

Genes Involved in X-Linked Intellectual Disability by Order of Discovery (revised March 2024)

Year	Gene Name	Gene Symbol / Band	Clinical Description	Function	How Discovered
1983	HYPOXANTHINE GUANINE PHOSPHORIBOSYLTRANSFERASE 1	<i>HPRT</i> (Xq26.2-q26.3)	Lesch-Nyhan	Enzyme	Met-Fu
1983	PHOSPHOGLYCERATE KINASE I	<i>PGK1</i> (Xq21.1)	Phosphoglycerokinase Deficiency	Enzyme	Met-Fu
1985	PROTEOLIPID PROTEIN 1	<i>PLP1</i> (Xq22.2)	Pelizaeus-Merzbacher, Spastic Paraplegia 2	Myelination	Mol-Fu
1986	ORNITHINE CARBAMOYLTRANSFERASE	<i>OTC</i> (Xp11.4)	Ornithine Transcarbamoylase Deficiency	Enzyme	Met-Fu
1987	DYSTROPHIN	<i>DMD</i> (Xp21.2-p21.1)	Duchenne Muscular Dystrophy, IDX85	Structure of skeletal muscle membrane	Chr-rea
1989	PYRUVATE DEHYDROGENASE, ALPHA-1	<i>PDHA1</i> (Xp22.12)	Pyruvate Dehydrogenase Deficiency	Enzyme	Met-Fu
1990	IDURONATE 2-SULFATASE	<i>IDS</i> (Xq28)	Hunter	Lysosomal enzyme	Met-Fu
1991	FRAGILE X MENTAL RETARDATION 1	<i>FMR1</i> (Xq27.3)	Fragile X	RNA-binding protein, gene regulation	Chr-rea, L-can
1992	L1 CELL ADHESION MOLECULE	<i>LICAM</i> (Xq28)	Hydrocephaly-MASA, Spastic Paraplegia 1, XL-ACC	Neuronal migration, cell adhesion	L-can
1992	NDP GENE	<i>NDP</i> (Xp11.3)	Norrie	Neuroectodermal cell interaction	Chr-rea
1992	OCRL GENE	<i>OCRL1</i> (Xq26.1)	Lowe	Enzyme	Chr-rea
1993	ATP-BINDING CASSETTE, SUBFAMILY D, MEMBER 1	<i>ABCD1 (ALDP)</i> (Xq28)	Adrenoleukodystrophy	Peroxisomal transport protein	L-can
1993	ATPase, Cu(2+)-TRANSPORTING, ALPHA POLYPEPTIDE	<i>ATP7A</i> (Xq21.1)	Menkes, Occipital Horn	Copper transport	Chr-rea
1993	MONOAMINE OXIDASE A	<i>MAOA</i> (Xp11.3)	Monoamine Oxidase A Deficiency	Enzyme	L-can
1995	ATR-X GENE; X-LINKED NUCLEAR PROTEIN GENE, HELICASE 2, X-LINKED	<i>ATRX (XNP, XH2)</i> (Xq21.1)	Alpha-Thalassemia Intellectual Disability, Carpenter-Waziri, Chudley-Lowry, Holmes-Gang, XLID-Hypotonic Facies, XLID-Spastic Paraplegia, XLID-Arch Fingerprints-Hypotonia	Transcription factor, helicase activities	L-can
1996	AF4/FMR2 FAMILY, MEMBER 2; FRAGILE SITE, FOLIC ACID TYPE, RARE, FRA(X)(q28) E, INCLUDED; FRAXE, INCLUDED	<i>AFF2 (FMR2)</i> (Xq28)	Fragile XE	Unknown	Chr-rea
1996	FYVE, RhoGEF, AND PH DOMAIN-CONTAINING PROTEIN 1; FACIOGENITAL DYSPLASIA	<i>FGD1 (FGDY)</i> (Xp11.22)	Aarskog-Scott	Guanine nucleotide exchange factor	Chr-rea
