33.5	32.4	31.3	30.3	29.3	28.4	27.5	26.7	25.9	25.1	24.4
170	77.3	38.2	36.9	35.6	34.4	33.3	32.2	31.2	30.2	29.2	28.3	27.5	26.7	25.9
180	81.8	40.5	39.0	37.7	36.4	35.2	34.1	33.0	32.0	30.9	30.0	29.1	28.2	27.4
190	86.4	42.7	41.2	39.8	38.4	37.2	36.0	34.8	33.7	32.7	31.7	30.7	29.8	29.0
200	90.9	45.0	43.4	41.9	40.5	39.1	37.9	36.6	35.5	34.4	33.4	32.4	31.4	30.5
210	95.5	47.2	45.5	44.0	42.5	41.1	29.8	38.5	37.3	36.1	35.0	34.0	33.0	32.0
220	100.0	49.5	47.7	46.1	44.5	43.1	41.7	40.3	39.1	37.8	36.7	35.6	34.5	33.5
230	104.5	51.7	49.9	48.2	46.5	45.0	43.6	42.1	40.8	39.5	38.4	37.2	36.1	35.1
240	109.1	53.9	42.0	50.3	48.5	47.0	45.5	44.0	42.6	41.3	40.0	38.8	37.7	36.6
250	113.6	56.2	54.2	52.4	50.6	48.9	47.4	45.8	44.4	43.0	41.7	40.5	39.2	38.1
260	118.2	58.4	56.4	54.5	52.6	50.9	49.3	47.6	46.2	44.7	43.4	42.1	40.8	39.6
270	122.7	60.7	58.5	56.6	54.6	52.8	51.1	49.5	47.9	46.4	45.0	43.7	42.4	41.1
280	127.3	62.9	60.7	58.7	56.6	54.8	53.0	51.3	49.7	48.1	46.7	45.3	43.9	43.7
290	131.8	65.2	62.9	60.8	58.7	56.8	54.9	53.1	51.5	49.9	48.4	46.9	45.5	44.2
300	136.4	67.4	65.0	62.8	60.7	58.7	56.8	55.0	53.3	51.6	50.0	48.5	47.1	45.7
310	140.9	69.7	67.2	64.9	62.7	60.7	58.7	56.8	55.0	53.3	51.7	50.2	48.6	47.2
320	145.5	71.9	69.4	67.0	64.7	62.6	60.6	58.6	56.8	55.0	53.4	51.8	50.2	48.8
330	150.0	74.2	71.5	69.1	66.8	64.6	62.5	60.5	58.6	56.7	55.0	53.4	51.8	50.3
340	154.5	76.4	73.7	71.2	68.8	66.5	64.4	62.3	60.4	58.5	56.7	55.0	53.4	51.8
350	159.1	78.7	75.9	73.3	70.8	68.5	66.3	64.1	62.1	60.2	58.4	56.6	54.9	53.3
360	163.6	80.9	78.0	75.4	72.8	70.5	68.2	66.0	63.9	61.9	60.0	58.3	56.5	54.9
370	168.2	83.2	80.2	77.5	74.8	72.4	70.1	67.8	65.7	63.6	61.7	59.9	58.1	56.4
380	172.7	85.4	82.4	79.6	76.9	74.4	72.0	69.6	67.5	65.3	63.4	61.5	59.6	57.9
390	177.3	87.7	84.5	81.7	78.9	76.3	73.9	71.5	69.2	67.1	65.0	63.1	61.2	59.4
400	181.8	89.9	86.7	83.8	80.9	78.3	75.8	73.3	71.0	68.8	66.7	64.7	62.8	61.0

and weight is where the horizontal line intersects the vertical line.

69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
175.3	177.8	180.3	182.9	185.4	188.0	190.5	193.0	195.6	198.1	200.7	203.2	205.7	208.3	210.8	213.4
14.8	14.4	14.0	13.6	13.2	12.9	12.5	12.2	11.9	11.6	11.3	11.0	10.7	10.5	10.2	10.0
16.3	15.8	15.4	14.9	14.5	14.1	13.8	13.4	13.1	12.7	12.4	12.1	11.8	11.5	11.3	11.0
17.7	17.3	16.8	16.3	15.9	15.4	15.0	14.6	14.3	13.9	13.5	13.2	12.9	12.6	12.3	12.0
19.2	18.7	18.2	17.7	17.2	16.7	16.3	15.9	15.4	15.1	14.7	14.3	14.0	13.6	13.3	13.0
20.7	20.1	19.6	19.0	18.5	18.0	17.5	17.1	16.6	16.2	15.8	15.4	15.0	14.7	14.3	14.0
22.2	21.6	21.0	20.4	19.8	19.3	18.8	18.3	17.8	17.4	16.9	16.5	16.1	15.7	15.3	15.0
23.7	23.0	22.4	21.7	21.2	20.6	20.0	19.5	19.0	18.5	18.1	17.6	17.2	16.8	16.4	16.0
25.1	24.4	23.8	23.1	22.5	21.9	21.3	20.7	20.2	19.7	19.2	18.7	18.3	17.8	17.4	17.0
26.6	25.9	25.2	24.5	23.8	23.1	22.5	22.0	21.4	20.8	20.3	19.8	19.3	18.9	18.4	18.0
28.1	27.3	26.6	25.8	25.1	24.4	23.8	23.2	22.6	22.0	21.4	20.9	20.4	19.9	19.4	19.0
29.6	28.8	28.0	27.2	26.4	25.7	25.1	24.4	23.8	23.2	22.6	22.0	21.5	21.0	20.5	20.0
31.1	30.2	29.4	28.5	27.8	27.0	26.3	25.6	24.9	24.3	23.7	23.1	22.6	22.0	21.5	21.0
32.5	31.6	30.8	29.9	29.1	28.3	27.6	26.8	26.1	25.5	24.8	24.2	23.6	23.0	22.5	22.0
34.0	33.1	32.2	31.3	30.4	29.6	28.8	28.1	27.3	26.6	26.0	25.3	24.7	24.1	23.5	23.0
35.5	34.5	33.6	32.6	31.7	30.9	30.1	29.3	28.5	27.8	27.1	26.4	25.8	25.1	24.5	24.0
37.0	35.9	35.0	34.0	33.1	32.2	31.3	30.5	29.7	29.0	28.2	27.5	26.9	26.2	25.6	25.0
38.5	37.4	36.4	35.3	34.4	33.4	32.6	31.7	30.9	30.1	29.3	28.6	27.9	27.2	26.6	26.0
39.9	38.8	37.8	36.7	35.7	34.7	33.8	32.9	32.1	31.3	30.5	29.7	39.0	28.3	27.6	26.9
41.4	40.3	39.2	38.0	37.0	36.0	35.1	34.2	33.3	32.4	31.6	30.8	30.1	29.3	28.6	27.9
42.9	41.7	40.5	39.4	38.3	37.3	36.3	35.4	34.5	33.6	32.7	31.9	31.2	30.4	29.7	28.9
44.4	43.1	41.9	40.8	39.7	38.6	37.6	36.6	35.6	34.7	33.9	33.0	32.2	31.4	30.7	29.9
45.9	44.6	43.3	42.1	41.0	39.9	38.8	37.8	36.8	35.9	35.0	34.1	33.3	32.5	31.7	30.9
47.3	46.0	44.7	43.5	42.3	41.2	40.1	39.0	38.0	37.1	36.1	35.2	34.4	33.5	32.7	31.9
48.8	47.4	46.1	44.8	43.6	42.4	41.3	40.3	39.2	38.2	37.2	36.3	35.5	34.6	33.8	32.9
50.3	48.9	47.5	46.2	45.0	43.7	52.6	41.5	40.4	39.4	38.4	37.4	36.5	35.6	34.8	33.9
51.8	50.3	48.9	47.6	46.3	45.0	43.8	42.7	41.6	40.5	39.5	38.5	37.6	36.7	35.8	34.9
53.2	51.8	50.3	48.9	47.6	46.3	45.1	43.9	42.8	41.7	40.6	39.6	38.7	37.7	36.8	35.9
54.7	53.2	51.7	50.3	48.9	47.6	46.3	45.2	44.0	42.9	41.8	40.7	39.7	38.8	37.8	36.9
56.2	54.6	53.1	51.6	50.3	48.9	47.6	46.4	45.1	44.0	42.9	41.8	40.8	39.8	38.9	37.9
57.7	56.1	54.5	53.0	51.6	50.2	48.8	47.6	46.3	45.2	44.0	42.9	41.9	40.9	39.9	38.9
59.2	57.5	55.9	54.4	52.9	51.4	50.1	48.8	47.5	46.3	45.1	44.0	43.0	41.9	40.9	39.9

