

### **Donor 6188**

# **Genetic Testing Summary**

Fairfax Cryobank recommends reviewing this genetic testing summary with your healthcare provider to determine suitability.

Last Updated: 12/21/22

Donor Reported Ancestry: English, Scottish, Italian, Hungarian Jewish Ancestry: No

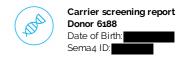
Genetic rest	Genetic Test*	Result	Comments/Donor's Residual Risk**
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Chromosome analysis (karyotype)	Normal male karyotype	No evidence of clinically significant chromosome abnormalities
Hemoglobin evaluation	Normal hemoglobin fractionation and MCV/MCH results	Reduced risk to be a carrier for sickle cell anemia, beta thalassemia, alpha thalassemia trait (aa/ and a-/a-) and other hemoglobinopathies
Cystic Fibrosis (CF) carrier screening	tic Fibrosis (CF) carrier screening  Negative by gene sequencing in the  CFTR gene	
Spinal Muscular Atrophy (SMA) carrier screening	Negative for deletions of exon 7 in the SMN1 gene	1/894
Expanded Genetic Disease Carrier Screening Panel attached- 283 diseases by gene sequencing  Carrier: Alpha thalassemia (HBA1/HBA: duplication aa/aaa  Negative for other genes sequenced		Partner testing recommended for Beta Thalassemia (HBB) before using this donor.
Special Testing		
Genes: SLC3A1, ANO5	Negative by gene sequencing	See attached for residual risks.

<sup>\*</sup>No single test can screen for all genetic disorders. A negative screening result significantly reduces, but cannot eliminate, the risk for these conditions in a pregnancy.

<sup>\*\*</sup>Donor residual risk is the chance the donor is still a carrier after testing negative.





### **Patient Information**

Name: Donor 6188 Date of Birth:

Sema4 ID:

Indication: Carrier Testing

### **Specimen Information**

Specimen Type: Blood
Date Collected: 01/14/2021
Date Received: 01/15/2021
Final Report: 02/02/2021



# Expanded Carrier Screen (283) Minus TSE

Number of genes tested: 283

### SUMMARY OF RESULTS AND RECOMMENDATIONS

⊕ Positive	○ Negative		
Variant Detected for Alpha-Thalassemia (AR)	Negative for all other genes tested		
Associated gene(s): HBA1/HBA2	To view a full list of genes and diseases tested		
Variant(s) Detected: One copy of the alpha 4.2 duplication	please see Table 1 in this report		

AR=Autosomal recessive; XL=X-linked

### Recommendations

- An alpha-thalassemia duplication allele is generally considered to be a benign polymorphism. Testing the partner for beta-thalassemia is recommended in order to rule out the possibility of being a thalassemia intermedia carrier couple. Genetic counseling is recommended.
- · Please note that for female carriers of X-linked diseases, follow-up testing of a male partner is not indicated.
- CGG repeat analysis of *FMR1* for fragile X syndrome is not performed on males as repeat expansion of premutation alleles is not expected in the male germline.
- Individuals of Asian, African, Hispanic and Mediterranean ancestry should also be screened for hemoglobinopathies by CBC and hemoglobin electrophoresis.
- Consideration of residual risk by ethnicity after a negative carrier screen is recommended for the other diseases on the panel, especially in the case of a positive family history for a specific disorder.





# Interpretation of positive results

### Alpha-Thalassemia (AR)

**Results and Interpretation** 

*HBA1* Copy Number: 2 *HBA2* Copy Number: 3

One copy of the alpha 4.2 duplication detected

HBA1/HBA2 Sequencing: Negative

**Gene(s) analyzed:** HBA1 (NM\_000558.4) and HBA2 (NM\_000517.4)

Inheritance: Autosomal Recessive

This patient carries an alpha 4.2 duplication allele, resulting in a total of five copies of the alpha-globin gene (aaa/aa). This duplication allele is considered to be a benign polymorphism and therefore the chance that this patient is an alpha-thalassemia carrier is decreased. However, testing the partner for beta-thalassemia is recommended in order to rule out the possibility of being a thalassemia intermedia carrier couple. The literature indicates that co-inheritance of a *beta*-thalassemia pathogenic variant with additional copies of the *HBA* genes (more than 4) can lead to a thalassaemia intermedia phenotype with a variable clinical presentation. No pathogenic or likely pathogenic variants were identified by sequence analysis.

Typically, individuals have four functional alpha-globin genes: 2 copies of *HBA1* and 2 copies of *HBA2*, whose expression is regulated by a cisacting regulatory element HS-40. Alpha-thalassemia carriers have three (silent carrier) or two (carrier of the alpha-thalassemia trait) functional alpha-globin genes with or without a mild phenotype. Individuals with only one functional alpha-globin gene have HbH disease with microcytic, hypochromic hemolytic anemia and hepatosplenomegaly. Loss of all four alpha-globin genes results in Hb Barts syndrome with the accumulation of Hb Barts in red blood cells and hydrops fetalis, which is fatal in utero or shortly after birth.

# Test description

This patient was tested for a panel of diseases using a combination of sequencing, targeted genotyping and copy number analysis. Please note that negative results reduce but do not eliminate the possibility that this individual is a carrier for one or more of the disorders tested. Please see Table 1 for a list of genes and diseases tested, and **go.sema4.com/residualrisk** for specific detection rates and residual risk by ethnicity. With individuals of mixed ethnicity, it is recommended to use the highest residual risk estimate. Only variants determined to be pathogenic or likely pathogenic are reported in this carrier screening test.

Anastasia Larmore, Ph.D., Associate Laboratory Director

Laboratory Medical Consultant: George A. Diaz, M.D., Ph.D.





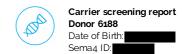
# Genes and diseases tested

For specific detection rates and residual risk by ethnicity, please visit go.sema4.com/residualrisk

### Table 1: List of genes and diseases tested with detailed results

Dise	ease	Gene	Inheritance Pattern	Status	Detailed Summary
① Pos	sitive				
Alp	oha-Thalassemia	HBA1/HBA2	AR	Reduced Risk (Duplication Detected)	HBA1 Copy Number: 2 HBA2 Copy Number: 3 One copy of the alpha 4.2 duplication detected HBA1/HBA2 Sequencing: Negative
○ Neg	gative				
	Beta-Hydroxysteroid Dehydrogenase Type II ficiency	HSD3B2	AR	Reduced Risk	
_	Methylcrotonyl-CoA Carboxylase Deficiency CCC1-Related)	MCCC1	AR	Reduced Risk	
_	Methylcrotonyl-CoA Carboxylase Deficiency  CCC2-Related)	MCCC2	AR	Reduced Risk	
3-M	Methylglutaconic Aciduria, Type III	OPA3	AR	Reduced Risk	
3-P	Phosphoglycerate Dehydrogenase Deficiency	PHGDH	AR	Reduced Risk	
6-P	Pyruvoyl-Tetrahydropterin Synthase Deficiency	PTS	AR	Reduced Risk	
Abe	etalipoproteinemia	MTTP	AR	Reduced Risk	
	hromatopsia ( <i>CNGB3</i> -related)	CNGB3	AR	Reduced Risk	
	rodermatitis Enteropathica	SLC39A4	AR	Reduced Risk	
Acu	ute Infantile Liver Failure	TRMU	AR	Reduced Risk	
	yl-CoA Oxidase I Deficiency	ACOX1	AR	Reduced Risk	
	enosine Deaminase Deficiency	ADA	AR	Reduced Risk	
-	renoleukodystrophy, X-Linked	ABCD1	XL	Reduced Risk	
	ardi-Goutieres Syndrome ( <i>SAMHD1</i> -Related)	SAMHD1	AR	Reduced Risk	
	pha-Mannosidosis	MAN2B1	AR	Reduced Risk	
	pha-Thalassemia Mental Retardation Syndrome	ATRX	XL	Reduced Risk	
	port Syndrome (COL4A3-Related)	COL4A3	AR	Reduced Risk	
	port Syndrome (COL4A4-Related)	COL4A4	AR	Reduced Risk	
	oort Syndrome (COL4A5-Related)	COL4A5	XL	Reduced Risk	
	trom Syndrome	ALMS1	AR	Reduced Risk	
	dermann Syndrome	SLC12A6	AR	Reduced Risk	
	gininosuccinic Aciduria	ASL	AR	Reduced Risk	
	omatase Deficiency	CYP19A1	AR	Reduced Risk	
	hrogryposis, Mental Retardation, and Seizures paragine Synthetase Deficiency	SLC35A3 ASNS	AR AR	Reduced Risk Reduced Risk	
	<u> </u>		AR	Reduced Risk	
	partylglycosaminuria uxia With Isolated Vitamin E Deficiency	AGA TTPA	AR	Reduced Risk	
	ixia-Telangiectasia	ATM	AR	Reduced Risk	
	tosomal Recessive Spastic Ataxia of Charlevoix-	7.1111	7 WX	reduced risk	
	quenay	SACS	AR	Reduced Risk	
	rdet-Biedl Syndrome ( <i>BBS10</i> -Related)	BBS10	AR	Reduced Risk	
	rdet-Biedl Syndrome ( <i>BBS12</i> -Related)	BBS12	AR	Reduced Risk	
	rdet-Biedl Syndrome ( <i>BBS1</i> -Related)	BBS1	AR	Reduced Risk	
	rdet-Biedl Syndrome (BBS2-Related)	BBS2	AR	Reduced Risk	
	re Lymphocyte Syndrome, Type II	CIITA	AR	Reduced Risk	
	rtter Syndrome, Type 4A	BSND	AR	Reduced Risk	
	mard-Soulier Syndrome, Type A1	GP1BA	AR	Reduced Risk	
-	mard-Soulier Syndrome, Type C	GP9	AR	Reduced Risk	
	ta-Globin-Related Hemoglobinopathies	HBB	AR	Reduced Risk	





