Name	Ataxia	Dystonia	Chorea/ athetosis	Myoclonus	Tremor	HRS	Other	Main age of MD onset	Diagnostic markers	Neuroimaging findings	Specific treatment	Representative references (PMID or DOI)
DISORDERS OF NITROGEN-CONTAINING COMPOUNDS												
Disorders of pyrimidine metabolism												
CAD trifunctional protein deficiency	X							Childhood	Hemoglobin (B)	Global brain atrophy	Uridine	28007989
Disorders of purine metabolism												
Phosphoribosyl pyrophosphate synthetase 1 superactivity	X							Childhood-adulthood	Uric acid (U, P), Purines (U)	Normal	Allopurinol	20380929, 1359249, 3017368, 28742244
Phosphoribosyl pyrophosphate synthetase 1 deficiency	X							Childhood-adulthood	Uric acid (U, P), Purines (U)	Mild brain and/or cerebellar atrophy		8498830, 24528855
Purine nucleoside phosphorylase deficiency	X							Childhood	Purines (U)	Normal		1929496, 11453975
Adenylosuccinate lyase deficiency	X							Childhood	Purines (CSF, U)	Brain and/or cerebellar atrophy, WM abnormalities		21625931, 28768552
Hypoxanthine guanine phosphoribosyltransferase deficiency	X	**X**	X					Infancy-childhood	Uric acid (U, P), Purines and pyrimidines (U)		Allopurinol	2455472, 16549399
Disorders of creatine metabolism												
Guanidinoacetate methyltransferase deficiency	X	X	X					Childhood-adolescence	Creatinine (P, U), Guanidino compounds (P, U)	Basal ganglia T2 hyperintensity	Creatine and ornithine supplementation, arginine restriction	24268530, 16855203, 19388150
Creatine transporter deficiency	X	X	X					Infancy-childhood	Creatinine (P, U), Guanidino compounds (P, U)	Mild cerebral atrophy and/or WM abnormalities	Creatine, arginine and glycine supplementation	23644449, 16601897, 20301745
Disorders of glutathione metabolism												
Gamma-glutamylcysteine synthetase deficiency	X							Adulthood	Hemoglobin (B), Reticulocytes (B), Glutathione (RBC)			4852017
Glutathione synthetase deficiency, severe	X							Adulthood	Hemoglobin (B), Reticulocytes (B), Glutathione (RBC), 5-Oxoproline (U)		N-acetylcysteine, vitamins E and C	DOI: 10.1056/NEJM197608192950802
Disorders of ammonia detoxification												
Ornithine transcarbamylase deficiency	X							Late childhood-adulthood	Ammonia (B), ASAT/ALAT (P), Urea (P), Amino acids (P), Orotic acid (U)	Cortical and subcortical edema. Basal ganglia T2-hyperintensity with thalamic sparing. Scalloped ribbon of DWI restriction at insular gray-white interface.	Protein restriction, ammonia scavengers, citrulline, liver transplant	8857803, 15201380
Argininosuccinate synthetase deficiency	X							Late childhood-adulthood	Ammonia (B), ASAT/ALAT (P), Urea (P), Amino acids (P), Orotic acid (U)		Protein restriction, ammonia scavengers, arginine, liver transplant	29695388
Argininosuccinate lyase deficiency	X							Late childhood-adulthood	Ammonia (B), ASAT/ALAT (P), Urea (P), Amino acids (P, U), Orotic acid (U)		Protein restriction, ammonia scavengers, arginine, liver transplant	28251416, 19635676
Arginase deficiency	X							Childhood	Ammonia (B), ASAT/ALAT (P), Urea (P), Amino acids (P), Orotic acid (U)		Protein restriction, ammonia scavengers	8474825, 2246859
Mitochondrial ornithine transporter deficiency	X			X				Adolescence	Ammonia (B), ASAT/ALAT (P), Urea (P), Amino acids (P, U), Orotic acid (U)		Protein restriction, ammonia scavengers, citrulline	3670619
Disorders of amino acid transport												
Hartnup disorder	X							Childhood	Amino acids (U)	Normal		13358233
Disorders of monoamine metabolism												
Tyrosine hydroxylase deficiency		X		X	X	X	X*	Infancy-adolescence	5HIAA/HVA/3OMD (CSF), Prolactin (P)	Normal to mild brain and/or cerebellar atrophy	L-dopa	20301610
Aromatic L-amino acid decarboxylase deficiency		X	X	X	X		X*	Infancy-childhood	5HIAA/HVA/3OMD (CSF), Prolactin (P)	Normal to mild brain atrophy	Dopamine agonists, MAO inhibitors, pyridoxine	28100251
Dopamine transporter deficiency		X	X		X	X	X*	Infancy-adulthood	5HIAA/HVA/3OMD (CSF), Prolactin (P)	Normal	Dopamine agonists	28749637, 24613933
Dopamine-serotonin vesicular transport defect	X	X				X	X*	Infancy	5HIAA/HVA (U)	Normal	Dopamine agonists	23363473, 26497564,
Disorders of phenylalanine and tetrahydrobiopterin metabolism												
Phenylketonuria					X	X		Adulthood	Amino acids (P)	WM abnormalities	Phe-restricted diet, sapropterin, pegvaliase	28285739, 25614310, 14654669
Autosomal recessive GTP cyclohydrolase I deficiency		X			X		X*	Neonatal-infancy	Amino acids (P), Pterins (DBS, U, CSF), 5HIAA/HVA/3OMD (CSF)	Normal	Low Phe/BH4 supplementation, L-dopa, 5-hydroxytryptophan	12552057, 18276179
