Supplementary Information

Loss of symmetric cell division of apical neural progenitors drives *DENND5A*-related developmental and epileptic encephalopathy

Emily Banks[1], Vincent Francis[1], Sheng-Jia Lin[2], Fares Kharfallah[1], Vladimir Fonov[1], Maxime Levesque[1], Chanshuai Han[1], Gopinath Kulasekaran[1], Marius Tuznik[1], Armin Bayati[1], Reem Al-Khater[3], Fowzan S. Alkuraya[4], Loukas Argyriou[5], Meisam Babaei[6], Melanie Bahlo[7], Behnoosh Bakhshoodeh[8], Eileen Barr[9], Lauren Bartik[10,11], Mahmoud Bassiony[12], Miriam Bertrand[13], Dominique Braun[14], Rebecca Buchert[13], Mauro Budetta[15], Maxime Cadieux-Dion[16], Daniel G. Calame[17-19], Heidi Cope[20], Donna Cushing[21], Stephanie Efthymiou[22], Marwa Abd Elmaksoud[24], Huda G. El Said[24], Tawfiq Froukh[25], Harinder K. Gill[26], Joseph G. Gleeson[27,28], Laura Gogoll[14], Elaine S.-Y. Goh[21], Vykuntaraju K. Gowda[29], Tobias B. Haack[13], Mais O. Hashem[4], Stefan Hauser[30,31], Trevor L. Hoffman[32], Jacob S. Hogue[33], Akimoto Hosokawa[34], Henry Houlden[22], Kevin Huang[2], Stephanie Huynh[26], Ehsan G. Karimiani[35,36], Silke Kaulfuß[5], G. Christoph Korenke[37], Amy Kritzer[38], Hane Lee[39], James R. Lupski[17-19,40], Elysa J. Marco[41], Kirsty McWalter[42], Arakel Minassian[43], Berge A. Minassian[44], David Murphy[23], Juanita Neira-Fresneda[9], Hope Northrup[45], Denis M. Nyaga[34], Barbara Oehl-Jaschkowitz[46], Matthew Osmond[47], Richard Person[42], Davut Pehlivan[17-19], Cassidy Petree[2], Lynette G. Sadleir[34], Carol Saunders[10,16,48], Ludger Schoels[30,31], Vandana Shashi[20], Rebecca C. Spillmann[20], Varunvenkat M. Srinivasan[29], Paria N. Torbati[36], Tulay Tos[49], Undiagnosed Diseases Network[†], Maha S. Zaki[50], Dihong Zhou[10,11], Christiane Zweier[14], Jean-François Trempe[51], Thomas M. Durcan[1], Ziv Gan-Or[1,52], Massimo Avoli[1], Cesar Alves[53], Gaurav K. Varshney[2], Reza Maroofian[22], David A. Rudko[1,54,55], Peter S. McPherson[1].

[1] Department of Neurology and Neurosurgery, the Neuro, McGill University, Montréal, QC H3A 2B4, Canada

[2] Genes & Human Disease Research Program, Oklahoma Medical Research Foundation, Oklahoma City, OK, 73104, USA

[3] Johns Hopkins Aramco Healthcare, Dhahran 34465, Saudi Arabia

[4] Department of Translational Genomics, Center for Genomic Medicine, King Faisal Specialist Hospital and Research Center, Riyadh 11211, Saudi Arabia

[5] Institute of Human Genetics, University Medical Center, Göttingen 37073, Germany

[6] Department of Pediatrics, North Khorasan University of Medical Sciences, Bojnurd, Iran

[7] Walter and Eliza Hall Institute for Medical Research, Parkville Victoria 3052, Australia

[8] Mashhad University of Medical Sciences, Mashhad, Iran

[9] Emory University, Department of Human Genetics, Atlanta, GA 30322, USA

[10] University of Missouri-Kansas City, School of Medicine, Kansas City, MO 64108, USA

[11] Department of Pediatrics, Division of Clinical Genetics, Children's Mercy Hospital, Kansas City, MO 64108, USA

[12] Faculty of Medicine, Alexandria University, Alexandria, Egypt

[13] Institute of Medical Genetics and Applied Genomics, University of Tübingen, 72076 Tübingen, Germany

[14] Department of Human Genetics, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

[15] Paediatric and Child Neurology Unit, Cava de' Tirreni AOU S. Giovanni di Dio e Ruggiero d'Aragona Hospital, Salerno, Italy

[16] Department of Pathology and Laboratory Medicine, Children's Mercy Hospital, Kansas City, MO 64108, USA

[17] Department of Pediatrics, Baylor College of Medicine, Houston, TX, USA

[18] Texas Children's Hospital, Houston, TX, USA

[19] Department of Molecular and Human Genetics, Baylor College of Medicine, Houston, TX, USA

[20] Division of Medical Genetics, Department of Pediatrics, Duke University Medical Center, Durham, NC 27710, USA

[21] Laboratory Medicine and Genetics, Trillium Health Partners, Mississauga, ON L5M 2N1, Canada

[22] Department of Neuromuscular Diseases, University College London (UCL) Queen Square Institute of Neurology, London, WC1N 3BG, UK

[23] Department of Clinical and Movement Neurosciences, University College London (UCL) Queen Square Institute of Neurology, London WC1N 3BG, UK

[24] Neurology Unit, Department of Pediatrics, Faculty of Medicine, University of Alexandria, Alexandria, Egypt

[25] Department of Biotechnology and Genetic Engineering, Philadelphia University, Amman 19392, Jordan

[26] Provincial Medical Genetics Program at BC Women's Health Centre, Vancouver, BC V6H 3N1, Canada

[27] Department of Neurosciences, University of California San Diego, La Jolla, CA, USA

[28] Rady Children's Institute for Genomic Medicine, San Diego, CA, USA

[29] Department of Pediatric Neurology, Indira Gandhi Institute of Child Health, Bangalore, India

[30] Center for Neurology and Hertie Institute for Clinical Brain Research, University Tübingen, Tübingen 72076, Germany