Beta-Ketothiolase Deficiency	ACAT1	AR	Reduced Risk	
Bilateral Frontoparietal Polymicrogyria	GPR56	AR	Reduced Risk	
Biotinidase Deficiency	BTD	AR	Reduced Risk	
Bloom Syndrome	BLM	AR	Reduced Risk	
Canavan Disease	ASPA	AR	Reduced Risk	
Carbamoylphosphate Synthetase I Deficiency	CPS1	AR	Reduced Risk	
Carnitine Palmitoyltransferase IA Deficiency	CPT1A	AR	Reduced Risk	
Carnitine Palmitoyltransferase II Deficiency	CPT2	AR	Reduced Risk	
Carpenter Syndrome	RAB23	AR	Reduced Risk	
Cartilage-Hair Hypoplasia	RMRP	AR	Reduced Risk	
Cerebral Creatine Deficiency Syndrome 1	SLC6A8	XL	Reduced Risk	
Cerebral Creatine Deficiency Syndrome 2	GAMT	AR	Reduced Risk	
Cerebrotendinous Xanthomatosis	CYP27A1	AR	Reduced Risk	
Charcot-Marie-Tooth Disease, Type 4D	NDRG1	AR	Reduced Risk	
Charcot-Marie-Tooth Disease, Type 4D  Charcot-Marie-Tooth Disease, Type 5 / Arts Syndrome	PRPS1	XL	Reduced Risk	
Charcot-Marie-Tooth Disease, X-Linked	GJB1	XL	Reduced Risk	
Choreoacanthocytosis	VPS13A	AR	Reduced Risk	
Choroideremia	CHM	XL	Reduced Risk	
Chronic Granulomatous Disease (CYBA-Related)	CHM	AR		
Chronic Granutomatous Disease (CYBB-Related)  Chronic Granutomatous Disease (CYBB-Related)	CYBB	XL	Reduced Risk Reduced Risk	
Citrin Deficiency	SLC25A13	AR	Reduced Risk	
· · · · · · · · · · · · · · · · · · ·	ASS1	AR	Reduced Risk	
Citrullinemia, Type 1	VPS13B	AR	Reduced Risk	
Cohen Syndrome		AR	Reduced Risk	
Combined Malonic and Methylmalonic Aciduria  Combined Oxidative Phosphorylation Deficiency 1	ACSF3 GFM1	AR	Reduced Risk	
Combined Oxidative Phosphorylation Deficiency 3	TSFM	AR	Reduced Risk	
Combined Oxidative Prospriorytation Deficiency 3  Combined Pituitary Hormone Deficiency 2	PROP1	AR	Reduced Risk	
Combined Pituitary Hormone Deficiency 3	LHX3	AR	Reduced Risk	
Combined SAP Deficiency	PSAP	AR	Reduced Risk	
Congenital Adrenal Hyperplasia due to 17-Alpha-	FSAF	AK	Reduced Risk	
Hydroxylase Deficiency	CYP17A1	AR	Reduced Risk	
Congenital Adrenal Hyperplasia due to 21-				CYP21A2 copy number: 2
Hydroxylase Deficiency	CYP21A2	AR	Reduced Risk	CYP21A2 sequencing: Negative
Congenital Amegakaryocytic Thrombocytopenia	MPL	AR	Reduced Risk	
Congenital Disorder of Glycosylation, Type Ia	PMM2	AR	Reduced Risk	
Congenital Disorder of Glycosylation, Type Ib	MPI	AR	Reduced Risk	
Congenital Disorder of Glycosylation, Type Ic	ALG6	AR	Reduced Risk	
Congenital Insensitivity to Pain with Anhidrosis	NTRK1	AR	Reduced Risk	
Congenital Myasthenic Syndrome (CHRNE-Related)	CHRNE	AR	Reduced Risk	
Congenital Myasthenic Syndrome (RAPSN-Related)	RAPSN	AR	Reduced Risk	
Congenital Neutropenia (HAX1-Related)	HAX1	AR	Reduced Risk	
Congenital Neutropenia (VPS45-Related)	VPS45	AR	Reduced Risk	
Corneal Dystrophy and Perceptive Deafness	SLC4A11	AR	Reduced Risk	
Corticosterone Methyloxidase Deficiency	CYP11B2	AR	Reduced Risk	
Cystic Fibrosis	CFTR	AR	Reduced Risk	
Cystinosis	CTNS	AR	Reduced Risk	
D-Bifunctional Protein Deficiency	HSD17B4	AR	Reduced Risk	
Deafness, Autosomal Recessive 77	LOXHD1	AR	Reduced Risk	
Duchenne Muscular Dystrophy / Becker Muscular				
Dystrophy	DMD	XL	Reduced Risk	
Dyskeratosis Congenita (RTEL1-Related)	RTEL1	AR	Reduced Risk	
Dystrophic Epidermolysis Bullosa	COL7A1	AR	Reduced Risk	
Ehlers-Danlos Syndrome, Type VIIC	ADAMTS2	AR	Reduced Risk	
Ellis-van Creveld Syndrome (EVC-Related)	EVC	AR	Reduced Risk	
Emery-Dreifuss Myopathy 1	EMD	XL	Reduced Risk	
Enhanced S-Cone Syndrome	NR2E3	AR	Reduced Risk	
Ethylmalonic Encephalopathy	ETHE1	AR	Reduced Risk	
· · · · · · · · · · · · · · · · · · ·			Reduced Risk	
Fabry Disease	GLA	λL		
Fabry Disease Factor IX Deficiency	GLA F9	XL XL	Reduced Risk	





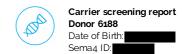
Familial Autosomal Recessive Hypercholesterolemia	LDLRAP1	AR	Reduced Risk	
Familial Dysautonomia	IKBKAP	AR	Reduced Risk	
Familial Hypercholesterolemia	LDLR	AR	Reduced Risk	
Familial Hyperinsulinism (ABCC8-Related)	ABCC8	AR	Reduced Risk	
Familial Hyperinsulinism (KCNJ11-Related)	KCNJ11	AR	Reduced Risk	
Familial Mediterranean Fever	MEFV	AR	Reduced Risk	
Fanconi Anemia, Group A	FANCA	AR	Reduced Risk	
Fanconi Anemia, Group C	FANCC	AR	Reduced Risk	
Fanconi Anemia, Group G	FANCG	AR	Reduced Risk	
Fragile X Syndrome	FMR1	XL	Reduced Risk	FMR1 CGG repeat sizes: Not Performed FMR1 Sequencing: Negative Fragile X CGG triplet repeat expansion testing w. not performed at this time, as the patient has eit been previously tested or is a male.
Furnarase Deficiency	FH	AR	Reduced Risk	
GRACILE Syndrome and Other <i>BCS1L</i> -Related Disorders	BCS1L	AR	Reduced Risk	
Galactokinase Deficiency	GALK1	AR	Reduced Risk	
Galactosemia	GALT	AR	Reduced Risk	
Gaucher Disease	GBA	AR	Reduced Risk	
Gitelman Syndrome	SLC12A3	AR	Reduced Risk	
Glutaric Acidemia, Type I	GCDH	AR	Reduced Risk	
•••	ETFA	AR	Reduced Risk	
Glutaric Acidemia, Type IIa	ETFDH	AR	Reduced Risk	
Glutaric Acidemia, Type IIc				
Glycine Encephalopathy (AMT-Related)	AMT	AR	Reduced Risk	
Glycine Encephalopathy (GLDC-Related)	GLDC	AR	Reduced Risk	
Glycogen Storage Disease, Type II	GAA	AR	Reduced Risk	
Glycogen Storage Disease, Type III	AGL	AR	Reduced Risk	
Glycogen Storage Disease, Type IV / Adult Polyglucosan Body Disease	GBE1	AR	Reduced Risk	
Glycogen Storage Disease, Type Ia	G6PC	AR	Reduced Risk	
Glycogen Storage Disease, Type Ib	SLC37A4	AR	Reduced Risk	
Glycogen Storage Disease, Type V	PYGM	AR	Reduced Risk	
Glycogen Storage Disease, Type VII	PFKM	AR	Reduced Risk	
HMG-CoA Lyase Deficiency	HMGCL	AR	Reduced Risk	
Hemochromatosis, Type 2A	HFE2	AR	Reduced Risk	
Hemochromatosis, Type 3	TFR2	AR	Reduced Risk	
Hereditary Fructose Intolerance	ALDOB	AR	Reduced Risk	
Hereditary Spastic Paraparesis 49	TECPR2	AR	Reduced Risk	
Hermansky-Pudlak Syndrome, Type 1	HPS1	AR	Reduced Risk	
Hermansky-Pudlak Syndrome, Type 3	HPS3	AR	Reduced Risk	
Holocarboxylase Synthetase Deficiency	HLCS	AR	Reduced Risk	
	CBS	AR	Reduced Risk	
Homocystinuria ( <i>CBS</i> -Related)				
Homocystinuria due to MTHFR Deficiency	MTHFR	AR	Reduced Risk	
Homocystinuria, cblE Type	MTRR	AR	Reduced Risk	
Hydrolethalus Syndrome  Hyperomithinemia-Hyperammonemia-	HYLS1 SLC25A15	AR AR	Reduced Risk  Reduced Risk	
Homocitrullinuria Syndrome	ED A	VI	Doduced Dist	
Hypohidrotic Ectodermal Dysplasia 1	EDA	XL	Reduced Risk	
Hypophosphatasia	ALPL	AR	Reduced Risk	
Inclusion Body Myopathy 2	GNE	AR	Reduced Risk	
Infantile Cerebral and Cerebellar Atrophy	MED17	AR	Reduced Risk	
Isovaleric Acidemia	IVD	AR	Reduced Risk	
Joubert Syndrome 2	TMEM216	AR	Reduced Risk	
Joubert Syndrome 7 / Meckel Syndrome 5 / COACH Syndrome	RPGRIP1L	AR	Reduced Risk	
Junctional Epidermolysis Bullosa ( <i>LAMA3</i> -Related)	LAMA3	AR	Reduced Risk	
Junctional Epidermolysis Bullosa ( <i>LAMB3</i> -Related)	LAMB3	AR	Reduced Risk	
Junctional Epidermolysis Bullosa ( <i>LAMC2</i> -Related)	LAMC2	AR	Reduced Risk	
Krabbe Disease	GALC	AR	Reduced Risk	
	J/ ILC	/ 11 \	NOGUCCU NISK	





