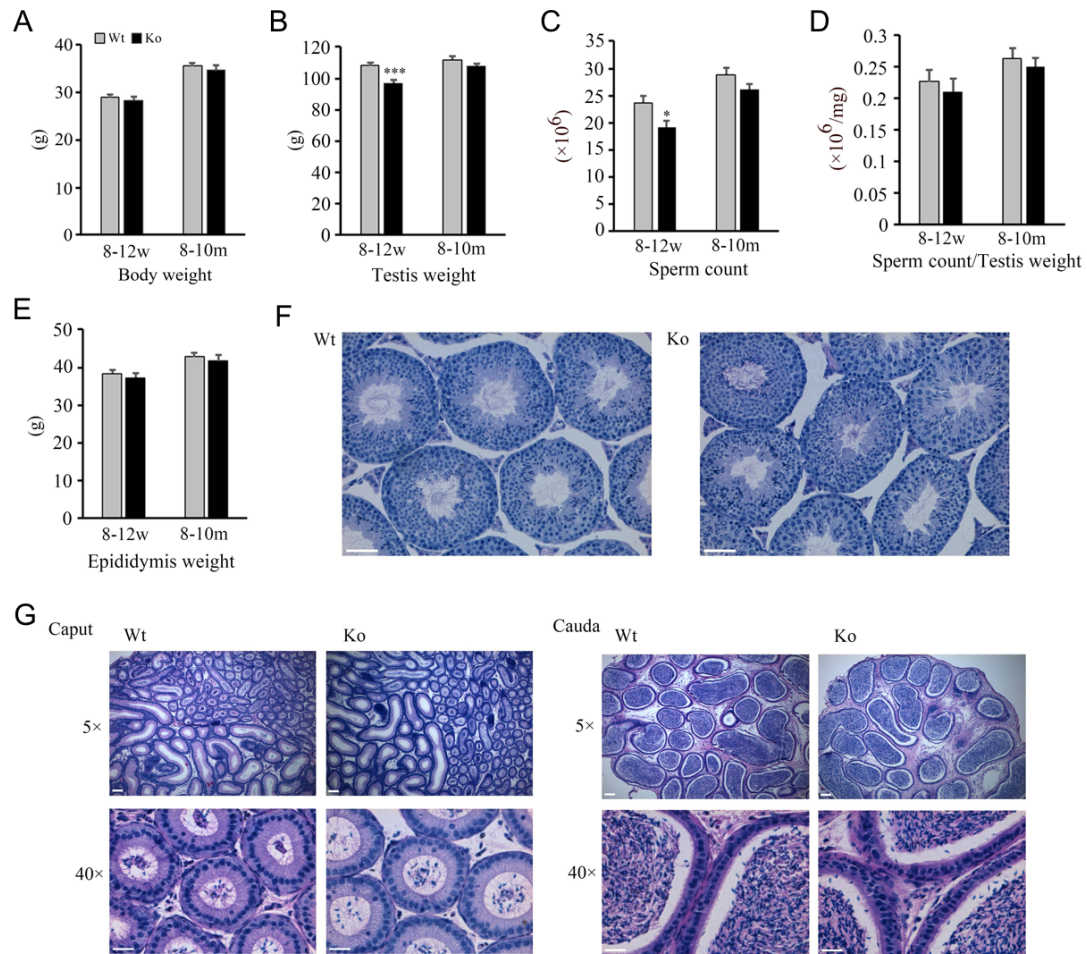


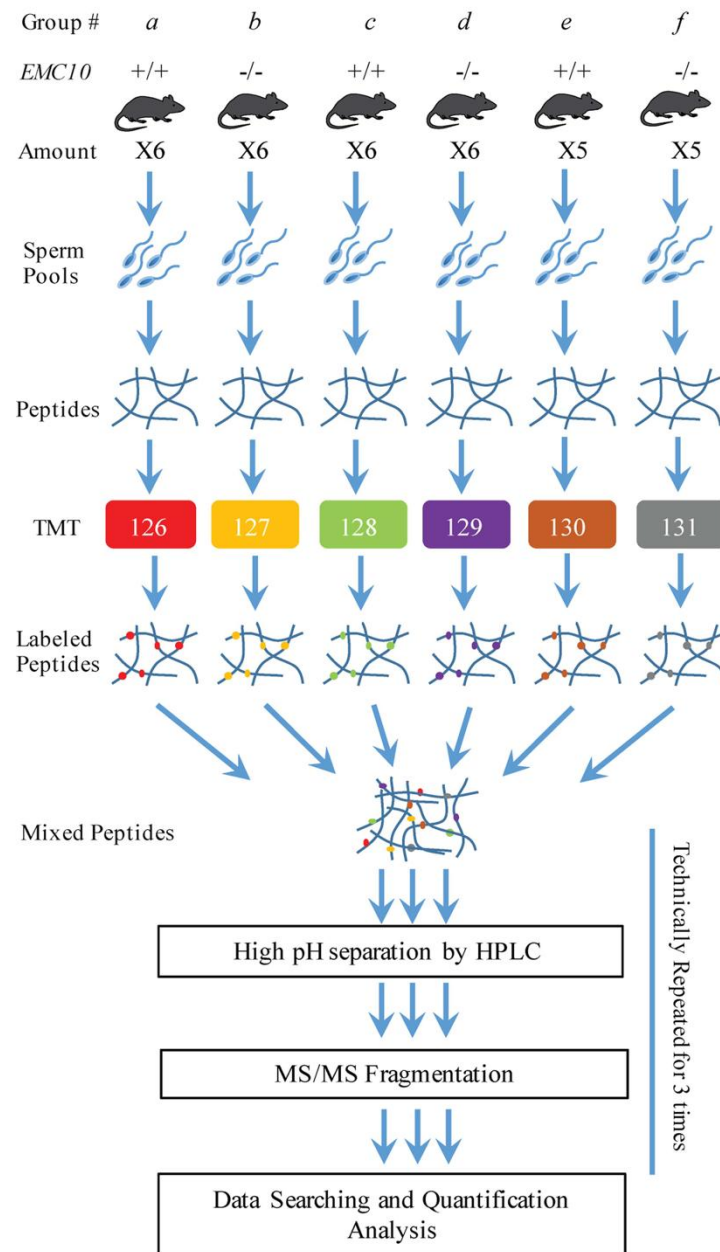
Supplementary Figure S1. Characterization of *Emc10* knockout mice.

(A) Targeting strategy to inactivate mouse *Emc10* allele by deleting exon 2. (B) The genotyping of gene disruption was confirmed by PCR. (C) EMC10 protein was totally deleted in homogenous mice by western blotting. EMC10 proteins were detectable by western blotting in the testis (Te) and epididymis (Ep) from wild type (+/+), heterozygous (+/-) mice but not homogenous (-/-) mice. β -actin was used as the protein loading control.