[31] German Center of Neurodegenerative Diseases (DZNE), Tübingen 72076, Germany

[32] Southern California Kaiser Permanente Medical Group, Department of Regional Genetics, Anaheim, CA 92806, USA

[33] Madigan Army Medical Center, Tacoma, WA 98431, USA

[34] Department of Paediatrics and Child Health, University of Otago, Wellington, 6242, New Zealand

[35] Molecular and Clinical Sciences Institute, St. George's, University of London, Cranmer Terrace, London SW17 0RE, UK

[36] Department of Medical Genetics, Next Generation Genetic Polyclinic, Mashhad, Iran

[37] Department of Neuropediatrics, University Children's Hospital, Klinikum Oldenburg, Oldenburg 26133, Germany

[38] Division of Genetics and Genomics, Boston Children's Hospital, Boston, MA 02115, USA

[39] 3billion, Inc, Seoul, South Korea

[40] Human Genome Sequencing Center, Baylor College of Medicine, Houston, TX, USA

[41] Cortica Healthcare, San Rafael, CA 94903, USA

[42] GeneDx, Gaithersburg, MD 20877, USA

[43] Centre for Applied Genomics, Genetics, and Genome Biology, Hospital for Sick Children, Toronto, ON M5G 0A4, Canada

[44] UT Southwestern Medical Center, Departments of Pediatrics and Neurology, Dallas, TX 75390, USA

[45] Department of Pediatrics, McGovern Medical School at the University of Texas Health Science Center at Houston (UTHealth) and Children's Memorial Hermann Hospital, Houston, TX 77030, USA

[46] BIOSCIENTIA-MVZ-Labor-Saar-Practice of Human Genetics, Homburg (Saar), Germany

[47] Children's Hospital of Eastern Ontario Research Institute, University of Ottawa, Ottawa K1H 8L1, Canada

[48] Center for Pediatric Genomic Medicine Children's Mercy - Kansas City, Missouri, USA

[49] University of Health Sciences, Zubeyde Hanim Research and Training Hospital of Women's Health and Diseases, Department of Medical Genetics, Ankara 06080, Turkey

[50] Human Genetics and Genome Research Institute, Clinical Genetics Department, National Research Centre, Cairo, Egypt

[51] Department of Pharmacology & Therapeutics and Centre de Recherche en Biologie Structurale, McGill University, Montréal, QC H3G 1Y6, Canada

[52] Department of Human Genetics, McGill University, Montréal, QC H3A 2B4, Canada

[53] Division of Neuroradiology, Boston Children's Hospital, Harvard Medical School, Boston, MA 02115, USA

[54] McConnell Brain Imaging Centre, the Neuro, Montréal, QC H3A 2B4, Canada

[55] Department of Biomedical Engineering, McGill University, Montréal, QC H3A 2B4, Canada

Email: peter.mcpherson@mcgill.ca (P. S. M.)

Table of Contents

Page

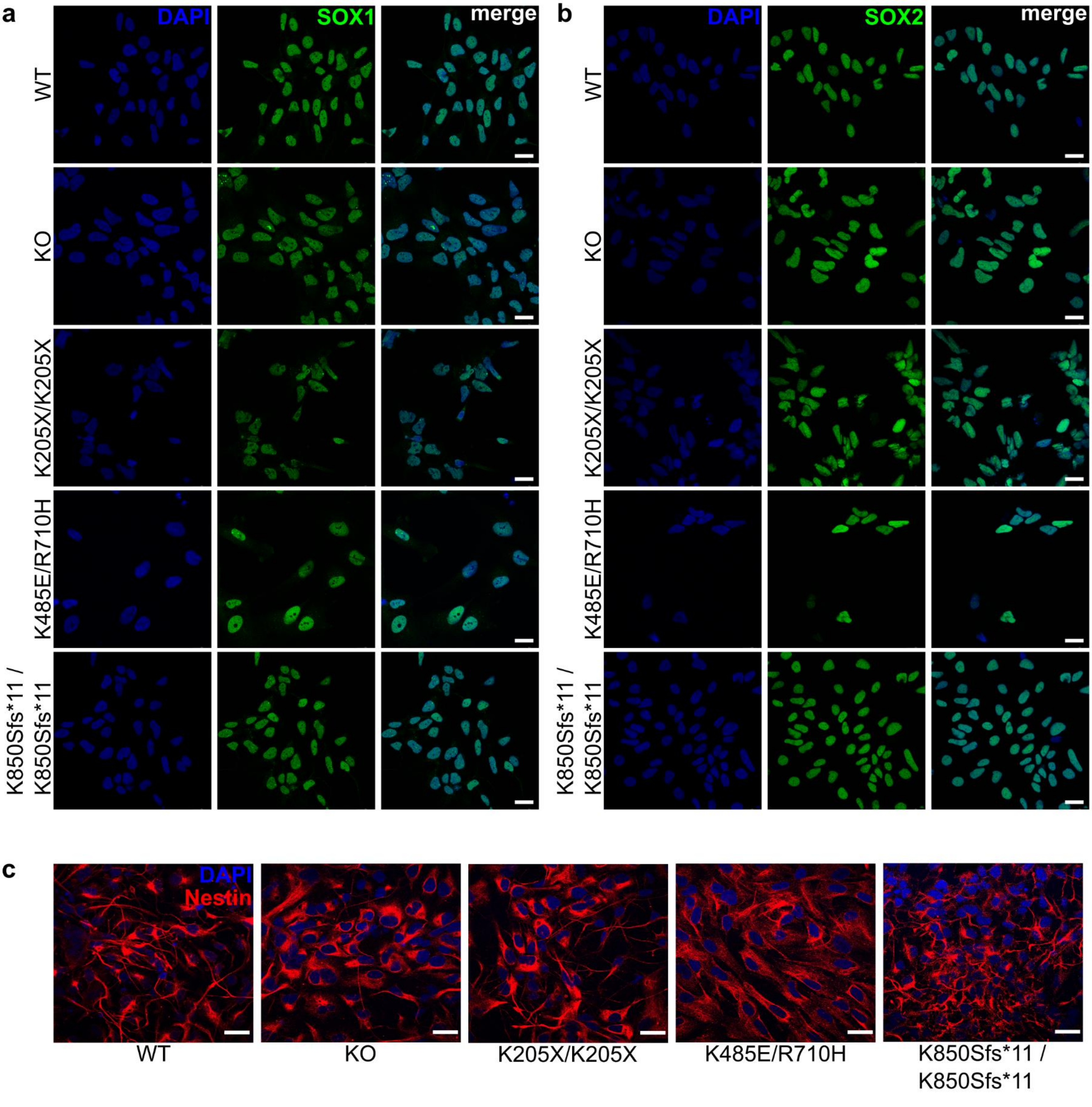
1. Supplementary Figures

Supplementary Figure 1……………………………………………………6-7
Supplementary Figure 2……………………………………………………8-9
Supplementary Figure 3…………………………………………………10-11
Supplementary Figure 4…………………………………………………12-13
Supplementary Figure 5…………………………………………………14-15