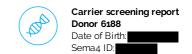
Leber Congenital Amaurosis 10 and Other CEP290-	CEP290	AR	Reduced Risk
Related Ciliopathies			
Leber Congenital Amaurosis 13	RDH12	AR	Reduced Risk
Leber Congenital Amaurosis 2 / Retinitis Pigmentosa 20	RPE65	AR	Reduced Risk
Leber Congenital Amaurosis 5	LCA5	AR	Reduced Risk
Leber Congenital Amaurosis 8 / Retinitis Pigmentosa 12	CRB1	AR	Reduced Risk
/ Pigmented Paravenous Chorioretinal Atrophy			
Leigh Syndrome, French-Canadian Type	LRPPRC	AR	Reduced Risk
Lethal Congenital Contracture Syndrome 1 / Lethal	GLE1	AR	Reduced Risk
Arthrogryposis with Anterior Horn Cell Disease	E/EoDe	4.0	Deduced Did.
Leukoencephalopathy with Vanishing White Matter	EIF2B5	AR AR	Reduced Risk  Reduced Risk
Limb-Girdle Muscular Dystrophy, Type 2A Limb-Girdle Muscular Dystrophy, Type 2B	CAPN3 DYSF	AR	Reduced Risk
Limb-Girdle Muscular Dystrophy, Type 2C	SGCG	AR	Reduced Risk
Limb-Girdle Muscular Dystrophy, Type 2D	SGCA	AR	Reduced Risk
Limb-Girdle Muscular Dystrophy, Type 2E	SGCB	AR	Reduced Risk
Limb-Girdle Muscular Dystrophy, Type 2I	FKRP	AR	Reduced Risk
Lipoamide Dehydrogenase Deficiency	DLD	AR	Reduced Risk
Lipoid Adrenal Hyperplasia	STAR	AR	Reduced Risk
Lipoprotein Lipase Deficiency	LPL	AR	Reduced Risk
Long-Chain 3-Hydroxyacyl-CoA Dehydrogenase Deficiency	HADHA	AR	Reduced Risk
Lysinuric Protein Intolerance	SLC7A7	AR	Reduced Risk
Maple Syrup Urine Disease, Type 1a	BCKDHA	AR	Reduced Risk
Maple Syrup Urine Disease, Type 1b	BCKDHB	AR	Reduced Risk
Meckel 1 / Bardet-Biedl Syndrome 13	MKS1	AR	Reduced Risk
Medium Chain Acyl-CoA Dehydrogenase Deficiency	ACADM	AR	Reduced Risk
Megalencephalic Leukoencephalopathy with Subcortical Cysts	MLC1	AR	Reduced Risk
Menkes Disease	ATP7A	XL	Reduced Risk
Metachromatic Leukodystrophy	ARSA	AR	Reduced Risk
Methylmalonic Acidemia ( <i>MMAA</i> -Related)	MMAA	AR	Reduced Risk
Methylmalonic Acidemia ( <i>MMAB</i> -Related)	MMAB	AR	Reduced Risk
Methylmalonic Acidemia ( <i>MUT</i> -Related)	MUT	AR	Reduced Risk
Methylmalonic Aciduria and Homocystinuria,	MMACHC	AR	Reduced Risk
Cobalamin C Type		7.11.	
Methylmalonic Aciduria and Homocystinuria, Cobalamin D Type	MMADHC	AR	Reduced Risk
Microphthalmia / Anophthalmia	VSX2	AR	Reduced Risk
Mitochondrial Complex I Deficiency (ACAD9-Related)	ACAD9	AR	Reduced Risk
Mitochondrial Complex I Deficiency ( <i>NDUFAF5</i> -Related)	NDUFAF5	AR	Reduced Risk
Mitochondrial Complex I Deficiency ( <i>NDUFS6</i> -Related)	NDUFS6	AR	Reduced Risk
Mitochondrial DNA Depletion Syndrome 6 / Navajo	MPV17	AR	Reduced Risk
Neurohepatopathy			
Mitochondrial Myopathy and Sideroblastic Anemia 1	PUS1	AR	Reduced Risk
Mucolipidosis II / IIIA	GNPTAB	AR	Reduced Risk
Mucolipidosis III Gamma	GNPTG	AR	Reduced Risk
Mucolipidosis IV	MCOLN1	AR	Reduced Risk
Mucopolysaccharidosis Type I	IDUA IDS	AR	Reduced Risk
Mucopolysaccharidosis Type II	SGSH	XL AR	Reduced Risk  Reduced Risk
Mucopolysaccharidosis Typo III A		AR	Reduced Risk
Mucopolysaccharidosis Type IIIA  Mucopolysaccharidosis Type IIIB	$NI\Delta(\pi I)II$	$\neg \neg$	NOGGOGG NISK
Mucopolysaccharidosis Type IIIB	NAGLU HGSNAT	ΔD	Reduced Risk
Mucopolysaccharidosis Type IIIB Mucopolysaccharidosis Type IIIC	HGSNAT	AR AR	Reduced Risk  Reduced Risk
Mucopolysaccharidosis Type IIIB Mucopolysaccharidosis Type IIIC Mucopolysaccharidosis Type IIID Mucopolysaccharidosis Type IVb / GM1		AR AR AR	Reduced Risk  Reduced Risk  Reduced Risk
Mucopolysaccharidosis Type IIIB Mucopolysaccharidosis Type IIIC Mucopolysaccharidosis Type IIID	HGSNAT GNS	AR	Reduced Risk