Autosomal dominant GTPCH deficiency		X			X	X	X	Childhood-adolescence	Pterins (DBS, U, CSF), 5HIAA/HVA/3OMD (CSF)	Normal	L-dopa	20301681
6-Pyruvoyl-tetrahydropterin synthase deficiency		X	X		X		X*,**	Infancy	Amino acids (P), Pterins (DBS, U, CSF), 5HIAA/HVA/3OMD (CSF)	Delayed myelination	Low Phe/BH4 supplementation, L-dopa, 5-hydroxytryptophan	16601879, 11388593, 20059486
Sepiapterin reductase deficiency		X	X	X	X	X	X*	Infancy-childhood	Pterins (DBS, U, CSF), 5HIAA/HVA/3OMD (CSF)	Normal (rarely atrophy or delayed myelination)	L-dopa, 5-hydroxytryptophan	22522443
Dihydropteridine reductase deficiency			X			X		Infancy	Amino acids (P), Pterins (DBS, U, CSF), 5HIAA/HVA/3OMD (CSF), 5-Methyl-THF (CSF)	Basal ganglia calcification	Low Phe, L-dopa, 5-hydroxytryptophan, folinic acid	28413401, 11174152
DNAJC12-deficient hyperphenylalaninemia		**X**				X	X*	Infancy-childhood	Amino acids (P), Pterins (DBS, U, CSF), 5HIAA/HVA/3OMD (CSF)	Normal	BH4, L-dopa and/or 5-hydroxytryptophan	28132689
Disorders of sulfur amino acid and sulfide metabolism												
Methionine adenosyltransferase I/III deficiency		X			X			Childhood	Amino acids (P), Homocysteine, total (P), SAH/SAM (P)	Normal to WM changes and/or delayed myelination		26289392
Classic homocystinuria	X	**X**		X				Childhood-adolescence	Homocysteine, total (P), Amino acids (P)	Normal to stroke	Met-restricted diet, betaine, pyridoxine	3404194, 7594264, 12118530, 16856143, 15300664
Sulfite oxidase deficiency	X	X	X				**X*** **	Neonatal (hyperekplexia) to childhood (dystonia)	Amino acids (P), Homocysteine, total (P), Sulfite (U), Pipecolic acid (CSF, U)	Diffuse swelling followed by cystic changes		8719749, 9600976, 24756183
Ethylmalonic encephalopathy	X	X						Childhood	Lactate (P), Organic acids (U), Acylcarnitines (DBS, P), Thiosulfate (U)	Basal ganglia T2 hyperintensity and/or brain atrophy	Liver transplant, N-acetylcysteine, metronidazole,	19289697, 12382164
Disorders of branched-chain amino acid metabolism												
Maple syrup urine disease type 1a	X	X			X		X#	Neonatal (bicycling, fencing), infancy-childhood (ataxia), adulthood (dystonia, tremors)	Amino acids (P), Organic acids (U)	Increased signal and cytotoxic edema myelinated structures, vasogenic edema of unmyelinated tracts	Low BCAA diet, valine/isoleucine supplementation	24394677, 21484869
Maple syrup urine disease type 1b	X	X			X		X#					
Maple syrup urine disease type 2	X	X			X		X#					
Dihydrolipoamide dehydrogenase deficiency	X							Childhood	Amino acids (P), Organic acids (U), Lactate (P), Pyruvate (P)	Basal ganglia T2 hyperintensity		12925875, 23290025
Isovaleric acidemia	X				X			Childhood	Amino acids (P), Organic acids (U), Acylcarnitines (DBS, P)	Normal to basal ganglia T2 hyperintensity	Glycine, carnitine	6015910, 888034
Methylglutaconic aciduria type I	X							Adulthood	Organic acids (U), Acylcarnitines (DBS, P)	Extensive WM disease		17130438, 20855850
Mitochondrial short-chain enoyl-CoA hydratase (ECHS1) deficiency	X	**X**						Childhood	Organic acids (U), Acylcarnitines (DBS, P)	Basal ganglia T2 hyperintensity		26099313, 27090768, 28039521
3-Hydroxyisobutyryl-CoA hydrolase (HIBCH) deficiency	X	**X**						Childhood	Amino acids (P), Organic acids (U), Acylcarnitines (DBS, P)	Basal ganglia T2 hyperintensity		24299452, 27400804
2-Methyl-3-hydroxybutyryl-CoA dehydrogenase deficiency	X	X	**X**	X		X		Childhood	Amino acids (P), Organic acids (U), Acylcarnitines (DBS, P)	Brain atrophy and/or basal ganglia T2 hyperintensity		10521307, 11102558, 22127393
Propionic acidemia PCCA	X	X	X					Infancy-adulthood	Amino acids (P), Organic acids (U), Acylcarnitines (DBS, P)	Normal to basal ganglia involvement	Low protein diet, carnitine	2797456, 23305374, 10488817, 22078457
Propionic acidemia PCCB	X	X	X						Amino acids (P), Organic acids (U), Acylcarnitines (DBS, P)		Low protein diet, carnitine	
Methylmalonyl-CoA epimerase deficiency	X								Organic acids (U), MMA (S)	Normal	Hydroxycobalamin	17823972
Methylmalonic aciduria due to methylmalonyl-CoA mutase deficiency	X	X	X					Infancy-childhood	Amino acids (P), Organic acids (U), MMA (S), Acylcarnitines (DBS, P)	Normal to basal ganglia involvement	Low protein diet, carnitine, hydroxycobalamin	9713004
Combined malonic and methylmalonic aciduria		X						Childhood	Organic acids (U), MMA (S)	WM T2 hyperintensities		21841779, 26915364
Malonic aciduria		X						Childhood	Organic acids (U), Acylcarnitines (DBS, P)	WM T2 hyperintensities	LCT restriction, MCT and carnitine supplementation	17535268, 24613099
Disorders of lysine metabolism												