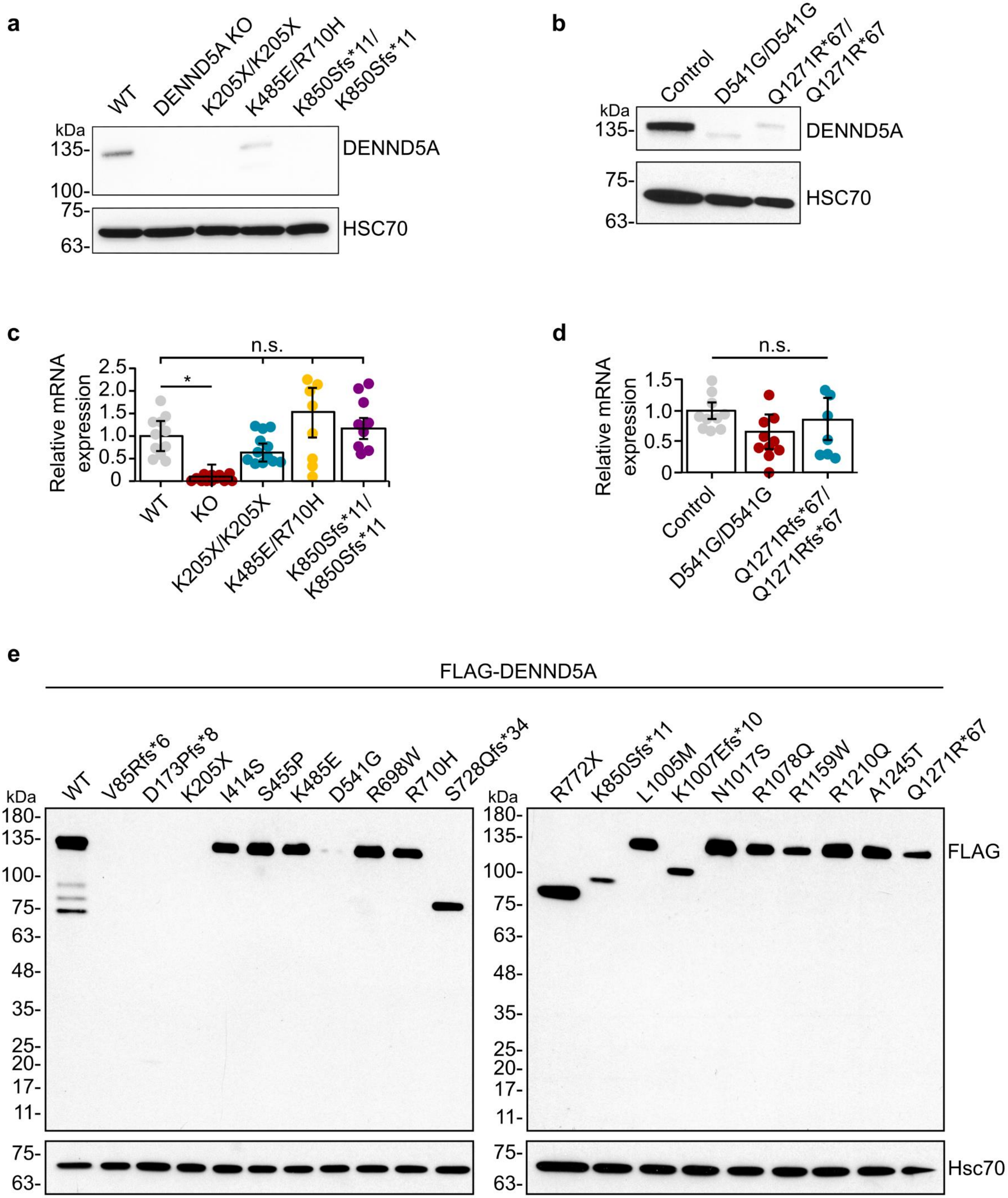
2. Supplementary Methods

Motor skills scoring system……………………………………………..16
Neurological phenotype scoring system………………………………..17
Communication skills scoring system…………………………………18
Comorbidities scoring system…………………………………………...19
3. Supplementary Note..……………………………………………………20-21