TABLE 3.21

Standard International Units (SI Units) for Reporting Clinical Data

Physical Quantity	Base Units	SI Symbol
I. Base Units		
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Amount	Moles	mol
Thermodynamic Temperature	Kelvin	K
Electric Current	Ampere	A
Luminous Intensity	Candela	cd
II. Derived Units		
Area	Square Meter	m^2
Volume	Cubic Meter	m^3
Force	Newton (N)	$kg \cdot m \cdot s^{-2}$
Pressure	Pascal (Pa)	$kg \cdot m^{-2} \cdot s^{-2}$ (N/m^2)
Work, Energy	Joule (J)	$kg \cdot m^2 \cdot s^{-2}$ $(N \cdot m)$
Mass Density	Kilogram per cubic meter	kg/m^3
Frequency	Hertz (Hz)	s^{-1}

TABLE 3.22

Conversion Factors for Values in Clinical Chemistry (SI Units)

Component	Present Reference Intervals (examples)	Present Unit	Conversion Factor	SI Reference Intervals	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
acetaminophen (P) - toxic	>5.0	mg/dL	66.16	>330	µmol/L	XXO	10 µmol/L
acetoacetate (S)	0.3-3.0	mg/dL	97.95	30-300	µmol/L	XXO	10 µmol/L
acetone (B,S)	0	mg/dL	172.2	0	µmol/L	XXO	10 µmol/L
acid phosphatase (S)	0-5.5	U/L	16.67	0-90	nkat/L	XX	2 nkat/L
adrenocorticotropin [ACTH] (P)	20-100	pg/mL	0.2202	4-22	pmol/L	XX	1 pmol/L
alanine aminotransferase [ALT] (S)	0-35	U/L	0.01667	0-0.58	µkat/L	X.XX	0.02 µkat/L
albumin (S)	4.0-6.0	g/dL	10.0	40-60	g/L	XX	1 g/L
aldolase (S)	0-6	U/L	16.67	0-100	nkat/L	XXO	20 nkat/L
aldosterone (S)							
normal salt diet	8.1-15.5	ng/dL	27.74	220-430	pmol/L	XXO	10 pmol/L
restricted salt diet	20.8-44.4	ng/dL	27.74	580-1240	pmol/L	XXO	10 pmol/L
aldosterone (U) - sodium excretion							
=25 mmol/d	18-85	µg/24 h	2.774	50-235	nmol/d	XXX	5 nmol/d
=75-125 mmol/d	5-26	µg/24 h	2.774	15-70	nmol/d	XXX	5 nmol/d
=200 mmol/d	1.5-12.5	µg/24 h	2.774	5-35	nmol/d	XXX	5 nmol/d
alkaline phosphatase (S)	0-120	U/L	0.01667	0.5-2.0	µkat/L	X.X	0.1 µkat/L
$alpha_1$-antitrypsin (S)	150-350	mg/dL	0.01	1.5-3.5	g/L	X.X	0.1 g/L
alpha-fetoprotein (S)	0-20	ng/mL	1.00	0-20	µg/L	XX	1 µg/L
alpha-fetoprotein (Amf)	Depends on gestation	mg/dL	10	Depends on gestation	mg/L	XX	1 mg/L
$alpha_2$-macroglobulin (S)	145-410	mg/dL	0.01	1.5-4.1	g/L	X.X	1 mg/L
aluminum (S)	0-15	µg/L	37.06	0-560	nmol/L	XXO	10 nmol/L
amino acid fractionation (P)							
alanine	2.2-4.5	mg/dL	112.2	245-500	µmol/L	XXX	5 µmol/L
alpha aminobutyric acid	0.1-0.2	mg/dL	96.97	10-20	µmol/L	XXX	5 µmol/L
arginine	0.5-2.5	mg/dL	57.40	30-145	µmol/L	XXX	5 µmol/L
asparagine	0.5-0.6	mg/dL	75.69	35-45	µmol/L	XXX	5 µmol/L
citrulline	0.2-1.0	mg/dL	75.13	0-20	µmol/L	XXX	5 µmol/L

TABLE 3.22 *(Continued)*

Conversion Factors for Values in Clinical Chemistry (SI Units)

