

Table 2. Enzyme-based diseases and syndromes.

Disease	Enzyme(s) Involved	Substrate(s)	Product(s)	Cofactor(s)	Intermediate(s) and Metabolite(s)	Clinical Manifestation(s)
Hemolytic anemia (multiple forms)	glucose-6-phosphate dehydrogenase pyruvate kinase	glucose-6-phosphate + NADP ⁺ phosphoenolpyruvate + ADP	6-phosphoglucono- δ -lactone + NADPH pyruvate + ATP	NADP ⁺		decreased RBC stability, drug-induced hemolysis
β -Aminoisobutyricaciduria	aminotransferase	β -aminoisobutyrate (β -alanine) + α KG	methylmalonic semialdehyde + glutamate	vit B ₆	β -aminoisobutyrate	benign, frequent in Orientals
Orotic aciduria (Type I)	orotate phosphoribosyl transferase orotidine-5'-phosphate decarboxylase	orotate + phosphoribosyl pyrophosphate (PRPP) orotidine-5'-phosphate	orotidine-5'-phosphate + pyrophosphate uridine-5'-monophosphate + CO ₂	Mg ²⁺	orotic acid found in serum and urine	pale, weak, fail to thrive, megaloblastic anemia, immunodeficiency, orotic acid crystalluria, autosomal recessive
Orotic aciduria (Type II)	orotidine-5'-phosphate decarboxylase	orotidine-5'-phosphate	uridine-5'-monophosphate + CO ₂		orotic acid found in serum and urine	orotidinuria, orotic aciduria, megaloblastic anemia, autosomal recessive
Gout	PRPP synthetase (5-phosphoribose pyrophosphokinase, increased V _{max} , resistance to feedback inhibition, low K _m for ribose-5-phosphate)	ribose-5-phosphate + ATP	PRPP + AMP	Mg ²⁺	uric acid in blood	X-linked recessive, renal problems, joint problems, hyperuricemia
Lesch-Nyhan syndrome	hypoxanthine-guanine-phosphoribosyltransferase	hypoxanthine + PRPP guanine + PRPP	inosine monophosphate + pyrophosphate (PP _i) guanine monophosphate + PP _i	Mg ²⁺	uric acid, hypoxanthine, xanthine	athetosis, self-mutilation, hyperuricemia, mental and physical retardation, X-linked recessive
Immunodeficiency	adenosine deaminase	adenosine + H ₂ O	inosine + NH ₄ ⁺		dATP in erythrocytes, S-adenosyl-L-homocysteine	combined T cell and B cell immunodeficiency, deoxyadenosinuria, autosomal recessive
Immunodeficiency	purine nucleoside phosphorylase	inosine, xanthosine, guanosine + P _i	hypoxanthine, xanthine, guanine + ribose-1-phosphate		decreased uric acid, guanosine, deoxyguanosine, inosine, deoxyinosine	T cell deficiency, inosinuria, deoxyinosinuria, guanosinuria, deoxyguanosinuria, hypouricemia
Renal lithiasis	adenine phosphoribosyltransferase	adenine + PRPP	AMP + PP _i	Mg ²⁺		renal problems, autosomal recessive
Xanthinuria	xanthine oxidase	hypoxanthine + O ₂ + H ₂ O xanthine + O ₂ + H ₂ O	xanthine + H ₂ O ₂ uric acid + H ₂ O ₂	Fe, Mo, FAD		hypouricemia, autosomal recessive
Pyruvate carboxylase deficiency	pyruvate carboxylase	pyruvate + ATP + HCO ₃ ⁻	oxaloacetate + ADP + P _i + H ⁺	biotin	reduced levels of amino acid neurotransmitters	fasting hypoglycemia, lactic acidosis, ketoacidosis, neurological symptoms

Pyruvate dehydrogenase deficiency	pyruvate dehydrogenase, dihydrolipoyl transacetylase, dihydrolipoyl dehydrogenase	pyruvate + NAD ⁺ + CoASH	CO ₂ + acetyl-CoA + NADH + H ⁺	NAD ⁺ , thiamin pyrophosphate (vitB ₁), CoA, lipoic acid, FAD, bioppterin	lactate, pyruvate, alanine	may be one of the causes of Reye's syndrome, lactic acidosis, neurological defects, ataxia