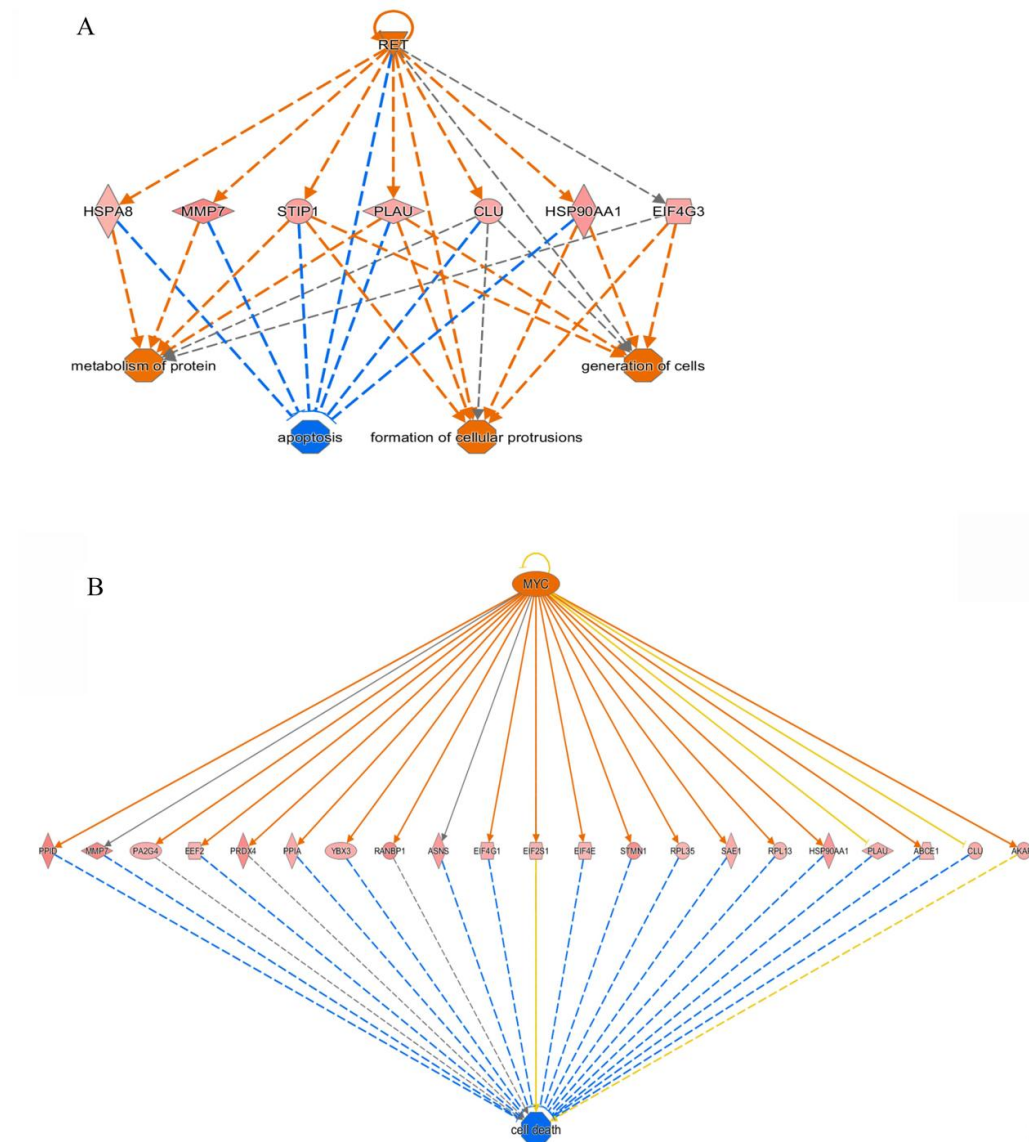
Supplementary Figure S2. Phenotypes associated with male fertility in wild type and *Emc10*-null mice.

The weights of whole body (A), testis (B) and epididymis (E) as well as sperm count (C) and the ratio of sperm count to testis weight (D) in *Emc10*^{+/+} and *Emc10*^{-/-} male mice were shown in histograms (n = 26 at 8-12 weeks; n = 16 at 8-10 months). Microscopic analysis of testis (F) and epididymis (G) from *Emc10*^{+/+} and *Emc10*^{-/-} male mice. The testes and epididymides were dissected and fixed in 4% paraformaldehyde, embedded in paraffin, and cut into 5 μ m sections. Tissues were stained with H&E and examined with 5 \times objective lens (scale bar, 100 μ m) and 40 \times objective lens (scale bar, 25 μ m). Data in bar graphs are presented as mean \pm SEM. **P* < 0.05; ****P* < 0.001.



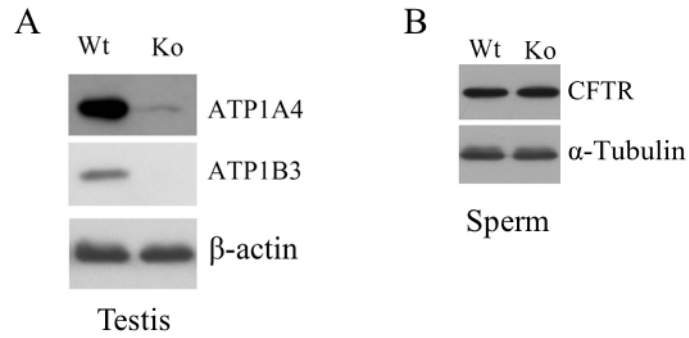
Supplementary Figure S3. Workflow chart of the Tandem Mass Tag (TMT) 6-plex labelling experiment.

Totally, 34 mice were divided into 6 groups including groups a, c, and e for wild type mice, and groups b, d, and f for *Emc10*^{-/-}. There were 6 mice in groups a, b, c, and d, and 5 in groups e and f, respectively. TMT- labelled peptides were mixed in equal proportions. Mixed peptides were analyzed by tandem mass spectrometry and repeated in triplicate.