Component	Present Reference Intervals (examples)	Present Unit	Conversion Factor	SI Reference Intervals	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
cystine	0.2-2.2	mg/dL	57.08	15-55	µmol/L	XXX	5 µmol/L
glutamic acid	0.2-2.8	mg/dL	67.97	15-190	µmol/L	XXX	5 µmol/L
glutamine	6.1-10.2	mg/dL	68.42	420-700	µmol/L	XXX	5 µmol/L
glycine	0.9-4.2	mg/dL	133.2	120-560	µmol/L	XXX	5 µmol/L
histidine	0.5-1.7	mg/dL	64.45	30-110	µmol/L	XXX	5 µmol/L
hydroxyproline	0-trace	mg/dL	76.26	0-trace	µmol/L	XXX	5 µmol/L
isoleucine	0.5-1.3	mg/dL	76.24	40-100	µmol/L	XXX	5 µmol/L
leucine	1.2-3.5	mg/dL	76.24	75-175	µmol/L	XXX	5 µmol/L
lysine	1.2-3.5	mg/dL	68.40	80-240	µmol/L	XXX	5 µmol/L
methionine	0.1-0.6	mg/dL	67.02	5-40	µmol/L	XXX	5 µmol/L
ornithine	0.4-1.4	mg/dL	75.67	30-400	µmol/L	XXX	5 µmol/L
phenylalanine	0.6-1.5	mg/dL	60.54	35-90	µmol/L	XXX	5 µmol/L
proline	1.2-3.9	mg/dL	86.86	105-340	µmol/L	XXX	5 µmol/L
serine	0.8-1.8	mg/dL	95.16	75-170	µmol/L	XXX	5 µmol/L
taurine	0.9-2.5	mg/dL	79.91	25-170	µmol/L	XXX	5 µmol/L
threonine	0.9-2.5	mg/dL	83.95	75-210	µmol/L	XXX	5 µmol/L
tryptophan	0.5-2.5	mg/dL	48.97	25-125	µmol/L	XXX	5 µmol/L
tyrosine	0.4-1.6	mg/dL	55.19	20-90	µmol/L	XXX	5 µmol/L
valine	1.7-3.7	mg/dL	85.36	145-315	µmol/L	XXX	5 µmol/L
amino acid nitrogen (P)	4.0-6.0	mg/dL	0.7139	2.9-4.3	mmol/L	X.X	0.1 mmol/L
amino acid nitrogen (U)	50-200	mg/24 h	0.07139	3.6-14.3	mmol/d	X.X	0.1 mmol/d
delta-aminolevulinate [as levulinic acid] (U)	1.0-7.0	mg/24 h	7.626	8-53	µmol/d	XX	1 µmol/d
amitriptyline (P,S) therapeutic	50-200	ng/mL	3.605	180-270	µmol/L	XO	10 nmol/L
ammonia (vP)							
as ammonia [NH_3]	10-80	µg/dL	0.5872	5-50	µmol/L	XXX	5 µmol/L
as ammonium ion [NH_4+]	10-85	µg/dL	0.5543	5-50	µmol/L	XXX	5 µmol/L
as nitrogen [N]	10-65	µg/dL	0.7139	5-50	µmol/L	XXX	5 µmol/L
amylase (S)	0-130	U/L	0.01667	0-2.17	µkat/L	XXX	0.01 µkat/L
androstenedione (S)							
male > 18 years	0.2-3.0	mg/L	3.492	0.5-10.5	nmol/L	XX.X	0.5 nmol/L
female > 18 years	0.8-3.0	mg/L	3.492	3.0-10.5	nmol/L	XX.X	0.5 nmol/L

angiotensin converting enzyme (S)	<40	nmol/mL/min	16.67	<670	nkat/L	XXO	10 nkat/L
arsenic (H) [as As]	<1	µg/g (ppm)	13.35	<13	nmol/g	XX.X	0.5 nmol/g
arsenic (U) [as As]	0-5	µg/24 h	13.35	0-67	nmol/d	XX	1nmol/d
[as As_2O_3]	<25	µg/dL	0.05055	<1.3	µmol/L	XX.X	0.1 µmol/L
ascorbate (P) [as ascorbic acid]	0.6-2.0	µg/dL	56.78	30-110	µmol/L	XO	10 µmol/L
aspartate amino-transferase [AST] (S)	0-35	U/L	0.0167	0-0.58	µkat/L	O.XX	0.01 µkat/L
barbiturate (S) overdose total expressed as: phenobarbital	Depends on composition of mixture.						
sodium phenobarbital							
barbitone	Usually not known.	mg/dL	43.06	. . .	µmol/L	XX	5 µmol/L
		mg/dL	39.34		µmol/L	XX	5 µmol/L
		mg/dL	54.29		µmol/L	XX	5 µmol/L
barbiturate (S) therapeutic							
see phenobarbital							
see pentobarbital	. . .	. . .	. . .	. . .	. . .	. . .	. . .
see thiopental							
bile acids, total (S)							
[as chenodeoxycholic acid]	Trace-3.3	µg/mL	2.547	Trace-8.4	µmol/L	X.X	0.2 µmol/L
cholic acid	Trace-1.0	µg/mL	2.448	Trace-2.4	µmol/L	X.X	0.2 µmol/L
chenodeoxycholic acid	Trace-1.3	µg/mL	2.547	Trace-3.4	µmol/L	X.X	0.2 µmol/L
deoxycholic acid	Trace-1.0	µg/mL	2.547	Trace-2.6	µmol/L	X.X	0.2 µmol/L
lithocholic acid	Trace	µg/mL	2.656	Trace	µmol/L	X.X	0.2 µmol/L
bile acids (Df) [after cholcystokinin stimulation]							
total as chenodeoxycholic acid	14.0-58.0	mg/mL	2.547	35.0-148	mmol/L	XX.X	0.2 mmol/L
cholic acid	2.4-33.0	mg/mL	2.448	6.8-81.0	mmol/L	XX.X	0.2 mmol/L
chenodeoxycholic acid	4.0-24.0	mg/mL	2.547	10.0-61.4	mmol/L	XX.X	0.2 mmol/L
deoxycholic acid	0.8-6.9	mg/mL	2.547	2.0-18.0	mmol/L	XX.X	0.2 mmol/L
lithocholic acid	0.3-0.8	mg/mL	2.656	0.8-2.0	mmol/L	XX.X	0.2 mmol/L
bilirubin, total (S)	0.1-1.0	mg/dL	17.10	2-18	µmol/L	XX	2 µmol/L
bilirubin, conjugated (S)	0-0.2	mg/dL	17.10	0-4	µmol/L	XX	2 µmol/L
bromide (S), toxic							
as bromide ion	>120	mg/dL	0.1252	>15	mmol/L	XX	1 mmol/L
as sodium bromide	>150	mg/dL	0.09719	>15	mmol/L	XX	1 mmol/L
	>15	mEq/L	1.00	>15	mmol/L	XX	1 mmol/L
cadmium (S)	<3	mg/dL	0.08897	<0.3	µmol/L	X.X	0.1 µmol/L
calcitonin (S)	<100	pg/mL	1.00	<100	ng/L	XXX	10 ng/L

TABLE 3.22 *(Continued)*

Conversion Factors for Values in Clinical Chemistry (SI Units)