Glutaric aciduria type I	X	**X**	X			X		Infancy-childhood	Organic acids (U), Acylcarnitines (DBS, P)	Basal ganglia involvement	Carnitine, lysine-restricted/arginine-rich diet	18823014
Disorders of proline and ornithine metabolism												
Pyrroline-5-carboxylate synthase deficiency		X	X					Infancy-childhood	Ammonia (B), Amino acids (P)	Atrophy and/or vessel tortuosity		18478038, 21739576
Disorders of β- and γ-amino acids												
β-ureidopropionase deficiency		X						Childhood	Purines and pyrimidines (U)	Atrophy and/or delayed myelination		11675655, 16541364
GABA transaminase deficiency			X					Neonatal-infancy	GABA (CSF), Beta-Alanine (CSF), Homocarnosine (CSF)	Atrophy and/or dysmyelination		28411234
Succinic semialdehyde dehydrogenase deficiency	X	X	X	X				Childhood	Organic acids (U)	Globus pallidus, dentate and subthalamic nucleus T2 hyperintensity		9093300, 27268762, 26499347, 16298354, 7726383, 17438226
Disorders of glutamate metabolism												
Glutamate aspartate transporter (EAAT1) deficiency	X							Childhood	No laboratoty tests --> DNA	Episodic edema		16116111, 19139306
Disorders of serine metabolism												
Phosphoglycerate dehydrogenase deficiency	X							Adulthood	Amino acids (CSF, P), 5-Methyl-THF (CSF)	Delayed myelination	Serine/glycine supplementation	22393170
Disorders of glycine metabolism												
Glycine encephalopathy due to glycine decarboxylase deficiency	X		X					Neonatal-childhood	Amino acids (P, CSF)	Hypogenesis of the CC, T2 hyperintensities and DWI restriction of myelinated tracts	Benzoate, NMDA receptor antagonist	16157495, 15077252
Glycine encephalopathy due to aminomethyltransferase deficiency	X		X						Amino acids (P, CSF)		Benzoate, NMDA receptor antagonist	
Hyperekplexia due to glycine transporter 2 defect							X***	Neonatal	No laboratoty tests --> DNA	Normal		16751771
Disorder of asparagine metabolism												
Asparaginase deficiency							X***	Neonatal	Amino acids (P, CSF)	Cerebral and pontine atrophy, delayed myelination		24139043, 27422383
DISORDERS OF VITAMINS, COFACTORS, METALS AND MINERALS												
Disorders of cobalamin metabolism												
Imerslund-Gräsbeck syndrome	X							Childhood	Homocysteine, total (P), B12 (S), Blood count	Normal to brain atrophy	Hydroxycobalamin	1940989
cblC disease	X							Late childhood-adulthood	Blood count, Organic acids (U), Acylcarnitines (DBS, P), Amino acids (P)	Normal to spinal cord involvement	Hydroxycobalamin, betaine	25398587
Methylcobalamin synthesis defect - cblD variant 1	X	X						Infancy-childhood	Blood count, Organic acids (U), Acylcarnitines (DBS, P), Amino acids (P)	Normal to cerebral and/or cerebellar atrophy	Hydroxycobalamin, betaine	15292234
Methionine synthase deficiency - cblG	X							Late childhood-adulthood	Homocysteine, total (P), Blood count, Amino acids (P)	Normal to brain atrophy	Hydroxycobalamin, betaine	2688421
cblX disease			X						Organic acids (U), MMA (S)			
Disorders of folate metabolism												
Hereditary folate malabsorption	X		X					Childhood	Folate (RBC, S), 5-Methyl-THF (CSF), Blood count	Normal to basal ganglia calcification	Folinic acid	5450108, 11807405
Folate receptor alpha deficiency	X		X		X			Childhood	5-Methyl-THF (CSF)	Normal to basal ganglia calcification, delayed myelination, and/or atrophy	Folinic acid	12571785, 24556562
Methylenetetrahydrofolate reductase deficiency	X							Adolescence-adulthood	Homocysteine, total (P), Amino acids (P), 5-Methyl-THF (CSF)	Normal to stroke and/or WM changes	Betaine	29391032, 29284203
Dihydrofolate reductase deficiency	X							Childhood	5-Methyl-THF (CSF), Blood count	Cerebral and/or cerebellar atrophy	Folinic acid	21310276
Disorders of biotin metabolism												
Biotinidase deficiency	X							Infancy-adolescence	Organic acids (U), Acylcarnitines (DBS, P)	Normal to basal ganglia calcification	Biotin	13679123, 11952077, 25284861,

Name	Ataxia	Dystonia	Chorea/ athetosis	Myoclonus	Tremor	HRS	Other	Main age of MD onset	Diagnostic markers	Neuroimaging findings	Specific treatment	Representative references (PMID or DOI)	
Holocarboxylase synthetase deficiency	X							[illegible]	Organic acids (U), Acylcarnitines (DBS, P), Lactate (P)	Normal to mycobiotin changes	Biotin	7436398	
Disorders of thiamine metabolism													
Biotin-thiamine-responsive basal ganglia disease	X	X						Childhood	Lactate (P), Free thiamine (CSF)	Basal ganglia T2 hyperintensity	Thiamine, biotin	24260777	
Thiamine pyrophosphokinase deficiency	X	X						Childhood	Organic acids (U), Lactate (P, CSF), thiamine pyrophosphate (B, M)	Normal to delayed myelination, WM and/or basal ganglia changes	Thiamine	22152682, 25458521	