Phenylketonuria (Type I, II, III) (Type IV) (Type V)	phenylalanine hydroxylase dihydrobiopterin reductase dihydrobiopterin biosynthesis	phenylalanine + O ₂ + tetrahydrobiopterin	tyrosine + H ₂ O + dihydrobiopterin		phenylpyruvic acid, phenylacetic acid	neurologic symptoms, mental retardation
Tyrosinemia (Type I, also denoted as Type VIII hyperphenylalaninemia)	fumarylacetoacetate hydrolase	fumoylacetoacetate	acetoacetate + fumarate		succinyl acetone, fumarylacetoacetate, maleylacetoacetate, tyrosine	hepatic cirrhosis, fulminating hepatic failure, renal tubular dysfunction, rickets, polyneuropathy, increased risk of hepatoma
Tyrosinemia (Type II, Richner-Hanhart syndrome, also denoted as Type VIII hyperphenylalaninemia)	tyrosine aminotransferase	tyrosine + αKG	<i>p</i> -hydroxyphenyl pyruvate	vit B ₆	N-acetyltyrosine, <i>p</i> -hydroxyphenylpyruvate, <i>p</i> -hydroxyphenyllactate, <i>p</i> -hydroxyphenylacetate, tyramine	mental retardation, keratitis, dermatitis Fanconi's syndrome,
Neonatal tyrosinemia (also denoted as Type VII hyperphenylalaninemia)	<i>p</i> -hydroxylphenylpyruvate oxidase	<i>p</i> -hydroxylphenylpyruvate + O ₂	homogentisate + CO ₂	Fe ²⁺		benign
Albinism	tyrosinase	tyrosine	dopamine	Cu ²⁺		pigment absent in skin, hair, eyes
Alcaptonuria	homogentisate oxidase	homogentisate + O ₂	maleylacetoacetate	Fe ²⁺	homogentisic acid	ochronosis, arthritis, dark urine
Histidinemia	L-histidine ammonia lyase (histidase)	histidine	urocanate + NH ₃		histidine, lack of urocanate in sweat	benign, retardation, neurologic manifestations
Maple syrup urine disease (various forms)	branched-chain keto acid dehydrogenase	α-keto-β-methylbutyrate, α-ketoisovalerate, α-ketoisocaproate + NAD ⁺ + CoA	α-methylbutyryl CoA, isobutyryl CoA, isovaleryl CoA + NADH + CO ₂ + H ⁺	CoA, NAD ⁺ , vit B ₁	α-keto acids, hydroxy acids	reflex changes, hypertonicity, convulsions, coma, death, urine odor
Valinemia	valine aminotransferase	valine + αKG	α-ketoisovalerate	vitB ₆	valine	retardation
Cystathioninuria	cystathionase	cystathionine	cysteine + α-ketobutyrate	pyridoxal phosphate (vit B ₆)	cystathionine in urine	benign trait
Homocystinemia	cystathionine synthetase	homocysteine + serine	cystathionine + H ₂ O	vit B ₆	homocysteine + methionine	skeletal abnormalities, ectopia lentis, retardation, thromboembolic disease
Glycinemia (nonketotic)	D-amino acid oxidase (glycine cleavage system)	glycine + NAD ⁺	CO ₂ + NH ₄ ⁺ + NADH + H ⁺	FAD, NAD ⁺ , folate, vit B ₆	glycine	convulsions, retardation
β-Alaninemia	β-alanine-α-ketoglutarate aminotransferase	alanine + αKG	pyruvate + glutamate	vit B ₆	alanine	seizures, somnolence, death

Prolinemia (Type I)	proline oxidase	proline	Δ^1 -pyrroline- δ -carboxylate		proline	hereditary nephritis, nerve deafness, sometimes benign convulsions, mental retardation
(Type II)	Δ^1 pyrroline-5-carboxylate dehydrogenase	Δ^1 -pyrroline- δ -carboxylate	glutamic semialdehyde	NAD ⁺ , NADP ⁺		
Hydroxyprolinemia	hydroxyproline oxidase	4-hydroxyproline	L- Δ^1 -pyrroline-3-hydroxy-5-carboxylate			mental retardation, CNS symptoms
Lysinemia and lysinuria	lysine α -keto-glutarate reductase (bifunctional enzyme, also denoted as saccharopine dehydrogenase)	lysine + α KG + NADPH	saccharopine + NADP ⁺	NADP ⁺ , NAD ⁺	lysine and saccharopine in blood and urine	muscle weakness, retardation, sometimes benign