1996	GLYCEROL KINASE	<i>GK</i> (Xp21.2)	Glycerol Kinase Deficiency	Metabolism, glycerol uptake	Met-Fu
1996	GLYPICAN 3	<i>GPC3</i> (Xq26.2)	Simpson-Golabi-Behmel	Cell adhesion, motility	L-can
1996	MYOTUBULARIN	<i>MTM1</i> (Xq28)	Myotubular Myopathy	Tyrosine phosphatase	L-can
1996	TRANSLOCASE OF INNER MITOCHONDRIAL MEMBRANE 8, YEAST, HOMOLOG OF, A; DEAFNESS/DYSTONIA PEPTIDE	<i>TMM8A (DDP)</i> (Xq22.1)	Mohr-Tranebjaerg, Jensen	Transcription factor	L-can
1997	RAB GDP-DISSOCIATION INHIBITOR 1	<i>GDI1</i> (Xq28)	IDX41, IDX48	Stabilizes GDP bound conformations	L-can
1997	MIDLINE 1	<i>MID1</i> (Xp22.2)	Telecanthus-Hypospadias, Opitz G/BBB	Zinc finger gene	L-can, Chr-rea
1997	RIBOSOMAL PROTEIN S6 KINASE, 90-KD, 3; RIBOSOMAL S6 KINASE 2;	<i>RPS6KA3 (RSK2)</i> (Xp22.12)	Coffin-Lowry, IDX19	Kinase signaling pathway	L-can
1998	CALCIUM/CALMODULIN-DEPENDENT SERINE PROTEIN KINASE	<i>CASK</i> (Xp11.4)	XLID-Nystagmus-Seizures	Synaptic functions	Mol-Fu
1998	DOUBLECORTIN	<i>DCX</i> (Xq23)	Lissencephaly, X-linked	Neuronal migration	Chr-rea (del)
1998	DYSKERIN	<i>DKC1</i> (Xq28)	Dyskeratosis Congenita	Cell cycle and nucleolar functions	L-can
1998	FILAMIN A	<i>FLNA (FLN1)</i> (Xq28)	Periventricular Heterotopias, OPD I, OPD II	Actin-binding protein	L-can
1998	OLIGOPHRENIN 1	<i>OPHN1</i> (Xq12)	IDX60	GTPase activating protein	L-can
1998	p21 PROTEIN-ACTIVATED KINASE 3	<i>PAK3</i> (Xq23)	IDX30, IDX47	Rac/Cdc 42 effector	Chr-rea
1999	INTERLEUKIN 1 RECEPTOR ACCESSORY PROTEIN-LIKE 1	<i>IL1RAPL1</i> (Xp21.3-p21.2)	IDX10, IDX21, IDX34	Unknown	Chr-rea
2000	RHO GUANINE NUCLEOTIDE EXCHANGE FACTOR 6	<i>ARHGEF6 (a-PIX)</i> (Xq26.3)	IDX46	Effector of the rho GTPases	Chr-rea
2000	LYSOSOME-ASSOCIATED MEMBRANE PROTEIN 2	<i>LAMP2</i> (Xq24)	Danon Cardiomyopathy	Membrane, lysosome	L-can
2000	NF-KAPPA-B ESSENTIAL MODULATOR	<i>NEMO (IKBK)</i> (Xq28)	Incontinentia Pigmenti	Activates the transcription factor NF-KB	L-can
2000	TRANSMEMBRANE 4 SUPERFAMILY, MEMBER 2	<i>TM4SF2</i> (Xp11.4)	IDX58	Interacts with integrins	Chr-rea
2001	METHYL-CpG-BINDING PROTEIN 2	<i>MECP2</i> (Xq28)	Rett, IDX16, IDX64, IDX79	Binds methylated CpGs	L-can
2001	OFD1 GENE; OROFACIODIGITAL SYNDROME 1	<i>OFD1</i> (Xp22.2)	Oral-Facial-Digital I	Unknown	L-can