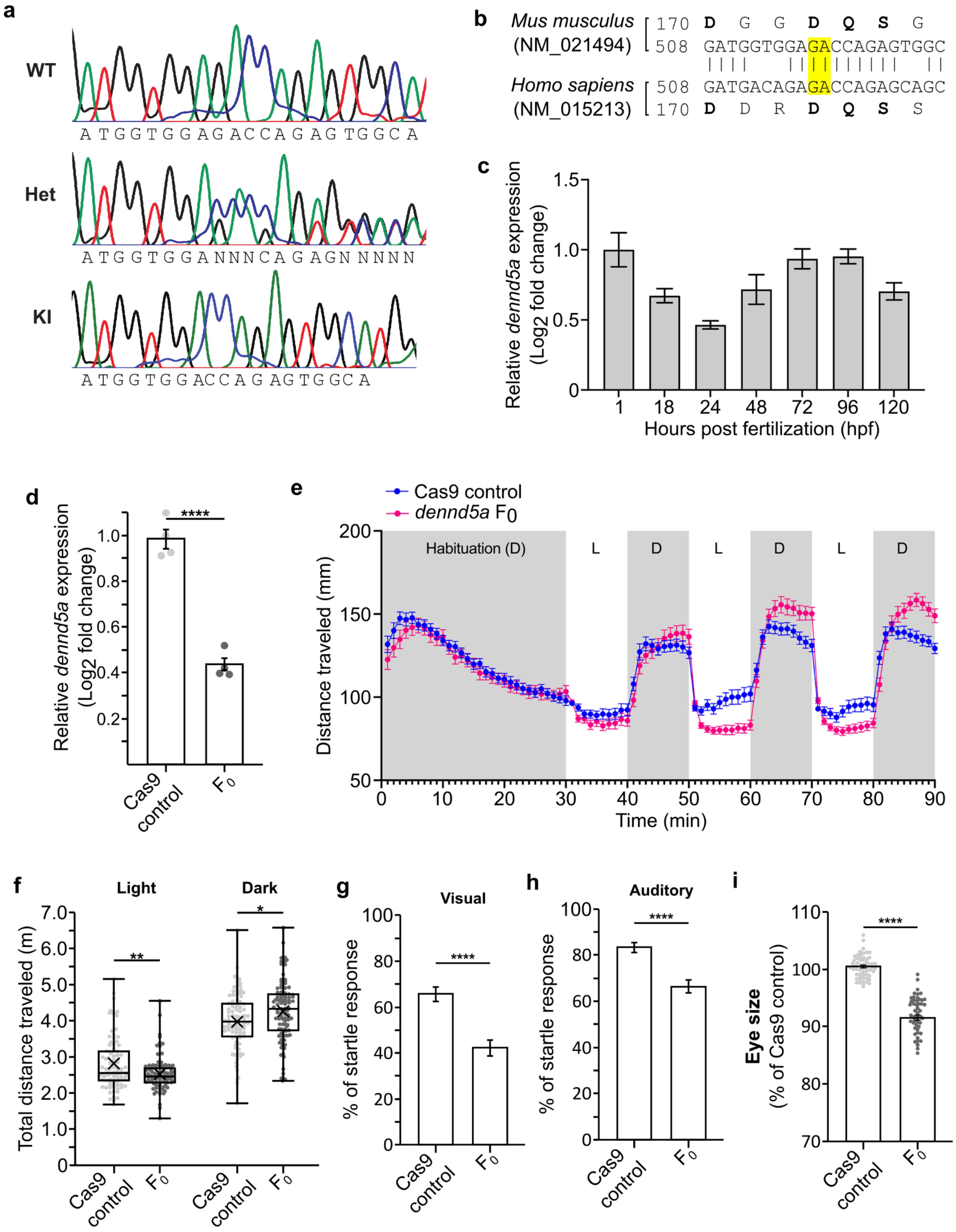
1. Supplementary Figures



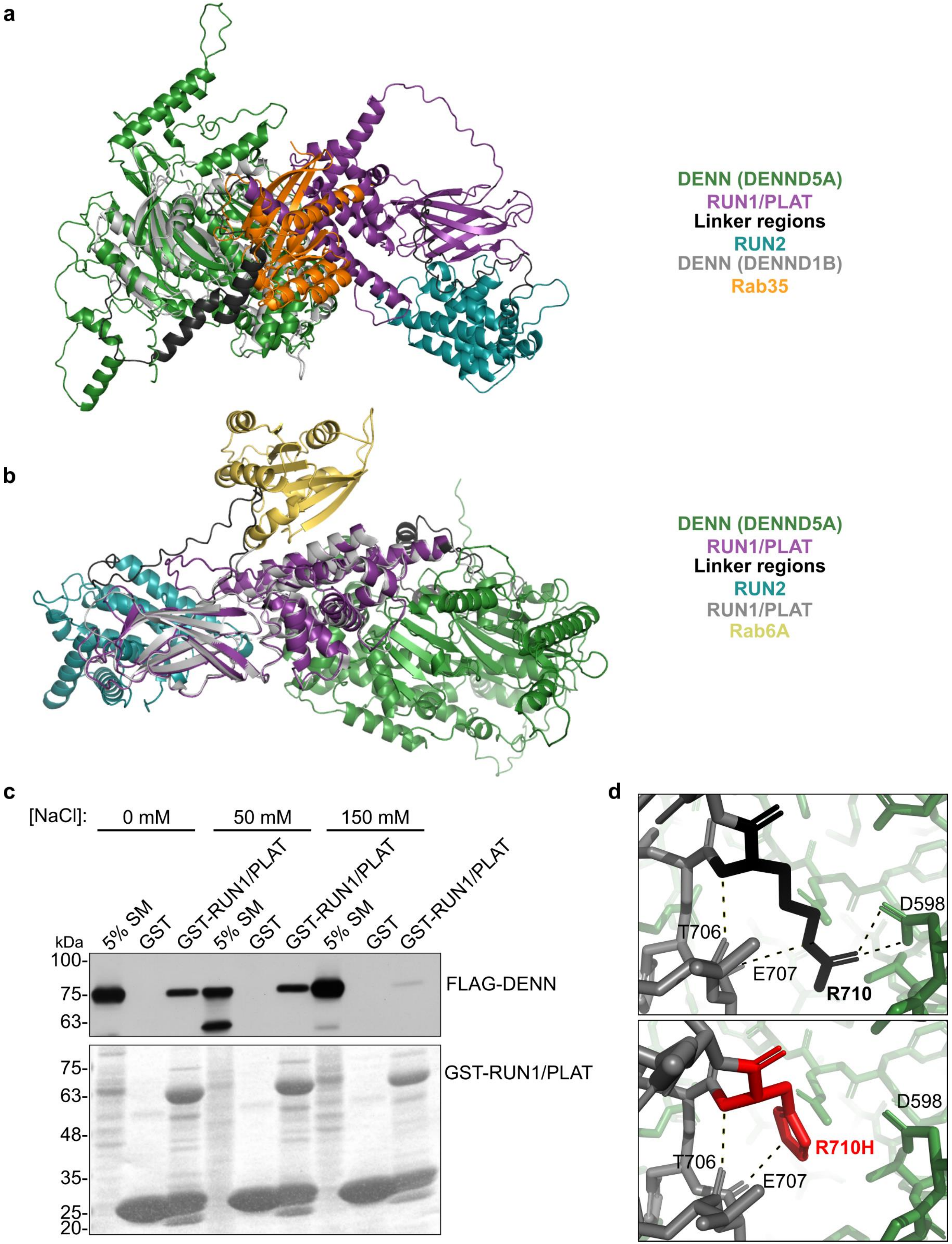
Supplementary Figure 1: All established NPC lines express neural progenitor-specific markers. hiPSCs differentiated into NPCs express **a,** SOX1 (green); **b,** SOX2 (green), and **c,** Nestin (red). Blue = DAPI. Scale bars = 20 μm. Results were reproduced each time NPCs were generated, for a total of 8 independent experiments.


