

**PATIENT**  
Name: **Patient, Sample**  
Accession #: 00-00000  
DOB: 01/01/1901  
Gender: Female  
MRN: N/A  
Indication: Diagnostic

**TEST INFORMATION**  
Portal Order #: 1234  
Family #: 0000  
Specimen #: N/A  
Specimen type: Blood EDTA  
Collection date: 00/00/2018  
Final Report: 00/00/2018

**PHYSICIAN**  
Sample Doctor, MD  
**ADDITIONAL RECIPIENTS**  
Sample GC  
Phone: 000-000-0000  
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**FACILITY**  
Sample Facility  
12345 Wonderful Lane  
Somewhere, NY 99999-9999  
Phone: 000-000-0000  
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## NEGATIVE: No clinically relevant alterations detected

Clinically Relevant Findings			Notable Findings
Characterized genes	Mitochondrial genome	Uncharacterized genes	
None	None	None	2(2)^

^ genes(alterations). Notable findings are alterations of unlikely clinical relevance, but which were unable to be ruled out. See details in the notable findings section of the supplemental report.

### Indication for Testing

Global developmental delay, spastic quadriplegia, microcephaly, epilepsy, brain anomalies.

### Results and Interpretation

- **These results indicate that the underlying cause of the patient's clinical symptoms has not been discovered.**
- Notable findings were detected in the following gene(s): *DPAGT1*, *TUBGCP6*. See the supplemental report for additional information.

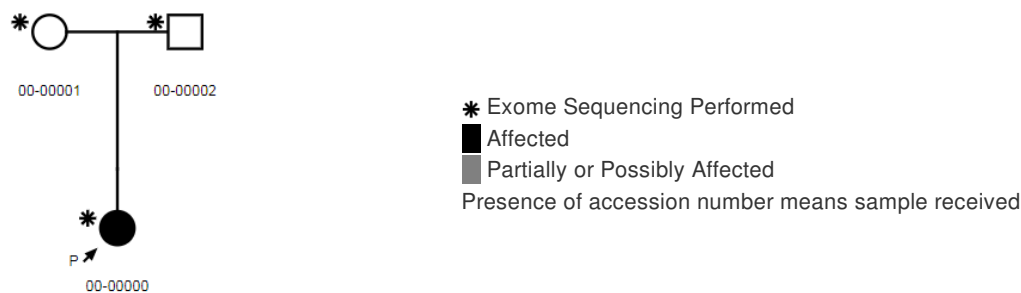
### Notes

- This patient opted out of secondary findings.
- Genetic counseling is a recommended option for all patients undergoing genetic testing.
- Any tests on hold, previously reported, and those that have been cancelled (including reflex testing steps cancelled due to a positive result in a preceding test) have not been included in this report. For additional information, please contact Ambry Genetics.

Electronically Signed By Sample Director, on 0/00/2018 at 0:00:00 PM

All content hereafter is supplemental information to the preceding report.

## Family Pedigree



## Analyses Performed

i) Full exome sequencing, bioinformatics, filtering and manual review based on autosomal and X-linked dominant and recessive inheritance models of the proband, mother, and father was performed. Medical review of characterized genetic etiologies did not reveal any alterations with likely clinical relevance.

ii) Medical review of uncharacterized genes\* and gene-disease relationships for potential candidate gene findings did not reveal any alterations with likely clinical relevance.

iii) Sequencing of mitochondrial DNA (mtDNA) followed by screening and analysis of 68 known pathogenic alterations related to the proband's clinical phenotype did not reveal any alterations with likely clinical relevance.

\*Uncharacterized genes are not currently established to underlie Mendelian genetic conditions. An uncharacterized gene will be classified as a "candidate" or "suspected candidate" when sufficient evidence, based on Ambry's comprehensive, rule-based scoring criteria, is available (Farwell Hagman, 2017) (<http://www.ambrygen.com/candidate-gene-reporting>).

## Raw Data

A table with additional variant filtering details can be found with the raw data filtered variant list (if requested). This list includes clinically irrelevant characterized genes and uncharacterized genes which could not be ruled out (if analyzed); these alterations are not systematically confirmed via Sanger sequencing.