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2001	SOLUTE CARRIER FAMILY 6 (NEUROTRANSMITTER TRANSPORTER, CREATINE), MEMBER 8	<i>SLC6A8</i> (Xq28)	XLID with Seizures	Creatine transporter	Met-Fu
2002	FATTY ACID CoA LIGASE, LONG CHAIN 4	<i>ACSL4 (FACL4)</i> (Xq23)	IDX63, IDX68	Fatty acid CoA ligase 4	Chr-rea (del)
2002	ANGIOTENSIN II RECEPTOR, TYPE 2	<i>AGTR2</i> (Xq23)	X-linked Optic Atrophy, IDX88	Angiotensin II receptor	Chr-rea
2002	ARISTALESS-RELATED HOMEBOX, X-LINKED	<i>ARX</i> (Xp21.3)	Hydranencephaly, Partington, Proud, West, Lissencephaly and Abnormal Genitalia, X-linked, IDX29, IDX32, IDX33, IDX36, IDX43, IDX54, IDX76	Neuronal migration	Chr-rea (del)
2002	CYCLIN-DEPENDENT KINASE-LIKE 5; SERINE/THREONINE PROTEIN KINASE 9	<i>CDKL5 (STK9)</i> (Xp22.13)	Rett-Like Seizures-Hypotonia	Unknown	Chr-rea
2002	KRUPPEL-LIKE FACTOR 8	<i>KLF8 *</i> (<i>ZNF741</i>) (Xp11.21)	IDX		Chr-rea
2002	PHD FINGER PROTEIN 6	<i>PHF6</i> (Xq26.2)	Börjeson-Forssman-Lehmann	Unknown	L-can
2002	SRY-BOX 3	<i>SOX3</i> (Xq27.1)	XLID-Growth Hormone Deficiency	Pituitary function, transcription factor	Chr-rea, L-can
2003	IMMUNOGLOBULIN-BINDING PROTEIN 1	<i>IGBP1</i> (Xq13.1)	Graham Coloboma		L-can
2003	NHS GENE; NANCE-HORAN SYNDROME GENE	<i>NHS</i> (Xp22.2-p22.1)	Nance-Horan	-	L-can
2003	NEUROLIGIN 3	<i>NLGN3</i> (Xq13.1)	Autism	Cell adhesion	L-can
2003	NEUROLIGIN 4	<i>NLGN4</i> (Xp22.32-p22.31)	Autism	Cell adhesion	L-can
2003	POLYGLUTAMINE-BINDING PROTEIN 1	<i>PQBPI</i> (Xp11.23)	Renpenning, Sutherland-Haan, Hamel Cerebro-Palato-Cardiac, Golabi-Ito-Hall, Porteous, IDX2, IDX55	Polyglutamine binding, regulates transcription	L-can
2003	SPERMINE SYNTHASE	<i>SMS</i> (Xp22.11)	Snyder-Robinson	Synthesis of spermine	L-can
2003	ZINC FINGER PROTEIN 41	<i>ZNF41 *</i> (Xp11.3)	IDX89	Zinger finger	Chr-rea
2003	ZINC FINGER PROTEIN 81	<i>ZNF81 *</i> (Xp11.23)	IDX45	Zinc finger	Chr-rea
2004	RHO GUANINE NUCLEOTIDE EXCHANGE FACTOR 9	<i>ARHGEF9</i> (Xq11.1)	XLID-Hypotonia-Seizures, XLID-Macrocephaly Macroorchidism	Regulation of Rho protein signal transduction	Chr-rea
2004	ATPase, H+ TRANSPORTING, LYSOSOMAL, ACCESSORY PROTEIN 2; RENIN RECEPTOR	<i>ATP6AP2 (ATP6A8-9)</i> (Xp11.4)	XLID-Infantile Epilepsy, gait disturbance, Parkinsonian manifestations	Renin receptor, transmembrane protein essential for ATPase involved in lysosomal function	L-can
