

Supplemental Data

A Lentiviral RNAi Library for Human and Mouse Genes Applied to an Arrayed Viral High-Content Screen

Jason Moffat, Dorre A. Grueneberg, Xiaoping Yang, So Young Kim, Angela M. Kloepper, Gregory Hinkle, Bruno Piqani, Thomas M. Eisenhaure, Biao Luo, Jennifer K. Grenier, Anne E. Carpenter, Shi Yin Foo, Sheila A. Stewart, Brent R. Stockwell, Nir Hacohen, William C. Hahn, Eric S. Lander, David M. Sabatini, and David E. Root

Table of Contents for Supplemental Data

Supplemental Experimental Procedures p. 2

Supplemental References p. 11

Supplemental Tables

Table S1. Cell Types that Have Been Infected by pLKO.1-Based Lentiviruses p. 12

Table S2. List of Genes Included in the Screening Collection p. 13

Table S3A. Genes and shRNAs that Induce Mitotic Indices Greater Than 14 p. 35

Table S3B. Genes and shRNAs that Induce Mitotic Indices Less than 0.3 p. 40

Table S4. Genes for which Two Distinct shRNAs Induced High Mitotic Index p. 41

Supplemental Figures

Figure S1. pLKO.1 Stability Assessed by Diagnostic Restriction Digestion p. 45

Figure S2. Library Cloning Success Rates by Sequencing Transformant Pools p. 46

Figure S3. Infection Rates for HT-Generated Virus in A549 Cells p. 47

Figure S4. Various Cell Types Infected with pLKO.1 Lentiviruses p. 48

Figure S5. Killing of HT29 Cells by Low-Titer shFASTK and shAKT3 Viruses p. 49

Figure S6. Dose-Response Effects on Cell Number and Mitotic Index p. 50

Figure S7. Test Interferon Induction by Selected Hits from Primary Screen p. 51

Supplemental Experimental Procedures

Library Production: Hairpin Design. To select shRNA sequences, we employed published criteria (Khvorova et al., 2003; Schwarz et al., 2003) for siRNAs to maximize knockdown and minimize off-target effects. Candidate 21-mers were selected from the transcript coding sequence (CDS) and the 3'UTR, excluding the first 25 bps of the CDS and the last 150 bps of the transcript. These 21-mers were first scored using criteria for knockdown. Then the 100 best-scoring 21-mer candidates for each transcript were compared by BLAST to the NCBI refseq and Unigene databases for specificity. Scores were adjusted to strongly favor candidates with > 3 mismatches to all other sequences, with at least 2 of the mismatches in positions 3-19 of the 21-mer stem. The top-scoring candidate from the 3' UTR was selected along with 4 candidates from the CDS. Scores of the CDS-targeted candidates were adjusted to favor spreading these selections out across the transcript. A more detailed description of the rules can be found at http://www.broad.mit.edu/genome_bio/trc/rnai.html.

Library Production: Vector Preparation. The shRNA library was produced with pLKO.1 containing a 1.9 kb stuffer sequence in place of the shRNA cassette. The pLKO.1 plasmid (20µg) was doubly digested by EcoRI (8695) and AgeI (6820) for 4-6 hours to release the 1.9 kb stuffer fragment (indicated in capitals in the pLKO.1 sequence below). DNA fragments were then separated using a 1% agarose gel. The 6kb EcoRI/AgeI band was excised and DNA was extracted using Qiaquick gel extraction kit (Qiagen). DNA was eluted with 2ml TE buffer (typically 5-7ng/µl).

Library Production: Oligo Pair Annealing, Ligation and Transformation. Mixed sense and antisense hairpin oligonucleotides were obtained from IDT DNA Technology in a 96-well plate format. Oligonucleotide pairs were annealed at a concentration of 2 µM in a volume of 50 µl. The annealing buffer was 1x NE Buffer 2 (New England Biolabs). The 96-well annealing plate was incubated in a thermal cycler (DNA Engine Tetrad 2, MJ Research), cooling exponentially from 95°C to 20°C over 150 min. Ligation was performed in 20 µl reaction volume using 400 units of T4 DNA ligase (New England Biolabs) in a 96-well plate format with 2 µl of annealed oligonucleotide pairs and 15-20 ng of prepped vector for 4 h at 16°C. 2µl of ligation mixture was used to transform 25µl Max Efficiency DH5α™ T1 Phage-resistant Competent Cells (Invitrogen), following manufacturer's heat shock protocol, in a 96-well format. The transformed cells were recovered in 200 µl of SOC for 1 h at 37°C and plated on agar plates.