Lysine intolerance	L-lysine:NAD oxidoreductase (deaminating)	saccharopine + NAD ⁺ + H ₂ O	α -aminoadipic-6-semialdehyde + NADH + glutamate	NAD ⁺		vomiting, coma, hyperammonemia, thin hair, muscle wasting, osteoporosis
Saccharopinuria	aminoadipic semialdehyde-glutamate reductase	α -aminoadipic-6-semialdehyde + NAD ⁺	α -aminoadipate + NADH	NAD ⁺		retardation
N-Acetylglutamate synthetase deficiency	N-acetylglutamate synthetase	glutamate + acetyl CoA	N-acetyl glutamate			lethargy, coma, vomiting, hyperammonemia (Type 1)
Carbamoyl phosphate synthetase deficiency	carbamoyl phosphate synthetase	CO ₂ + 2ATP + NH ₃	carbamoyl phosphate + ADP	ATP, Mg ²⁺		vomiting, lethargy, acidosis, coma, death, hyperammonemia (Type 2)
Ornithine-transcarbamylase deficiency	ornithine transcarbamylase	carbamoyl phosphate + ornithine	citruline		glutamine in blood, cerebrospinal fluid (CSF), and urine	recurrent vomiting, irritability, protein intolerance, hepatic encephalopathy, lethargy, coma, seizures, X-linked, lethal in males
Citrullinemia	argininosuccinic acid synthetase	citruline + ATP + aspartate	argininosuccinate + AMP	Mg ²⁺ , ATP	citruline	vomiting, coma, convulsions
Argininosuccinicacidemia	argininosuccinase (lyase)	argininosuccinate	arginine + fumarate		argininosuccinate in blood, CSF, and urine	seizures, retardation, coma, vomiting, hepatomegaly, trichor-rhexis nodosa
Argininemia	arginase	arginine + H ₂ O	urea + ornithine	Mn ²⁺	arginine in blood and CSF	retardation, seizures, spasticity
Ornithinemia	ornithine keto-acid (d-amino) trans-aminase	ornithine + α -keto acid	glutamic semialdehyde + α -amino acid	vit B ₆		gyrate atrophy of choroid and retina
Pyroglutamic acidemia	glutathione synthetase	γ -glutamylcysteine + glycine + ATP	glutathione + ADP + P _i	ATP	5-oxoproline, γ -glutamylcysteine	acidosis, increased hemolysis, episodic vomiting, retardation
Glutathione deficiency	5-oxoprolinase	5-oxoproline + ATP	glutamate + ADP + P _i	ATP	5-oxoproline	benign
	γ -glutamylcysteine synthetase	glutamate + cysteine + ATP	γ -glutamylcysteine + ADP + P _i	ATP		hemolysis
Isovaleric acidemia	isovaleryl-CoA dehydrogenase	isovaleryl CoA + FAD	β -methylcrotonyl-CoA + FADH ₂	FAD	isovalerate in blood	vomiting, lethargy, acidosis, retardation, sweating feet odor, cheesy breath, neonatal death
β -Hydroxyisovaleric aciduria	β -methylcrotonyl-CoA carboxylase	β -methylcrotonyl-CoA + ATP + CO ₂	β -methylglutaconyl-CoA + H ₂ O + ADP + P _i	ATP, biotin	β -methylcrotonylglycine, β -hydroxyisovalerate	retardation, muscle atrophy, unpleasant urine odor

HMG-CoA lyase deficiency	3-hydroxy-3-methylglutaryl CoA lyase	β -hydroxy- β -methylglutaryl-CoA	acetyl-CoA + acetoacetate			acidosis, hypoglycemia, hypotonia, lethargy
α -Methylacetoacetate accumulation	acetyl-CoA thiolase (acetyl-CoA acyl transferase)	α -methylacetoacetyl-CoA	acetyl-CoA + propionyl-CoA			episodes of acidosis, coma, retardation
Propionicacidemia (two forms)	propionyl-CoA carboxylase	propionyl-CoA	D-methylmalonyl-CoA + CO_2	biotin	propionate, propionylglycine, methylcitrate, tiglate	acidosis, lethargy, coma, mental and physical retardation