2004	BCL6 COREPRESSOR	<i>BCOR</i> (Xp11.4)	Lenz Microphthalmia (1 type)	Histone/protein deacetylation	L-can
2004	DISCS LARGE, DROSOPHILA, HOMOLOG OF, 3; NEUROENDOCRINE DLG	<i>DLG3</i> (Xq13.1)	IDX8, IDX90	NMDA-receptor, mediated signaling, synaptic plasticity	X seq
2004	FTSJ HOMOLOG 1	<i>FTSJ1</i> (Xp11.23)	IDX9, IDX44	Methylase	L-can
2004	LYSINE-SPECIFIC DEMETHYLASE 5C; JUMONJI, AT-RICH INTERACTIVE DOMAIN 1C	<i>KDM5C (JARID1C, SMX)</i> (Xp11.22)	IDX13	Regulates transcription, chromatin remodelling	L-can
2004	NEURITE EXTENSION AND MIGRATION FACTOR; KIAA2022 PROTEIN	<i>KIAA2022 (NEXMIF)</i> (Xq13.3)	Cantagrel Spastic Paraplegia	DNA synthesis, DNA polymerase activity	Chr-rea
2004	PHD FINGER PROTEIN 8	<i>PHF8</i> (Xp11.22)	XLID-Cleft Lip-Cleft Palate	Regulates transcription, binds DNA	L-can
2004	SHROOM FAMILY MEMBER 4; KIAA1202 PROTEIN	<i>SHROOM4 (KIAA1202)</i> (Xp11.22)	Stoccos dos Santos	Roles in cellular architecture, neurulation, and ion channel function	Chr-rea
2004	SOLUTE CARRIER FAMILY 16 (MONOCARBOXYLIC ACID TRANSPORTER), MEMBER 2	<i>SLC16A2 (MCT8)</i> (Xq13.2)	Allan-Herndon-Dudley, IDX22	T3 receptor	L-can
2004	SYNAPSIN I	<i>SYNI</i> (Xp11.3-p11.2)	Epilepsy-Macrocephaly, IDX50	Synaptic vesicle protein	L-can
2005	ZINC FINGER DHHC DOMAIN-CONTAINING PROTEIN 15	<i>ZDHHC15</i> (Xq13.3)	IDX91		Chr-rea
2006	ADAPTOR-RELATED PROTEIN COMPLEX 1, SIGMA-2 SUBUNIT	<i>APIS2</i> (Xp22.2)	Turner XLID, Hydrocephaly-Basal Ganglia Calcification, IDX59	Assembly of endocytic vesicles	X-seq
2006	FANCB GENE; FANCONI ANEMIA-ASSOCIATED POLYPEPTIDE, 95-KD	<i>FANCB</i> (Xp22.2)	VACTERL-Hydrocephaly	DNA repair	Mol-Fu
2006	HOLOCYTOCHROME C SYNTHASE	<i>HCCS</i> (Xp22.2)	MIDAS	Energy production, cytochrome homolyase	Chr-rea (del)
2006	STRUCTURAL MAINTENANCE OF CHROMOSOMES 1A	<i>SMC1A/SMC1L1</i> (Xp11.22)	Cornelia de Lange, X-linked	Cell cycle, mitotic spindle organization and biogenesis, chromosome segregation	Mol-Fu
2006	SUSHI REPEAT-CONTAINING PROTEIN, X-LINKED, 2	<i>SRPX2</i> (Xq22.1)	XLID-Rolandic Seizures	Signal transduction, growth factor 2	Mol-Fu
2006	UBIQUITIN-CONJUGATING ENZYME E2A	<i>UBE2A</i> (Xq24)	XLID-Nail Dystrophy-Seizures	Ubiquitin cycle, ubiquitin-protein ligase	L-can