a
WT
DENND5A KO
K205X/K205X
K485E/R710H
K850Sfs*11/
K850Sfs*11
kDa
135-
100-
75-
63-
DENND5A
HSC70
b
Control
D541G/D541G
Q1271R*67/
Q1271R*67
kDa
135-
75-
63-
DENND5A
HSC70
c
Relative mRNA expression
2.5
2.0
1.5
1.0
0.5
0
n.s.
*
WT
KO
K205X/K205X
K485E/R710H
K850Sfs*11/
K850Sfs*11
d
Relative mRNA expression
1.5
1.0
0.5
0
n.s.
Control
D541G/D541G
Q1271Rfs*67/
Q1271Rfs*67
e
FLAG-DENND5A
WT
V85Rfs*6
D173Pfs*8
K205X
I414S
S455P
K485E
D541G
R698W
R710H
S728Qfs*34
R772X
K850Sfs*11
L1005M
K1007Efs*10
N1017S
R1078Q
R1159W
R1210Q
A1245T
Q1271R*67
kDa
180-
135-
100-
75-
63-
48-
35-
25-
20-
17-
11-
75-
63-
FLAG
Hsc70

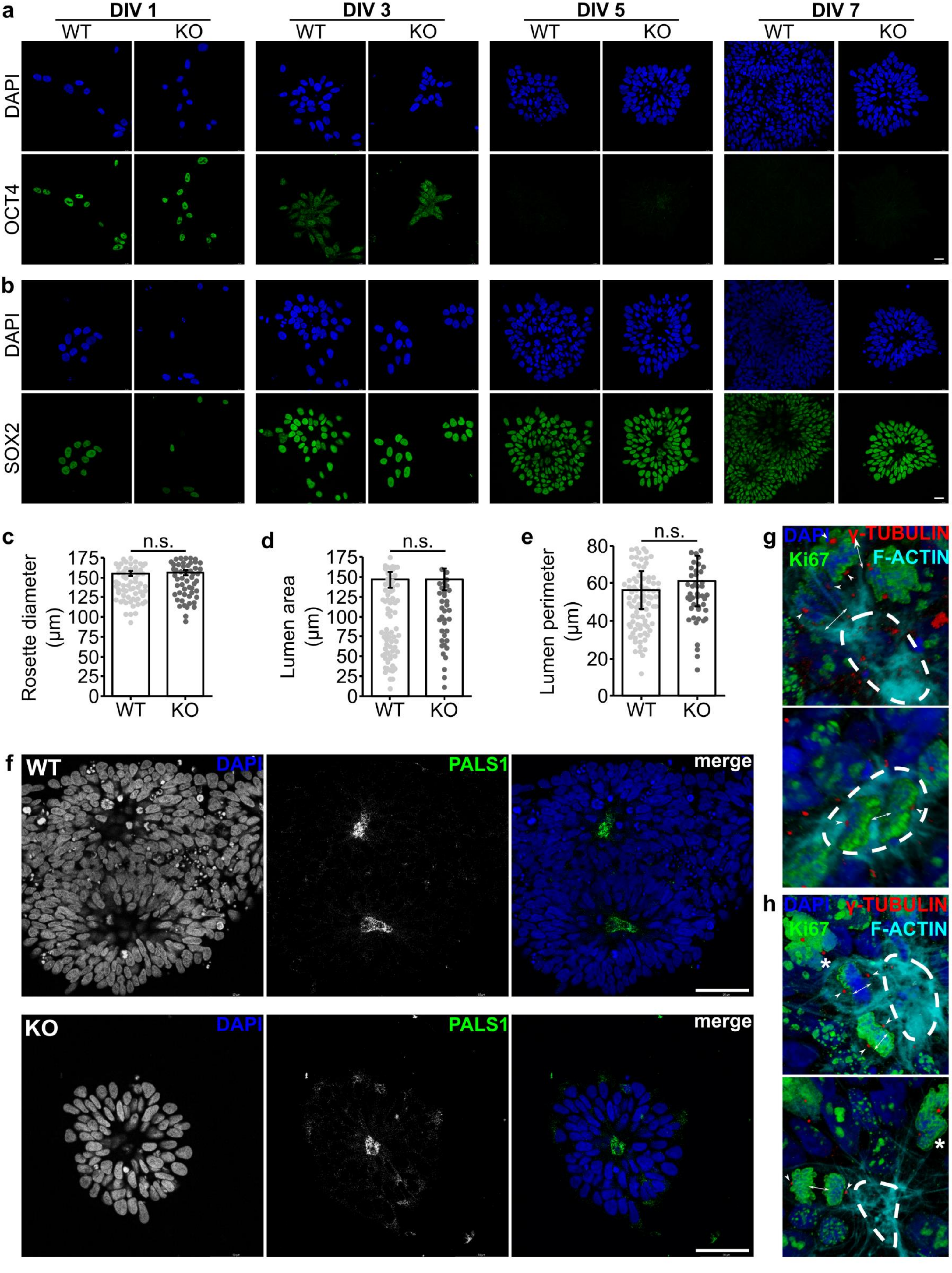
Supplementary Figure 2: DENND5A expression varies depending on the variant. DENND5A protein expression in **a,** NPCs and **b,** lymphoblasts. Results were reproduced in 3 independent experiments. **c,** Relative *DENND5A* mRNA expression measured by RT-qPCR in NPCs. Measurements were made with 4 technical replicates on $n = 3$ independent samples. Data are mean ± SEM analyzed via Kruskal-Wallis tests with Bonferroni-corrected pairwise comparisons ($H(4) = 21.75$, $p = .0002$). **d,** Relative *DENND5A* mRNA expression measured by RT-qPCR in lymphoblasts. Measurements were made with 4 technical replicates on $n = 3$ independent samples. Data are mean ± SEM analyzed via Kruskal-Wallis tests with Bonferroni-corrected pairwise comparisons ($H(2) = 2.451$, $p = .294$). **e,** Overexpression of FLAG-DENND5A mutagenized to contain several variants influences protein stability and expression levels in HEK293T. Results were reproduced in 3 independent experiments. Source data for each panel are provided as a Source Data file.