Component	Present Reference Intervals (examples)	Present Unit	Conversion Factor	SI Reference Intervals	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
calcium (S)							
male	8.8-10.3	mg/dL	0.2495	2.20-2.58	mmol/L	X.XX	0.02 mmol/L
female <50 y	8.8-10.0	mg/dL	0.2495	2.20-2.50	mmol/L	X.XX	0.02 mmol/L
female >50 y	8.8-10.2	mg/dL	0.2495	2.20-2.56	mmol/L	X.XX	0.02 mmol/L
	4.4-5.1	mEq/L	0.500	2.20-2.56	mmol/L	X.XX	0.02 mmol/L
calcium ion (S)	2.00-2.30	mEq/L	0.500	1.00-1.15	mmol/L	X.XX	0.01 mmol/L
calcium (U), normal diet							
	<250	mg/24 h	0.02495	<6.2	mmol/d	X.X	0.1 mmol/d
carbamazepine (P)							
- therapeutic	4.0-10.0	mg/L	4.233	17-42	µmol/L	XX	1 µmol/L
carbon dioxide content (B, P, S)							
[bicarbonate + CO_2]	22-28	mEq/L	1.00	22-28	mmol/L	X	1 mmol/L
carbon monoxide (B)							
[proportion of Hb which is COHb]	<15	%	0.01	<0.15	1	0.XX	0.01
beta carotenes (S)	50-250	mg/dL	0.01863	0.9-4.6	µmol/L	X.X	0.1 µmol/L
catecholamines, total (U)							
[as norepinephrine]	<120	mg/24 h	5.911	<675	nmol/d	XXO	10 mg/d
ceruloplasmin (S)	20-35	mg/dL	10.0	200-350	mg/L	XXO	10 mg/L
Chlordiazepoxide (P)							
- therapeutic	0.5-5.0	mg/L	3.336	2-17	µmol/L	XX	1 µmol/L
- toxic	>10.0	mg/L	3.336	>33	µmol/L	XX	1 µmol/L
chloride (S)	95-105	mEq/L	1.00	95105	mmol/L	XXX	1 mmol/L
chlorimipramine (P)							
[includes desmethyl metabolite}	50-400	ng/mL	3.176	150-1270	nmol/L	XXO	10 nmol/L
chlorpromazine (P)	50-300	ng/mL	3.136	150-950	nmol/L	XXO	10 nmol/L
chlorpropamide (P)							
-therapeutic	75-250	mg/L	3.613	270-900	mmol/L	XXO	10 mmol/L
cholestanol (P) [as a fraction of total							
cholesterol]	1-3	%	0.01	0.01-0.03	1	0.XX	0.01
cholesterol (P)							
- <29 years	<200	mg/dL	0.02586	<5.20	mol/L	X.XX	0.05 mmol/L

- 30-39 years	<225	mg/dL	0.02586	<5.85	mmol/L	X.XX	0.05 mmol/L
- 40-49 years	<245	mg/dL	0.02586	<6.35	mmol/L	X.XX	0.05 mmol/L
- >50 years	<265	mg/dL	0.02586	<6.85	mmol/L	X.XX	0.05 mmol/L
cholesterol esters (P) [as a fraction of total cholesterol]							
	60-75	%	0.01	0.60-0.75	1	0.XX	0.01
cholinesterase (S)	620-1370	U/L	0.01667	10.3-22.8	mkat/L	XX.X	0.1 mkat/L
chorionic gonadotropin (P) [beta HCG]	0 if not pregnant	mIU/mL	1.00	0 if not pregnant	IU/L	XX	1 IU/L
citrate (B) [as citric acid]	1.2-3.0	mg/dL	52.05	60-160	µmol/L	XXX	5 µmol/L
complement, C3 (S)	70-160	mg/dL	0.01	0.7-1.6	g/L	X.X	0.1 g/L
complement, C4 (S)	20-40	mg/dL	0.01	0.2-0.4	g/L	X.X	0.1 g/L
copper (S)	70-140	µg/dL	0.1574	11.0-22.0	µmol/L	XX.X	0.2.µmol/L
copper (U)	<40	µg/24 h	0.01574	<0.6	µmol/d	X.X	0.2 µmol/L
coproporphyrins (U)	<200	µg/24 h	1.527	<300	nmol/d	XXO	10 nmol/d
cortisol (S)							
-800 h	4-19	µg/dL	27.59	110-520	nmol/L	XXO	10 nmol/L
-1600 h	2-15	µg/dL	27.59	50-410	nmol/L	XXO	10 nmol/L
-2400 h	5	µg/dL	7.59	140	nmol/L	XXO	10 nmol/L
cortisol, free (U)	10-110	µg/24 h	2.759	30-300	nmol/d	XXO	10 nmol/d
creatine (S)							
-male	0.17-0.50	µg/dL	76.25	10-40	mmol/L	XO	10 mmol/L
-female	0.35-0.93	µg/dL	76.25	30-70	mmol/L	XO	10 mmol/L
creatine (U)							
-male	0-40	mg/24 h	7.625	0-300	µmol/d	XXO	10 µmol/d
-female	0-80	mg/24 h	7.625	0-600	µmol/d	XXO	10 µmol/d
creatine kinase [CK] (S)							
creatine kinase isoenzymes (S)	0-130	U/L	0.01667	0-2.16	µkat/L	X.XX	0.01 µkat/L
-MB fraction	>5 in myocardial infarction	%	0.01	>0.05	1	O.XX	0.01
creatinine (S)	0.6-1.2	mg/dL	88.40	50-110	µmol/L	XXO	10 µmol/L
creatinine (U)	Variable	g/24 h	8.840	Variable	mmol/d	XX.X	0.1 mmol/d
creatinine clearance (S, U)	75-125	mL/min	0.01667	1.24-2.08	mL/s	X.XX	0.02 mL/s
	$\text{creatinine clearance corrected for body} = \frac{\text{mmol / L (urine creatinine)}}{\text{mmol / L (serum creatinine)}} \times \text{mL / s} \times \frac{1.73}{A}$				[where A is the body surface area in square meters (m^2)]		
cyanide (B) - lethal	>0.10	mg/dL	384.3	>40	µmol/L	XXX	5 µmol/L
cyanocobalamin (S)							

TABLE 3.22 *(Continued)*

Conversion Factors for Values in Clinical Chemistry (SI Units)

Component	Present Reference Intervals (examples)	Present Unit	Conversion Factor	SI Reference Intervals	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
[vitamin B_{12}]	200-100	pg/mL	0.7378	150-750	pmol/L	XXO	10 pmol/L
cyclic AMP (S)	2.6-6.6	µg/L	3.038	8-20	nmol/L	XXX	1 nmol/L
cyclic AMP (U)							
-total urinary	2.9-5.6	µmol/g creatinine	113.1	330-630	nmol/mmol creatinine	XXO	10 nmol/mmol creatinine
-renal tubular	<2.5	µmol/g creatinine	113.1	<280	nmol/mmol creatinine	XXO	10 nmol/mmol creatinine
cyclic GMP (S)	0.6-3.5	µg/L	2.897	1.7-10.1	nmol/L	XX.X	0.1 nmol/L
cyclic GMP (U)	0.3-1.8	µmol/g creatinine	113.1	30-200	nmol/mmol creatinine	XXO	10 nmol/mmol creatinine
cystine (U)	10-100	mg/24 h	4.161	40-420	mmol/d	XXO	10 mmol/d
dehydroepiandrosterone (P,S)							
[DHEA]- 1-4 years	0.2-0.4	µg/L	3.467	0.6-1.4	nmol/L	XX.X	0.2 nmol/L
4-8 years	0.1-1.9	µg/L	3.467	0.4-6.6	nmol/L	XX.X	0.2 nmol/L
8-10 years	0.2-2.9	µg/L	3.467	0.6-10.0	nmol/L	XX.X	0.2 nmol/L
10-12 years	0.5-9.2	µg/L	3.467	1.8-31.8	nmol/L	XX.X	0.2 nmol/L
12-14 years	0.9-20.0	µg/L	3.467	3.2-69.4	nmol/L	XX.X	0.2 nmol/L
14-16 years	2.5-20.0	µg/L	3.467	8.6-69.4	nmol/L	XX.X	0.2 nmol/L
premenopausal female	2.0-15.0	µg/L	3.467	7.0-52.0	nmol/L	XX.X	0.2 nmol/L
male	0.8-10.0	µg/L	3.467	2.8-34.6	nmol/L	XX.X	0.2 nmol/L
dehydroepiandrosterone (U)	See Steroids	Fractionation	. . .	. . .	. . .	. . .	. . .
dehydroepiandrosterone sulphate [DHEA-S] (P, S)							
newborn	1670-3640	ng/mL	0.002714	4.5-9.9	µmol/L	XX.X	µmol/L
pre-pubertal children	100-600	ng/mL	0.002714	0.3-1.6	µmol/L	XX.X	µmol/L
male	2000-3500	ng/mL	0.002714	5.4-9.1	µmol/L	XX.X	µmol/L
female (premenopausal)	820-3380	ng/mL	0.002714	2.2-9.2	µmol/L	XX.X	µmol/L
female (post-menopausal)	110-610	ng/mL	0.002714	0.3-1.7	µmol/L	XX.X	µmol/L
pregnancy [term]	0-1170	ng/mL	0.002714	0.6-3.2	µmol/L	XX.X	µmol/L
11-deoxycortisol (S)	0-2	µg/dL	28.86	0-60	nmol/L	XXO	10 nmol/L
desipramine (P)							
-therapeutic	50-200	ng/mL	3.754	170-700	nmol/L	XXO	10 nmol/L