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2006	ZINC FINGER PROTEIN 674	<i>ZNF674</i> * (Xp11.3)	XLID-Retinal Dystrophy-Short Stature and IDX92	Transcription regulation	Chr-rea (del)
2007	BROMODOMAIN- AND WD REPEAT-CONTAINING PROTEIN 3	<i>BRWD3</i> (Xq21.1)	XLID-Macrocephaly-Large Ears, IDX93	Transcription factor	X-seq
2007	CULLIN 4B	<i>CUL4B</i> (Xq24)	XLID-Hypogonadism-Tremor	Cell cycle, ubiquitin cycle, E3 ubiquitin ligase	X-seq
2007	GLUTAMATE RECEPTOR, IONOTROPIC, AMPA 3	<i>GRIA3</i> (Xq25)	Chiyonobu XLID, IDX94	Signal transduction, ion transport, glutamate signaling pathway	Chr-rea, Exp-Arr, X-seq
2007	17-BETA-HYDROXYSTEROID DEHYDROGENASE X	<i>HSD17B10 (HADH2)</i> (Xp11.22)	XLID-Choreoathetosis, Isoleucine degradation defect	Lipid metabolism	L-can
2007	MEDIATOR COMPLEX SUBUNIT 12NOTE: MEDIATOR COMPLEX SUBUNIT 12	<i>MED12 (HOPA)</i> (Xq13.1)	Opitz FG, Lujan, IDX67	Transcription regulation, RNA polymerase II transcription mediator activity, ligand-dependent nuclear receptor transcription coactivator activity, vitamin D receptor and thyroid hormone receptor binding	L-can
2007	NADH-UBIQUINONE OXIDOREDUCTASE 1 ALPHA SUBCOMPLEX, 1	<i>NDUFA1</i> (Xq24)	Mitochondrial Complex 1 Deficiency	Energy production, oxidoreductase activity	Mol-Fu
2007	NUCLEAR RNA EXPORT FACTOR 5	<i>NXF5</i> (Xq22.1)	XLID-Short Stature-Muscle Wasting	mRNA processing, mRNA export from nucleus	Chr-rea
2007	PORCUPINE, DROSOPHILA, HOMOLOG	<i>PORCN</i> (Xp11.23)	Goltz	Wnt receptor signaling pathway, acyltransferase activity, integral to membrane of endoplasmic reticulum	Chr-rea (del)
2007	PHOSPHORIBOSYLPYROPHOSPHATE SYNTHETASE 1	<i>PRPS1</i> (Xq22.3)	Arts, PRPS1 Superactivity	Ribonucleotide monophosphate biosynthesis	L-can
2007	RIBOSOMAL PROTEIN L10	<i>RPL10</i> (Xq28)	Autism	Protein synthesis, ribosomal protein	X-seq
2007	UPF3, YEAST, HOMOLOG OF, B	<i>UPF3B</i> (Xq24)	Lujan/FG Phenotype, IDX62	mRNA catabolism, nonsense-mediated decay	X-seq
2007	ZINC FINGER DHHC DOMAIN-CONTAINING PROTEIN 9	<i>ZDHHC9</i> (Xq26.1)	XLID-Macrocephaly-Marfanoid Habitus	Palmitoyltransferase: posttranslational modification important for protein trafficking and neuronal development	X-seq
2008	HECT, UBA, AND WWE DOMAINS-CONTAINING PROTEIN 1	<i>HUWE1</i> (Xp11.22)	XLID-Macrocephaly, Juberg-Marsidi-Brooks, IDX17, IDX31	Ubiquitin-protein ligase, mRNA transport	M-CGH
2008	PROTODADHERIN 19	<i>PCDH19</i> (Xq22.1)	Epilepsy-Intellectual Disability Limited to Females		L-can
2008	SMAD-INTERACTING ZINC FINGER PROTEIN 1	<i>SIZN1 (ZCCHC12)</i> (Xq24)	IDX	Modulates BMP signaling, influences forebrain cholinergic neurons	L-can
2008	SOLUTE CARRIER FAMILY 9, MEMBER 6	<i>SLC9A6</i> (Xq26.3)	Christianson, X-linked Angelman-like	Sodium-hydrogen antiporter activity, lysosome organization and biogenesis, regulation of endosome volume	L-can
2009	MAGNESIUM TRANSPORTER 1	<i>MAGT1</i> * (Xq21.1)	IDX95	Magnesium transporter with N-glycosylation sites and putative phosphorylation sites	L-can, X-seq
2009	MEMBRANE-BOUND TRANSCRIPTION FACTOR PROTEASE, SITE 2	<i>MBTPS2</i> (Xp22.12)	Ichthyosis Follicularis, Atrichia, Photophobia (IFAP)	Protease activity, activates signaling proteins	L-can
2009	NAD(P)H STEROID DEHYDROGENASE-LIKE PROTEIN	<i>NSDHL</i> (Xq28)	CK (microcephaly, pachygyria, facial dysmorphism, seizures), also in CHILD syndrome	Sterol metabolism	L-can
2009	SYNAPTOPHYSIN	<i>SYP</i> (Xp11.23)	IDX96	Membrane protein of small synaptic vesicles	X-seq
2009	ZINC FINGER PROTEIN 711	<i>ZNF711</i> (Xq21.1)	IDX97	Binds to a subset of PHF8 target genes	X-seq
2010	IQ MOTIF- AND SEC7 DOMAIN-CONTAINING PROTEIN 2	<i>IQSEC2</i> (Xp11.22)	IDX1, IDX18, and other Nonsyndromal XLID	Regulation of vesicular transport and organelle structure	X-seq
2010	PATCHED DOMAIN-CONTAINING PROTEIN 1	<i>PTCHD1</i> (Xp22.11)	Autism-XLID	Transmembrane protein related to hedgehog receptors	M-CGH
2010	RAS-ASSOCIATED PROTEIN	<i>RAB39B</i> (Xq28)	XLID-Macrocephaly-Seizures - Autism, Waisman-Laxova, IDX72	Formation and maintenance of synapse	L-can
2011	CHLORIDE CHANNEL 4	<i>CLCN4</i> (Xp22.2)	IDX15, IDX49	Chloride transport	X-seq
2011	CONNECTOR ENHANCER OF KSR 2	<i>CNKS2</i> (Xp22.12)	XLID-Microcephaly-Seizures	Stimulates MAPK signalling	M-CGH
2011	EUKARYOTIC TRANSLATION INITIATION FACTOR 2, SUBUNIT 3	<i>EIF2S3</i> (Xp22.11)	MEHMO	Initiates translation	X-seq
2011	HOST CELL FACTOR C1	<i>HCFC1</i> (Xq28)	IDX3	Cell proliferation	X-seq
2011	HISTONE DEACETYLASE 6	<i>HDAC6</i> (Xp11.23)	Chassaing-Lacombe Chondrodysplasia	Tubulin deacetylase	L-can
2011	HISTONE DEACETYLASE 8	<i>HDAC8</i> (Xq13.1)	Cornelia de Lange, X-linked	Chromatin cohesion	Mol-Fu, X-seq
2011	LAS1-LIKE RIBOSOME BIOGENESIS FACTOR	<i>LAS1L</i> (Xq12)	Wilson-Turner	Nucleolar protein, cell proliferation and ribosome biogenesis	X-seq