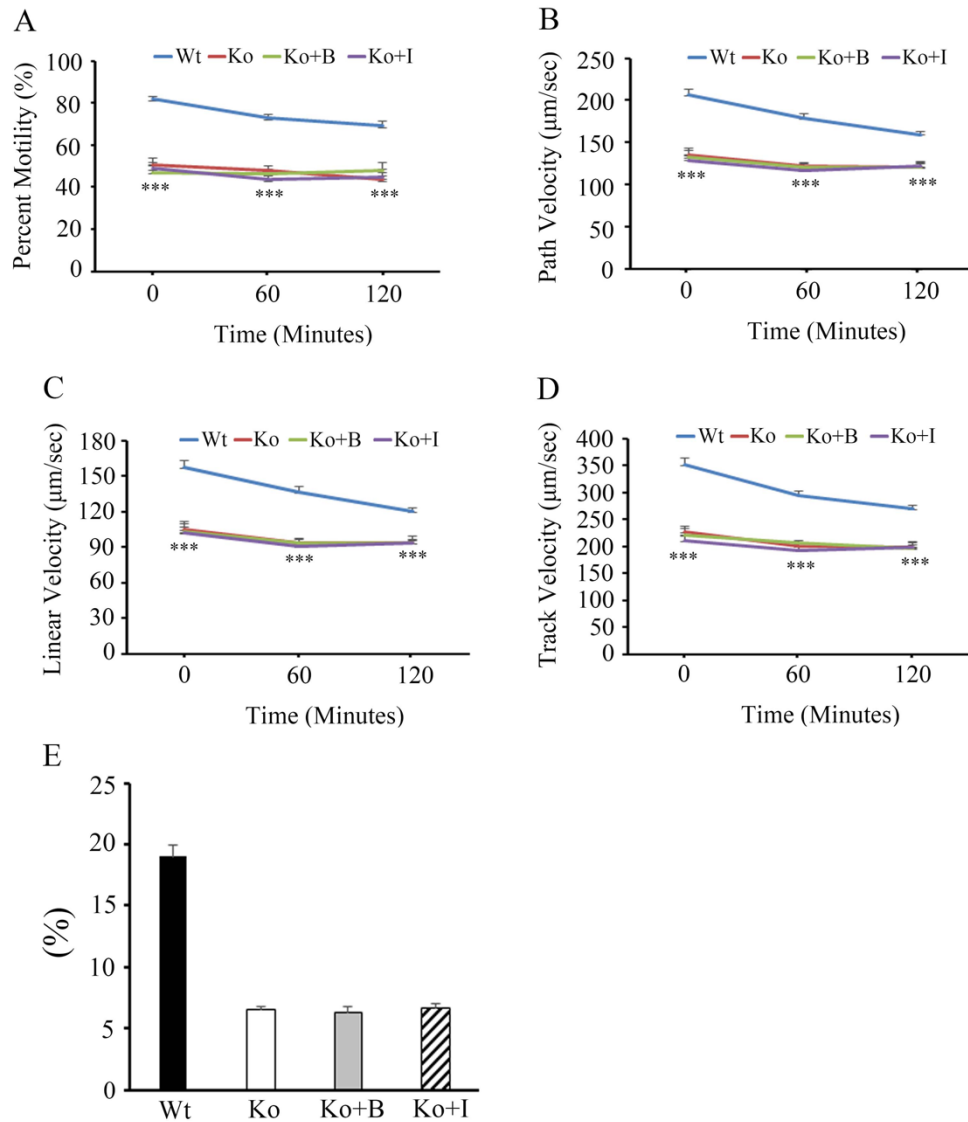
Supplementary Figure S4. The predicted work modules based on the 327 significantly altered proteins (> 1.5-fold) in the sperm of *Emc10*^{-/-} mice.

The predicted work modules were based on the regulation of RET (A) and MYC (B) pathways, which were significantly activated in *Emc10*^{-/-} sperm cells. Orange labelling indicates increased measurement (e.g. RET and MYC), or the effects predicted to be activated (e.g. the metabolism of protein, the formation of cellular protrusions and the generation of cells), while the blue characters represent the effects predicted to be inhibited (e.g. apoptosis and cell death). The dashed lines indicate the predicted interactions between network proteins, and the directions of the interaction are indicated by orange arrows (activation), blue-blocked lines (inhibition) or grey lines (effect not predicted).



Supplementary Figure S5. The protein levels of ATP1A4, ATP1B3 and CFTR in wild type (Wt) and *Emc10*^{-/-} (Ko) mice.

(A) The expression of ATP1A4 and ATP1B3 was measured in testis tissues by western blotting. β -actin was used as the protein loading control. (B) CFTR expression was detected in epididymal sperm. α -tubulin was used as control.



Supplementary Figure S6. Effects of 8-Bromo-cAMP and IBMX on *Emc10*^{-/-} sperm function.

The motility parameters including the motility percentage (A), path velocity (B), linear velocity (C), and track velocity (D), as well as acrosome reaction (E) of spermatozoa from WT and *Emc10*-null mice were unable to be rescued by adding 8-Bromo-cAMP or IBMX to the medium. Data are presented as mean \pm SEM. n = 7, ***p<0.001, when compared with controls at each time point.

Supplementary Methods

Sperm protein digestion and TMT labelling

Seventeen *Emc10*^{+/+} mice and 17 *Emc10*^{-/-} mice, both of which were 8 to 12 weeks old, were randomly assigned into six groups, which were three *Emc10*^{+/+} sperm pools and three *Emc10*^{-/-} sperm pools. One millilitre of lysis buffer (8 M urea, 1x Protease Inhibitor Cocktail (Roche Ltd. Basel, Switzerland) was added to the pellet of sperm sample pool, followed by sonication on ice and centrifugation. 100 µg protein per condition were transferred into a new tube and adjusted to a final volume of 100 µL with 100 mM TEAB (triethylammonium bicarbonate). 5 µL of the 200 mM DTT was added and the sample incubated at 55°C for 1 h, then 5 µL of 500 mM iodoacetamide was added the sample incubated for 30 min protected from light at room temperature. For each sample, proteins were precipitated with ice-cold acetone and then were re-dissolved in 100 µL TEAB. Then proteins were typically digested with sequence-grade modified trypsin (Promega, Madison, WI, USA), and the resultant peptide mixture was labelled by chemicals from the TMT reagent kit (Pierce Biotechnology, Rockford, USA). Proteins were labelled with TMT as follows: *Emc10*^{-/-} samples were labelled with 126, 128, and 130 isobaric tags, while *Emc10*^{+/+} samples were labelled with 127, 129 and 131 isobaric tags. The labelled samples were combined and dried in vacuo.

Separation by ultra performance liquid chromatography

The dried peptide mixture was dissolved in the buffer A (10 mM ammonium formate in water, pH 10.0, adjusted with ammonium hydroxide), and then fractionated by high pH separation by using an Aquity UPLC system (Waters Corporation, Milford, MA, USA) connected to a reverse phase column (BEH C18 column, 2.1 mm x 150 mm, 3.5 µm, 300 Å, Waters Corporation, Milford, MA, USA). High pH separation was performed on a linear gradient, starting from 0% buffer B (10 mM ammonium formate in 90% ACN, pH 10.0, adjusted with ammonium hydroxide) to 45% buffer B in 35 min (Gilar et al., 2005). The column was re-equilibrated at initial conditions for 15 min. The column flow rate was maintained at 200 µL/min and the column

temperature was maintained at room temperature. Sixteen fractions were collected, each fraction was dried in a vacuum concentrator for the following step.