diazepam (P)							
-therapeutic	0.10-0.25	mg/L	3512	350-900	nmol/L	XXO	10 nmol/L
-toxic	>1.0	mg/L	3512	>3510	nmol/L	XXO	10 nmol/L
dicoumarol (P)							
-therapeutic	8-30	mg/L	2.974	25-90	µmol/L	XX	5 µmol/L
digoxin (P)							
-therapeutic	0.5-2.2	ng/mL	1.281	0.6-2.8	nmol/L	X.X	0.1 nmol/L
	0.5-2.2	µg/L	1.281	0.6-2.8	nmol/L	X.X	0.1 nmol/L
-toxic	>2.5	ng/mL	1.281	>3.2	nmol/L	X.X	0.1 nmol/L
dimethadione (P)							
-therapeutic	<1.00	g/L	7.745	<7.7	mmol/L	X.X	0.1 mmol/L
disopyramide (P)							
-therapeutic	2.0-6.0	mg/L	2.946	6-18	µmol/L	XX	1 µmol/L
doxepin (P)							
-therapeutic	50-200	n/mL	3.579	180-720	nmol/L	XO	10 nmol/L
electrophoresis, protein (S)							
albumin	60-65	%	0.01	0.60-0.65	1	O.XX	0.01
alpha$_1$-globulin	1.7-5.0	%	0.01	0.02-0.05	1	O.XX	0.01
alpha$_2$-globulin	6.7-12.5	%	0.01	0.07-0.13	1	O.XX	0.01
beta-globulin	8.3-16.3	%	0.01	0.08-0.16	1	O.XX	0.01
gamma-globulin	10.7-20.0	%	0.01	0.11-0.20	1	O.XX	0.01
albumin	3.6-5.2	g/dL	10.0	36-52	g/L	XX	1 g/L
alpha$_1$-globulin	0.1-0.4	g/dL	10.0	1-4	g/L	XX	1 g/L
alpha$_2$-globulin	0.4-1.0	g/dL	10.0	4-10	g/L	XX	1 g/L
beta-globulin	0.5-1.2	g/dL	10.0	5-12	g/L	XX	1 g/L
gamma-globulin	0.6-1.6	g/dL	10.0	6-16	g/L	XX	1 g/L
epinephrine (P)	31-95 (at rest for 15 min)	pg/mL	5.458	170-520	pmol/L	XXO	10 pmol/L
epinephrine (U)	<10	µg/24 h	5.458	<55	nmol/d	XX	5 nmol/d
estradiol (S)							
male >18 yrs	15-40	pg/mL	3.671	55-150	pmol/L	XX	1 pmol/L
estriol (U)							
[non pregnant]							
onset of menstruation	4-25	µg/24 h	3.468	15-85	nmol/d	XXX	5 nmol/d
ovulation peak	28-99	µg/24 h	3.468	95-345	nmol/d	XXX	5 nmol/d
luteal peak	22-105	µg/24 h	3.468	75-365	nmol/d	XXX	5 nmol/d
menopausal woman	1.4-19.6	µg/24 h	3.468	5-70	nmol/d	XXX	5 nmol/d
male	5-18	µg/24 h	3.468	15-60	nmol/d	XXX	5 nmol/d

TABLE 3.22 *(Continued)*

Conversion Factors for Values in Clinical Chemistry (SI Units)

Component	Present Reference Intervals (examples)	Present Unit	Conversion Factor	SI Reference Intervals	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
estrogens (S) [as estradiol]							
female	20-300	pg/mL	3.671	70-1100	pmol/L	XXXO	10 pmol/L
peak production	200-800	pg/mL	3.671	750-2900	pmol/L	XXXO	10 pmol/L
male	<50	pg/mL	3.671	<180	pmol/L	XXO	10 pmol/L
estrogens, placental (U) [as estriol]	Depends on period of gestation	mg/24 h	3.468	Depends on period of gestation	µmol/d	XXX	1 µmol/d
estrogen receptors (T)							
negative	0-3	fmol estradiol bound/mg cytosol protein	1.00	0-3	fmol estradiol/ mg cytosol protein	XXX	1 fmol/mg protein
doubtful	4-10	fmol estradiol bound/mg cytosol protein	1.00	4-10	fmol estradiol/ mg cytosol protein	XXX	1 fmol/mg protein
positive	>10	fmol estradiol bound/mg cytosol protein	1.00	>10	fmol estradiol/ mg cytosol protein	XXX	1 fmol/mg protein
estrone (P, S)							
- female 1-10 days of cycle	43-180	pg/mL	3.699	160-665	pmol/L	XXX	5 pmol/L
-female 11-20 days of cycle	75-196	pg/mL	3.699	275-725	pmol/L	XXX	5 pmol/L
-female 20-39 days of cycle	131-201	pg/mL	3.699	485-745	pmol/L	XXX	5 pmol/L
-male	29-75	pg/mL	3.699	105-275	pmol/L	XXX	5 pmol/L
estrone (U) female	2-25	µg/24 h	3.699	5-90	nmol/d	XXX	5 nmol/d
ethanol (P)							
legal limit [driving]	<80	mg/dL	0.2171	<17	mmol/L	XX	1 nmol/L
-toxic	>100	mg/dL	0.2171	>22	mmol/L	XX	1 mmol/L
ethchlorvynol (P) toxic	>40	mg/L	6.915	>280	µmol/L	XXO	10 µmol/L
ethosuximide (P)							
therapeutic	40-110	mg/L	7.084	280-780	µmol/L	XXO	10 µmol/L
ethylene glycol (P)							
toxic	>30	mg/dL	0.1611	>5	mmol/L	XX	1 mmol/L