Mitochondrial thiamine pyrophosphate transporter deficiency	X	X						Childhood	Organic acids (U), Lactate (P, CSF)	Basal ganglia T2 hyperintensity		DOI: 10.1055/s-0037-1602924	
Disorders of NAD metabolism													
Mitochondrial NAD kinase 2 deficiency	X	X	X					Childhood	Amino acids (P), Acylcamitines (DBS, P), Lactate (P), Pipecolic acid (P)	Atrophy, WM and/or basal ganglia changes		24847004, 27940755	
NAXE deficiency	X							Childhood	Cyclic NADHX (F)	Cerebellar edema and/or myelopathy	Niacin?	27616477	
Disorders of pantothenate metabolism													
Pantothenate kinase-associated neurodegeneration (PKAN)		X	X			X		Childhood	Iron (brain)	Eye of the tiger		20301663	
Coenzyme A synthase deficiency	X	X				X		Childhood-adolescence	Iron (brain)	Basal ganglia and thalamus T2 hyperintensity		28489334, 24360804	
Disorder of pyridoxine metabolism													
Pyridoxine-dependent epilepsy		X		X	X			Neonatal-childhood	PLP (CSF), Pipecolic acid (CSF, S, U), AASA (CSF, P, U)	Usually normal; can have dysgenetic corpus callosum	Pyridoxine and arginine supplementation, lysine restriction	20370816	
PNPO deficiency		X						Childhood	5HIAA/HVA/3OMD (CSF), Amino acids (P)	Normal to WM edema	PLP	15772097, 24645144	
Disorder of vitamin E metabolism													
Alpha-tocopherol transfer protein deficiency	X							Childhood-adulthood	Vitamin E (P)	Normal to cerebellar atrophy	Vitamin E	24369383	
Disorders of molybdenum metabolism													
Molybdenum cofactor deficiency	X	X	X			X	X***	Neonatal (hyperekplexia) to adulthood (parkinsonism)	Purines (U), Uric acid (U, P), Homocysteine, total (P), Sulfite (U), Pipecolic acid (CSF)	Diffuse swelling followed by cystic changes	cPMP (type A)	16429380, 23436702	
Disorders of copper metabolism													
Wilson disease	X	**X**	X	X	X	X	X**	Childhood	Copper (S, U), Ceruloplasmin (S), ASAT/ALAT (P), Blood count	Midbrain "face of the giant panda" sign	Zinc, penicillamine, trientine	11481698, 27103860, 17435591, 17078070	
Menkes disease	X							Childhood	Copper (S, U), Ceruloplasmin (S), VLCFA (P)	Arterial tortuosity and/or subdural collection	Copper histidine	7452417, 3189408, 3181204	
Disorders of iron metabolism													
Neuroferritinopathy		X	X			X	X**	Adulthood	Iron (brain)	Iron deposition in basal ganglia		17142829, 15390132	
Aceruloplasminemia	X	X	X		X	X		Adulthood	Iron (brain, S), copper (S), Ceruloplasmin (S), Ferritin (S), Blood count	Iron deposition in basal ganglia	Iron chelation	20301666	
Disorders of manganese metabolism													
SLC30A10 deficiency		X			X	X		Childhood (dystonia) to adulthood (parkinsonism)	ASAT/ALAT (P), Blood count, Manganese (B)	Basal ganglia T1 hyperintensity	Chelation (EDTA), iron supplementation	22934317	
SLC39A14 deficiency		X			X	X		Infancy-childhood	Manganese (B)	Basal ganglia T1 hyperintensity	Chelation (EDTA)	28541650	
SLC39A8 deficiency	X	X						Infancy	Sialotransferins (S), manganese (B, U)	Basal ganglia T2 hyperintensity	Uridine + galactose, manganese	28749473, 27995398	
Disorders of zinc metabolism													
Birk-Landau-Perez syndrome	X	X	X					Childhood	No laboratoty tests --> DNA	Normal		28334855	
Disorders of selenium metabolism													
Selenocysteine synthase SepSecS) deficiency	X							Childhood	No laboratoty tests --> DNA	Progressive cerebellocerebral atrophy		29464431, 26888482	
DISORDERS OF CARBOHYDRATES													
Disorders of carbohydrate transport and absorption													
Glucose transporter 1 deficiency	**X**	X	X	X	X	X	X##	Infancy-adulthood	Glucose (P, CSF), Lactate (P, CSF), Blood count	Normal	Ketogenic diet, triheptanoin	23801573, 20063428	
Disorders of galactose metabolism													
Classic galactosemia	X	X	X		X	X		Adulthood	Galactose-1-P (RBC), GALT enzyme activity (RBC)	Normal to atrophy and/or WM changes	Galactose restriction	23400815, 7676142, 1622520	
Disorders of the pentose phosphate pathway and polyol metabolism													
Ribose-5-phosphate isomerase deficiency	X							Childhood	Polyols (P, U, CSF)	Extensive WM disease		14988808	
Disorders of gluconeogenesis													
Pyruvate carboxylase deficiency	X	X			X	X		Neonatal (HRS and tremor), childhood (ataxia)	Lactate (P), Pyruvate (P), Amino acids (P)	Periventricular WM cysts and/or atrophy		16278852, DOI:10.1007/978-94-009-9215-3_16	
Disorders of glycolysis													
Triosephosphate isomerase deficiency		X		X	X			Childhood	Dihydroxyacetone phosphate (RBC)			4004168, 10209987	
MITOCHONDRIAL DISORDERS OF ENERGY METABOLISM													
Disorders of pyruvate metabolism													