a
WT
A T G G T G G A G A C C A G A G T G G C A
Het
A T G G T G G A N N N C A G A G N N N N N
KI
A T G G T G G A C C A G A G T G G C A
b
Mus musculus (NM_021494)
170 D G G D Q S G
508 GATGGTGGAGACCAGAGTGGC
Homo sapiens (NM_015213)
508 GATGACAGAGACCAGAGCAGC
170 D D R D Q S S
c
Relative dennd5a expression (Log2 fold change)
1.5
1.0
0.5
0
1
18
24
48
72
96
120
Hours post fertilization (hpf)
d
Relative dennd5a expression (Log2 fold change)
1.0
0.8
0.6
0.4
0.2
****
Cas9 control
F0
e
Cas9 control
dennd5a F0
Distance traveled (mm)
200
150
100
50
Habituation (D)
L
D
L
D
L
D
0
10
20
30
40
50
60
70
80
90
Time (min)
f
Light
Dark
Total distance traveled (m)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
**
*
Cas9 control
F0
Cas9 control
F0
g
Visual
% of startle response
100
80
60
40
20
0
****
Cas9 control
F0
h
Auditory
% of startle response
100
80
60
40
20
0
****
Cas9 control
F0
i
Eye size (% of Cas9 control)
110
100
90
80
70
****
Cas9 control
F0

Supplementary Figure 3: Features of *DENND5A* transgenic animals make them valid models to study *DENND5A*-related DEE. a, Sample chromatograms demonstrating DENND5A DNA sequences in WT, heterozygous (Het), and knock-in (KI) mice. **b,** DNA and amino acid sequence alignment between human and mouse DENND5A sequences. Highlighted base pairs indicate bases deleted using CRISPR/Cas9. **c,** The temporal expression of zebrafish *dennd5a* mRNA by RT-qPCR at different developmental stages from 3 experiments performed with technical triplicates. Expression levels were normalized to the *18S* housekeeping gene and compared to 1 hpf embryos. Data are mean ± SD. **d,** Expression of *dennd5a* mRNA in Cas9 controls and *dennd5a* F_0 knockouts detected by RT-qPCR at 5 dpf. 4 experiments were performed with technical triplicates. Data are mean ± SEM analyzed via two-tailed student's *t*-test ($t(6) = 10.706$, $p = .000039$). **e,** Locomotor activities of zebrafish larvae at 5 dpf with $n = 96$ larvae for each group. Data are mean ± SEM. D = Dark period, L = light period. **f,** Quantification of distance traveled by each larva during the cycles of light or dark periods, analyzed via two-tailed Mann-Whitney U test (light; $Z = -2.81$, $p = .005$) and two-tailed student's *t*-test (dark; $t(190) = -2.438$, $p = .016$) with $n = 96$ larvae for each group. Each dot represents one larva. **g,** Visual startle response in $n = 143$ larvae at 6 dpf. Data are mean ± SEM analyzed via two-tailed Mann-Whitney U test ($Z = -4.957$, $p = 7.15 \times 10^{-7}$). **h,** Acoustic evoked behavioral response in $n = 134$ larvae at 6 dpf. Data are mean ± SEM analyzed via two-tailed Mann-Whitney U test ($Z = -4.947$, $p = 7.53 \times 10^{-7}$). **i,** Quantification of eye size in $n = 60$ larvae. Each dot represents one larva. Data are mean ± SEM analyzed via two-tailed Welch's *t*-test ($t(96.016) = 17.831$, $p = 3.16 \times 10^{-32}$). Source data for (**d-i**) are provided as a Source Data file.


a
DENN (DENND5A)
RUN1/PLAT
Linker regions
RUN2
DENN (DENND1B)
Rab35
b
DENN (DENND5A)
RUN1/PLAT
Linker regions
RUN2
RUN1/PLAT
Rab6A
c
[NaCl]:
0 mM
50 mM
150 mM
5% SM
GST
GST-RUN1/PLAT
5% SM
GST
GST-RUN1/PLAT
5% SM
GST
GST-RUN1/PLAT
kDa
100
75
63
FLAG-DENN
75
63
48
35
25
20
GST-RUN1/PLAT
d
D598
T706
E707
R710
D598
R710H
T706
E707

Supplementary Figure 4: Analysis of the predicted DENND5A structure indicates intramolecular interactions may regulate other protein-protein interactions. a, Structural alignment between the predicted DENND5A structure and PDB:3TW8 (gray, yellow) **b,** Structural alignment between the predicted DENND5A structure and PDB:3CWZ (gray, yellow) **c,** Pulldown experiment showing binding capacity between GST-RUN1/PLAT and FLAG-DENN domains of DENND5A under varying NaCl concentrations. Results were reproduced in 2 independent experiments. Uncropped blots are provided as a Source Data file. **d,** The R710H variant found in the cohort and within the region that interacts with PALS1/MUPP1 results in the removal of two hydrogen bonds with D598 of the DENN domain. Dotted lines indicate hydrogen bonds.