Multiple Sulfatase Deficiency	SUMF1	AR	Reduced Risk
Muscle-Eye-Brain Disease and Other POMGNT1-	·		
Related Congenital Muscular Dystrophy-	POMGNT1	AR	Reduced Risk
Dystroglycanopathies			
Myoneurogastrointestinal Encephalopathy	TYMP	AR	Reduced Risk
Myotubular Myopathy 1	MTM1	XL	Reduced Risk
N-Acetylglutamate Synthase Deficiency	NAGS	AR	Reduced Risk
Nemaline Myopathy 2	NEB	AR	Reduced Risk
Nephrogenic Diabetes Insipidus, Type II	AQP2	AR	Reduced Risk
Nephrotic Syndrome (NPHS1-Related) / Congenital			
Finnish Nephrosis	NPHS1	AR	Reduced Risk
Nephrotic Syndrome (NPHS2-Related) / Steroid-			
Resistant Nephrotic Syndrome	NPHS2	AR	Reduced Risk
Neuronal Ceroid-Lipofuscinosis (CLN3-Related)	CLN3	AR	Reduced Risk
Neuronal Ceroid-Lipofuscinosis ( <i>CLN5</i> -Related)	CLN5	AR	Reduced Risk
Neuronal Ceroid-Lipofuscinosis ( <i>CLN6</i> -Related)	CLN6	AR	Reduced Risk
Neuronal Ceroid-Lipofuscinosis (CLN8-Related)	CLN8	AR	Reduced Risk
Neuronal Ceroid-Lipofuscinosis (MFSD8-Related)	MFSD8	AR	Reduced Risk
Neuronal Ceroid-Lipofuscinosis (PPT1-Related)	PPT1	AR	Reduced Risk
<u>'</u>			
Neuronal Ceroid-Lipofuscinosis ( <i>TPP1</i> -Related)  Niemann-Pick Disease ( <i>SMPD1</i> -Related)	TPP1	AR	Reduced Risk
	SMPD1	AR	Reduced Risk
Niemann-Pick Disease, Type C (NPC1-Related)	NPC1	AR	Reduced Risk
Niemann-Pick Disease, Type C (NPC2-Related)	NPC2	AR	Reduced Risk
Nijmegen Breakage Syndrome	NBN	AR	Reduced Risk
Non-Syndromic Hearing Loss ( <i>GJB2</i> -Related)	GJB2	AR	Reduced Risk
Odonto-Onycho-Dermal Dysplasia / Schopf-Schulz-	WNT10A	AR	Reduced Risk
Passarge Syndrome			
Omenn Syndrome (RAG2-Related)	RAG2	AR	Reduced Risk
Omenn Syndrome / Severe Combined	DCLRE1C	AR	Reduced Risk
Immunodeficiency, Athabaskan-Type	DOLKLIO	7 11 (	Noduoca Nisk
Omithine Aminotransferase Deficiency	OAT	AR	Reduced Risk
Ornithine Transcarbamylase Deficiency	OTC	XL	Reduced Risk
Osteopetrosis 1	TCIRG1	AR	Reduced Risk
Pendred Syndrome	SLC26A4	AR	Reduced Risk
Phenylalanine Hydroxylase Deficiency	PAH	AR	Reduced Risk
Polycystic Kidney Disease, Autosomal Recessive	PKHD1	AR	Reduced Risk
Polyglandular Autoimmune Syndrome, Type 1	AIRE	AR	Reduced Risk
Pontocerebellar Hypoplasia, Type 1A	VRK1	AR	Reduced Risk
Pontocerebellar Hypoplasia, Type 6	RARS2	AR	Reduced Risk
Primary Carnitine Deficiency	SLC22A5	AR	Reduced Risk
Primary Ciliary Dyskinesia ( <i>DNAH5</i> -Related)	DNAH5	AR	Reduced Risk
Primary Ciliary Dyskinesia (DNA/1-Related)	DNAI1	AR	Reduced Risk
Primary Ciliary Dyskinesia ( <i>DNAI2</i> -Related)	DNAI2	AR	Reduced Risk
Primary Hyperoxaluria, Type 1	AGXT	AR	Reduced Risk
Primary Hyperoxaluria, Type 2	GRHPR	AR	Reduced Risk
Primary Hyperoxaluria, Type 3	HOGA1	AR	Reduced Risk
Progressive Cerebello-Cerebral Atrophy	SEPSECS	AR	Reduced Risk
Progressive Familial Intrahepatic Cholestasis, Type 2	ABCB11	AR	Reduced Risk
Propionic Acidemia ( <i>PCCA</i> -Related)	PCCA	AR	Reduced Risk
Propionic Acidemia (PCCB-Related)	PCCB	AR	Reduced Risk
	CTSK	AR	Reduced Risk
Pyrnyato Dobydrogopaco Et. Alpha Doficioney			
Pyruvate Dehydrogenase E1-Alpha Deficiency	PDHA1	XL	Reduced Risk
Pyruvate Dehydrogenase E1-Beta Deficiency	PDHB	AR	Reduced Risk
Renal Tubular Acidosis and Deafness	ATP6V1B1	AR	Reduced Risk
Retinitis Pigmentosa 25	EYS	AR	Reduced Risk
Retinitis Pigmentosa 26	CERKL	AR	Reduced Risk
Retinitis Pigmentosa 28	FAM161A	AR	Reduced Risk
Retinitis Pigmentosa 59	DHDDS	AR	Reduced Risk
Dhiramadia Chandradrantranta Drugatata Trusa 4	PEX7	AR	Reduced Risk
Rhizomelic Chondrodysplasia Punctata, Type 1 Rhizomelic Chondrodysplasia Punctata, Type 3	AGPS	AR	Reduced Risk





Roberts Syndrome	ESCO2	AR	Reduced Risk	
Salla Disease	SLC17A5	AR	Reduced Risk	
Sandhoff Disease	HEXB	AR	Reduced Risk	
Schimke Immunoosseous Dysplasia	SMARCAL1	AR	Reduced Risk	
Segawa Syndrome	TH	AR	Reduced Risk	
Sjogren-Larsson Syndrome	ALDH3A2	AR	Reduced Risk	
Smith-Lemli-Opitz Syndrome	DHCR7	AR	Reduced Risk	
Spinal Muscular Atrophy	SMN1	AR	Reduced Risk	SMN1 copy number: 2 SMN2 copy number: 2 c.*3+80T>G: Negative
Spondylothoracic Dysostosis	MESP2	AR	Reduced Risk	
Steel Syndrome	COL27A1	AR	Reduced Risk	
Stuve-Wiedemann Syndrome	LIFR	AR	Reduced Risk	
Sulfate Transporter-Related Osteochondrodysplasia	SLC26A2	AR	Reduced Risk	
Tay-Sachs Disease	HEXA	AR	Reduced Risk	
Tyrosinemia, Type I	FAH	AR	Reduced Risk	
Usher Syndrome, Type IB	MYO7A	AR	Reduced Risk	
Usher Syndrome, Type IC	USH1C	AR	Reduced Risk	
Usher Syndrome, Type ID	CDH23	AR	Reduced Risk	
Usher Syndrome, Type IF	PCDH15	AR	Reduced Risk	
Usher Syndrome, Type IIA	USH2A	AR	Reduced Risk	
Usher Syndrome, Type III	CLRN1	AR	Reduced Risk	
Very Long Chain Acyl-CoA Dehydrogenase Deficiency	ACADVL	AR	Reduced Risk	
Walker-Warburg Syndrome and Other <i>FKTN</i> -Related Dystrophies	FKTN	AR	Reduced Risk	
Wilson Disease	ATP7B	AR	Reduced Risk	
Wolman Disease / Cholesteryl Ester Storage Disease	LIPA	AR	Reduced Risk	
X-Linked Juvenile Retinoschisis	RS1	XL	Reduced Risk	
X-Linked Severe Combined Immunodeficiency	IL2RG	XL	Reduced Risk	
Zellweger Syndrome Spectrum (PEX10-Related)	PEX10	AR	Reduced Risk	
Zellweger Syndrome Spectrum (PEX1-Related)	PEX1	AR	Reduced Risk	
Zellweger Syndrome Spectrum ( <i>PEX2</i> -Related)	PEX2	AR	Reduced Risk	
Zellweger Syndrome Spectrum (PEX6-Related)	PEX6	AR	Reduced Risk	

AR=Autosomal recessive; XL=X-linked

### Test methods and comments

Genomic DNA isolated from this patient was analyzed by one or more of the following methodologies, as applicable:

### Fragile X CGG Repeat Analysis (Analytical Detection Rate >99%)

PCR amplification using Asuragen, Inc. Amplide $X^{\otimes}FMR^{1}$  PCR reagents followed by capillary electrophoresis for allele sizing was performed. Samples positive for FMR1 CGG repeats in the premutation and full mutation size range were further analyzed by Southern blot analysis to assess the size and methylation status of the FMR1 CGG repeat.

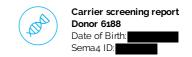
### Genotyping (Analytical Detection Rate >99%)

Multiplex PCR amplification and allele specific primer extension analyses using the MassARRAY<sup>®</sup> System were used to identify certain recurrent variants that are complex in nature or are present in low copy repeats. Rare sequence variants may interfere with assay performance.

### Multiplex Ligation-Dependent Probe Amplification (MLPA) (Analytical Detection Rate >99%)

 $MLPA^{(0)}$  probe sets and reagents from MRC-Holland were used for copy number analysis of specific targets versus known control samples. False positive or negative results may occur due to rare sequence variants in target regions detected by MLPA probes. Analytical sensitivity and specificity of the MLPA method are both 99%.





For alpha thalassemia, the copy numbers of the *HBA1* and *HBA2* genes were analyzed. Alpha-globin gene deletions, triplications, and the Constant Spring (CS) mutation are assessed. This test is expected to detect approximately 90% of all alpha-thalassemia mutations, varying by ethnicity, carriers of alpha-thalassemia with three or more *HBA* copies on one chromosome, and one or no copies on the other chromosome, may not be detected. With the exception of triplications, other benign alpha-globin gene polymorphisms will not be reported. Analyses of *HBA1* and *HBA2* are performed in association with long-range PCR of the coding regions followed by short-read sequencing.

For Duchenne muscular dystrophy, the copy numbers of all *DMD* exons were analyzed. Potentially pathogenic single exon deletions and duplications are confirmed by a second method. Analysis of *DMD* is performed in association with sequencing of the coding regions.

For congenital adrenal hyperplasia, the copy number of the *CYP21A2* gene was analyzed. This analysis can detect large deletions typically due to unequal meiotic crossing-over between *CYP21A2* and the pseudogene *CYP21A1P*. Classic 30-kb deletions make up approximately 20% of *CYP21A2* pathogenic alleles. This test may also identify certain point mutations in *CYP21A2* caused by gene conversion events between *CYP21A2* and *CYP21A1P*. Some carriers may not be identified by dosage sensitive methods as this testing cannot detect individuals with two copies (duplication) of the *CYP21A2* gene on one chromosome and loss of *CYP21A2* (deletion) on the other chromosome. Analysis of *CYP21A2* is performed in association with long-range PCR of the coding regions followed by short-read sequencing.