Pyruvate dehydrogenase complex deficiency	X	X	X					Childhood	Lactate (P), Pyruvate (P)	Brain atrophy and/or basal ganglia T2 hyperintensity	Ketogenic diet	22079328, 18504677, 15473177, 21470495, 20022530, 4313434	
Disorders of the Krebs cycle													
Mitochondrial aconitase deficiency			X					Infancy	cis-aconitate (P), isocitrate (P)	Progressive cerebellar atrophy		22405087	
Succinyl-CoA ligase β subunit (SUCLA2) deficiency	X	**X**	X					Neonatal-infancy	Lactate (P), Pyruvate (P), Organic acids (U), MMA (S), Acylcarnitines (P)	Basal ganglia T2 hyperintensity and/or cerebral atrophy		17301081, 19666145, 26409464	
Succinyl-CoA ligase α subunit (SUCLG1) deficiency	X	**X**	X	X				Neonatal-infancy	Lactate (P), Pyruvate (P), Organic acids (U), MMA (S), Acylcarnitines (P)	Basal ganglia T2 hyperintensity		28358460	
Fumarase deficiency		X						Infancy-childhood	Organic acids (U)	Bilateral polymicrogyria and open Sylvian operculum		8200987	
Mitochondrial malate dehydrogenase deficiency		X						Childhood	Lactate (CSF, P), Organic acids (U)	Cerebral atrophy and/or delayed myelination		27989324	
Plasma membrane citrate transporter deficiency	X	X	**X**					Infancy-childhood	Citrate (P)	Normal to periventricular WM changes		26384929, 24995870	
Disorders of metabolite repair													
L-2-hydroxyglutaric aciduria	X	X	**X**		X	X		Adolescence-adulthood	Organic acids (U), Amino acids/lysine (P)	Leukoencephalopathy		24753671, 26788335, 15314137, 10688474, 1642474	
Disorders of mitochondrial carriers													
Aspartate-glutamate carrier 1 (aralar) deficiency		X						Childhood	Lactate (brain), N-Acetylaspartic acid (brain)	Delayed myelination	Ketogenic diet?	Neurology Apr 2015, 84 (14 Supplement) P2.138	
Disorders of mitochondrial complex subunits and assembly													
Leigh Syndrome (various genes)	X	**X**				X		Infancy-childhood	Lactate (P)	Basal ganglia and brainstem T2 hyperintensity		26425749, 8392142	
Mitochondrial encephalomyopathy, lactic acidosis, and stroke-like episodes (various genes)	**X**	X	X	X	X	X		Childhood-adulthood		Stroke-like episodes		23079769, 7600089	
Myoclonic epilepsy with ragged red fibers (various genes)	X			X				Childhood-adulthood	Lactate (P), CK (P)	Atrophy of cerebellum and superior cerebellar peduncles		23635963, 17200493	
Neuropathy, ataxia and retinitis pigmentosa (NARP)	X							Childhood	Lactate (P), Amino acids (P)	Normal to cerebral and/or cerebellar atrophy		20301352	
Disorders of mitochondrial DNA depletion													
POLG deficiency	X	X	X	**X**	X	X		Infancy-adulthood	Lactate (P), ASAT/ALAT (P)	Normal to cerebral atrophy		30167885, 20818669	
MPV17 deficiency	X	X				X		Infancy	Lactate (P), ASAT/ALAT (P)	WM abnormalities		29282788, 22964873	
Twinkle mitochondrial DNA helicase deficiency	X		X					Infancy-childhood	mtDNA liver content	Cortical edema followed by atrophy		20301746	
FBXL4 deficiency	X	X	X		X			Neonatal-infancy	Lactate (P), ASAT/ALAT (P), CK (P), Blood count	WM T2 hyperintensities		28383868	
Disorders of mitochondrial translation factors													
C12orf65 release factor deficiency	X							Childhood	No laboratoty tests --> DNA	Thalamus and brainstem T2 hyperintensity		20598281	
Disorders of mitochondrial tRNA incorporation and recycling													
Mitochondrial aspartyl-tRNA synthetase deficiency	X							Childhood	Lactate (P)	Leukoencephalopathy with brainstem and spinal cord involvement		17384640, 21749991	
Mitochondrial methionyl-tRNA synthetase deficiency	**X**	X						Childhood-adulthood	No laboratoty tests --> DNA	Cerebellar atrophy and WM changes		22448145	
Mitochondrial tryptophanyl-tRNA synthetase deficiency						X		Infancy-childhood	No laboratoty tests --> DNA	Leukoencephalopathy		29120065	
Disorders of mitochondrial fusion													
OPA1 deficiency	X	X			X	X		Adulthood	No laboratoty tests --> DNA	Normal to atrophy		23387428, 25820230	
Costeff syndrome	X		**X**					Childhood-adulthood	Organic acids (U)	Normal to atrophy		20301646	
MSTO1 deficiency	X				X			Childhood	CK (P)	Cerebellar hypoplasia		28544275	
Disorders of mitochondrial phospholipid metabolism													
MEGDEL Syndrome		X						Childhood	Organic acids (U), Lactate (P)	Basal ganglia involvement with sparing of central putamen		29205472	
Disorders of mitochondrial protein import													
DNAJC19 deficiency	**X**	X				X		Childhood	Organic acid (U), Blood count	Basal ganglia involvement		16055927, 27928778	
Mohr-Tranebjaerg syndrome		X						Adolescence	No laboratoty tests --> DNA	Brain atrophy in males >40 yo		20301395	
Disorders of mitochondrial protein quality control													
Mitochondrial processing peptidase alpha deficiency	X	X						Childhood-adolescence	No laboratoty tests --> DNA	Cerebellar atrophy		25808372, 26657514	