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2011	N-ALPHA-ACETYLTRANSFERASE 10, NATA CATALYTIC SUBUNIT	<i>NAAI10</i> (Xq28)	N-Alpha-Acetyltransferase Deficiency, Graham anophthalmia	N-terminal acetylation	X-seq
2011	RAS-ASSOCIATED PROTEIN RAB40A-LIKE	<i>RAB40AL</i> * (Xq22.1)	Martin-Probst (?) Questioned: Hum Mutat 35:1171, 2014	Ras-like GTPase protein	X-seq
2011	RNA-BINDING MOTIF PROTEIN 10	<i>RBM10</i> (Xp11.3)	TARP	RNA-binding	X-seq
2011	THO COMPLEX, SUBUNIT 2	<i>THOC2</i> (Xq25)	IDX12, IDX35	mRNA transcription or export	X-seq
2012	APOPTOSIS-INDUCING FACTOR, MITOCHONDRIA-ASSOCIATED, 1	<i>AIFM1</i> (Xq26.1)	Charcot-Marie-Tooth disease, Cowchock variant and XLID-spondyloepimetaphyseal dysplasia	Induces apoptosis	X-seq
2012	ALG13, S. CEREVISIAE, HOMOLOG	<i>ALG13</i> (Xq23)	CDG1s	Glycosylation	Ex
2012	COILED-COIL DOMAIN-CONTAINING PROTEIN 22	<i>CCDC22</i> (Xp11.23)	Cardiofacioskeletal (like 3C/Ritscher-Schinzel)	Unknown	X-seq
2012	CHLORIDE INTRACELLULAR CHANNEL 2	<i>CLIC2</i> (Xq28)	XLID-Cardiomegaly-Seizures	Regulating ryanodine receptor channel activity	X-seq
2012	CYTOCHROME C OXIDASE, SUBUNIT 7B	<i>COX7B</i> (Xq21.1)	Linear skin defects and other anomalies	Respiratory chain defect	L-can
2012	EMOPAMIL-BINDING PROTEIN	<i>EBP</i> (Xp11.23)	Male EBP disorder with neurological defects (MEND)	Enzyme in cholesterol metabolism	Met-Fu
2012	LYSINE-SPECIFIC DEMETHYLASE 6A	<i>KDM6A</i> (Xp11.3)	Kabuki syndrome 2	Histone demethylase and methyltransferase	Chr-rea
2012	PHOSPHATIDYLINOSITOL GLYCAN ANCHOR BIOSYNTHESIS CLASS A PROTEIN	<i>PIGA</i> (Xp22.2)	XLID-Brain iron accumulation	Enzyme, signal transduction pathway, adhesion molecules	X-seq
2012	EPSILON-TRIMETHYLLYSINE HYDROXYLASE	<i>TMLHE</i> (Xq28)	Autism-ID	Enzyme in carnitine synthesis	X-seq
2013	B-CELL RECEPTOR-ASSOCIATED PROTEIN 31	<i>BCAP31</i> (Xq28)	XLID-microcephaly-dystonia	ER & golgi structure and metabolism	X-seq
2013	SIGNAL SEQUENCE RECEPTOR, DELTA	<i>SSR4</i> (Xq28)	XLID-glycosylation defect	Glycosylation	Ex
2013	WD REPEAT-CONTAINING PROTEIN 45	<i>WDR45</i> (Xp11.23)	Neurodegeneration with brain iron accumulation-XLID	Autophagy and other cellular functions	Ex
2013	ZINC FINGER C4H2 DOMAIN-CONTAINING PROTEIN	<i>ZC4H2</i> (Xq11.2)	Wieacker-Wolff, Miles-Carpenter	Axon guidance	Ex, Chr-rea, M-CGH
2013	UPD-GALACTOSE TRANSPORTER	<i>SLC35A2</i> (Xp11.3)	CDG type 2M	Addition of galactose to glycoproteins	Ex