Multiple carboxylase deficiency (two forms)	holocarboxylase synthetase biotinidase	β -methylcrotonyl-CoA + ATP + CO_2 propionyl-CoA	β -methylglutaconyl-CoA + H_2O + ADP + P_i D-methylmalonyl-CoA + CO_2	biotin		acidosis, skin rash, alopecia, hypotonia, defective T- and B-cell immunity, hearing loss
Methylmalonic acidemia (two forms)	methylmalonyl-CoA mutase methylmalonyl-CoA racemase	D-methylmalonyl-CoA L-methylmalonyl-CoA	L-methylmalonyl-CoA succinyl-CoA	cobalamine (vit B ₁₂)	methylmalonate	acidosis, lethargy, coma, mental and physical retardation
Methylmalonic acidemia-homocystinuria	methylmalonyl-CoA mutase and homocysteine:methyl tetrahydrofolate methyl transferase	D-methylmalonyl-CoA	L-methylmalonyl-CoA	vit B ₁₂		retardation, failure to thrive, seizures, megaloblastic anemia
Hypermethioninemia	liver methionine adenosyltransferase	methionine + ATP + H_2O	S-adenosyl-methionine + P_i + PP_i	ATP, Mg^{2+}	methionine	benign
Sulfitoria (sulfocysteinuria)	sulfite oxidase (thiosulfate sulfur transferase)	SO_3^{2-} (sulfite) + O_2 + H_2O	SO_4^{2-} (sulfate) + H_2O_2 + H^+	Mo	sulfite	
3-Mercaptopyruvate-cysteine disulfiduria	3-mercapto-pyruvate sulfur transferase	3-mercaptopyruvate + SO_3^{2-}	pyruvate + $\text{S}_2\text{O}_3^{2-}$ (thiosulfate)			
Fructosuria	fructokinase	fructose + ATP	fructose-1-phosphate + ADP	Mg^{2+}	initial rise in fructose	benign, autosomal recessive
Fructose intolerance	fructose-1-phosphate aldolase	fructose-1-phosphate	dihydroxyacetone phosphate (DHAP) + glyceraldehyde		fructose-1-phosphate	cell lysis
Fructose-1,6-bisphosphatase deficiency	fructose-1,6-bisphosphatase	fructose-1,6-bisphosphate	DHAP + glyceraldehyde-3-phosphate		certain amino acids, lactic acid, ketoacids	hypoglycemia, acidosis
Galactosemia	galactokinase galactose-1-phosphate uridylyl transferase	galactose + ATP galactose-1-phosphate + UDP-glucose	galactose-1-phosphate + ADP UDP-galactose + glucose-1-phosphate		galactitol, elevated galactose in blood	cataracts anorexic, vomiting, jaundice, liver enlargement, physical abnormalities, autosomal recessive
Galactose epimerase deficiency	UDP galactose-4-epimerase	UDP-galactose	UDP-glucose	NAD^+	galactose-1-phosphate in blood	similar to classical galactosemia
Pentosuria	xylulose reductase	L-xylulose + NADPH	xylitol + NADP^+	NADP^+	xylulose in urine	benign
Lactose intolerance	lactase	lactose	glucose + galactose		lactose	diarrhea, borborygmi, bloating, flatus, nausea, abdominal cramps

Crigler-Najjar syndrome (Gilbert's syndrome is milder form)	UDP-glucuronyl-transferase	UDP-glucuronic acid + bilirubin	bilirubin glucuronide		bilirubin in blood	autosomal recessive type I (complete), jaundice, neurological problems, kernicterus, hyperbilirubinemia autosomal dominant type II (partial) less severe symptoms
Glycogen storage deficiency (Type 0)	glycogen synthetase	glucose _n + UDP-glucose	glucose _{n+1} + UDP			enlarged fatty liver, fasting hypoglycemia, autosomal recessive
von Gierke's disease (Type Ia)	glucose-6-phosphatase	glucose-6-phosphate	glucose + P _i		glycogen in liver and renal tubule cells, lactate	hypoglycemia, acidosis, ketosis, hyperlipemia, gouty arthritis, large liver and kidneys, hyperuricemia, autosomal recessive
(Type Ib)	glucose-6-phosphatase translocase	transport of G6P into endoplasmic reticulum				