CLPB deficiency	X	X	X	X				Infancy-childhood	Organic acids (U), Blood count	Cerebellar and basal ganglia atrophy, basal ganglia T2 hyperintensities		25597510, 25597511	
Sacsin deficiency	X							Childhood	No laboratoty tests --> DNA	Cerebellar atrophy		20301432	
AFG3L2 deficiency	X							Adulthood	No laboratoty tests --> DNA	Cerebellar atrophy		21595125	
Parkin deficiency						X		Adulthood	No laboratoty tests --> DNA	Normal		20301651	
Primary CoQ10 deficiencies													
COQ2 deficiency				X	X			Childhood	CoQ10 (L, P)	Cerebellar atrophy	CoQ10	16400613	
COQ6 deficiency	X							Childhood	CoQ10 (L, P)	Normal to cerebellar atrophy	CoQ10	21540551	
COQ8A deficiency	X	X		X	X			Childhood	CoQ10 (L, P)	Cerebellar atrophy	CoQ10	18319074, 24218524, 22036850	
DISORDERS OF LIPIDS													
Disorders of ketone body metabolism													
Beta-ketothiolase deficiency	X	X	X	X				Childhood	Organic acids (U), Acylcarnitines (DBS, P), Acetoacetate (P, U), Glucose (B)	Normal to basal ganglia T2 hyperintensity	Protein restriction, carnitine supplementation	23818432, 28726122	
Disorders of fatty acid synthesis and elongation													
Mitochondrial enoyl-coA reductase deficiency		**X**	X	X				Childhood	Lactate (brain)	Basal ganglia T2 hyperintensity		27817865	
ELOVL4 deficiency	X							Adolescence-adulthood	No laboratoty tests --> DNA	Hot cross bun sign		26010696	
ELOVL5 deficiency	X							Adulthood	Arachidonic acid (P), DHA (P)	Cerebellar atrophy		25065913	
Disorders of the fatty alcohol cycle													
Sjögren-Larsson syndrome		X			X			Childhood	Fatty alcohols (P)	WM T2 hyperintensities		11071513	
Disorders of intracellular triglyceride metabolism													
Chanarin-Dorfman syndrome	X							Childhood-adulthood	ASAT/ALAT (P)	Normal		4277517	
Celia's encephalopathy	X	X		X	X			Childhood	No laboratoty tests --> DNA	Normal to atrophy	Metreleptin, PUFA-rich diet?	23564749	
Disorders of non-mitochondrial phospholipid metabolism													
Phosphatidylserine flippase ATP8A2 deficiency	X							Childhood-adulthood	No laboratoty tests --> DNA	Normal to mild atrophy		22892528	
PLA2G6-associated neurodegeneration		X				X		Childhood-adulthood	Iron (brain)	Iron deposition in basal ganglia		20301718	
PNPLA6 deficiency	X							Childhood-adulthood	No laboratoty tests --> DNA	Cerebellar atrophy		24355708	
PHARC syndrome	X				X			Adulthood	No laboratoty tests --> DNA	Normal to cerebellar atrophy		20797687	

Name	Ataxia	Dystonia	Chorea/ athetosis	Myoclonus	Tremor	HRS	Other	Main age of MD onset	Diagnostic markers	Neuroimaging findings	Specific treatment	Representative references (PMID or DOI)	
Disorders of non-lysosomal sphingolipid metabolism													
Fatty acid hydroxylase-associated neurodegeneration	X	X						Childhood-adolescence	Iron (brain)	Iron deposition in basal ganglia and WM changes		21735565	
GBA2 deficiency	X							Childhood-adolescence	No laboratoty tests --> DNA	Cerebellar atrophy		23332917, 24252062	
Disorders of palmitoylation													
CLN1	X			X				Childhood-adulthood	Enzyme activity (DBS, L, F)	Cerebral and/or cerebellar atrophy		11506414, 29627028	
Disorders of lipoprotein metabolism													
Apolipoprotein B deficiency (familial hypobetalipoproteinemia)	X							Childhood-adolescence	Lipid panel (S), Vitamins A and E (P), Apo B (P)	Normal		7229035, 15984016	
Abetalipoproteinemia	X	X						Childhood-adolescence	Lipid panel (S), Vitamins A and E (P), Apo B (P)	Normal		18611256	
Disorders of cholesterol biosynthesis													
Mevalonate kinase deficiency	X							Childhood	Organic acids (U), Leukotrienes (U)	Normal to cerebellar atrophy		2850914, 8386351	
Disorders of bile acid synthesis													
Oxysterol 7α-hydroxylase deficiency	X							Childhood-adulthood	25/27-hydroxycholesterol (P)	WM changes to cerebral and/or cerebellar atrophy		21214876	
Cerebrotendinous xanthomatosis	X	X	X	X	X	X		Adolescence-adulthood	Sterols (P)	Dentate nucleus T2 hyperintensity	Chenodeoxycholic acid	30054180	
α-Methylacyl-CoA racemase deficiency					X			Adulthood	Pristanic acid (S)	WM T2 hyperintensities		15249642, 23286897	
Peroxisomal branched-chain acyl-CoA oxidase (ACOX2) deficie	X							Childhood	Bile acid intermediates (U)	Normal		27647924	
DISORDERS OF TETRAPYRROLES													
Disorders of heme metabolism													
Recessive porphobilinogen deaminase deficiency	X							Childhood	Porphobilinogen (P, U), aminolevulinic acid (P, U), porphyrins (P, U, feces), enzyme (RBC)	Leukodystrophy, later cerebellar atrophy	Hematin	27558376, 15534187	