2013	APC MEMBRANE RECRUITMENT PROTEIN 1	<i>AMER1</i> (Xq11.2)	Osteopathia striata congenita with cranial sclerosis	Proteasomal degradation	MLPA, L-can
2013	BCL6 COREPRESSOR-LIKE 1	<i>BCORL1</i> (Xq26.1)	ID, autism, dysmorphic facies	Transcriptional repressor	Ex
2014	HIGH MOBILITY GROUP BOX 3	<i>HMGGB3</i> (Xq28)	Microphthalmia 13	DNA replication, transcription, nucleosome assembly	Ex
2014	KINESIN FAMILY MEMBER 4A	<i>KIF4A</i> (Xq13.1)	IDX100	Moves proteins along microtubule	Ex
2014	MIDLINE 2	<i>MID2</i> (Xq22.3)	IDX101	Enzyme, ubiquity ligase E3 microtubule stabilization	L-can, Ex
2014	UBIQUITIN-SPECIFIC PROTEASE 9, X-LINKED	<i>USP9X</i> (Xp11.4)	IDX99	Neuronal migration growth	X-seq
2014	ZINC FINGER, MYM-TYPE 3	<i>ZMYM3</i> * (Xq13.1)	XLID-aortic stenosis-hypospadias	Component of histone deacetylase-containing multiple protein complexes	X-seq
2015	DEAD/H BOX 3, X-LINKED	<i>DDX3X</i> (Xp11.4)	Variable cognitive, neurologic and nonneurologic manifestations, IDX102	RNA helicase	Ex
2015	FERM AND PDZ DOMAINS-CONTAINING PROTEIN 4	<i>FRMPD4</i> (Xp22.2)	XLID-aphasia-seizures, IDX104	Regulates spine morphogenesis	X-seq
2015	KELCH-LIKE 15	<i>KLHL15</i> (Xp22.11)	Mild to moderate cognitive impairment, facial dysmorphism, IDX103	Uncertain	X-seq
2015	MALE-SPECIFIC LETHAL 3, DROSOPHILA, HOMOLOG	<i>MSL3</i> (Xp22.2)	MSL3-Related XLID, Basalicata-Aktar syndrome	Transcription regulation, chromatin modifier (acetylation of histone H4 on lysine 16)	Ex
2015	NON-POU DOMAIN-CONTAINING OCTAMER-BINDING PROTEIN	<i>NONO</i> (Xq13.1)	Miresof-Langouët	Regulation of transcription (activation, repression, splicing, pre-mRNA processing, RNA transport)	Ex
2015	RNA-BINDING MOTIF PROTEIN, X CHROMOSOME	<i>RBMX</i> (Xq26.3)	Shashi, Gustavson	RNA binding	Ex
2015	RIPPLY1 ZEBRAFISH HOMOLOG	<i>RIPPLY1</i> (Xq22.3)	Ataxia-seizures-hearing loss	Regulates trascription	Ex
2015	RING FINGER PROTEIN, LIM DOMAIN-INTERACTING	<i>RLIM</i> (<i>RNF12</i>) (Xq13.2)	IDX with variable microcephaly, behaviour abnormalities and other manifestation, IDX61	Enzyme, ubiquity ligase E3	X-seq
2015	RING FINGER PROTEIN 113A	<i>RNF113A</i> (Xq24)	Trichothiodystrophy 5	Gene regulation, DNA repair	Ex
2015	TAF1 RNA POLYMERASE II, TATA BOX-BINDING PROTEIN-ASSOCIATED FACTOR, 250-KD	<i>TAF1</i> (Xq13.1)	XLID-Craniofacial-Caudal, Abidi	Key role in initiating transcription	Gen-seq
2015	UBIQUITIN-SPECIFIC PROTEASE 27, X-LINKED	<i>USP27X</i> (Xp11.23)	Variable cognitive and speech impairment and behavioural abnormalities, IDX105	Peptidase	X-seq