Pompe's disease (Type II)	α-[1,4]- and [1,6]-glucosidase (acid maltase)	maltose	glucose		glycogen in lysosomes	large liver or heart, cardiomegaly, autosomal recessive
Cori's or Forbe's disease (Type III, limit dextrinosis)	4-α-D-glucanotransferase amylo-α-[1,6]-glucosidase (debranching enzymes)	branched glycogen	less branched glycogen		branched polysaccharide	hepatomegaly, fasting hypoglycemia, autosomal recessive
Andersen's disease (Type IV, amylopectinosis)	amylo-(1,4/1,6)-transglycosylase (branching enzyme)	glycogen branch	glycogen with more branches		polysaccharide with few branches	cardiac or liver failure, autosomal recessive
McArdle's disease (Type V, myophosphorylase deficiency)	muscle glycogen phosphorylase	glycogen _n + P _i	α-D-glucose-1-phosphate + glycogen _{n-1}		high glucose in muscle, no lactate after exercise	cramps on exercise, autosomal recessive
Hers' disease (Type VI)	liver glycogen phosphorylase	glycogen _n + P _i	α-D-glucose-1-phosphate + glycogen _{n-1}		high glycogen in liver	enlarged liver, fasting hypoglycemia, often benign, autosomal recessive
Tarui's disease (Type VII)	phosphofruktokinase	fructose-6-phosphate + ATP	fructose-1,6-bis-phosphate + ADP	ATP, Mg ²⁺		cramps on exercise, hemolysis, autosomal recessive
Type VIII, IX, X, XI rare disorders	liver phosphorylase kinase cascade	α-glycogen phosphorylase <i>b</i> + ATP	<i>m</i> -glycogen phosphorylase <i>a</i> + ADP	ATP		autosomal recessive, X-linked Type IX
Fucosidosis	α-fucosidase	Cer-Glc-Gal-GalNAc-Gal-Fuc	Cer-Glc-Gal-GalNAc-Gal + Fuc		Cer-Glc-Gal-GalNAc-Gal-Fuc H-isoantigen, pentahexosylfucoglycolipid	cerebral degeneration, muscle spasticity, thick skin
Aspartylglycosylaminuria	4-L-aspartyl-glycosylamine amidohydrolase	glycoside-GlcNAc-Asn	glycoside-GlcNAc + Asn		glycoside-GlcNAc-Asn	hepatosplenomegaly, neurological symptoms, cataracts
α-Mannosidosis	α-mannosidase	glycoside-Man-Man-glycoside	glycoside-Man + Man-glycoside		glycoside-Man-Man-glycoside	hepatosplenomegaly, neurological symptoms, cataracts
Sialidosis (mucopolipidosis I)	sialidase	NeuAc-Gal-glycoside	NeuAc + Gal-glycoside		NeuAc-Gal-glycoside	hepatosplenomegaly, neurological symptoms, cataracts
β-Mannosidosis	β-mannosidase	glycoside-Man-GlcNAc-glycoside	glycoside-Man + GlcNAc-glycoside		glycoside-Man-GlcNAc-glycoside	hepatosplenomegaly, neurological symptoms, cataracts
Mucopolipidosis II (I-cell disease)	UDP-GlcNAc-lysosomal enzyme precursor GlcNAc phosphotransferase	lysosomal hydrolase-mannose marker	lysosomal hydrolase-mannose-6-phosphate			hepatosplenomegaly, neurological symptoms, cataracts

Hyperlipoproteinemia (Type I, exogenous hypertriglyceridemia, familial fat-induced lipemia, hyperchylomicronemia)	lipoprotein lipase	lipoprotein	lipid + protein		triglycerides in blood	eruptive xanthomas, lipemia retinalis, hepatosplenomegaly, pancreatitis
Generalized gangliosidosis	G _{M1} -b-galactosidase	Cer-Glc-Gal(NeuAc)-GalNAc-Gal	Cer-Glc-Gal(NeuAc)-GalNAc + Gal		Cer-Glc-Gal(NeuAc)-GalNAc-Gal G _{M1} ganglioside	mental retardation, liver enlargement, skeletal deformation
Tay-Sachs disease (G _{M2} gangliosidosis)	hexosaminidase A	Cer-Glc-Gal(NeuAc)-GalNAc	Cer-Glc-Gal(NeuAc) + GalNAc		Cer-Glc-Gal(NeuAc)-GalNAc G _{M2} ganglioside	mental retardation, blindness, muscular weakness, cherry red spots on macula