Coproporphyrinogen oxidase deficiency	X							Adulthood	Porphobilinogen (P, U), aminolevulinic acid (P, U), porphyrins	Normal	Hematin	24156084	
Congenital methemoglobinemia due to CYB5R3 deficiency		X	X					Infancy-childhood	Methemoglobin (B)	Delayed myelination to cerebral and/or cerebellar atrophy		18202104, 9266404, 10874300	
STORAGE DISORDERS													
Disorders of autophagy													
Beta-propeller protein-associated neurodegeneration (BPAN)	X	X				X		Adolescence-adulthood	Iron (brain)	T1 hyperintensity of the globlus pallidus and substantia nigra, the latter with hyperintense halo		23687123	
SNX14 deficiency	X							Infancy-childhood	No laboratoty tests --> DNA	Cerebellar atrophy		24501761, 25439728	
Neuronal ceroid lipofuscinosis													
CLN2 disease	**X**	X	X	X				Childhood	Enzyme (DBS, L, F)	Cerebral and/or cerebellar atrophy	Cerliponase alfa	27553878	
CLN4 disease	X			**X**				Adulthood	No laboratoty tests --> DNA	Cerebral and/or cerebellar atrophy		11489285, 5132971	
CLN5 disease	X			X				Childhood-adulthood	No laboratoty tests --> DNA	Cerebral and/or cerebellar atrophy		25359263, 15728307	
CLN7 disease	X			X				Childhood	No laboratoty tests --> DNA	Cerebral and/or cerebellar atrophy and periventricular WM changes		19201763	
CLN8 disease	X			X				Childhood	No laboratoty tests --> DNA	Cerebral and/or cerebellar atrophy and periventricular WM changes		26443629	
CLN10 disease	X							Childhood-adolescence	Cathepsin D (DBS, LC, FB)	Cerebral and/or cerebellar atrophy		16685649, 25298308	
CLN11 disease	X							Adulthood	No laboratoty tests --> DNA	Cerebellar atrophy		22608501	
ATP13A2 deficiency		X		X		**X**		Adulthood	Iron (brain)	Iron deposition in basal ganglia, cerebellar and cortical atrophy		21060012, 28137957	
CLN13 disease	X			X	X			Adulthood	No laboratoty tests --> DNA	Cerebral atrophy		25274848, 23297359	
CLN14 disease	X	X		**X**				Infancy-childhood	No laboratoty tests --> DNA	Cerebral atrophy		22693283, 22748208	
Sphingolipidoses													
Gaucher disease	X	X		X	X	X		Childhood-adulthood	Enzyme (DBS, L, F)	Normal	ERT, substrate reduction	20084461, 27789132	
Gaucher disease-like disorder due to saposin C deficiency				X				Childhood	Enzyme (DBS, L, F)	Normal		2615292	
GM1 gangliosidosis		**X**				X		Childhood-adulthood	Enzyme (DBS, L, F), Oligosaccharide (U)	Basal ganglia T2 hyperintensity		1336295, 8355822, 15389993	
Beta-hexosaminidase alpha subunit deficiency (Tay-Sachs disease)	**X**	X	X			X		Childhood-adulthood	Enzyme (DBS, L, F), Oligosaccharide (U)	Normal to cerebellar atrophy		24327357, 18642377, 12433276, 15714079	
Beta-hexosaminidase beta subunit deficiency (Sandhoff disease)	**X**	X	X					Childhood-adulthood	Enzyme (DBS, L, F), Oligosaccharide (U)	Normal to cerebellar atrophy		15159655, 20798201, 25916337	
Krabbe disease	X							Childhood-adulthood	Enzyme (DBS, L, F), Protein (CSF)	Leukodystrophy		11166794, 26915362, 23197103	
Metachromatic leukodystrophy	X	X						Childhood-adulthood	Enzyme (DBS, L, F), Sulfatide (U), Protein (CSF)	Leukodystrophy	Bone marrow transplant	6115727, 12445909	
Multiple sulfatase deficiency	X							Childhood	Sulfatide (U), Glycosaminoglycans (U)	Leukodystrophy		2899861, 25222778, 11737681	
Combined saposin deficiency				X				Neonatal	Enzyme (DBS, L, F)	Gray matter heterotopia		2514102, 15944902, 19267410	
Oligosaccharidoses													
Sialidosis	X			X				Adulthood	Enzyme (F), Oligosaccharide (U)	Normal to cerebellar atrophy		24808020, 496393	
Galactosialidosis	X			X				Adulthood	Enzyme (DBS, L, F), Oligosaccharide (U)	Normal to cerebellar atrophy		21312277, 12932252	
Alpha-mannosidosis	X							Adulthood	Enzyme (DBS, L, F), Oligosaccharide (U)	Cerebral and/or cerebellar atrophy	Enzyme replacement therapy, bone marrow transplant	20301570, 10447604	
Beta-mannosidosis	X							Childhood	Enzyme (DBS, L, F), Oligosaccharide (U)	Brain atrophy		18980795	
Fucosidosis		X						Childhood	Enzyme (DBS, L, F), Oligosaccharide (U)	Iron deposition in basal ganglia		24636010, 26713028, 8719750	
Disorders of lysosomal cholesterol metabolism													
Niemann-Pick disease type C	X	X	X	X	X	X		Infancy-adulthood	Enzyme (DBS, L, F), Filipin test (F)			16755579, 27581084, 17003072, 24178705	
Disorders of lysosomal transport or sorting													
Salla disease	X		X					Infancy-childhood	Sialic acid, free (U)	Delayed myelination		6681560, 6681560	
Action myoclonus-renal failure syndrome	X			X	X			Adolescence-adulthood	No laboratoty tests --> DNA	Normal to atrophy		26677510	
DISORDERS OF PEROXISOMES													
Disorders of peroxisomal fatty acid oxidation													