Nano-HPLC-MS/MS analysis

The fractions were re-suspended in 30 μ l solvent C (0.1% formic acid in water), separated by nano-LC and analyzed by on-line electrospray tandem mass spectrometry. The experiments were performed on a Nano Aquity UPLC system (Waters Corporation, Milford, MA, USA) connected to a quadrupole-Orbitrap mass spectrometer (Q-Exactive) (Thermo Fisher Scientific, Bremen, Germany) equipped with an online nano-electrospray ion source. 10 μ l peptide sample was loaded onto the trap column (Thermo Scientific Acclaim PepMap C18, 100 μ m x 2 cm), with a flow of 10 μ l/min for 3 min and subsequently separated on the analytical column (Acclaim PepMap C18, 75 μ m x 25 cm) with a linear gradient, from 2% solvent D (ACN with 0.1% formic acid) to 40% solvent D in 105 min. The column was re-equilibrated at initial conditions for 15 min. The column flow rate was maintained at 300 nL/min and column temperature was maintained at 40°C. The electrospray voltage of 2.2 kV versus the inlet of the mass spectrometer was used. The Q-Exactive mass spectrometer was operated in the data-dependent mode to switch automatically between MS and MS/MS acquisition. Survey full-scan MS spectra (m/z 350-1200) were acquired with a mass resolution of 70K, followed by ten sequential high energy collisional dissociation (HCD) MS/MS scans with a resolution of 17.5K. In all cases, one microscan was recorded by dynamic exclusion of 30 seconds. MS/MS fixed first mass was set at 100.

Database searching

Tandem mass spectra were extracted by Proteome Discoverer software (Thermo Fisher Scientific, version 1.4.0.288). Charge state de-convolution and de-isotoping were not performed. All MS/MS samples were analyzed by the Mascot (Matrix Science, London, UK; version 2.3.2). Mascot was set up to search the Mouse SwissProt database (Release 2016_01_06, 16747 entries) assuming the digestion

enzyme trypsin. Mascot was searched with a fragment ion mass tolerance of 0.050 Da and a parent ion tolerance of 10.0 PPM. Carbamidomethyl of cysteine and TMT-6plex of lysine and the n-terminus were specified in Mascot as fixed modifications. Oxidation of methionine was specified in Mascot as a variable modification.

Quantitative data analysis

Scaffold Q+ (version Scaffold_4.3.4, Proteome Software Inc., Portland, OR, USA) was used to quantify Label Based Quantitation (TMT) peptide and protein identifications. Peptide identifications were accepted if they could be established at greater than 92.0% probability to achieve an FDR less than 1.0% by the Scaffold Local FDR algorithm. Protein identifications were accepted if they could be established at greater than 99.0% probability to achieve an FDR less than 1.0% and contained at least two unique peptides. Protein probabilities were assigned by the Protein Prophet algorithm (Nesvizhskii et al., 2003). Proteins that contained similar peptides and could not be differentiated based on MS/MS analysis alone were grouped to satisfy the principles of parsimony. Proteins sharing significant peptide evidence were grouped into clusters. Channels were corrected by the matrix in all samples according to the algorithm described in i-Tracker (Shadforth et al., 2005). Acquired intensities in the experiment were globally normalized across all acquisition runs. Individual quantitative samples were normalized within each acquisition run. Intensities for each peptide identification were normalized to the assigned protein. The reference channels were normalized to produce a 1:1 fold change. All normalization calculations were performed by using medians to multiplicatively normalize data. Differentially expressed proteins were determined by Permutation Test analysis using Bonferroni multiple testing corrections.

Bioinformatic analysis

Ingenuity Pathway Analysis (IPA) software was applied as a systems biology approach to explore the statistically significant molecular networks or pathways in which proteins from *Emc10*^{+/+} and *Emc10*^{-/-} mice were expressed differently. Briefly,

all the MS/MS data were submitted to IPA (<http://www.ingenuity.com>), followed by analysis and interpretation in default parameters. Fisher test was applied and pathway enrichment was performed.

References

Gilar M., Olivova P., Daly A.E., Gebler J.C. 2005. Two-dimensional separation of peptides using RP-RP-HPLC system with different pH in first and second separation dimensions. *J Sep Sci* 28:1694-1703.

Nesvizhskii A.I., Keller A., Kolker E., Aebersold R. 2003. A statistical model for identifying proteins by tandem mass spectrometry. *Anal Chem* 75:4646-4658.

Shadforth I.P., Dunkley T.P., Lilley K.S., Bessant C. 2005. i-Tracker: for quantitative proteomics using iTRAQ. *BMC Genomics* 6:145.

Supplementary Table S1. Proteins altered significantly with >1.5-fold expression in *Emc10*-null spermatozoa (KO) in comparison with wild-type (WT).

Accession	Protein Name	Gene Name	Relative ratio (KO/WT)
AT1A4_MOUSE	Sodium/potassium-transporting ATPase subunit alpha-4	Atp1a4	0.31
AT1B3_MOUSE	Sodium/potassium-transporting ATPase subunit beta-3	Atp1b3	0.31
A8DUK4_MOUSE	Beta-globin	Hbbt1	0.47
RNLS_MOUSE	Renalase	Rnls	0.55
DFB20_MOUSE	Beta-defensin 20	Defb20	0.55
M4A13_MOUSE	Membrane-spanning 4-domains subfamily A member 13	Ms4a13	0.55
Q497L9_MOUSE	Protein Slc22a14	Slc22a14	0.63
E9PWQ7_MOUSE	Zonadhesin	Zan	0.63
DFB18_MOUSE	Beta-defensin 18	Defb18	0.64
A0A1B0GSD2_MOUSE	Transporter	Slc6a21	0.64
CN166_MOUSE	UPF0568 protein C14orf166 homolog	Null	1.50
A0A0R4J0D3_MOUSE	Dolichyl-diphosphooligosaccharide--protein glycosyltransferase subunit STT3B	Stt3b	1.50
ACTZ_MOUSE	Alpha-centractin	Actr1a	1.50
RL35_MOUSE	60S ribosomal protein L35	Rpl35	1.50
SUGP2_MOUSE	SURP and G-patch domain-containing protein 2	Sugp2	1.50
E9Q1S3_MOUSE	Protein transport protein Sec23A	Sec23a	1.50
IFT56_MOUSE	Intraflagellar transport protein 56	Ttc26	1.50
E9Q284_MOUSE	Coilin	Coil	1.50
CBPM_MOUSE	Carboxypeptidase M	Cpm	1.50
AP3D1_MOUSE	AP-3 complex subunit delta-1	Ap3d1	1.50
IF5A1_MOUSE	Eukaryotic translation initiation factor 5A-1	Eif5a	1.50
A0A087WQM0_MOUSE	Protein Tns1	Tns1	1.50
PM34_MOUSE	Peroxisomal membrane protein PMP34	Slc25a17	1.50
RSSA_MOUSE	40S ribosomal protein SA	Rpsa	1.51
E9QA46_MOUSE	Peroxisomal biogenesis factor 3	Pex3	1.51
E9Q7K1_MOUSE	Guanylate kinase	Guk1	1.51
RL14_MOUSE	60S ribosomal protein L14	Rpl14	1.51
ABCE1_MOUSE	ATP-binding cassette sub-family E member 1	Abce1	1.51
Q3U2G2_MOUSE	Heat shock 70 kDa protein 4	Hspa4	1.51
XPO2_MOUSE	Exportin-2	Cse1l	1.51
DYHC2_MOUSE	Cytoplasmic dynein 2 heavy chain 1	Dync2h1	1.51
HNRPF_MOUSE	Heterogeneous nuclear ribonucleoprotein F	Hnrnpf	1.51
CAZA1_MOUSE	F-actin-capping protein subunit alpha-1	Capza1	1.51
CST8_MOUSE	Cystatin-8	Cst8	1.52
Q0PD67_MOUSE	RAB1, member RAS oncogene family, isoform CRA_a	Rab1a	1.52