For spinal muscular atrophy (SMA), the copy numbers of the *SMN1* and *SMN2* genes were analyzed. The individual dosage of exons 7 and 8 as well as the combined dosage of exons 1, 4, 6 and 8 of *SMN1* and *SMN2* were assessed. Copy number gains and losses can be detected with this assay. Depending on ethnicity, 6 - 29 % of carriers will not be identified by dosage sensitive methods as this testing cannot detect individuals with two copies (duplication) of the *SMN1* gene on one chromosome and loss of *SMN1* (deletion) on the other chromosome (silent 2+0 carrier) or individuals that carry an intragenic mutation in *SMN1*. Please also note that 2% of individuals diagnosed with SMA have a causative *SMN1* variant that occurred *de novo*, and therefore cannot be picked up by carrier screening in the parents. Analysis of *SMN1* is performed in association with short-read sequencing of exons 2a-7, followed by confirmation using long-range PCR (described below).

The presence of the c.\*3+80T>G (chr5:70,247,901T>G) variant allele in an individual with Ashkenazi Jewish or Asian ancestry is typically indicative of a duplication of *SMN1*. When present in an Ashkenazi Jewish or Asian individual with two copies of *SMN1*, c.\*3+80T>G is likely indicative of a silent (2+0) carrier. In individuals with two copies of *SMN1* with African American, Hispanic or Caucasian ancestry, the presence or absence of c.\*3+80T>G significantly increases or decreases, respectively, the likelihood of being a silent 2+0 silent carrier.

MLPA for Gaucher disease (*GBA*), cystic fibrosis (*CFTR*), and non-syndromic hearing loss (*GJB2/GJB6*) will only be performed if indicated for confirmation of detected CNVs. If *GBA* analysis was performed, the copy numbers of exons 1, 3, 4, and 6 - 10 of the *GBA* gene (of 11 exons total) were analyzed. If *CFTR* analysis was performed, the copy numbers of all 27 *CFTR* exons were analyzed. If *GJB2/GJB6* analysis was performed, the copy number of the two *GJB2* exons were analyzed, as well as the presence or absence of the two upstream deletions of the *GJB2* regulatory region, del(*GJB6*-D13S1830) and del(*GJB6*-D13S1854).

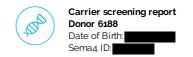
### Next Generation Sequencing (NGS) (Analytical Detection Rate >95%)

NGS was performed on a panel of genes for the purpose of identifying pathogenic or likely pathogenic variants.

Agilent SureSelect<sup>TM</sup>XT Low Input technology was used with a custom capture library to target the exonic regions and intron/exon splice junctions of the relevant genes, as well as a number of UTR, intronic or promoter regions that contain previously reported mutations. Libraries were pooled and sequenced on the Illumina NovaSeq 9000 platform, using paired-end 100 bp reads. The sequencing data was analyzed using a custom bioinformatics algorithm designed and validated in house.

The coding exons and splice junctions of the known protein-coding RefSeq genes were assessed for the average depth of coverage (minimum of 20X) and data quality threshold values. Most exons not meeting a minimum of >20X read depth across the exon are further analyzed by Sanger sequencing. Please note that several genomic regions present difficulties in mapping or obtaining read depth >20X. These regions, which are described below, will not be reflexed to Sanger sequencing if the mapping quality or coverage is poor. Any variants identified during testing in these regions are confirmed by a second method and reported if determined to be pathogenic or likely pathogenic. However, as there is a possibility of false negative results within these regions, detection rates and residual risks for these genes have been calculated with the presumption that variants in these exons will not be detected, unless included in the MassARRAY<sup>®</sup> genotyping platform.





Exceptions: ABCD1 (NM\_000033.3) exons 8 and 9; ADA (NM\_000022.2) exon 1; ADAMTS2 (NM\_014244.4) exon 1; AGPS (NM\_003659.3) chr2:178.257,512 - 178.257,649 (partial exon 1); ALMS1 (NM\_015120.4) chr2:73,612,990 - 73,613,041 (partial exon 1); CEP290 (NM\_025114.3) exon 5, exon 7, chr12:88.519,017 - 88.519,039 (partial exon 13), chr12:88.514,049 - 88.514,058 (partial exon 15), chr12:88.502,837 - 88.502,841 (partial exon 23), chr12:88.481.551 - 88.481.589 (partial exon 32), chr12:88.471,605 - 88.471,700 (partial exon 40); CFTR (NM\_000492.3) exon 10; COL4A4 (NM\_00092.4) chr2:227,942,604 - 227,942,619 (partial exon 25); CYP11B2 (NM\_000498.3) exons 3 - 7; DNAI2 (NM\_023036.4) chr17:72,308.136 - 72,308.147 (partial exon 12); EVC (NM\_153717.2) exon 1; FH (NM\_000143.3) exon 1; GAMT (NM\_000156.5 exon 1; GLDC (NM\_000170.2) exon 1; GNPTAB (NM\_024312.4) chr17:4,837,000 - 4,837,400 (partial exon 2); GNPTG (NM\_032520.4) exon 1; HGSNAT (NM\_152419.2) exon 1; IDS (NM\_000202.6) exon 3; LIFR (NM\_002310.5) exon 19; NEB (NM\_001271208.1) exons 82 - 105; NPC1 (NM\_000271.4) chr18:21,123.519 - 21,123.538 (partial exon 14); PUS1 (NM\_025215.5) ; chr12:132,414,446 - 132,414,532 (partial exon 2); RPGRIP1L (NM\_015272.2) exon 23; SGSH (NM\_000199.3) chr17:78,194,022 - 78,194,072 (partial exon 1); SLC6A8 (NM\_005629.3) exons 3 and 4.

This test will detect variants within the exons and the intron-exon boundaries of the target regions. Variants outside these regions may not be detected, including, but not limited to, UTRs, promoters, and deep intronic areas, or regions that fall into the Exceptions mentioned above. This technology may not detect all small insertion/deletions and is not diagnostic for repeat expansions and structural genomic variation. In addition, a mutation(s) in a gene not included on the panel could be present in this patient.

Variant interpretation and classification was performed based on the American College of Medical Genetics Standards and Guidelines for the Interpretation of Sequence Variants (Richards et al., 2015). All potentially pathogenic variants may be confirmed by either a specific genotyping assay or Sanger sequencing, if indicated. Any benign variants, likely benign variants or variants of uncertain significance identified during this analysis will not be reported.

### Next Generation Sequencing for SMN1

Exonic regions and intron/exon splice junctions of *SMN1* and *SMN2* were captured, sequenced, and analyzed as described above. Any variants located within exons 2a-7 and classified as pathogenic or likely pathogenic were confirmed to be in either *SMN1* or *SMN2* using gene-specific long-range PCR analysis followed by Sanger sequencing. Variants located in exon 1 cannot be accurately assigned to either *SMN1* or *SMN2* using our current methodology, and so these variants are considered to be of uncertain significance and are not reported.

### Copy Number Variant Analysis (Analytical Detection Rate >95%)

Large duplications and deletions were called from the relative read depths on an exon-by-exon basis using a custom exome hidden Markov model (XHMM) algorithm. Deletions or duplications determined to be pathogenic or likely pathogenic were confirmed by either a custom arrayCGH platform, quantitative PCR, or MLPA (depending on CNV size and gene content). While this algorithm is designed to pick up deletions and duplications of 2 or more exons in length, potentially pathogenic single-exon CNVs will be confirmed and reported, if detected.

### Exon Array (Confirmation method) (Accuracy >99%)

The customized oligonucleotide microarray (Oxford Gene Technology) is a highly-targeted exon-focused array capable of detecting medically relevant microdeletions and microduplications at a much higher resolution than traditional aCGH methods. Each array matrix has approximately 180,000 60-mer oligonucleotide probes that cover the entire genome. This platform is designed based on human genome NCBI Build 37 (hg19) and the CGH probes are enriched to target the exonic regions of the genes in this panel.

### Quantitative PCR (Confirmation method) (Accuracy >99%)

The relative quantification PCR is utilized on a Roche Universal Library Probe (UPL) system, which relates the PCR signal of the target region in one group to another. To test for genomic imbalances, both sample DNA and reference DNA is amplified with primer/probe sets that specific to the target region and a control region with known genomic copy number. Relative genomic copy numbers are calculated based on the standard  $\Delta\Delta$ Ct formula.

### Long-Range PCR (Analytical Detection Rate >99%)

Long-range PCR was performed to generate locus-specific amplicons for *CYP21A2*, *HBA1* and *HBA2* and *GBA*. The PCR products were then prepared for short-read NGS sequencing and sequenced. Sequenced reads were mapped back to the original genomic locus and run through the bioinformatics pipeline. If indicated, copy number from MLPA was correlated with the sequencing output to analyze the results. For *CYP21A2*, a certain percentage of healthy individuals carry a duplication of the *CYP21A2* gene, which has no clinical consequences. In cases where two copies of a gene are located on the same chromosome in tandem, only the second copy will be amplified and assessed for potentially pathogenic variants, due to size limitations of the PCR reaction. However, because these alleles contain at least two copies of the





CYP21A2 gene in tandem, it is expected that this patient has at least one functional gene in the tandem allele and this patient is therefore less likely to be a carrier. When an individual carries both a duplication allele and a pathogenic variant, or multiple pathogenic variants, the current analysis may not be able to determine the phase (cis/trans configuration) of the CYP21A2 alleles identified. Family studies may be required in certain scenarios where phasing is required to determine the carrier status.