## Metrics and Coverage

The values below represent metrics from the family's exome sequencing. Complete coverage data for this proband can be e-mailed or made available for download through AmbryPort by request.

Relationship	Depth of coverage	
	% Bases $\geq$ 10x	% Bases $\geq$ 20x
Proband	98.55	98.16
Mother	98.59	98.28
Father	98.71	98.19

**Notable Findings (alterations of unlikely clinical relevance)**

Total "notable findings" detected: 2 notable genes (2 unique alterations).

Notable Findings are alterations of unlikely clinical relevance, but which were unable to be ruled out. These may include (1) alterations in characterized genes with minimal or inconsistent clinical overlap, (2) a single heterozygous alteration in a recessive gene with limited or inconsistent clinical overlap, or (3) alterations in characterized or uncharacterized genes which failed to co-segregate with disease in the current family. These alterations are not systematically confirmed via Sanger sequencing.

Gene (RefSeq ID): <i>DPAGT1</i> (NM_001382)					
Alteration(s)	Genotype	Alteration Type	Alteration Classification	MAF <sup>1</sup>	Database Records <sup>2</sup>
c.980_981delCT (p.S327Ffs*22)	Heterozygous, paternal	Frameshift	Pathogenic Mutation	0.01%	N/A
<b>Relevant Associated Syndrome (Inheritance)<sup>3</sup>:</b> Congenital disorder of glycosylation (AR)					
<b>Rationale:</b> The alteration is unlikely to explain the patient's phenotype because the patient has a single heterozygous alteration in a gene generally associated with an autosomal recessive syndrome. All exons were covered 100% at 20x or greater					
<b>Clinical Correlation:</b> Likely Positive (carrier only)					
Gene (RefSeq ID): <i>TUBGCP6</i> (NM_020461)					
Alteration(s)	Genotype	Alteration Type	Alteration Classification	MAF <sup>1</sup>	Database Records <sup>2</sup>
c.4597C>T (p.Q1533*)	Heterozygous, maternal	Nonsense	Pathogenic Mutation	N/A	N/A
<b>Relevant Associated Syndrome (Inheritance)<sup>3</sup>:</b> Microcephaly and chorioretinopathy (AR)					
<b>Rationale:</b> The alteration is unlikely to explain the patient's phenotype because the patient has a single heterozygous alteration in a gene generally associated with an autosomal recessive syndrome. All exons were covered 100% at 20x or greater.					
<b>Clinical Correlation:</b> Uncertain (carrier only)					

<sup>1</sup>MAF = minor allele frequency. The number displayed reflects the highest ethnicity-specific MAF in gnomAD.<sup>2</sup>dbSNP and/or HGMD alteration record.<sup>3</sup>Relevant syndrome data collected from HGMD, OMIM, the medical literature, and/or internal Ambry data.

AD= autosomal dominant, AR= autosomal recessive, XL= X-linked, XLR= X-linked recessive, XLD= X-linked dominant, YL= Y-linked, CX= complex inheritance (including multiple modes of inheritance).

Recessive Diseases: Cannot rule out undetectable biallelic alteration or potential gain-of-function, haploinsufficiency, or dominant-negative effect.