Q3U890_MOUSE	Putative uncharacterized protein	Hars	1.52
A8W660_MOUSE	ARD1 homolog B (<i>S. cerevisiae</i>)	Naa11	1.52
Q3UW40_MOUSE	Putative uncharacterized protein	Rpl24	1.52
IF4H_MOUSE	Eukaryotic translation initiation factor 4H	Eif4h	1.52
EIF3I_MOUSE	Eukaryotic translation initiation factor 3 subunit I	Eif3i	1.52
UFL1_MOUSE	E3 UFM1-protein ligase 1	Ufl1	1.52
Q5SWZ5_MOUSE	Myosin phosphatase Rho-interacting protein	Mprip	1.52
Q8CC70_MOUSE	Protein 9230110C19Rik	9230110C19Rik	1.52
B2RXB0_MOUSE	Family with sequence similarity 71, member F2	Fam71f2	1.52
FHL5_MOUSE	Four and a half LIM domains protein 5	Fhl5	1.53
DAD1_MOUSE	Dolichyl-diphosphooligosaccharide--protein glycosyltransferase subunit DAD1	Dad1	1.53
ERGI2_MOUSE	Endoplasmic reticulum-Golgi intermediate compartment protein 2	Ergic2	1.53
A0A0N4SW73_MOUSE	Rab11 family-interacting protein 5	Rab11fip5	1.53
F134C_MOUSE	Protein FAM134C	Fam134c	1.53
G5E8T3_MOUSE	Signal recognition particle 19 kDa protein	Srp19	1.53
Q8BMA8_MOUSE	Putative uncharacterized protein	Eef2	1.53
A0A087WQS2_MOUSE	Basic leucine zipper and W2 domain-containing protein 1	Bzw1	1.53
IF2H_MOUSE	Eukaryotic translation initiation factor 2 subunit 3, Y-linked	Eif2s3y	1.53
MYH10_MOUSE	Myosin-10	Myh10	1.53
RL34_MOUSE	60S ribosomal protein L34	Rpl34	1.53
B2RXQ4_MOUSE	Nek1 protein	Nek1	1.53
CACO1_MOUSE	Calcium-binding and coiled-coil domain-containing protein 1	Calcoco1	1.53
SPAG1_MOUSE	Sperm-associated antigen 1	Spag1	1.53
G3UZX6_MOUSE	Small ubiquitin-related modifier 3 (Fragment)	Sumo3	1.53
G5E924_MOUSE	Heterogeneous nuclear ribonucleoprotein L (Fragment)	Hnrnpl	1.53
H2B1A_MOUSE	Histone H2B type 1-A	Hist1h2ba	1.53
DBLOH_MOUSE	Diablo homolog, mitochondrial	Diablo	1.54
A0A0G2JH04_MOUSE	Eukaryotic translation initiation factor 4E	Eif4e	1.54
B2RXQ0_MOUSE	MCG1039825	Ttc30a2	1.54
ATG3_MOUSE	Ubiquitin-like-conjugating enzyme ATG3	Atg3	1.54
Q3U8B3_MOUSE	Putative uncharacterized protein	Rpa1	1.54
SYIC_MOUSE	Isoleucine--tRNA ligase, cytoplasmic	Iars	1.54
ACBD6_MOUSE	Acyl-CoA-binding domain-containing protein 6	Acbd6	1.54
OST48_MOUSE	Dolichyl-diphosphooligosaccharide--protein glycosyltransferase 48 kDa subunit	Ddost	1.54
KIF2C_MOUSE	Kinesin-like protein KIF2C	Kif2c	1.54

TDRD7_MOUSE	Tudor domain-containing protein 7	Tdrd7	1.55
IFT46_MOUSE	Intraflagellar transport protein 46 homolog	Ift46	1.55
SYFA_MOUSE	Phenylalanine--tRNA ligase alpha subunit	Farsa	1.55
TBCB_MOUSE	Tubulin-folding cofactor B	Tbcb	1.55
B9EHJ3_MOUSE	Tight junction protein ZO-1	Tjp1	1.55
PDIA3_MOUSE	Protein disulfide-isomerase A3	Pdia3	1.55
PLEC_MOUSE	Plectin	Plec	1.55
SYEP_MOUSE	Bifunctional glutamate/proline--tRNA ligase	Eprs	1.55
Q4VBX4_MOUSE	MCG127675	Ube2v2	1.56
Q3TG12_MOUSE	Putative uncharacterized protein (Fragment)	Farsb	1.56
RL13_MOUSE	60S ribosomal protein L13	Rpl13	1.56
Q32MW4_MOUSE	Allantoicase	Allc	1.56
Q4FJL2_MOUSE	Reticulon	Rtn1	1.56
Q6A099_MOUSE	MKIAA0248 protein (Fragment)	Gbf1	1.56
F7D3N3_MOUSE	Phytanoyl-CoA hydroxylase-interacting protein-like	Phyhipl	1.56
DYHC1_MOUSE	Cytoplasmic dynein 1 heavy chain 1	Dync1h1	1.56
Q7TSZ3_MOUSE	Leucyl-tRNA synthetase	Lars	1.56
Q0P5W2_MOUSE	MCG129075	Tmx4	1.56
Q5RKP4_MOUSE	Dolichyl-diphosphooligosaccharide--protein glycosyltransferase subunit 1 (Fragment)	Rpn1	1.57
EIF3B_MOUSE	Eukaryotic translation initiation factor 3 subunit B	Eif3b	1.57
ABCF1_MOUSE	ATP-binding cassette sub-family F member 1	Abcf1	1.57
B2RY64_MOUSE	Enthd1 protein	Enthd1	1.57
IF2A_MOUSE	Eukaryotic translation initiation factor 2 subunit 1	Eif2s1	1.58
ASPC1_MOUSE	Tether containing UBX domain for GLUT4	Aspscr1	1.58
NU214_MOUSE	Nuclear pore complex protein Nup214	Nup214	1.58
GTA1L_MOUSE	N-acetyllactosaminide alpha-1,3-galactosyltransferase-like 1	Ggta1l1	1.58
G3X9K4_MOUSE	SAPS domain family, member 2, isoform CRA_a	Ppp6r2	1.58
DAAF1_MOUSE	Dynein assembly factor 1, axonemal	Dnaaf1	1.58
NCBP1_MOUSE	Nuclear cap-binding protein subunit 1	Ncbp1	1.58
SPP2C_MOUSE	Signal peptide peptidase-like 2C	Sppl2c	1.58
DDX1_MOUSE	ATP-dependent RNA helicase DDX1	Ddx1	1.58
LY6A_MOUSE	Lymphocyte antigen 6A-2/6E-1	Ly6a	1.59
TMCO3_MOUSE	Transmembrane and coiled-coil domain-containing protein 3	Tmco3	1.59
F134A_MOUSE	Protein FAM134A	Fam134a	1.59
MO4L1_MOUSE	Mortality factor 4-like protein 1	Morf4l1	1.59
A0A087WQD8_MOUSE	TRAF3-interacting protein 1	Traf3ip1	1.59
MEIG1_MOUSE	Meiosis-expressed gene 1 protein	Meig1	1.59