#### **Residual Risk Calculations**

Carrier frequencies and detection rates for each ethnicity were calculated trough the combination of internal curations of >30,000 variants and genomic frequency data from >138,000 individuals across seven ethnic groups in the gnomAD database. Additional variants in HGMD and novel deleterious variants were also incorporated into the calculation. Residual risk values are calculated using a Bayesian analysis combining the *a priori* risk of being a pathogenic mutation carrier (carrier frequency) and the detection rate. They are provided only as a guide for assessing approximate risk given a negative result, and values will vary based on the exact ethnic background of an individual. This report does not represent medical advice but should be interpreted by a genetic counselor, medical geneticist or physician skilled in genetic result interpretation and the relevant medical literature.

### Personalized Residual Risk Calculations

Agilent SureSelect<sup>TM</sup>XT Low-Input technology was utilized in order to create whole-genome libraries for each patient sample. Libraries were then pooled and sequenced on the Illumina NovaSeq platform. Each sequencing lane was multiplexed to achieve 0.4-2x genome coverage, using paired-end 100 bp reads. The sequencing data underwent ancestral analysis using a customized, licensed bioinformatics algorithm that was validated in house. Identified sub-ethnic groupings were binned into one of 7 continental-level groups (African, East Asian, South Asian, Non-Finnish European, Finnish, Native American, and Ashkenazi Jewish) or, for those ethnicities that matched poorly to the continental-level groups, an 8<sup>th</sup> "unassigned" group, which were then used to select residual risk values for each gene. For individuals belonging to multiple high-level ethnic groupings, a weighting strategy was used to select the most appropriate residual risk. For genes that had insufficient data to calculate ethnic-specific residual risk values, or for sub-ethnic groupings that fell into the "unassigned" group, a "worldwide" residual risk was used. This "worldwide" residual risk was calculated using data from all available continental-level groups.

### Sanger Sequencing (Confirmation method) (Accuracy >99%)

Sanger sequencing, as indicated, was performed using BigDye Terminator chemistry with the ABI 3730 DNA analyzer with target specific amplicons. It also may be used to supplement specific guaranteed target regions that fail NGS sequencing due to poor quality or low depth of coverage (<20 reads) or as a confirmatory method for NGS positive results. False negative results may occur if rare variants interfere with amplification or annealing.

Please note these tests were developed and their performance characteristics were determined by Mount Sinai Genomics, Inc. They have not been cleared or approved by the FDA. These analyses generally provide highly accurate information regarding the patient's carrier or affected status. Despite this high level of accuracy, it should be kept in mind that there are many potential sources of diagnostic error, including misidentification of samples, polymorphisms, or other rare genetic variants that interfere with analysis. Families should understand that rare diagnostic errors may occur for these reasons.

### **SELECTED REFERENCES**

### **Carrier Screening**

Grody W et al. ACMG position statement on prenatal/preconception expanded carrier screening. Genet Med. 2013 15:482-3.

### Fragile X syndrome:

Chen L et al. An information-rich CGG repeat primed PCR that detects the full range of Fragile X expanded alleles and minimizes the need for Southern blot analysis. *J Mol Diag* 2010 12:589-600.

### Spinal Muscular Atrophy:

Luo M et al. An Ashkenazi Jewish SMN1 haplotype specific to duplication alleles improves pan-ethnic carrier screening for spinal muscular atrophy. *Genet Med.* 2014 16:149-56.

### Ashkenazi Jewish Disorders:

Scott SA et al. Experience with carrier screening and prenatal diagnosis for sixteen Ashkenazi Jewish Genetic Diseases. Hum. Mutat. 2010 31:1-11.

### Duchenne Muscular Dystrophy:





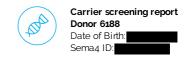
Flanigan KM et al. Mutational spectrum of DMD mutations in dystrophinopathy patients: application of modern diagnostic techniques to a large cohort. *Hum Mutat.* 2009 30:1657-66.

### Variant Classification:

Richards S et al. Standards and guidelines for the interpretation of sequence variants: a joint consensus recommendation of the American College of Medical Genetics and Genomics and the Association for Molecular Pathology. *Genet Med.* 2015 May;17(5):405-24

Additional disease-specific references available upon request.





### **Patient Information**

Name: Donor 6188

Date of Birth:

Sema4 ID:

Client ID:

Indication: Carrier Screening

### **Specimen Information**

Specimen Type: Purified DNA
Date Collected: 11/30/2022
Date Received: 12/01/2022
Final Report: 12/20/2022

# Referring Provider

Fairfax Cryobank, Inc.

# Custom Carrier Screen (2 genes)

with Personalized Residual Risk

### SUMMARY OF RESULTS AND RECOMMENDATIONS

Negative

Negative for all genes tested: ANO5, and SLC3A1

To view a full list of genes and diseases tested

please see Table 1 in this report

AR=Autosomal recessive: XL=X-linked

### Recommendations

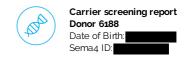
- Consideration of residual risk by ethnicity after a negative carrier screen is recommended for the other diseases on the panel, especially in the case of a positive family history for a specific disorder. Please note that residual risks for X-linked diseases (including full repeat expansions for Fragile X syndrome) may not be accurate for males and the actual residual risk is likely to be lower.
- As genetic technologies may improve and variant classifications may change over time, it is recommended to obtain a new carrier screening test or reanalysis when a new pregnancy is being considered.

# Test description

This patient was tested for the genes listed above using one or more of the following methodologies: target capture and short-read sequencing, long-range PCR followed by short-read sequencing, targeted genotyping, and/or copy number analysis. Please note that negative results reduce but do not eliminate the possibility that this individual is a carrier for one or more of the disorders tested. Please see Table 1 for a list of genes and diseases tested with the patient's personalized residual risk. If personalized residual risk is not provided, please see the complete residual risk table at **go.sema4.com/residualrisk**. Only known pathogenic or likely pathogenic variants are reported. This carrier screening test does not report likely benign variants and variants of uncertain significance (VUS). If reporting of likely benign variants and VUS are desired in this patient, please contact the laboratory at 800-298-6470, option 2 to request an amended report.

Anastasia Larmore, Ph.D., Associate Laboratory Director





### Genes and diseases tested

The personalized residual risks listed below are specific to this individual. The complete residual risk table is available at **go.sema4.com/residualrisk** 

### Table 1: List of genes and diseases tested with detailed results

	Disease	Gene	Inheritance Pattern	Status	Detailed Summary
Θ	Negative				
	Cystinuria ( <i>SLC3A1</i> -Related)	SLC3A1	AR	Reduced Risk	Personalized Residual Risk: 1 in 590
	Limb-Girdle Muscular Dystrophy, Type 2L	ANO5	AR	Reduced Risk	Personalized Residual Risk: 1 in 660

AR=Autosomal recessive: XL=X-linked

# Test methods and comments

Genomic DNA isolated from this patient was analyzed by one or more of the following methodologies, as applicable:

### Fragile X CGG Repeat Analysis (Analytical Detection Rate >99%)

PCR amplification using Asuragen, Inc. Amplide $X^{\otimes}$  FMR1 PCR reagents followed by capillary electrophoresis for allele sizing was performed. Samples positive for FMR1 premutations and full mutations greater than 90 CGG repeats in length were further analyzed by Southern blot analysis or methylation PCR to assess the size and methylation status of the FMR1 CGG repeat. Additional testing to determine the status of AGG interruptions within the FMR1 CGG repeat will be automatically performed for premutation alleles ranging from 55 to 90 repeats. These results, which may modify risk for expansion, will follow in a separate report.

### Genotyping (Analytical Detection Rate >99%)

Multiplex PCR amplification and single-base pair probe extension analyses using the Agena Bioscience iPlex Pro chemistry on a MassARRAY<sup>®</sup> System were used to identify certain recurrent variants that are complex in nature or are present in low copy repeats. Rare sequence variants may interfere with assay performance.

### Multiplex Ligation-Dependent Probe Amplification (MLPA) (Analytical Detection Rate >99%)

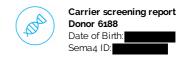
Conventional MLPA and/or digitalMLPA<sup>®</sup> probe sets and reagents from MRC-Holland were used for copy number variations (CNVs) analysis of specific targets versus known control samples. digitalMLPA<sup>®</sup> is a semi-quantitative technique, based on the well-established conventional MLPA method, followed by Illumina based sequencing to determine read number for amplicon quantification. False positive or negative results may occur due to rare sequence variants in target regions detected by conventional MLPA or digitalMLPA<sup>®</sup> probes. Analytical sensitivity and specificity of both the conventional MLPA method and the digitalMLPA<sup>®</sup> method are greater than 99%.

For alpha thalassemia, the copy numbers of the *HBA1* and *HBA2* genes were analyzed. Alpha-globin gene deletions, duplications, and the Constant Spring (CS) mutation are assessed. This test is expected to detect approximately 90% of all alpha-thalassemia mutations, varying by ethnicity. Carriers of alpha-thalassemia with three or more *HBA* copies on one chromosome, and one or no copies on the other chromosome, may not be precisely specified without phase analysis. With the exception of duplications, other benign alpha-globin gene polymorphisms will not be reported. Analyses of *HBA1* and *HBA2* are performed in association with long-range PCR of the coding regions followed by short-read sequencing.