## Resources Used for Bioinformatics, Medical Review Filtering, and Reporting

- 1000 Genomes [Internet]: 1000 Genomes Project Consortium (2010) *Nature* **467**(7319):1061-1073. Available from: <http://www.1000genomes.org>.
- Ambry Clinical Validity Assessment: Smith ED, *et al.* (2017) *Hum Mutat.* **38**(5):600-608.
- Berkeley Drosophila Genome Project [Internet]: Reese MG, *et al.* (1997) *J Comp Biol* **4**(3), 311-23. [http://www.fruitfly.org/seq\\_tools/splice.html](http://www.fruitfly.org/seq_tools/splice.html).
- ClinGen Clinical Validity Classifications [Internet]: <https://www.clinicalgenome.org/knowledge-curation/gene-curation/clinical-validity-classifications>; Rehm HL, *et al.* (2015) *N Engl J Med* **372**(23):2235-2242.
- Clinical Genomic Database [Internet]: Solomon BD, *et al.* (2013) *Proc Natl Acad Sci U S A.* **110**(24):9851-5. Available from: <http://research.nhgri.nih.gov/CGD>.
- Combined Annotation Dependent Depletion (CADD) [Internet]: Kircher M, *et al.* (2014) *Nat Genet.* **46**(3):310-5. Available from: <http://cadd.gs.washington.edu>.
- Database of Single Nucleotide Polymorphisms (dbSNP) [Internet]: Bethesda (MD): National Center for Biotechnology Information, National Library of Medicine. (dbSNP Build ID: 135). Available from: <http://www.ncbi.nlm.nih.gov/projects/SNP>.
- DECIPHER: Database of Chromosomal Imbalance and Phenotype in Humans using Ensembl Resources. Firth, H.V. *et al.* (2009). *Am J Hum Genet* **84**:524-533.
- ESEfinder [Internet]: Smith PJ, *et al.* (2006) *Hum Mol Genet* **15**(16):2490-2508 and Cartegni L, *et al.* (2003) *Nucleic Acid Res* **31**(13):3568-3571. Available from: <http://cb.utdallas.edu/tools/ESE>
- Exome Aggregation Consortium (ExAC) [Internet], Cambridge, MA (URL: <http://exac.broadinstitute.org>). (Lek M, *et al.* 2016: see below)
- Exome Variant Server, NHLBI Exome Sequencing Project (ESP) [Internet]: Seattle, WA. Available from: <http://evs.gs.washington.edu/EVS>.
- Expression Atlas: Differential and Baseline Expression [Internet]: Petryszak, R. *et al.* (2013) *Nucleic Acids Res* **10**.1093/nar/gkt1270. Available from: <http://www.ebi.ac.uk/gxa/home>.
- Farwell Hagman KD, *et al.* (2016) *Genet Med* doi:10.1038/gim.2016.95.
- GeneMANIA [Internet]: Warde-Farley D, *et al.* (2010) *Nucleic Acids Res* **38**(Web Server issue):W214-20. doi: 10.1093/nar/gkq537. Available from: <http://genemania.org>.
- GeneReviews [Internet]: Pagon RA, *et al.* editors. (1993-) Seattle, WA: University of Washington, Seattle. Available from: <http://www.ncbi.nlm.nih.gov/books/NBK1116>.
- Genome Aggregation Database (gnomAD) [Internet], Cambridge, MA. Available from: <http://gnomad.broadinstitute.org/> (Lek M, *et al.* 2016: see below)
- Grantham prediction: Grantham R. (1974) *Science* **185**(4151):862-864.
- Green RC, *et al.* (2013) *Genet Med* **15**(7):565-74.
- HGMD@ [Internet]: Stenson PD, *et al.* (2014) *Hum Genet.* **133**(1):1-9. Available from: <http://www.hgmd.cf.ac.uk>.
- Integrative Genomics Viewer (IGV): Thorvaldsdóttir H, *et al.* (2012) *Brief Bioinform* **14**(2):178-192.
- Kalia SS, *et al.* (2016) *Genet Med* doi:10.1038/gim.2016.190.
- Kyoto Encyclopedia of Genes and Genomes (KEGG) [Internet]: Kanehisa M, *et al.* (2014) *Nucleic Acids Res* **42**. <http://www.genome.jp/kegg>.
- Lek M, *et al.* (2016) *Nature* 536(7616):285-91.
- Mouse Gene Expression Database (GXD): Finger JH, *et al.* (2011): *Nucleic Acids Res* **39**(suppl 1):D835-D841. Available from: <http://www.informatics.jax.org>.
- Mouse Genome Database (MGD) [Internet]: Eppig JT, *et al.* (2012) *Nucleic Acids Res* **40**(1):D881-86 Available from: <http://www.informatics.jax.org>.
- Mutation Assessor (functional impact of protein mutations) [Internet]: Reva BA *et al.* (2011) *Nucleic Acids Res* **39**(17):e118. Available from: <http://mutationassessor.org>.
- NeXtProt [Internet]: Lane L, *et al.* (2012) neXtProt: a knowledge platform for human proteins. *Nucleic Acids Res* **40**(D1): D76-D83. Available from: <http://www.nextprot.org>.
- Maquat LE. Nonsense-mediated mRNA decay: splicing, translation and mRNP dynamics. *Nat Rev Mol Cell Biol* 2004 **5**(2):89-99.
- OMIM (Online Inheritance in Man) [Internet]: Copyright© 1966-2012 Johns Hopkins University. Available from: <http://www.omim.org>.
- PolyPhen [Internet]: Adzhubei IA, *et al.* (2010) *Nat Methods* **7**(4):248-249. Available from: <http://genetics.bwh.harvard.edu/pph2>.
- RefSeq: The NCBI handbook [Internet]: Bethesda (MD): National Library of Medicine (US), National Center for Biotechnology Information; 2002 Oct. Chapter 18, The Reference Sequence (RefSeq) Project. Available from: <http://www.ncbi.nlm.nih.gov/refseq>.
- Richards, *et al.* On behalf of the ACMG Laboratory Quality Assurance Committee (2015) 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*, 17(5), 405–424. <http://doi.org/10.1038/gim.2015.30>.
- SIFT [Internet]: Kumar P *et al.* (2009) *Nat Protoc.* **4**(7):1073-81. <http://sift.jcvi.org>.