E9PUZ5_MOUSE	PRKCA-binding protein	Pick1	1.60
GKAP1_MOUSE	G kinase-anchoring protein 1	Gkap1	1.60
A2BGI8_MOUSE	Peptidyl-prolyl cis-trans isomerase (Fragment)	Ppih	1.60
KHDR1_MOUSE	KH domain-containing, RNA-binding, signal transduction-associated protein 1	Khdrbs1	1.60
HSP7C_MOUSE	Heat shock cognate 71 kDa protein	Hspa8	1.60
IF122_MOUSE	Intraflagellar transport protein 122 homolog	Ift122	1.60
NGLY1_MOUSE	Peptide-N(4)-(N-acetyl-beta-glucosaminy)asparagine amidase	Ngly1	1.61
LZTL1_MOUSE	Leucine zipper transcription factor-like protein 1	Lztlf1	1.61
E9QKB2_MOUSE	Intracellular hyaluronan-binding protein 4	Habp4	1.61
PSME4_MOUSE	Proteasome activator complex subunit 4	Psme4	1.61
PPM1G_MOUSE	Protein phosphatase 1G	Ppm1g	1.61
A2A9Q2_MOUSE	Nardilysin	Nrd1	1.62
Q6ZQ61_MOUSE	MCG121979, isoform CRA_c (Fragment)	Matr3	1.62
ACL7B_MOUSE	Actin-like protein 7B	Actl7b	1.62
TMED4_MOUSE	Transmembrane emp24 domain-containing protein 4	Tmed4	1.62
E9Q7F5_MOUSE	Protein Gm6792	Gm6792	1.63
CKAP4_MOUSE	Cytoskeleton-associated protein 4	Ckap4	1.63
EF1B_MOUSE	Elongation factor 1-beta	Eef1b	1.63
HBS1L_MOUSE	HBS1-like protein	Hbs1l	1.63
A0A0U1RPL0_MOUSE	Ataxin-2-like protein	Atxn2l	1.63
B1AVB4_MOUSE	Protein Scml2	Scml2	1.63
1433E_MOUSE	14-3-3 protein epsilon	Ywhae	1.63
PPP5_MOUSE	Serine/threonine-protein phosphatase 5	Ppp5c	1.63
AIMP1_MOUSE	Aminoacyl tRNA synthase complex-interacting multifunctional protein 1	Aimp1	1.63
TEX22_MOUSE	Testis-expressed sequence 22 protein	Tex22	1.64
B7ZP22_MOUSE	Heterogeneous nuclear ribonucleoprotein A2/B1	Hnrnpa2b1	1.64
1433T_MOUSE	14-3-3 protein theta	Ywhaq	1.64
B2RSU5_MOUSE	Intraflagellar transport 140 homolog (Chlamydomonas)	Ift140	1.64
ABCF2_MOUSE	ATP-binding cassette sub-family F member 2	Abcf2	1.64
IMPA3_MOUSE	Inositol monophosphatase 3	Impad1	1.64
YBOX3_MOUSE	Y-box-binding protein 3	Ybx3	1.64
DNJC2_MOUSE	DnaJ homolog subfamily C member 2	Dnajc2	1.65
LYAR_MOUSE	Cell growth-regulating nucleolar protein	Lyar	1.65
MARE3_MOUSE	Microtubule-associated protein RP/EB family member 3	Mapre3	1.65
SIM23_MOUSE	Small integral membrane protein 23	Smim23	1.65
SAE1_MOUSE	SUMO-activating enzyme subunit 1	Sae1	1.65
SPC1L_MOUSE	Speriolin-like protein	Spatc1l	1.65

B2MG_MOUSE	Beta-2-microglobulin	B2m	1.65
SPS2_MOUSE	Selenide, water dikinase 2	Sephs2	1.65
PX11C_MOUSE	Peroxisomal membrane protein 11C	Pex11g	1.65
A0A087WNR4_MOUSE	Testis-expressed sequence 35 protein	Tex35	1.66
Q5ERI8_MOUSE	CRS4C-6	AY761185	1.66
ZMY10_MOUSE	Zinc finger MYND domain-containing protein 10	Zmynd10	1.67
B2M1R6_MOUSE	Heterogeneous nuclear ribonucleoprotein K	Hnrnpk	1.67
E9PVC5_MOUSE	Eukaryotic translation initiation factor 4 gamma 1	Eif4g1	1.67
HSP7E_MOUSE	Heat shock 70 kDa protein 14	Hspa14	1.67
A0A087WQ65_MOUSE	Lymphocyte antigen 6E (Fragment)	Ly6e	1.67
A0A0R4IZY0_MOUSE	Thimet oligopeptidase	Thop1	1.67
A3KGG8_MOUSE	Small kinetochore-associated protein	Knstrn	1.68
LSM12_MOUSE	Protein LSM12 homolog	Lsm12	1.68
PA2G4_MOUSE	Proliferation-associated protein 2G4	Pa2g4	1.68
BBS2_MOUSE	Bardet-Biedl syndrome 2 protein homolog	Bbs2	1.68
SDF2L_MOUSE	Stromal cell-derived factor 2-like protein 1	Sdf2l1	1.69
WDR19_MOUSE	WD repeat-containing protein 19	Wdr19	1.69
A2RTT4_MOUSE	MCG4297	Ube2n	1.69
CB39L_MOUSE	Calcium-binding protein 39-like	Cab39l	1.69
A2AR60_MOUSE	Protein CASC4 (Fragment)	Casc4	1.69
TTC12_MOUSE	Tetratricopeptide repeat protein 12	Ttc12	1.69
Q5EBP9_MOUSE	Tripartite motif-containing 28	Trim28	1.69
D3YUB9_MOUSE	Polyadenylate-binding protein 2 (Fragment)	Pabpn1	1.69
A8DV41_MOUSE	Beta-globin	Hbbt2	1.69
IMB1_MOUSE	Importin subunit beta-1	Kpnb1	1.69
Q790I0_MOUSE	Valyl-tRNA synthetase 2, isoform CRA_b	Vars	1.70
E9QQ38_MOUSE	Phospholipase DDHD1	Ddhd1	1.70
DC1L2_MOUSE	Cytoplasmic dynein 1 light intermediate chain 2	Dync1li2	1.70
SIA8C_MOUSE	Sia-alpha-2,3-Gal-beta-1,4-GlcNAc-R:alpha 2,8-sialyltransferase	St8sia3	1.71
5NTC_MOUSE	Cytosolic purine 5'-nucleotidase	Nt5c2	1.71
CLUS_MOUSE	Clusterin	Clu	1.71
LIS1_MOUSE	Platelet-activating factor acetylhydrolase IB subunit alpha	Pafah1b1	1.71
Q3TF87_MOUSE	Putative uncharacterized protein	Dars	1.71
A1L329_MOUSE	Neighbor of Brca1 gene 1	Nbr1	1.71
F7CB97_MOUSE	CAP-Gly domain-containing linker protein 1 (Fragment)	Clip1	1.71
PPIA_MOUSE	Peptidyl-prolyl cis-trans isomerase A	Ppia	1.72
IF4A2_MOUSE	Eukaryotic initiation factor 4A-II	Eif4a2	1.72
IF5_MOUSE	Eukaryotic translation initiation factor 5	Eif5	1.72