For Duchenne muscular dystrophy, the copy numbers of all *DMD* exons were analyzed. Potentially pathogenic single exon deletions and duplications are confirmed by a second method. Analysis of *DMD* is performed in association with sequencing of the coding regions.

For congenital adrenal hyperplasia, the copy number of the *CYP21A2* gene was analyzed. This analysis can detect large deletions typically due to unequal meiotic crossing-over between *CYP21A2* and the pseudogene *CYP21A1P*. Classic 30-kb deletions make up approximately 20% of *CYP21A2* pathogenic alleles. This test may also identify certain point mutations in *CYP21A2* caused by gene conversion events between *CYP21A2* and *CYP21A1P*. Some carriers may not be identified by dosage sensitive methods as this testing cannot detect individuals with two copies (duplication) of the *CYP21A2* gene on one chromosome and loss of *CYP21A2* (deletion) on the other chromosome. Analysis of *CYP21A2* is performed in association with long-range PCR of the coding regions followed by short-read sequencing.





For spinal muscular atrophy (SMA), the copy numbers of the *SMN1* and *SMN2* genes were analyzed. The individual dosage of exons 7 and 8 as well as the combined dosage of exons 1, 4, 6 and 8 of *SMN1* and *SMN2* were assessed. Copy number gains and losses can be detected. Depending on ethnicity, 6 - 29 % of carriers will not be identified by dosage sensitive methods as this testing cannot distinguish individuals with two copies (duplication) of the *SMN1* gene on one chromosome and loss of *SMN1* (deletion) on the other chromosome (silent 2+0 carrier) or identify intragenic mutation in *SMN1*. Please also note that 2% of individuals diagnosed with SMA have a causative *SMN1* variant that occurred de novo, therefore cannot be picked up by carrier screening in the parents. Analysis of *SMN1* is performed in association with short-read sequencing of exons 2a-7, followed by confirmation using long-range PCR (described below).

In individuals with two copies of *SMN1* with Ashkenazi Jewish, East Asian, African American, Native American or Caucasian ancestry, the presence or absence of c.\*3+80T>G significantly increases or decreases, respectively, the likelihood of being a silent 2+0 silent carrier. MLPA for Gaucher disease (*GBA*), cystic fibrosis (*CFTR*), and non-syndromic hearing loss (*GJB2/GJB6*) will only be performed if indicated for confirmation of detected CNVs. If *GBA* analysis was performed, the copy numbers of exons 1, 3, 4, and 6 - 10 of the GBA gene (of 11 exons total) were analyzed. If *CFTR* analysis was performed, the copy numbers of all 27 *CFTR* exons were analyzed. If *GJB2/GJB6* analysis was performed, the copy number of the two *GJB2* exons were analyzed, as well as the presence or absence of the two upstream deletions of the *GJB2* regulatory region, del(*GJB6*-D13S1830) and del(*GJB6*-D13S1854).

### Next Generation Sequencing (NGS) (Analytical Detection Rate >95%)

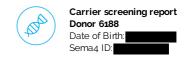
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Agilent SureSelect<sup>TM</sup>XT Low Input technology was used with a custom capture library to target the exonic regions and intron/exon splice junctions of the relevant genes, as well as a number of UTR, intronic or promoter regions that contain previously reported mutations. Libraries were pooled and sequenced on the Illumina NovaSeq 6000 platform, using paired-end 100 bp reads. The sequencing data was analyzed using a custom bioinformatics algorithm designed and validated in house.

The coding exons and splice junctions of the known protein-coding RefSeq genes were assessed for the average depth of coverage (minimum of 20X) and data quality threshold values. Most exons not meeting a minimum of >20X read depth across the exon are further analyzed by Sanger sequencing. Please note that several genomic regions present difficulties in mapping or obtaining read depth >20X. These regions, which are described below, will not be reflexed to Sanger sequencing if the mapping quality or coverage is poor. Any variants identified during testing in these regions are confirmed by a second method and reported if determined to be pathogenic or likely pathogenic. However, as there is a possibility of false negative results within these regions, detection rates and residual risks for these genes have been calculated with the presumption that variants in these exons will not be detected, unless included in the MassARRAY<sup>®</sup> genotyping platform.

Exceptions: ABCD1 (NM\_000033.3) exons 8 and 9; ACADSB (NM\_001609.3) chr10:124,810,695-124,810,707 (partial exon 9); ADA (NM\_000022.2) exon 1; ADAMTS2 (NM\_014244.4) exon 1; AGPS (NM\_003659.3) chr2:178,257,512-178,257,649 (partial exon 1); ALDH7A1 (NM\_001182.4) chr5:125,911,150-125,911,163 (partial exon 7) and chr5:125,896,807-125,896,821 (partial exon 10); ALMS1 (NM\_015120.4) chr2:73,612,990-73,613,041 (partial exon 1); APOPTI (NM\_032374.4) chr14:104,040,437-104,040,455 (partial exon 3); CDAN1 (NM\_138477.2) exon 2; CEP152 (NM\_014985.3) chr15;49,061,146-49,061,165 (partial exon 14) and exon 22; CEP2go (NM\_025114.3) exon 5, exon 7, chr12:88,519,017-88,519,039 (partial exon 13), chr12:88,514,049-88,514,058 (partial exon 15), chr12:88,502,837-88,502,841 (partial exon 23), chr12:88,481,551-88,481,589 (partial exon 32), chr12:88,471,605-88,471,700 (partial exon 40); CFTR (NM\_000492.3) exon 10; COL4A4 (NM\_000092.4) chr2:227,942,604-227,942,619 (partial exon 25); COX10 (NM\_001303.3) exon 6; CYP11B1 (NM\_000497.3) exons 3-7; CYP11B2 (NM\_000498.3) exons 3-7; DNAI2 (NM\_023036.4) chr17:72,308,136-72,308,147 (partial exon 12); DOK7 (NM\_173660.4) chr4:3,465,131-3,465,161 (partial exon 1) and exon 2; DUOX2 (NM\_014080.4) exons 6-8; EIF2AK3 (NM\_004836.5 exon 8; EVC (NM\_153717.2) exon 1; F5(NM\_000130.4) chr1:169,551,662-169,551,679 (partial exon 2); FH (NM\_000143.3) exon 1; GAMT (NM\_000156.5 exon 1; *GLDC*(NM\_000170.2) exon 1; *GNPTAB* (NM\_024312.4) chr17:4,837,000-4,837,400 (partial exon 2); *GNPTG* (NM\_032520.4) exon 1; GHR (NM\_000163,4) exon 3; GYS2 (NM\_021957,3) chr12:21,699,370-21,699,409 (partial exon 12); HGSNAT (NM\_152419,2) exon 1; IDS (NM\_000202.6 exon 3; ITGB4 (NM\_000213.4) chr17:73,749,976-73,750,060 (partial exon 33); JAK3 (NM\_000215.3) chr19:17,950,462-17,950,483 (partial exon 10); LIFR (NM\_002310.5 exon 19; LMBRD1 (NM\_018368.3) chr6:70,459,226-70,459,257 (partial exon 5), chr6:70,447,828-70,447,836 (partial exon 7) and exon 12; LYST (NM\_000081.3) chr1:235,944,158-235,944,176 (partial exon 16) and chr1:235,875,350-235,875,362 (partial exon 43); MLYCD (NM\_012213.2) chr16:83,933,242-83,933,282 (partial exon 1); MTR (NM\_000254.2) chr1 237,024,418-237,024,439 (partial exon 20) and chr1:237,038,019-237,038,029 (partial exon 24); NBEAL2 (NM\_015175.2) chr3 47,021,385-47,021,407 (partial exon 1); NEB (NM\_001271208.1 exons 82-105; NPC1 (NM\_000271.4) chr18:21,123,519-21,123,538 (partial exon 14); NPHP1 (NM\_000272.3)chr2:110,937,251-110,937,253 (partial exon 3); OCRL (NM\_000276.3) chrX:128,674,450-128,674,460 (partial exon 1); PHKB (NM\_000293.2) exon 1 and chr16:47,732,498-47,732,504 (partial exon 30); PIGN (NM\_176787.4) chr18;59,815,547-59,815,576 (partial exon 8); PIP5K1C (NM\_012398.2) exon 1 and chr19;3637602-3637616 (partial exon 17); POU1F1 (NM\_000306.3) exon 5; PTPRC (NM\_002838.4) exons 11 and 23; PUS1 (NM\_025215.5 chr12:132,414,446-132,414,532 (partial exon 2); RPGRIP1L (NM\_015272.2) exon 23; SGSH (NM\_000199.3) chr17;78,194,022-78,194,072 (partial exon 1); SLC6A8 (NM\_005629.3) exons 3 and 4; ST3GAL5 (NM\_003896.3) exon 1; SURF1 (NM\_003172.3) chrg:136,223,269-136,223,307 (partial exon 1); TRPM6 (NM\_017662.4) chrg:77,362,800-77,362,811 (partial exon 31); TSEN54





(NM\_207346.2) exon 1; *TYR* (NM\_000372.4) exon 5; *VWF* (NM\_000552.3) exons 24-26, chr12:6,125,675-6,125,684 (partial exon 30), chr12:6,121,244-6,121,265 (partial exon 33), and exon 34.