Sandhoff's disease (Sandhoff-Jatzkewitz disease, G _{M2} gangliosidosis variant O)	β-N-acetylhexosaminidase A and B	Cer-Glc-Gal-Gal-GalNAc	Cer-Glc-Gal-Gal + GalNAc		Cer-Glc-Gal-Gal-GalNAc globoside plus G _{M2} ganglioside	more rapid Tay-Sachs symptoms
Fabry's disease (angiokeratoma corporis diffusum universale; α-galactosidase deficiency)	α-galactosidase	Cer-Glc-Gal-Gal	Cer-Glc-Gal + Gal		Cer-Glc-Gal-Gal globotriaosylceramide	skin rash, kidney failure (full symptoms in male), X-linked recessive
Ceramide lactoside lipidosis	ceramide lactosidase (β-galactosidase)	Cer-Glc-Gal	Cer-Glc + Gal		Cer-Glc-Gal ceramide lactoside	progressing brain damage, liver and spleen enlargement
Metachromatic leukodystrophy (sulfatide lipidosis)	arylsulfatase A	Cer-Gal-OSO ₃ ⁻	Cer-Gal + OSO ₃ ²⁻		Cer-Gal-OSO ₃ ⁻ 3-sulfogalactosylceramide	mental retardation and sychologic disturbances in adults, metachromasia, demyelination
Krabbe's disease	β-galactosidase	Cer-Gal	Cer + Gal		Cer-Gal galactosylceramide	mental retardation, myelin almost absent
Gaucher's disease (glucosylcerobros-ide lipidosis; Type I, adult chronic noneuronopathic; Type II, infantile neuronopathic; Type III, juvenile)	β-glucosidase	Cer-Glc	Cer + Glc		Cer-Glc glucosylceramide	hepatosplenomegaly, skin pigment-ation, reticulum cell hyperplasia, erosion of long bones, mental retardation in infants
Niemann-Pick disease (sphingomyelin lipidosis; five forms)	sphingomyelinase	Cer-phosphocholine	Cer + phosphocholine		Cer-phosphocholine sphingomyelin	hepatosplenomegaly, pancytopenia, mental retardation, fatal in early life
Farber's disease (lipogranulomatosis)	ceramidase	ceramide + H ₂ O	sphingosine + fatty acid		acylsphingosine ceramide	hoarseness, dermatitis, skeletal deformation, mental retardation, fatal in early life
Wolman's disease (acid cholesteryl ester hydrolase deficiency)	cholesteryl ester hydrolase	cholesteryl linoleoate	cholesterol + linoleic acid		neutral lipids, cholesteryl esters	autosomal recessive, hepatosplenomegaly, steatorrhea, adrenal calcification, death
Cerebrotendinous xanthomatosis (van Bogart's disease)	sterol hydroxylase	bile acid sterol	hydroxylated sterol in bile acid pathway		cholestanol (dihydrocholesterol) in nervous system, lungs, blood, xanthomas	premature arteriosclerosis, ataxia, dementia, cataracts, tendon xanthomas
Hurler and Scheie syndrome (MPS I H, MPS I S, MPS I H/S)	α-L-iduronidase	-IduA-GalNAc-	-IduA + GalNAc-		dermatan sulfate, heparan sulfate	clouding of cornea, stiff joints, aortic regurgitation, death with MPS I H form

Hunter's disease (MPS II)	iduronate sulfatase	-IduA-OSO ₃ H	-IduA + HOSO ₃ ⁻		dermatan sulfate, heparan sulfate	grave manifestations, death
Sanfilippo A syndrome (MPS III)	heparan sulfamidase	-GlcN-OSO ₃ H	-GlcN- + HOSO ₃ ⁻		heparan sulfate	mild somatic, severe CNS effects
Sanfilippo B syndrome (MPS III)	<i>N</i> -acetylglucosaminidase	-GlcNAc-glycoside	-GlcNAc- + glycoside		heparan sulfate	mild somatic, severe CNS effects
Sanfilippo D syndrome (MPS III)	<i>N</i> -acetylglucosamine-6-sulfatase	-GlcNAc-OSO ₃ H	-GlcNAc- + HOSO ₃ ⁻		heparan sulfate	mild somatic, severe CNS effects