IF2B_MOUSE	Eukaryotic translation initiation factor 2 subunit 2	Eif2s2	1.73
H11_MOUSE	Histone H1.1	Hist1h1a	1.73
ARL3_MOUSE	ADP-ribosylation factor-like protein 3	Arl3	1.73
E2F697_MOUSE	GnT1IP-L	Mgat4d	1.73
B1AQZ2_MOUSE	Kinesin-like protein	Kif3a	1.74
IFT81_MOUSE	Intraflagellar transport protein 81 homolog	Ift81	1.74
ASAP1_MOUSE	Arf-GAP with SH3 domain, ANK repeat and PH domain-containing protein 1	Asap1	1.74
A0AUN0_MOUSE	Sec23ip protein (Fragment)	Sec23ip	1.75
HYOU1_MOUSE	Hypoxia up-regulated protein 1	Hyou1	1.75
PSPC1_MOUSE	Paraspeckle component 1	Pspc1	1.75
Q0VBA8_MOUSE	Plasminogen activator, urokinase	Plau	1.76
Q80U27_MOUSE	Kinesin-like protein (Fragment)	Kif3b	1.76
B2RSW8_MOUSE	Pericentriolar material 1	Pcm1	1.76
PIWL1_MOUSE	Piwi-like protein 1	Piwil1	1.77
Q3V086_MOUSE	DEAD box polypeptide 4	Ddx4	1.77
CPIN1_MOUSE	Anamorsin	Ciapi1	1.77
ENPP4_MOUSE	Bis(5'-adenosyl)-triphosphatase enpp4	Enpp4	1.77
MCA3_MOUSE	Eukaryotic translation elongation factor 1 epsilon-1	Eef1e1	1.78
Q9EQR4_MOUSE	Chloride channel calcium activated 2	Clca3a2	1.78
FCL_MOUSE	GDP-L-fucose synthase	Tsta3	1.78
E9PZ50_MOUSE	Tudor domain-containing protein 6	Tdrd6	1.78
HS74L_MOUSE	Heat shock 70 kDa protein 4L	Hspa4l	1.79
EF1G_MOUSE	Elongation factor 1-gamma	Eef1g	1.79
WDR35_MOUSE	WD repeat-containing protein 35	Wdr35	1.79
Q3UGE1_MOUSE	Putative uncharacterized protein	Trappc12	1.79
AKAP1_MOUSE	A-kinase anchor protein 1, mitochondrial	Akap1	1.80
Q9D9G7_MOUSE	1700074P13Rik protein	1700074P13Rik	1.80
Q3V1Z5_MOUSE	40S ribosomal protein S4	Rps4l	1.80
ERF3A_MOUSE	Eukaryotic peptide chain release factor GTP-binding subunit ERF3A	Gspt1	1.80
PABP1_MOUSE	Polyadenylate-binding protein 1	Pabpc1	1.80
E0CZ72_MOUSE	Kinesin-like protein	Kif2a	1.80
A2BFF7_MOUSE	Dynein cytoplasmic 1 intermediate chain 2	Dync1i2	1.80
PPM1J_MOUSE	Protein phosphatase 1J	Ppm1j	1.81
D3YTR3_MOUSE	RNA-binding protein MEX3D	Mex3d	1.81
A0A0R4J225_MOUSE	Bernardinelli-Seip congenital lipodystrophy 2 homolog (Human), isoform CRA_a	Bscl2	1.82
B2RQZ0_MOUSE	Intraflagellar transport 57 homolog (Chlamydomonas)	Ift57	1.82
A2AQL0_MOUSE	Serine/threonine kinase 39, STE20/SPS1 homolog (Yeast)	Stk39	1.83
B9EJ80_MOUSE	PDZ domain containing 8	Pdzd8	1.83
GIT1_MOUSE	ARF GTPase-activating protein GIT1	Git1	1.83

OCAD2_MOUSE	OCIA domain-containing protein 2	Ociad2	1.83
A0A0R4J1E2_MOUSE	Elongation factor 1-delta	Eef1d	1.83
TEX2_MOUSE	Testis-expressed sequence 2 protein	Tex2	1.83
A2RS22_MOUSE	Coronin	Coro1b	1.84
HSP72_MOUSE	Heat shock-related 70 kDa protein 2	Hspa2	1.84
A0A0N4SVL0_MOUSE	Eukaryotic translation initiation factor 4 gamma 3	Eif4g3	1.84
RAI14_MOUSE	Ankycorbin	Rai14	1.84
K1C13_MOUSE	Keratin, type I cytoskeletal 13	Krt13	1.84
EF1A1_MOUSE	Elongation factor 1-alpha 1	Eef1a1	1.84
B1AU75_MOUSE	Nuclear autoantigenic sperm protein	Nasp	1.85
B2KF25_MOUSE	T-complex protein 11	Tcp11	1.85
B1ASP8_MOUSE	Doublesex- and mab-3-related transcription factor B1 (Fragment)	Dmrtb1	1.85
O35539_MOUSE	Hepatoma-derived growth factor	Hdgfl1	1.85
BSDC1_MOUSE	BSD domain-containing protein 1	Bsdc1	1.87
PACS1_MOUSE	Phosphofurin acidic cluster sorting protein 1	Pacs1	1.87
ERGI3_MOUSE	Endoplasmic reticulum-Golgi intermediate compartment protein 3	Ergic3	1.88
E9QK36_MOUSE	WD repeat-containing protein 62	Wdr62	1.88
Q9DAE2_MOUSE	Protein Rbmxl2	Rbmxl2	1.88
TRXR3_MOUSE	Thioredoxin reductase 3	Txnrd3	1.88
MESD_MOUSE	LDLR chaperone MESD	Mesdc2	1.89
A0A0A0MQN4_MOUSE	Ubiquitin-like modifier-activating enzyme ATG7	Atg7	1.89
HOOK1_MOUSE	Protein Hook homolog 1	Hook1	1.89
I1E4X6_MOUSE	Phosphoinositide phospholipase C	Plch1	1.90
ASNA_MOUSE	ATPase Asna1	Asna1	1.90
K2C79_MOUSE	Keratin, type II cytoskeletal 79	Krt79	1.90
E9Q4X2_MOUSE	Protein Ugg2	Ugg2	1.90
RL10L_MOUSE	60S ribosomal protein L10-like	Rpl10l	1.91
DJB11_MOUSE	DnaJ homolog subfamily B member 11	Dnajb11	1.91
RPGR1_MOUSE	X-linked retinitis pigmentosa GTPase regulator-interacting protein 1	Rpgrip1	1.91
E9PUQ5_MOUSE	Golgin subfamily A member 2	Golga2	1.91
Q3THQ5_MOUSE	Putative uncharacterized protein	Stip1	1.93
CYBP_MOUSE	Calcyclin-binding protein	Cacybp	1.93
Q3TG02_MOUSE	Putative uncharacterized protein	Stt3a	1.93
Q58E35_MOUSE	MCG10168	Rplp1	1.93
NP1L1_MOUSE	Nucleosome assembly protein 1-like 1	Nap1l1	1.93
PSIP1_MOUSE	PC4 and SFRS1-interacting protein	Psip1	1.94
Q9D4E6_MOUSE	Polyadenylate-binding protein	Pabpc6	1.94
ENPL_MOUSE	Endoplasmin	Hsp90b1	1.95
Q8BMU5_MOUSE	Putative uncharacterized protein	Tusc3	1.98
G3X9Z7_MOUSE	Intraflagellar transport 88 homolog (Chlamydomonas)	Ift88	1.98
AP2B1_MOUSE	AP-2 complex subunit beta	Ap2b1	1.98
ASNS_MOUSE	Asparagine synthetase [glutamine-	Asns	1.98