fat (F)							
[as stearic acid]	2.0-6.0	g/24 h	3.515	7-21	mmol/d	XXX	1 mmol/d
fatty acids, non-							
esterified (P)	8-20	mg/dL	10.00	80-200	mg/L	XXO	10 mg/L
ferritin (S)	18-300	ng/mL	1.00	18-300	µg/L	XXO	10 µg/L
fibrinogen (P)	200-400	mg/dL	0.01	2.0-4.0	g/L	X.X	0.1 g/L
fluoride (U)	<1.0	mg/24 h	52.63	<50	µmol/d	XXO	10 µmol/d
folate (S) [as pteroylglutamic acid]	2-10	ng/mL	2.266	4-22	nmol/L	XX	2 nmol/L
		µg/dL	22.66		nmol/L		2 nmol/L
folate (Erc)	140-960	ng/mL	2.266	550-2200	nmol/L	XXO	10 nmol/L
follicle stimulating hormone							
[FSH] (P)							
female	2.0-15.0	mIU/mL	1.00	2-15	IU/L	XX	1 IU/L
peak production	20-50	mIU/mL	1.00	20-50	IU/L	XX	1 IU/L
male	1.0-10.0	mIU/mL	1.00	1-10	IU/L	XX	1 IU/L
follicle stimulating hormone [FSH] (U)							
follicular phase	2-15	IU/24 h	1.00	2-15	IU/d	XXX	1 IU/d
midcycle	8-40	IU/24 h	1.00	8-40	IU/d	XXX	1 IU/d
luteal phase	2-10	IU/24 h	1.00	2-10	IU/d	XXX	1 IU/d
menopausal women	35-100	IU/24 h	1.00	35-100	IU/d	XXX	1 IU/d
male	2-15	IU/24 h	1.00	2-15	IU/d	XXX	1 IU/d
fructose (P)	<10	mg/dL	0.05551	<0.6	mmol/L	X.XX	0.1 mmol/L
galactose (P) [children]	<20	mg/dL	0.05551	<1.1	mmol/L	X.XX	0.1 mmol/L
gases (aB)							
pO_2	75-105	mm Hg (= Torr)	0.1333	10.0-14.0	kPa	XX.X	0.1 kPa
pCO_2	33-44	mm Hg (= Torr)	0.1333	4.4-5.9	kPa	X.X	0.1 kPa
gamma-glutamyltransferase [GGT] (S)	0-30	U/L	0.01667	0-0.50	µkat/L	X.XX	0.01 µkat/L
gastrin (S)	0-180	pg/mL	1	0-180	ng/L	XXO	10 ng/L
globulins (S) [see immunoglobulins]	...	...	...	...	...	...	...
glucagon (S)	50-100	pg/mL	1	50-100	ng/L	XXO	10 ng/L
glucose (P) fasting	70110	mg/dL	0.05551	3.9-6.1	mmol/L	XX.X	0.1 mmol/L
glucose (Sf)	50-80	mg/dL	0.05551	2.8-4.4	mmol/L	XX.X	0.1 mmol/L
glutethimide (P)							
-therapeutic	<10	mg/L	4.603	<46	µmol/L	XX	1 µmol/L
-toxic	>20	mg/L	4.603	>92	µmol/L	XX	1 µmol/L
glycerol, free (S)	<1.5	mg/dL	0.1086	<0.16	mmol/L	X.XX	0.01 mmol/L
gold (S) therapeutic	300-800	µg/dL	0.05077	15.0-40.0	µmol/L	XX.X	0.1 µmol/L
gold (U)	<500	µg/24 h	0.005077	<2.5	µmol/d	X.X	0.1 µmol/d

TABLE 3.22 *(Continued)*

Conversion Factors for Values in Clinical Chemistry (SI Units)

Component	Present Reference Intervals (examples)	Present Unit	Conversion Factor	SI Reference Intervals	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
palmitic acid (Amf)	Depends on gestation	mmol/L	1000	Depends on gestation	µmol/L	XXX	5 µmol/L
pentobarbital (P)	20-40	mg/L	4.419	90-170	µmol/L	XX	5 µmol/L
phenobarbital (P)							
-therapeutic	2-5	mg/L	43.06	85-215	µmol/L	XXX	5 µmol/L
phensuximide (P)	4-8	mg/L	5.285	20-40	µmol/L	XX	5 µmol/L
phenylbutazone (P)							
-therapeutic	<100	mg/L	3.243	<320	µmol/L	XXO	10 µmol/L
phenytoin (P)							
-therapeutic	10-20	mg/L	3.964	40-80	µmol/L	XX	5 µmol/L
-toxic	>30	mg/L	3.964	>12	µmol/L	XX	5 µmol/L
phosphate (S) [as phosphorus, inorganic]	2.5-5.0	mg/dL	0.3229	0.80-1.60	mmol/L	X.XX	0.05 mmol/L
phosphate (U) [as phosphorus, inorganic]	Diet dependent	g/24 h	32.29	Diet dependent	mmol/d	XXX	1 mmol/d
phospholipid phosphorus, total (P)	5-12	mg/dL	0.3229	1.60-3.90	mmol/L	X.XX	0.05 mmol/L
phospholipid phosphorus, total (Erc)	1.2-12	mg/dL	0.3229	0.40-3.90	mmol/L	X.XX	0.05 mmol/L
phospholipids (P)							
substance fraction of total phospholipid							
phosphatidyl choline	65-70	%/total	0.01	0.65-0.70	1	O.XX	0.01
phosphatidyl ethanolamine	4-5	%/total	0.01	0.04-0.05	1	O.XX	0.01
sphingomyelin	15-20	%/total	0.01	0.15-0.20	1	O.XX	0.01
lysophosphatidyl choline	3-5	%/total	0.01	0.03-0.05	1	O.XX	0.01
phospholipids (Erc)							
substance fraction of total phospholipid							
phosphatidyl choline	28-33	%/total	0.01	0.28-0.33	1	O.XX	0.01
phosphatidyl ethanolamine	24-31	%/total	0.01	0.24-0.31	1	O.XX	0.01
sphingomyelin	22-29	%/total	0.01	0.22-0.29	1	O.XX	0.01