Morquio syndrome (Type A, MPS IV A) (Type B, MPS IV B)	<i>N</i> -acetylgalactosamine-6-sulfatase β-galactosidase	-GalNAc-OSO ₃ H -Glc-Gal-	-GalNAc- + HOSO ₃ ⁻ -Glc- + Gal-		keratan sulfate	severe bone changes, cloudy cornea, aortic regurgitation moderate bone changes, dwarfism, spinal malalignment
Maroteaux-Lary disease (MPS VI)	<i>N</i> -acetylgalactosamine sulfatase	-GalNAc-OSO ₃ H	-GalNAc- + HOSO ₃ ⁻		dermatan sulfate	severe osseous and corneal change
Mucopolipidosis VII	β-glucuronidase	-GlcUA-GalNAc-	-GlcUA + GalNAc-		dermatan sulfate	hepatosplenomegaly, dysostosis multiplex, WBC inclusions, mental retardation
DiFerrante syndrome (MPS VIII)	<i>N</i> -acetylglucosamine-6-sulfatase	-GlcNAc-OSO ₃ H	-GlcNAc- + HOSO ₃ ⁻		heparan sulfate, keratan sulfate	various symptoms as above MPS
Carnitine deficiency	carnitine palmitoyl transferase I (outer mitochondrial membrane) and II (inner mitochondrial membrane)	carnitine + acetyl-CoASH acylcarnitine + CoASH	acylcarnitine + CoASH carnitine + acetyl-CoASH			muscle pain, myoglobinuria
Long chain acyl-CoA dehydrogenase, Medium CAD, Short CAD deficiency	acyl-CoA dehydrogenase	long-, medium-, short-chain-saturated fatty acid-CoA + FAD-protein	long-, medium-, short-chain-unsaturated fatty acid-CoA + FADH ₂ -protein	FAD	LCA, MCA, SCA in tissues, same and carboxylic acid and ester forms in urine	vomiting, lethargy, coma, hypoketotic hypoglycemia, dicarboxylic aciduria, may be what had been diagnosed as Reye's-like syndrome and sudden infant death syndrome
Refsum's syndrome	phytanic acid hydroxylase	phytanic acid	α-hydroxyphytanic acid		phytanic acid in plasma and tissues	peripheral neuropathy, cerebellar ataxia, retinitis pigmentosa, bone and skin changes
Ehlers-Danlos syndrome (Type VI, ocular-scoliotic)	lysyl hydroxylase	Gly-X-Lys	Gly-X-hydroxyLys	Cu ²⁺ , ascorbic acid (vit C)		autosomal recessive, microcornea, scleral perforation, retinal detachment, scoliosis
Ehlers-Danlos syndrome (Type VII, arthrochalis multiplex congenita)	procollagen aminopeptidase	N-terminalprocollagen	collagen			autosomal recessive, articular hypermobility, short stature, micrognathia
Ehlers-Danlos syndrome (Type V, Cutis laxa)	lysyl oxidase	lysine	allysine	Cu ²⁺ , vit C		loose skin, joint hypermobility, X-linked
Menkes' disease	Cu metabolism, lysyl oxidase	lysine	allysine	Cu ²⁺ , vit C		severe mental retardation, sparse, steely, or kinky hair

Congenital adrenal hyperplasias	desmolase P450-3 β -OL dehydrogenase P450-17-hydroxylase P450-21-hydroxylase P450-11-hydroxylase P450-18-hydroxylase	cholesterol pregnenolone pregnenolone 17-hydroxypregesterone 11-deoxycorticosterone corticosterone	pregnenolone + i-socaproic aldehyde pregesterone 17-hydroxypregnenolone 11-deoxycortisol corticosterone 18-OH-corticosterone		lipid in adrenal dehydroepiandrosterone, pregnenolone, 17-hydroxypregnenolone, corticosterone, 11-deoxycorticosterone, androgens, 11-deoxycorticosterone, corticosterone	adrenal insufficiency sodium loss, adrenal insufficiency, male hypospadias, female mild virilism, immature female, ambiguous genitalia in males, hypertension, low potassium, alkalosis masculinization, sodium loss, adrenal insufficiency masculinization, hypertension, sodium loss