a
DIV 1
WT
KO
DIV 3
WT
KO
DIV 5
WT
KO
DIV 7
WT
KO
DAPI
OCT4
b
DAPI
SOX2
c
n.s.
Rosette diameter (µm)
175
150
125
100
75
50
25
0
WT
KO
d
n.s.
Lumen area (µm)
175
150
125
100
75
50
25
0
WT
KO
e
n.s.
Lumen perimeter (µm)
80
60
40
20
0
WT
KO
g
DAPI
γ-TUBULIN
Ki67
F-ACTIN
h
DAPI
γ-TUBULIN
Ki67
F-ACTIN
*
*
f
WT
DAPI
PALS1
merge
KO
DAPI
PALS1
merge

Supplementary Figure 5: WT and *DENND5A* KO neural rosettes differ in density and cell division properties, but not in marker expression or size. Expression of **a,** OCT4 and **b,** SOX2 during neural rosette development. Blue = DAPI, green = OCT4/SOX2. Scale bars = 20 µm. Results were reproduced in 2 independent experiments **c,** Average diameter of individual rosettes. *n* = 159 rosettes were analyzed from 2 independent experiments. Data are mean ± SEM and analyzed via two-tailed student's *t*-test (*t*(157) = -0.182, *p* = .856). **d,** Average lumen area of rosettes. *n* = 294 rosettes were analyzed from 2 independent experiments. Data are mean ± SEM and analyzed via two-tailed Mann-Whitney U test (*Z* = -0.091, *p* = .928). **e,** Average lumen perimeter of rosettes. *n* = 294 rosettes were analyzed from 2 independent experiments. Data are mean ± SEM and analyzed via two-tailed Mann-Whitney U test (*Z* = -0.917, *p* =.359). **f,** PALS1 staining (green) shows an apical localization in both WT and KO neural rosettes. Scale bars = 50 µm. Results were reproduced in 2 independent experiments. **g,** 3D-rendered images of apical progenitors of WT neural rosettes. Blue = DAPI, green = Ki67, red = -tubulin, cyan = F-actin. Arrowheads indicate centrosomes, arrows indicate orientation of cell divisions, dotted lines indicate the lumen. Results were reproduced in 2 independent experiments. **h,** 3D-rendered images of apical progenitors of KO neural rosettes. Blue = DAPI, green = Ki67, red = -tubulin, cyan = F-actin. Arrowheads indicate centrosomes, arrows indicate orientation of cell divisions, asterisks indicate abnormally condensed chromatin, dotted lines indicate the lumen. Results were reproduced in 2 independent experiments. Source data for (**c-e**) are provided as a Source Data file.

2. Supplementary Methods

Motor skills scoring system

Item	**Scoring**
Able to reach/grasp objects	**+1** if positive
Able to roll over	**+1** if positive
Able to sit with support	**+1** if positive OR is able to sit without support
Able to sit without support	**+1** if positive
Able to stand with support	**+1** if positive OR is able to stand without support
Able to stand without support	**+1** if positive
Able to walk with support	**+1** if positive OR is able to walk without support
Able to walk without support	**+1** if positive
Muscle tone or spasm problems	**+1** if negative for all (hyperreflexia, spastic tetraplegia, clonus, and current hyper/hypotonia)
Motor regression after seizure	**+1** if negative AND could perform one of the above behaviors in past
TOTAL	**10**

Scoring system used for quantifying motor abilities. A low score reflects minimal motor abilities, a high score indicates a high degree of motor capabilities. If a child's ability to do a skill is unknown, it is counted as positive.

Neurological phenotype scoring system

Item	**Scoring**
Seizures	**+1** if positive
Reduced volume (cerebral or supratentorial parenchymal volume loss)	**+1** if positive
Cerebellum abnormalities (hypoplastic vermis, reduced volume)	**+1** if positive
Thalamus abnormalities (thalami fusion or reduced volume, massa intermedia prominence)	**+1** if positive
Basal ganglia abnormalities (dysplasia or reduced volume)	**+1** if positive
Calcifications	**+1** if positive
Ventricle or CSF abnormalities	**+1** if positive
White matter abnormalities (reduced corpus callosum or other white matter tract volume, delayed myelination or hyperintensity)	**+1** if positive
Hemorrhage or ischemic event	**+1** if positive
Cortical visual impairment	**+1** if positive
TOTAL	**10**

Scoring system used for quantifying neurological phenotypes. A low score corresponds to few neurological abnormalities, a high score indicates many neurological abnormalities.

Communication skills scoring system

Item	**Scoring**
Smiles	**+1** if positive
Eye contact	**+1** if positive
Points at objects/people	**+1** if positive
Babbles	**+1** if positive OR if speaks in at least single words
Uses PECS board	**+1** if positive OR if speaks in at least single words
Speaks in single words	**+1** if positive OR if speaks in at least short phrases
Speaks in short phrases	**+1** if positive OR if speaks in sentences
Speaks in sentences	**+1** if positive
Language regression after seizure	**+1** if negative AND if had language skills in past
Receptive language delay	**+1** if negative AND at least babbles
TOTAL	**10**

Scoring system used for quantifying communication abilities. A low score reflects minimal communication ability, a high score reflects more advanced language and communication abilities.

Comorbidities scoring system

Item	**Scoring**
Chronic constipation	**+1** if positive
Autism spectrum disorder (formally diagnosed or clinically suspected)	**+1** if positive
Psychiatric disorders (ADHD, anxiety)	**+1** if positive
Behavioral disorders or abnormalities (self-injury, poor sleep, hyperphagia)	**+1** if positive
Lung or breathing abnormalities (restrictive lung disease, asthma)	**+1** if positive
Cardiac abnormalities (ventricular/atrial septal defects, arrythmia)	**+1** if positive
Blindness	**+1** if positive
Obesity	**+1** if positive
Bone abnormalities (low density or osteoporosis, scoliosis, vertebral fusion, posterior fossa abnormality)	**+1** if positive
GERD	**+1** if positive
TOTAL	**10**

Scoring system used for quantifying neurological phenotypes. A low score corresponds to few comorbidities, a high score indicates many comorbidities.