phosphatidyl serine + phosphatidyl inositol	12-20	%/total	0.01	0.12-0.20	1	O.XX	0.01
lysophosphatidyl choline	1-2	%/total	0.01	0.01-0.02	1	O.XX	0.01
phytanic acid (P)	Trace-0.3	mg/dL	32.00	<10	µmol/L	XX	5 µmol/L
[human] placental lactogen (SO [HPL]	>4.0 after 30 wk gestation	µg/mL	46.30	>180	nmol/L	XXO	10 nmol/L
porphobilinogen (U)	0.0-2.0	mg/24 h	4.420	0-9.0	µmol/d	X.X	0.5 µmol/d
porphyrins							
coproporphyrin (U)	45-180	µg/24 h	1.527	68-276	nmol/d	XXX	2 nmol/d
protoporphyrin (Erc)	15-50	µg/dL	0.0177	0.28-0.90	µmol/L	X.XX	0.02 µmol/L
uroporphyrin (U)	5-20	µg/24 h	1.204	6-24	nmol/d	XX	2 nmol/d
uroporphyrinogen synthetase (Erc)	22-42	mmol/mL/h	0.2778	6.0-11.8	mmol/ (L.s)	X.X	0.2 mmol/(L.s)
potassium ion (S)	3.5-5.0	mEq/L	1.00	3.5-5.0	mmol/L	X.X	0.1 mmol/L
		mg/dL	0.2558		mmol/L	X.X	0.1 mmol/L
potassium ion (U)							
[diet dependent]	25-100	mEq/24 h	1.00	25-100	mmol/d	XX	1 mmol/d
pregnaediol (U)							
-normal	1.0-6.0	mg/24 h	3.120	3.0-18.5	µmol/d	XX.X	0.5 µmol/d
-pregnancy	Depends on gestation						
pregnanetriol (U)	0.5-2.0	mg/24 h	2.972	1.5-6.0	µmol/d	XX.X	0.5 µmol/d
primidone (P)							
-therapeutic	6.0-10.0	mg/L	4.582	25-46	µmol/L	XX	1 µmol/L
-toxic	>10.0	mg/L	4.582	>46	µmol/L	XX	1 µmol/L
procainamide (P)							
-therapeutic	4.0-8.0	mg/L	4.249	17-34	µmol/L	XX	1 µmol/L
-toxic	>12.0	mg/L	4.249	>50	µmol/L	XX	1 µmol/L
N-acetyl procainamide (P)							
-therapeutic	4.0-8.0	mg/L	3.606	14-29	µmol/L	XX	1 µmol/L
progesterone (P)							
follicular phase	<2	ng/mL	3.180	<6	nmol/L	XX	2 nmol/L
luteal phase	2-20	ng/mL	3.180	6-64	nmol/L	XX	2 nmol/L
progesterone receptors (T)							
negative	0-3	fmol progesterone bound/mg cytosol protein	1.00	0-3	fmol progesterone bound/mg cytosol protein	XX	1 fmol/mg protein

TABLE 3.22 *(Continued)*

Conversion Factors for Values in Clinical Chemistry (SI Units)

Component	Present Reference Intervals (examples)	Present Unit	Conversion Factor	SI Reference Intervals	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
doubtful	4-10	fmol progesterone bound/mg cytosol protein	1.00	4-10	fmol progesterone bound/mg cytosol protein	XX	1 fmol/mg protein
positive	>10	fmol progesterone bound/mg cytosol protein	1.00	>10	fmol progesterone bound/mg cytosol protein	XX	1 fmol/mg protein
prolactin (P)	<20	ng/mL	1.00	<20	µg/L	XX	1 µg/L
propoxyphene (P) toxic	>2.0	mg/L	2.946	>5.9	µmol/L	X.X	0.1 µmol/L
propranolol (P)							
[Inderal] therapeutic	50-200	ng/mL	3.856	190-770	nmol/L	XXO	10 nmol/L
protein, total (S)	6.0-8.0	g/dL	10.0	60-80	g/L	XX	1 g/L
protein, total (Sf)	<40	mg/dL	0.01	<0.40	g/L	X.XX	0.1 g/L
protein, total (U)	<150	mg/24 h	0.001	<0.15	g/d	X.XX	0.01 g/d
protryptyline (P)	100-300	ng/mL	3.797	380-1140	nmol/L	XXO	10 nmol/L
pyruvate (B) [as pyruvic acid]	0.30-0.90	mg/dL	113.6	35-100	µmol/L	XXX	1 µmol/L
quinidine (P)							
-therapeutic	1.5-3.0	mg/L	3.082	4.6-9.2	µmol/L	X.X	0.1 µmol/L
-toxic	>6.0	mg/L	3.082	>18.5	µmol/L	X.X	0.1 µmol/L
renin (P)							
normal sodium diet	1.1-4.1	ng/mL/h	0.2778	0.30-1.14	ng/(L.s)	X.XX	0.2 ng/(L.s)
restricted sodium diet	6.2-12.4	ng/mL/h	0.2778	1.72-3.44	ng/(L.s)	X.XX	0.02 ng/(L.s)
salicylate (S) [salicylic acid]							
toxic	>20	mg/dL	0.07240	>1.45	mmol/L	X.XX	0.05 mmol/L
serotonin (B) [5 hydroxytryptamine]	8-21	µg/dL	0.05675	0.45-1.20	µmol/L	X.XX	0.05 µmol/L
sodium ion (S)	135-147	mEq/L	1.00	135-147	mmol/L	XXX	1 mmol/L

sodium ion (U)	Diet dependent	mEq/24 h	1.00	Diet dependent	mmol/d	XXX	2 mmol/d
steroids							
17-hydroxy-corticosteroids (U) [as cortisol]							
-female	2.0-8.0	mg/24 h	2.759	5-25	µmol/d	XX	1 µmol/d
-male	3.0-10.0	mg/24 h	2.759	10-30	µmol/d	XX	1 µmol/d
17-ketogenic steroids (U) [as dehydroepian-drosterone]							
-female	7.0-12.0	mg/24 h	3.467	25-40	µmol/d	XX	1 µmol/d
-male	9.0-17.0	mg/24 h	3.467	30-60	µmol/d	XX	1 µmol/d
17-ketosteroids (U) [as dehydroepian-drosterone]							
-female	6.0-17.0	mg/24 h	3.467	20-60	µmol/d	XX	1 µmol/d
-male	6.0-20.0	mg/24 h	3.467	20-70	µmol/d	XX	1 µmol/d
ketosteroid fractions (U) androsterone							
-female	0.5-2.0	mg/24 h	3.443	1-10	µmol/d	XX	1 µmol/d
-male	2.0-5.0	mg/24 h	3.443	7-17	µmol/d	XX	1 µmol/d
dehydroepiandrosterone							
-female	0.2-1.8	mg/24 h	3.467	1-6	µmol/d	XX	1 µmol/d
-male	0.2-2.0	mg/24 h	3.467	1-7	µmol/d	XX	1 µmol/d
etiocholanolone							
-female	0.8-4.0	mg/24 h	3.443	2-14	µmol/d	XX	1 µmol/d
-male	1.4-5.0	mg/24 h	3.443	4-17	µmol/d	XX	1 µmol/d
sulfonamides (B) [as sulfanilamide]							
-therapeutic	10.0-15.0	mg/dL	58.07	580-870	µmol/L	XXO	10 µmol/L
testosterone (P)							
-female	0.6	ng/mL	3.467	2.0	nmol/L	XX.X	0.5 nmol/L
-male	4.6-8.0	ng/mL	3.467	14.0-28.0	nmol/L	XX.X	0.5 nmol/L
theophylline (P)							
-therapeutic	10.0-20.0	mg/L	5.550	55-110	µmol/L	XX	1 µmol/L
thiocyanate (P) (nitroprusside toxicity)	10.0	mg/dL	0.1722	1.7	mmol/L	X.XX	0.1 mmol/L
thiopental (P)	individual	mg/L	4.126	individual	µmol/L	XX	5 µmol/L
thyroid tests:							
thyroid stimulating hormone [TSH] (S)	2-11	µU/mL	1.00	2-11	mU/L	XX	1 mU/L
thyroxine [T_4] (S)	4.0-11.0	µg/dL	12.87	51-142	nmol/L	XXX	1 nmol/L

TABLE 3.22 *(Continued)*

Conversion Factors for Values in Clinical Chemistry (SI Units)