ALA (d-aminolevulinic acid) dehydratase porphyria	ALA dehydratase	ALA	porphobilinogen		ALA in urine, Zn-protoporphyrin IX (ZnPP IX) in RBC	autosomal recessive, muscle hypotonia, respiratory insufficiency
Acute intermittent porphyria (Swedish porphyria, pyrroloporphyria)	uroporphyrinogen (Uro) I synthetase porphobilinogen (PBG) deaminase	porphobilinogen	hydroxymethylbilane (to uroporphyrinogen I)		ALA, PBG in urine	autosomal dominant, abdominal pain, nausea, vomiting, constipation, diarrhea, abdominal distention, ileus, urinary retention, incontinence, dysuria, tachycardia, hypertension, motor and sensory neuropathy, seizures
Congenital erythropoietic porphyria (Günther's disease, congenital hematoporphyria, erythropoietic uroporphyrinogen III cosynthetase)	Uro III cosynthetase	hydroxymethylbilane	uroporphyrinogen III		Uro I, Copro I in RBC, plasma, urine	autosomal recessive, photosensitivity, bullae, crusts, scar formation, sclerodermoid, hyper- and hypopigmentation, hypertrichosis, erythrodontia, hemolytic anemia, splenomegaly
Porphyria cutanea tarda (Type I, II, III), symptomatic porphyria, porphyria cutanea symptomatica, idiosyncratic porphyria, hepatoerythropoietic porphyria	Uro decarboxylase	uroporphyrinogen I and III (carboxymethyl side chains)	coporphyrinogen I and III (methyl side chains)		Uro and 7-carboxyl-Por in plasma, urine, and stool, isocoporphyrin (Isocopro) in stool, Zn-PP in RBC, Uro and 7-carboxy-Por in plasma, urine, and stool, Isocopro in stool	acquired (Type I) autosomal dominant (Type II and III) autosomal recessive photosensitivity, skin fragility, bullae, crusts, sclerodermoid, hyper- and hypopigmentation, hypertrichosis photosensitivity, bullae, crusts, scar formation, sclerodermoid, hyper- and hypopigmentation, hypertrichosis, erythrodontia, hemolytic anemia, splenomegaly, abdominal pain, nausea, vomiting, constipation, diarrhea, abdominal distention, ileus, urinary retention, incontinence, dysuria, tachycardia, hypertension, motor and sensory neuropathy, seizures

Hereditary coproporphyria	coproporphyrinogen (Copro) oxidase	coporphyrinogen III	protoporphyrinogen IX		ALA and PBG in urine, Copro in plasma, urine, and stool	autosomal dominant, abdominal pain, nausea, vomiting, constipation, diarrhea, abdominal distention, ileus, urinary retention, incontinence, dysuria, tachycardia, hypertension, motor and sensory neuropathy, seizures, photosensitivity, skin fragility, bullae, crusts, sclerodermoid, hyper- and hypopigmentation, hypertrichosis
Variete porphyria (protocoporphyrin, South African genetic porphyria, royal malady)	protoporphyrinogen oxidase	Proto IX	protoporphyrin IX (PP IX)		ALA and PBG in urine, Proto in plasma and stool	autosomal dominant, abdominal pain, nausea, vomiting, constipation, diarrhea, abdominal distention, ileus, urinary retention, incontinence, dysuria, tachycardia, hypertension, motor and sensory neuropathy, seizures, photosensitivity, skin fragility, bullae, crusts, sclerodermoid, hyper- and hypopigmentation, hypertrichosis
Erythropoietic (hereditary) protoporphyria	ferrochelatase	PP IX + Fe	heme	Fe	Proto in RBC, plasma, and stool	autosomal dominant, photosensitivity, burning sensation, edema, erythema, itching, scarring, vesicles