3. Supplementary Note

Members of the Undiagnosed Diseases Network include:

Maria T. Acosta, Margaret Adam, David R. Adams, Pankaj B. Agrawal, Mercedes E. Alejandro, Justin Alvey, Laura Amendola, Ashley Andrews, Euan A. Ashley, Mahshid S. Azamian, Carlos A. Bacino, Guney Bademci, Eva Baker, Ashok Balasubramanyam, Dustin Baldridge, Jim Bale, Michael Bamshad, Deborah Barbouth, Gabriel F. Batzli, Pinar Bayrak-Toydemir, Anita Beck, Alan H. Beggs, Edward Behrens, Gill Bejerano, Jimmy Bennet, Beverly Berg-Rood, Raphael Bernier, Jonathan A. Bernstein, Gerard T. Berry, Anna Bican, Stephanie Bivona, Elizabeth Blue, John Bohnsack, Carsten Bonnenmann, Devon Bonner, Lorenzo Botto, Brenna Boyd, Lauren C. Briere, Elly Brokamp, Gabrielle Brown, Elizabeth A. Burke, Lindsay C. Burrage, Manish J. Butte, Peter Byers, William E. Byrd, John Carey, Olveen Carrasquillo, Ta Chen Peter Chang, Sirisak Chanprasert, Hsiao-Tuan Chao, Gary D. Clark, Terra R. Coakley, Laurel A. Cobban, Joy D. Cogan, F. Sessions Cole, Heather A. Colley, Cynthia M. Cooper, Heidi Cope, William J. Craigen, Andrew B. Crouse, Michael Cunningham, Precilla D'Souza, Hongzheng Dai, Surendra Dasari, Mariska Davids, Jyoti G. Dayal, Matthew Deardorff, Esteban C. Dell'Angelica, Shweta U. Dhar, Katrina Dipple, Daniel Doherty, Naghmeh Dorrani, Emilie D. Douine, David D. Draper, Laura Duncan, Dawn Earl, David J. Eckstein, Lisa T. Emrick, Christine M. Eng, Cecilia Esteves, Tyra Estwick, Marni Falk, Liliana Fernandez, Carlos Ferreira, Elizabeth L. Fieg, Paul G. Fisher, Brent L. Fogel, Irman Forghani, Laure Fresard, William A. Gahl, Ian Glass, Rena A. Godfrey, Katie Golden-Grant, Alica M. Goldman, David B. Goldstein, Alana Grajewski, Catherine A. Groden, Andrea L. Gropman, Irma Gutierrez, Sihoun Hahn, Rizwan Hamid, Neil A. Hanchard, Kelly Hassey, Nichole Hayes, Frances High, Anne Hing, Fuki M. Hisama, Ingrid A. Holm, Jason Hom, Martha Horike-Pyne, Alden Huang, Yong Huang, Rosario Isasi, Fariha Jamal, Gail P. Jarvik, Jeffrey Jarvik, Suman Jayadev, Jean M. Johnston, Lefkothea Karaviti, Emily G. Kelley, Jennifer Kennedy, Dana Kiley, Isaac S. Kohane, Jennefer N. Kohler, Deborah Krakow, Donna M. Krasnewich, Elijah Kravets, Susan Korrick, Mary Koziura, Joel B. Krier, Seema R. Lalani, Byron Lam, Christina Lam, Brendan C. Lanpher, Ian R. Lanza, C. Christopher Lau, Kimberly LeBlanc, Brendan H. Lee, Hane Lee, Roy Levitt, Richard A. Lewis, Sharyn A. Lincoln, Pengfei Liu, Xue Zhong Liu, Nicola Longo, Sandra K. Loo, Joseph Loscalzo, Richard L. Maas, Ellen F. Macnamara, Calum A. MacRae, Valerie V. Maduro, Marta M. Majcherska, May Christine V. Malicdan, Laura A. Mamounas, Teri A. Manolio, Rong Mao, Kenneth

Maravilla, Thomas C. Markello, Ronit Marom, Gabor Marth, Beth A. Martin, Martin G. Martin, Julian A. Martínez-Agosto, Shruti Marwaha, Jacob McCauley, Allyn McConkie-Rosell, Colleen E. McCormack, Alexa T. McCray, Elisabeth McGee, Heather Mefford, J. Lawrence Merritt, Matthew Might, Ghayda Mirzaa, Eva Morava-Kozicz, Paolo M. Moretti, Marie Morimoto, John J. Mulvihill, David R. Murdock, Mariko Nakano-Okuno, Avi Nath, Stan F. Nelson, John H. Newman, Sarah K. Nicholas, Deborah Nickerson, Donna Novacic, Devin Oglesbee, James P. Orengo, Laura Pace, Stephen Pak, J. Carl Pallais, Christina GS. Palmer, Jeanette C. Papp, Neil H. Parker, John A. Phillips III, Jennifer E. Posey, Lorraine Potocki, Barbara N. Pusey, Aaron Quinlan, Wendy Raskind, Archana N. Raja, Genecee Renteria, Chloe M. Reuter, Lynette Rives, Amy K. Robertson, Lance H. Rodan, Jill A. Rosenfeld, Natalie Rosenwasser, Robb K. Rowley, Maura Ruzhnikov, Ralph Sacco, Jacinda B. Sampson, Susan L. Samson, Mario Saporta, C. Ron Scott, Judy Schaechter, Timothy Schedl, Kelly Schoch, Daryl A. Scott, Prashant Sharma, Vandana Shashi, Jimann Shin, Rebecca Signer, Catherine H. Sillari, Edwin K. Silverman, Janet S. Sinsheimer, Kathy Sisco, Edward C. Smith, Kevin S. Smith, Emily Solem, Lilianna Solnica-Krezel, Rebecca C. Spillmann, Joan M. Stoler, Nicholas Stong, Jennifer A. Sullivan, Kathleen Sullivan, Angela Sun, Shirley Sutton, David A. Sweetser, Virginia Sybert, Holly K. Tabor, Cecelia P. Tamburro, Queenie K.-G. Tan, Mustafa Tekin, Fred Telischi, Willa Thorson, Cynthia J. Tifft, Camilo Toro, Alyssa A. Tran, Brianna M.