Year	Gene Name	Gene Symbol / Band	Clinical Description	Function	How Discovered
2015	SWI/SNF-RELATED, MATRIX-ASSOCIATED, ACTIN DEPENDENT REGULATOR OF CHROMATIN SUBFAMILY A	<i>SMARCA1 (Xq25-26.1)</i>	SMARCA1-related XLID (ID, microcephaly, regression)	Translation regulation	Chr-rea
2016	CYCLIN-DEPENDENT KINASE 16	<i>CDK16 (Xp11.3)</i>	XLID-Spasticity	Kinase	Ex
2016	EF-HAND DOMAIN (C-TERMINAL)-CONTAINING PROTEIN 2	<i>EFHC2 (Xp11.3)</i>	IDX74	Calcium binding and other unknown functions	L-can
2016	GRIPI-ASSOCIATED PROTEIN 1	<i>GRASP1 (GRIPAP1) (Xp11.23)</i>	XLID-Short Stature-Spasticity	Synaptic function and neuronal connectivity	X-seq
2016	HETEROGENEOUS NUCLEAR RIBONUCLEOPROTEIN H2	<i>HNRNP2 (Xp22.1)</i>	Bain XLID, female limited	Nuclear localization	Ex
2016	SOLUTE CARRIER FAMILY 25 (MITOCHONDRIAL CARRIER, ADENINE NUCLEOTIDE TRANSLOCATOR), MEMBER A5	<i>SLC25A5 (Xq24)</i>	IDX70	Mitochondrial exchange of ADP/ATP	M-CGH
2016	STROMAL ANTIGEN 2	<i>STAG2 (Xq25)</i>	STAG2-Related XLID	Chromatin cohesion	M-CGH
2016	GLYCINE RECEPTOR A2	<i>GLRA2 (Xp22.2)</i>	Pilorge type XLID		WES
2017	G-PATCH DOMAIN AND KOW MOTIFS	<i>GPLOW (Xp11.23)</i>	XLID-Microcephaly-early lethality	Spliceosome component	X-seq
2017	GABA RECEPTOR A3	<i>GABRA3 (Xq28)</i>	GABRA3 related seizures	GABA receptor	X-seq, M-CGH, Ex
2017	L ANTIGEN FAMILY, MEMBER 3	<i>LAGE3 (Xq28)</i>	X-linked Galloway-Mowat syndrome - 2	Endopeptidase	Ex
2017	OTU DOMAIN-CONTAINING PROTEIN 5	<i>OTUD5 (Xq11.23)</i>	XLID-hydrocephaly +	Deubiquitination	Gen-seq
2017	O-LINKED N-ACETYLGUCOSAMINE TRANSFERASE	<i>OGT (Xq13.1)</i>	XLID-Faciogenital	Post translational modification of nucleocytoplasmic proteins	Ex
2018	CHROMOSOME X OPEN READING FRAME 56	<i>CXorf56 (Xq24)</i>	Dysmorphic faces, long face, prominent chin, mild ID, behavior problems	Dendritic neuronal protein	Gen-seq
2018	FAMILY WITH SEQUENCE SIMILARITY 50, MEMBER A	<i>FAM50A (Xq28)</i>	Short stature, ocular problems, seizures, small hands, feet, DD, mild ID, Armfield syndrome	Spliceosome protein	X-seq, L-can
2018	ZINC FINGER PROTEIN 92	<i>ZFP92 (ZNF897) (Xq28)</i>	Hypotonia, behavioral, mitochondrial issues, DD, ID	Mitochondrial functions	Ex, L-can
2018	SOLUTE CARRIER FAMILY 9, MEMBER 7	<i>SLC9A7 (Xp11.3)</i>	IDX (hypotonia, muscle weakness, brisk reflexes)	Cation exchange factor	X-seq
2018	HEPARAN SULFATE 6-O-SULFOTRANSFERASE 2	<i>HS6ST2 (Xq26.2)</i>	ID, seizures, myopia, retinopathy	Sulfotransferase of heparan sulfate proteoglycans	Ex
2019	POLYMERASE, DNA, ALPHA-1; POLA1	<i>POLA1 (Xp22.11-p21.3)</i>	ID, growth impairment, hypogonadism	Subunit of polymerase alpha-primase	Ex, L-can
2019	NFKB ACTIVATING PROTEIN	<i>NKAP (Xq24)</i>	XLID-Craniofacioskeletal	Transcriptional regulation	Ex
2019	GLYPICAN 4	<i>GPC4 (Xq26.2)</i>	Keipert	Regulates growth factor signaling	L-can, Ex
2020	PRAJA 1	<i>PJAI (Xq13.1)</i>	XLID-Trigonocephaly	E3 ubiquitin ligase	Ex
2020	APOLIPOPROTEIN O	<i>APOO (Xp22.11)</i>	XLID-mitochondrial myopathy	Assembly and maintenance of inner mitochondrial membrane	Ex
2020	CLEAVAGE STIMULATION FACTOR, 3-PRIME preRNA, SUBUNIT 2	<i>CSTF2 (Xq22.1)</i>	ID nonsyndromal	mRNA cleavage and polyadenylation	Ex
2020	TRANSCRIPTION FACTOR E3	<i>TFE3 (Xp11.23)</i>	XLID-pigmentary mosaicism	Transcription factor	Ex
2022	WITH NO LYSINE KINASE 3	<i>WNK3 (Xp11.22)</i>	Prieto	Phosphorylation of a neuronal-specific chloride transported	Ex
2022	TRANSCRIPTION ELONGATION FACTOR A-LIKE 1	<i>TCEAL1 (Xq22.2)</i>	TCEAL1-related	Regulates transcription	Ex, microarray, Gen-seq
2022	SLIT TRANSMEMBRANE PROTEIN RK2	<i>SLITRK2 (Xq27.3)</i>	XLID-III	Neurite modulation	Ex
2023	PLASMA MEMBRANE ATPASE CA2+, TRANSPORTING 3	<i>ATP2B3 (Xq28)</i>	Cerebellar ataxia, ID, seizures	Ion transport	Ex
2024	SH3-DOMAIN KINASE BINDING PROTEIN 1	<i>SH3KBP1 (Xp22.12)</i>	SH3KBP1-related XLID (ID, DD, dysgenesis of corpus callosum)	apoptosis, cytoskeletal organization, cell adhesion	CMA
2024	INTERLEUKIN 1 RECEPTOR ACCESSORY PROTEIN-LIKE 2	<i>IL1RAPL2 (Xq22.3)</i>	IL1RAPL2-related XLID (ID, ataxia, seizures)	interleukin receptor	CMA
2024	ZINC FINGER PROTEIN, X-LINKED	<i>ZFX (Xp22.1)</i>	ZFX-related XLID (ID, behavior)	transcription	Ex

Total

171

* Association of *ZNF41*, *ZNF81*, *ZNF674*, *ZNF741 (KCF8)*, *RAB40AL*, *ZMYM3*, *MAGT1* with XLID considered uncertain

Chr-rea = chromosome rearrangement

Ex = exome sequencing

Gen-seq = genome sequencing

Exp-Arr = expression array

L-can = linkage and candidate gene testing

M-CGH = array-comparative genomic hybridization

Met-Fu = exploitation of metabolic alteration

Year	Gene Name	Gene Symbol / Band	Clinical Description	Function	How Discovered
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Mol-Fu = exploitation of molecular finding

X-seq = sequencing of exons plus

MLPA =