X-linked adrenoleukodystrophy	X	X						Childhood-adulthood	VLCFA (P)	WM T2 hyperintensities	Bone marrow transplant	16804268, 1512606, 24954351, 28964670, 24718842	
Peroxisomal acyl-CoA oxidase deficiency	X	X			X			Childhood	VLCFA (P)	WM T2 hyperintensities		20185470	
D-Bifunctional protein deficiency	X	X						Childhood-adolescence	VLCFA (P), Pristanic acid (S), Pristanic acid (S)	WM abnormalities and/or cerebellar atrophy		28017249, 24553428	
Sterol carrier protein-2 deficiency		X						Adolescence-adulthood	Pristanic acid (S)	WM T2 hyperintensities		16685654	
Refsum disease (classic, adult)	X							Adulthood	Phytanic acid (S), Protein (CSF)	possible	Phytanic acid restriction, lipapheresis	11948235	
Disorders of peroxisomal biogenesis													
Zellweger spectrum disorders - Peroxin deficiencies	X							Childhood-adolescence	VLCFA (P), Pristanic acid (S), Phytanic acid (S), ASAT/ALAT (P), Plasmalogens (RBC), Pipecolic acid (S, U)	WM abnormalities and cerebral and/or cerebellar atrophy	Cholic acid	23430938, 20647552, 20695019, 21392394	
CONGENITAL DISORDERS OF GLYCOSYLATION													
Disorders of N-linked glycosylation													
Phosphomannomutase 2 deficiency	**X**	X						Infancy-childhood	Sialotransferins (S), ASAT/ALAT (P), coagulation factors (P)	Cerebellar atrophy		26502900, 28566178	
DPAGT1-CDG	X							Childhood-adolescence	Sialotransferins (S), ASAT/ALAT (P), coagulation factors (P)	Normal to cerebral and/or cerebellar atrophy		30117111	
ALG1-CDG	X							Childhood	Sialotransferins (S), ASAT/ALAT (P), coagulation factors (P)	Normal to cerebral and/or cerebellar atrophy		22966035	
RFT1-CDG	X							Childhood-adulthood	Sialotransferins (S), ASAT/ALAT (P), coagulation factors (P)	Normal to brain atrophy		23111317	
ALG6-CDG	X							Childhood	Sialotransferins (S), ASAT/ALAT (P), coagulation factors (P)	Normal to cerebral and/or cerebellar atrophy		27287710	
ALG13-CDG			X					Infancy-childhood	Sialotransferins (S)	Cerebellar atrophy		26482601	
Disorders of glycosylphosphatidylinositol biosynthesis													
PIGG-CDG	X							Childhood	GPI-anchored protein flow cytometry	Cerebellar atrophy		26996948, 28581210	
PIGN-CDG			X		X			Infancy-childhood	GPI-anchored protein flow cytometry	Normal to atrophy and/or delayed myelination		21493957, 24253414	
PGAP1-CDG							X$$	Childhood	GPI-anchored protein flow cytometry	Cerebral atrophy		25823418	
PGAP3-CDG	X						X###	Childhood	GPI-anchored protein flow cytometry, ALP (S)	Normal to atrophy		27120253, 24439110	
Disorders of glycolipid glycosylation													
ST3GAL5-CDG	X		**X**		X			Childhood	No laboratoty tests --> DNA	Normal		30185102, 24026681, 27232954	
B4GALNT1-CDG	X						X$	Childhood	No laboratoty tests --> DNA	Normal		28626794	
Disorders of dolichol metabolism													
DPM1-CDG	X							Childhood	Sialotransferins (S), CK (P)	Normal to atrophy		16641202, 15669674	
MPDU1-CDG	X							Childhood	Sialotransferins (S)	Brain atrophy		11733556	
Steroid 5 alpha-reductase 3 deficiency	**X**	X						Childhood	Sialotransferins (S)	Cerebellar atrophy		20852264	
Glycosylation disorders of vesicular trafficking													
TRAPPC11-CDG	X	X	X					Childhood	CK (P)	Normal to atrophy		23830518	
COG4-CDG								Childhood	Sialotransferins (S), Apo-CIII (S), ASAT/ALAT (P), coagulation factors (P)	Normal		19494034	
COG5-CDG	X							Childhood	Sialotransferins (S), Apo-CIII (S)	Normal to cerebral and/or cerebellar atrophy		19690088, 28960046	
COG8-CDG	X			X				Childhood	Sialotransferins (S), Apo-CIII (S)	Normal to cerebellar atrophy		17220172	
GOSR2-CDG	X			X				Childhood	CK (P)	Normal		21549339	
Disorder of deglycosylation													
N-glycanase 1 deficiency							X$$$	Infancy-childhood	Oligosaccharide (U)	Normal to atrophy and/or delayed myelination		27388694	

Types of movement disorders described in inherited metabolic disorders. IEMs with movement disorder as a primary or prominent feature are in bold. For IEMs associated with multiple types of movement disorders, the most prevalent one is also marked in bold. Abbreviations: AASA, alpha-aminoadipic acid semialdehyde; ALP, alkaline phosphatase; B, blood; CSF, cerebrospinal fluid; ERT, enzyme replacement therapy; F, fibroblasts; HRS, hypokinetic-rigid syndrome; L, leukocytes; M, muscle; P, plasma; RBC, red blood cells; S, serum; U, urine.

* Oculogyric crises.

** Orolingual/facial dyskinesia.

*** Hyperekplexia.

Stereotyped fencing and/or bicycling movements.

Paroxysmal exercise-induced dyskinesia.

Midline hand movements.
$ Myokimia.

$$ Stereotypic/dyskinetic movements.

$$$ Variously described as choreiform, athetoid, dystonic, myoclonic, or action tremor.