	hydrolyzing]		
MEA1_MOUSE	Male-enhanced antigen 1	Mea1	1.98
IFT52_MOUSE	Intraflagellar transport protein 52 homolog	Ift52	2.00
CCD91_MOUSE	Coiled-coil domain-containing protein 91	Ccdc91	2.00
F6QS57_MOUSE	Protein Gm6792 (Fragment)	Gm6792	2.03
B2RRH9_MOUSE	Guanine monphosphate synthetase	Gmps	2.03
B2RUF0_MOUSE	Y box protein 2	Ybx2	2.03
A2ABY3_MOUSE	Ethanolamine-phosphate cytidyltransferase	Pcyt2	2.04
Q3TEU8_MOUSE	Coronin	Coro1c	2.04
DFB40_MOUSE	Beta-defensin 40	Defb40	2.05
Q91YS2_MOUSE	Rangap1 protein	Rangap1	2.05
A2AUF7_MOUSE	Rab9 effector protein with kelch motifs	Rabepk	2.05
HS90A_MOUSE	Heat shock protein HSP 90-alpha	Hsp90aa1	2.05
EFHD2_MOUSE	EF-hand domain-containing protein D2	Efhd2	2.05
CLGN_MOUSE	Calmegin	Clgn	2.07
IPO4_MOUSE	Importin-4	Ipo4	2.07
Q14AA6_MOUSE	GTP-binding nuclear protein Ran	1700009N14Rik	2.08
COG4_MOUSE	Conserved oligomeric Golgi complex subunit 4	Cog4	2.08
B9EIA2_MOUSE	DNA segment, Chr 1, Pasteur Institute 1	D1Pas1	2.09
CRBG3_MOUSE	Beta/gamma crystallin domain-containing protein 3	Crybg3	2.10
MFGM_MOUSE	Lactadherin	Mfge8	2.10
GLRX3_MOUSE	Glutaredoxin-3	Glrx3	2.16
A0A0R4J2A3_MOUSE	Transketolase-like protein 2	Tktl2	2.17
CREL2_MOUSE	Cysteine-rich with EGF-like domain protein 2	Creld2	2.18
B1Q2L7_MOUSE	Calsperin	Calr3	2.18
PEX13_MOUSE	Peroxisomal membrane protein PEX13	Pex13	2.20
LRC46_MOUSE	Leucine-rich repeat-containing protein 46	Lrrc46	2.21
SPT20_MOUSE	Spermatogenesis-associated protein 20	Spata20	2.21
D3Z0Y8_MOUSE	Ubiquitin thioesterase OTUB2	Otub2	2.21
ERO1B_MOUSE	ERO1-like protein beta	Ero1b	2.22
EWS_MOUSE	RNA-binding protein EWS	Ewsr1	2.22
Q545B6_MOUSE	MCG12955, isoform CRA_a	Stmn1	2.25
CHSP1_MOUSE	Calcium-regulated heat stable protein 1	Carhsp1	2.26
PGP_MOUSE	Glycerol-3-phosphate phosphatase	Pgp	2.27
CFA36_MOUSE	Cilia- and flagella-associated protein 36	Cfap36	2.28
B1AZS9_MOUSE	Peroxisredoxin-4 (Fragment)	Prdx4	2.28
Q9D9Y4_MOUSE	1700029H14Rik protein	1700029H14Rik	2.29
ADNP_MOUSE	Activity-dependent neuroprotector homeobox protein	Adnp	2.29
FXR1_MOUSE	Fragile X mental retardation syndrome-related protein 1	Fxr1	2.29
RANG_MOUSE	Ran-specific GTPase-activating protein	Ranbp1	2.38
E9Q0C6_MOUSE	Protein Gm14569	Gm14569	2.42
MMP7_MOUSE	Matrilysin	Mmp7	2.44

Q91XK4_MOUSE	Nuclear transition protein 2	Tnp2	2.50
CCD54_MOUSE	Coiled-coil domain-containing protein 54	Ccdc54	2.53
PPID_MOUSE	Peptidyl-prolyl cis-trans isomerase D	Ppid	2.53
TBC21_MOUSE	TBC1 domain family member 21	Tbc1d21	2.56
ARHG6_MOUSE	Rho guanine nucleotide exchange factor 6	Arhgef6	2.56
H1T_MOUSE	Histone H1t	Hist1h1t	2.57
PEX14_MOUSE	Peroxisomal membrane protein PEX14	Pex14	2.66
B9EJ34_MOUSE	Uncharacterized protein	AY761185	2.80
C3U1R6_MOUSE	Protamine 2	Prm2	2.80
Q3TT92_MOUSE	Dihydropyrimidinase-related protein 3	Dpysl3	2.83
Q3V2I7_MOUSE	Cystatin	Cstl1	2.83
IPO5_MOUSE	Importin-5	Ipo5	2.89
CT027_MOUSE	UPF0687 protein C20orf27 homolog	Null	3.00
TSKS_MOUSE	Testis-specific serine kinase substrate	Tsks	3.07
SPERT_MOUSE	Spermatid-associated protein	Spert	3.10
PDILT_MOUSE	Protein disulfide-isomerase-like protein of the testis	Pdilt	3.11
A0A0J9YV03_MOUSE	Protein FAM187B	Fam187b	3.22
Q9D548_MOUSE	Cellular nucleic acid binding protein 2	Zcchc13	3.22
E9Q3A0_MOUSE	E3 ubiquitin-protein ligase Trim36	Trim36	3.48
KIF5C_MOUSE	Kinesin heavy chain isoform 5C	Kif5c	3.50
F8WIV1_MOUSE	Zinc finger B-box domain-containing protein 1	Zbbx	3.78
TM247_MOUSE	Transmembrane protein 247	Tmem247	4.09
CABS1_MOUSE	Calcium-binding and spermatid-specific protein 1	Cabs1	4.40