This test will detect variants within the exons and the intron-exon boundaries of the target regions. Variants outside these regions may not be detected, including, but not limited to, UTRs, promoters, and deep intronic areas, or regions that fall into the Exceptions mentioned above. This technology may not detect all small insertion/deletions and is not diagnostic for repeat expansions and structural genomic variation. In addition, a mutation(s) in a gene not included on the panel could be present in this patient.

Variant interpretation and classification was performed based on the American College of Medical Genetics Standards and Guidelines for the Interpretation of Sequence Variants (Richards et al., 2015). All potentially pathogenic variants may be confirmed by either a specific genotyping assay or Sanger sequencing, if indicated. Any benign variants, likely benign variants or variants of uncertain significance identified during this analysis will not be reported.

### Next Generation Sequencing for SMN1

Exonic regions and intron/exon splice junctions of *SMN1* and *SMN2* were captured, sequenced, and analyzed as described above. Any variants located within exons 2a-7 and classified as pathogenic or likely pathogenic were confirmed to be in either *SMN1* or *SMN2* using gene-specific long-range PCR analysis followed by Sanger sequencing. Variants located in exon 1 cannot be accurately assigned to either *SMN1* or *SMN2* using our current methodology, and so these variants are not reported.

### Copy Number Variant (CNV) Analysis (Analytical Detection Rate >98% for CNVs of 3 exons and larger, >90% for CNVs of 2 exons)

Large duplications and deletions were called from the relative read depths on an exon-by-exon basis using a custom exome hidden Markov model (XHMM) algorithm. Deletions or duplications determined to be pathogenic or likely pathogenic were confirmed by either a custom arrayCGH platform, quantitative PCR, or MLPA (depending on CNV size and gene content). While this algorithm is designed to pick up deletions and duplications of 2 or more exons in length, potentially pathogenic single-exon CNVs will be confirmed and reported, if detected. Deletions and duplications near the lower limit of detection may not be detected due to run variability. Genomic regions with high homology or highly repetitive sequences are excluded from this analysis.

### Exon Array Comparative Genomic Hybridization (aCGH) (Confirmation method) (Accuracy >99%)

The customized oligonucleotide microarray (Oxford Gene Technology) is a highly-targeted exon-focused array capable of detecting medically relevant microdeletions and microduplications at a much higher resolution than traditional aCGH methods. Each array matrix has approximately 1,000,000 60-mer oligonucleotide probes that cover the entire genome. This platform is designed based on human genome NCBI Build 37 (hg19) and the CGH probes are enriched to target the exonic regions of the genes in this panel.

### Quantitative PCR (Confirmation method) (Accuracy >99%)

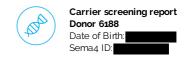
The relative quantification PCR is utilized on a Roche SYBR Green reagents on a LightCycler  $^{\circledR}$  480 System, which relates the PCR signal of the target region in one group to another. To test for genomic imbalances, both sample DNA and reference DNA is amplified with primer/probe sets that specific to the target region and a control region with known genomic copy number. Relative genomic copy numbers are calculated based on the standard  $\Delta\Delta$ Ct formula.

### Long-Range PCR (Analytical Detection Rate >99%)

Long-range PCR was performed to generate locus-specific amplicons for CYP21A2, HBA1 and HBA2 and GBA. The PCR products were then prepared for short-read NGS sequencing and sequenced. Sequenced reads were mapped back to the original genomic locus and run through the bioinformatics pipeline. If indicated, copy number from MLPA was correlated with the sequencing output to analyze the results. Please note that in rare cases, allele drop-out may occur, which has the potential to lead to false negative results. For CYP21A2, a certain percentage of healthy individuals carry a duplication of the CYP21A2 gene, which has no clinical consequences. In cases where multiple copies of CYP21A2 are located on the same chromosome in tandem, only the last copy will be amplified and assessed for potentially pathogenic variants, due to size limitations of the PCR reaction. However, because these alleles contain at least two copies of the CYP21A2 gene in tandem, it is expected that this patient has at least one functional gene in the tandem allele and this patient is therefore less likely to be a carrier. A CYP21A1P/CYP21A2 hybrid gene detected only by MLPA but not by long-range PCR will not be reported when the long-range PCR indicates the presence of two full CYP21A2 gene copies (one on each chromosome), as the additional hybrid gene is nonfunctional. Classic 30-kb deletions are identified by MLPA and are also identified by the presence of multiple common pathogenic CYP21A2 variants by long-range PCR. Since multiple pseudogene-derived variants are detected in all cases with the classic 30kb deletion, we cannot rule out the possibility that some variant(s) detected could be present in trans with the chimeric CYP21A1P/CYP21A2 gene created by the 30kb deletion. When an individual carries both a duplication allele and a pathogenic variant, or multiple pathogenic variants, the current analysis may not be able to determine the phase (cis/trans configuration) of the CYP21A2 alleles identified. Family studies may be required in certain scenarios where phasing is required to determine the carrier status.

### **Residual Risk Calculations**





Carrier frequencies and detection rates for each ethnicity were calculated through the combination of internal curations of >30,000 variants and genomic frequency data from >138,000 individuals across seven ethnic groups in the gnomAD database. Additional variants in HGMD and novel deleterious variants were also incorporated into the calculation. Residual risk values are calculated using a Bayesian analysis combining the a *priori* risk of being a pathogenic mutation carrier (carrier frequency) and the detection rate. They are provided only as a guide for assessing approximate risk given a negative result, and values will vary based on the exact ethnic background of an individual. This report does not represent medical advice but should be interpreted by a genetic counselor, medical geneticist or physician skilled in genetic result interpretation and the relevant medical literature.

### Personalized Residual Risk Calculations

Agilent SureSelect<sup>TM</sup>XT Low-Input technology was utilized in order to create whole-genome libraries for each patient sample. Libraries were then pooled and sequenced on the Illumina NovaSeq platform. Each sequencing lane was multiplexed to achieve 0.4-2x genome coverage, using paired-end 100 bp reads. The sequencing data underwent ancestral analysis using a customized, licensed bioinformatics algorithm that was validated in house. Identified sub-ethnic groupings were binned into one of 7 continental-level groups (African, East Asian, South Asian, Non-Finnish European, Finnish, Native American, and Ashkenazi Jewish) or, for those ethnicities that matched poorly to the continental-level groups, an 8<sup>th</sup> "unassigned" group, which were then used to select residual risk values for each gene. For individuals belonging to multiple high-level ethnic groupings, a weighting strategy was used to select the most appropriate residual risk. For genes that had insufficient data to calculate ethnic-specific residual risk values, or for sub-ethnic groupings that fell into the "unassigned" group, a "worldwide" residual risk was used. This "worldwide" residual risk was calculated using data from all available continental-level groups.

Several genes have multiple residual risks associated to reflect the likelihood of the tested individual being a carrier for different diseases that are attributed to non-overlapping pathogenic variants in that gene. When calculating the couples' combined reproductive risk, the highest residual risk for each patient was selected.

### Sanger Sequencing (Confirmation method) (Accuracy >99%)

Sanger sequencing, as indicated, was performed using BigDye Terminator chemistry with the ABI 3730 DNA analyzer with target specific amplicons. It also may be used to supplement specific guaranteed target regions that fail NGS sequencing due to poor quality or low depth of coverage (<20 reads) or as a confirmatory method for NGS positive results. False negative results may occur if rare variants interfere with amplification or annealing.

### Tay-Sachs Disease (TSD) Enzyme Analysis (Analytical Detection Rate >98%)

Hexosaminidase activity and Hex A% activity were measured by a standard heat-inactivation, fluorometric method using artificial 4-MU-β-N-acetyl glucosaminide (4-MUG) substrate. This assay is highly sensitive and accurate in detecting Tay-Sachs carriers and individuals affected with TSD. Normal ranges of Hex A% activity are 55.0-72.0 for white blood cells and 58.0-72.0 for plasma. It is estimated that less than 0.5% of Tay-Sachs carriers have non-carrier levels of percent Hex A activity, and therefore may not be identified by this assay. In addition, this assay may detect individuals that are carriers of or are affected with Sandhoff disease. False positive results may occur if benign variants, such as pseudodeficiency alleles, interfere with the enzymatic assay. False negative results may occur if both *HEXA* and *HEXB* pathogenic or pseudodeficiency variants are present in the same individual.

Please note that it is not possible to perform Tay-Sachs disease enzyme analysis on saliva samples, buccal swabs, tissue samples, semen samples, or on samples received as extracted DNA.

This test was developed, and its performance characteristics determined by Sema4 Opco, Inc. It has not been cleared or approved by the US Food and Drug Administration. FDA does not require this test to go through premarket FDA review. This test is used for clinical purposes. It should not be regarded as investigational or for research. This laboratory is certified under the Clinical Laboratory Improvement Amendments (CLIA) as qualified to perform high complexity clinical laboratory testing. These analyses generally provide highly accurate information regarding the patient's carrier or affected status. Despite this high level of accuracy, it should be kept in mind that there are many potential sources of diagnostic error, including misidentification of samples, polymorphisms, or other rare genetic variants that interfere with analysis. Families should understand that rare diagnostic errors may occur for these reasons.

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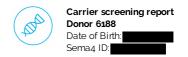
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Additional disease-specific references available upon request.