## ExomeNext™ Assay Information

**General Information:** Ambry's ExomeNext™ is a cost-effective, comprehensive, integrated exome sequencing assay designed to increase the diagnostic yield for genetic disorders that have eluded definitive delineation using traditional diagnostic approaches. The exome represents virtually all the exons, which are the regions in the human genome that are translated into proteins. It is estimated that the protein-coding regions of the human genome contain about 85% of the disease-causing mutations. Whole-exome sequencing has been successfully applied to identify both inherited and *de novo* mutations in a diverse variety of autosomal dominant, recessive, and X-linked disorders.

**Result Reports:** A primary clinical report will only be generated for the proband regardless of number of family members submitted. However, it may be possible to infer information about family member's results based on the proband's report. Pathogenic mutation(s) likely to factor into the patient's current clinical condition are always reported. Since new scientific information becomes available on a regular basis, this could alter the interpretation of previously reported results. In the event of a change in interpretation, an unsolicited re-classification/amended report may be issued to the ordering clinician.

**Expected (Normal) Value:** Diagnostic: 0, 1, or more mutation(s) detected.

**Test Limitations:** This test was developed and its performance characteristics were determined by Ambry Genetics. It has not been cleared or approved by the US Food and Drug Administration. The FDA does not require this test to go through premarket FDA review. It should not be regarded as investigational or for research. This test should be interpreted in context with other clinical findings. This report does not represent medical advice. Any questions, suggestions, or concerns regarding interpretation of results should be referred to a genetic counselor, medical geneticist, or physician skilled in evaluating the relevant medical literature. This laboratory is certified under the Clinical Laboratory Improvement Amendments (CLIA) as qualified to perform high complexity clinical laboratory testing. The following types of mutations are detectable: nucleotide substitutions, small deletions, small insertions and small indels. Exome sequencing is not intended to analyze the following types of mutations: gross deletions/duplications, gross rearrangements, deep intronic variations, long repeat sequences, portions of genes with highly homologous pseudogenes, trinucleotide repeat sequences, mutations involved in tri-allelic inheritance, certain mitochondrial genome mutations, epigenetic effects, oligogenic inheritance, and X-linked recessive mutations in females who manifest disease due to skewed X-inactivation and other unknown abnormalities. A negative result from the analysis cannot rule out the possibility that the tested individual carries a rare unexamined mutation or mutations in an undetectable region. Ambry's ExomeNext detection rate is 30% for positive or likely positive relevant findings identified in established disease-gene associations, and an additional 7% for candidate gene findings (Farwell K, *et al.*, Genet Med., 2014 and Farwell Hagman K, *et al.*, Genet Med., 2017). Although molecular tests are highly accurate, rare diagnostic errors may occur. Possible diagnostic errors include sample mix-up, erroneous paternity identification, technical errors, clerical errors, and genotyping errors. Genotyping errors can result from trace contamination of PCR reactions, from rare genetic variants that may interfere with analysis, or from other sources.