Component	Present Reference Intervals (examples)	Present Unit	Conversion Factor	SI Reference Intervals	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
thyroxine binding globulin [TGB] (S) [as thyroxine]	12.0-28.0	µg/dL	12.87	150-360	nmol/L	XXO	1 nmol/L
thyroxine, free (S)	0.8-2.8	ng/dL	12.87	10-36	pmol/L	XX	1 pmol/L
triiodothyronine [T_3] (S)	75-220	ng/dL	0.01536	1.2-3.4	nmol/L	X.X	0.1 nmol/L
T_3 uptake (S)	25-35	%	0.01	0.25-0.35	1	O.XX	0.01
tolbuamide (P)							
-therapeutic	50-120	mg/L	3.699	180-450	mmol/L	XXO	10 mmol/L
transferrin (S)	170-370	mg/dL	0.01	1.70-3.70	g/L	X.XX	0.01 g/L
triglycerides (P) [as triolein]	<160	mg/dL	0.01129	<1.80	mmol/L	X.XX	0.02 mmol/L
trimethadione (P)							
- therapeutic	<50	mg/L	6.986	<350	µmol/L	XXO	10 µmol/L
trimipramine (P)							
-therapeutic	50-200	ng/mL	3.397	170-680	nmol/L	XXO	10 nmol/L
urate (S) [as uric acid]	2.0-7.0	mg/dL	59.48	120-420	µmol/L	XXO	10 µmol/L
urate (U) [as uric acid]	Diet dependent	g/24 h	5.948	Diet dependent	mmol/d	XX	1 mmol/d
urea nitrogen (S)	8-18	mg/dL	0.3570	3.0-6.5	mmol/L UREA	X.X	0.5 mmol/L
urea nitrogen (U)	2.0-20.0 diet dependent	g/24 h	35.700	450-700	mmol/d UREA	XXO	10 mol/d
urobilinogen (U)	0.0-4.0	mg/24 h	1.693	0.0-6.8	µmol/d	X.X	0.1 µmol/d
valproic acid (P)							
-therapeutic	50-100	mg/L	6.934	350-700	µmol/L	XO	10 µmol/L
vanillylmandelic acid [VMA] (U)*	<6.8	mg/24 h	5.046	<35	µmol/d	XX	1 µmol/d

vitamin A [retinol] (P,S)	10-50	µg/dL	0.03491	0.35-1.75	µmol/L	X.XX	0.05 µmol/L
vitamin B_1 [thiamine hydrochloride] (U)	60-500	mg/24 h	0.002965	0.18-1.48	µmol/d	ZX.XX	0.01 µmol/d
vitamin B_2 [riboflavin] (S)	2.6-3.7	µg/dL	26.57	70-100	nmol/L	XXX	5 nmol/L
vitamin B_6 [pyridoxal] (B)	20-90	ng/mL	5.982	120-540	nmol/L	XXX	5 nmol/L
vitamin B_{12} (P,S) [cyanocobalamin]	200-1000	pg/mL	0.7378	150-750	pmol/L	XO	10 pmol/L
vitamin C [see ascorbate] (B,P,S)	...	...	...	...	...	...	...
vitamin D_3 [cholecalciferol] (P)	24-40	mg/mL	2.599	60-105	nmol/L	XXX	5 nmol/L
25 OH-cholecacliferol	18-36	ng/mL	.496	45-90	nmol/L	XXX	5 mmol/L
vitamin E [alpha-tocopherol] (P,S)	0.78-1.25	mg/dL	23.22	18-29	µmol/L	XX	1 µmol/L
warfarin (P)							
-therapeutic	1.0-3.0	mg/L	3.243	3.3-9.8	µmol/L	XX.X	0.1 µmol/L
xanthine (U)							
-hypoxanthine	5-30	mg/24	6.574	30-200	µmol/d	XXO	10 µmol/d
		hmg/24 h	7.347		µmol/d	XXO	10 µmol/d
D-xylose (B) [25 g dose]	30-40 (30-60 min)	mg/dL	0.06661	.0-2.7 (30-60 min)	mmol/L	X.X	0.1 mmol/L
D-xylose excretion (U) [25 g dose]	21-31	%	0.01	0.21-0.31 (excreted in 5 h)	1	0.XX	0.01
zinc (S)	75-120	µg/dL	0.1530	11.5-18.5	µmol/L	XX.X	0.1 µmol/L
zinc (U)	150-1200	µg/24 h	0.01530	2.3-18.3	µmol/d	XX.X	0.1 µmol/d

TABLE 3.23

Small Animal Analogs of Human Degenerative Diseases*

Type 1 Diabetes Mellitus (IDDM)	Obesity
Streptozotocin or alloxan treated animals of most species	Zucker rat
Pancreatectomy will also produce IDDM	db/db mouse
BB rat, NOD mouse (Both of these develop diabetes as an autoimmune disease and both mimic Type I diabetes mellitus as found in humans.)	SHR/N-cp rat
db/db mouse	LA/N-cp rat
FAT mouse	ob/ob mouse
NZO mouse	Ventral hypothalamus lesioned animals
TUBBY mouse	Osborne-Mendel rats fed high fat diets
Adipose mouse	**Hypertension**
Chinese hampster (*Cricetulus griseus*)	SHR rats — WKY rats
South African hamster (*Mystromys alb*)	JCR:LA rats — Transgenic rats
Tuco-Tuco (*Clenomys tabarum*)	**Gallstones**
Type 2 Diabetes Mellitus	(The rat does not have a gall bladder nor does it have stones.)
ob/ob mouse	Gerbil fed a cholesterol-rich, cholic acid-rich diet
KK, yellow KK mouse	Hamster, prairie dog, squirrel monkey, or tree shrew fed a cholesterol-rich diet
A^{vy}, A^{y} yellow mouse	**Lipemia**
P, PB 13/Ld mouse	Zucker fatty rat
db PAS mouse	BHE/Cdb rat
BHE/Cdb rat	NZW mouse
Zucker diabetic rat	Transgenic mice given gene for atherosclerosis
SHR/N-cp rat	**Atherosclerosis**
Spiny mouse	Transgenic mice given gene for atherosclerosis
HUS rat	NZW mouse
LA/N-cp rat	JCR:LA cp/cp rat
Wistar Kyoto rat	

* There are several compilations of animal models for human disease. See the series of books edited by Shafrir having the general title *Lessons from Animal Diabetes* published by Smith Gordon, London. See also the NIH Guide for Animal Resources, updated annually, and the Jackson Laboratory catalog, Bar Harbor, Maine.

TABLE 3.24

Composition of the AIN-93 Maintenance (M) and Growth (G) Diets

Ingredient	AIN-93M (g/kg)	AIN-93G (g/kg)
Casein	140	200
Cornstarch	465.692	397.486
Dextrose	155	132
Sucrose	100	100
Cellulose	50	50
Soybean oil	40	70
Mineral mix	35	35
Vitamin mix	10	10
L-cystine	1.8	3
Choline bitartrate	2.5	2.5
t-Butylhydroquinone	0.008	0.014
Energy	~3.8 kcal or ~16 kJ/g	~3.9 kcal or ~16.4 kJ/g

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