**Methodology:** Genomic deoxyribonucleic acid (gDNA) is isolated from the patient's whole blood. Samples are prepared using the SeqCap EZ VCRome 2.0 (Roche NimbleGen) or the IDT xGen Exome Research Panel V1.0 (IDT). Each DNA sample is sheared, adaptor ligated, PCR-amplified and incubated with the exome baits. Captured DNA is eluted and PCR amplified. Final quantified libraries are seeded onto an Illumina flow cell and sequenced using paired-end, 100 or 150 cycle chemistry on the Illumina HiSeq or NextSeq. Initial data processing, base calling, alignments and variant calls are generated by various bioinformatics tools. Data is annotated with the Ambry Variant Analyzer tool (AVA), including: nucleotide and amino acid conservation, biochemical nature of amino acid substitutions, population frequency, and predicted functional impact. Data analysis is focused on small insertions and deletions, canonical splice site alterations, and non-synonymous alterations. The following sites are used to search for previously described gene mutations and polymorphisms: the Human Gene Mutation Database (HGMD), the Single Nucleotide Polymorphism database (dbSNP), ExAC, ESP, 1000 genomes, and online search engines (e.g., PubMed). Variants are then filtered further based on applicable inheritance models. Co-segregation studies are performed if family members are available. All relevant findings undergo manual review by molecular geneticists using integrated genomics software (IGV) and/or undergo confirmation either by automated fluorescence dideoxy (aka "Sanger") sequencing or via trio exome sequencing with coverage and alternate read ratios above established confidence thresholds. Co-segregation results may be confounded by many factors which cannot be completely ruled out including haploinsufficiency, reduced penetrance, age-of-onset, and/or variable expressivity. Relevant findings are evaluated from among the genes in Ambry's internal, dynamic gene database which classifies genes as characterized or uncharacterized Mendelian disease genes based on clinical validity (Smith E, *et al.*, Hum Mutat, 2017). Characterized genes are those currently known to underlie at least one Mendelian genetic condition. Uncharacterized genes are those not currently known or with insufficient evidence to be associated with a Mendelian genetic condition. Characterized genes are analyzed first. If no positive findings are identified, reflex analysis of uncharacterized genes occurs for potential identification of a candidate gene finding. The analysis of candidate gene findings is only performed when an informative trio is received for testing and focuses on *de novo*, autosomal recessive, or X-linked inherited alterations. Each alteration remaining after inheritance model filtering is analyzed and/or reviewed by board certified molecular geneticists to identify the most likely causative alteration(s). Interpretation is based on the clinical, family, and test information provided by the referring provider and the current knowledge of genes and alterations at the time of reporting. Screening and analysis of known mtDNA mutations related to the proband's clinical phenotype is included if ordered. Amplification of the entire mitochondrial genome is carried out by long distance PCR and sequencing of mitochondrial DNA (mtDNA) is performed separately on Illumina MiSeq.

**Analysis of Alterations:** The following lines of evidence are used to assess the pathogenic nature of an alteration: presence in affected and healthy populations, co-segregation information, functional studies, alteration type, conservation, *in silico* predictions, and presence in a functional protein domain. The absence of a particular line of evidence implies that no information was found or it does not apply for that alteration type (eg. *in silico* for truncating alterations).

**Analytical range:** Approximately 75% of the bases are expected to have quality scores of Q30 or higher, which translates to an expected base-calling error rate of 1:1000, or an expected base-calling accuracy of 99.9%. Additionally, 90% and 95% of the exome will be covered at  $\geq 20x$  and  $\geq 10x$  respectively under current run conditions, generally sufficient for high quality heterozygous and homozygous variant calling for germline variants. For any given individual ~ 10% of the targeted exome is not sequenced well enough to make a confident call. Each individual may have slightly different coverage yield distributions within the exome. Exons plus at least 2 bases into the 5' and 3' ends of all the introns are analyzed and reported. The mean depth of coverage for targeted mitochondrial bases is greater than 1,000X.