Library Production: Colony Picking and Sequencing Validation. To facilitate automation of bacterial colony picking, the 90 wells of transformants on each 96-well plate were pooled. Each pool was concentrated by centrifugation and then resuspended into 3 ml of SOC. 1 ml of concentrated cells was plated onto a 9"x9" LB agar plate containing 100 µg/ml ampicillin. The agar plate was incubated at 37°C overnight. A Q-pix robot (Genetex) was used to pick 672 colonies into seven 96-well deep-well growth plates with 1.2 ml of TB and 100 µg/ml ampicillin in each well. We found that picking 672 colonies from the pool (7-fold coverage) gave the same success rate as picking 4 colonies for each well from individual LB agar plates (Figure S2). The

deep-well growth plates were incubated at 37°C on a shaker for 16 h. Three glycerol plate copies were made from each of these 7 growth plates. One copy of the seven 96-well glycerol plates originating from each ligation plate was sequenced using TempliPhi (Amersham) template amplification. BigDye V3.21 and dGTP Big Dye (Applied Biosystems) were used in a 4:1 mixture. Sequencing reactions were detected by an ABI 3730xl (Applied Biosystems). For each of the 90 hairpin oligonucleotides in a plate, one sequence-verified clone with a high-quality sequence read was selected when available (94% of clones). When more than one correct read was obtained, the one with highest read quality was selected. The selected clones were assembled in a library glycerol master plate. Each master plate was sequenced to verify that the clones were correctly placed.

Library Production: Quality Assessment of Library Glycerol Plates. All library plates were tested for contamination. Empty wells in the final plates were used to test for library contamination. Six wells in every master library plate (H7-H12) were left empty and an additional 0-10 of the remaining wells are also empty due to the 6% cloning failure rate. Glycerol stock plates were stamped on agar plates using a disposable pin tool (V&P Scientific, VP264). The stamped plates were incubated at 37°C overnight, photographed and then compared with the plate maps to look for growth in empty wells.

Library Production: Tests for Recombination. A statistical test of recombination rate was performed on three library plates using a PvuII restriction digestion that is expected to produce 3 fragments of 3.6 kb, 2.3 kb and 0.8 kb. Three library glycerol plates were chosen to make 10 sequential copies of each plate. We found no examples of recombination observed by changes in the PvuII digestion pattern in either the 1st or 10th generation plates. An example agarose gel is shown in Supplemental Figure S1.

High-Throughput DNA Production. Transfection quality DNA was prepped with 96-well Purelink kits (Invitrogen) with average yields of 4 µg DNA/well. The manufacturer's protocol was modified slightly. After clarification of lysate, the flow-through was incubated at 70°C for 30 min. DNA was quantified by PicoGreen assay (Molecular Probes) using a Synergy HT plate reader (Bio-Tek). DNA concentrations were normalized robotically (Multiprobe II robot, Packard) across plates. Relative transfection efficiencies varied by <2-fold across a single plate as measured by FACS analysis of GFP fluorescence using a modified version of pLKO.1 expressing GFP. Updated protocols for DNA production are available online at http://www.broad.mit.edu/genome_bio/trc/rnai.html.

High-Throughput Lentiviral Production. Lentiviruses were made by transfecting packaging cells (293T) with a 3-plasmid system as previously described (Naldini et al., 1996; Zufferey et al., 1997). Transfections were performed in 96-well plates to generate lentiviruses in a HT manner. Packaging cells were robotically seeded at a density of 2.2×10^4 cells per well in 100 µl media (DMEM/10% IFS/no antibiotics) 24 hours before transfection and grown at 37°C/5%CO₂. DNA for transfections was prepared by mixing 100 ng pCMVΔR.89 and 10 ng pMD.G with 120 ng pLKO.1 library plasmids in each

well. A mixture of 15 μ l OptiMEM (Gibco) and 0.6 μ l FUGENE (Roche) were then added to the DNA and this mixture was incubated for 15 min before addition to the packaging cells. Cells were incubated for 12 h, and the media was changed to remove remaining transfection reagent. Lentiviral supernatants were collected at 36, 48 and 60 h post-transfection. The supernatants from the 36 and 48 h timepoints were then pooled and re-arrayed into 384-well plates for the MI screen. Lentiviruses were frozen at -20°C or -80°C for long term storage. Updated protocols for viral production are available online at http://www.broad.mit.edu/genome_bio/trc/rnai.html.

High-Throughput Lentiviral Infections and Mitotic-Index Assay. Infection conditions were optimized in 384-well plates for growth conditions, plate types, viral dose and assay times prior to large-scale screening. Seeding HT29 cells at a density of 300-350 cells/well in a 384-well assay plate (Costar 3712) was optimal for assaying mitotic index 4 d post infection. This resulted in cells being ~50-70% confluent at the time of assay. Target cells were seeded robotically in 384-well plates in 50 μ l media (DMEM/10%IFS/antibiotics) and plates were kept at room temperature for 1 h prior to incubation at 37°C/5%CO₂. After 24 h, 25 μ l of the media was removed from each well and 3 μ L of polybrene was added to each well to achieve a final polybrene concentration of 8 μ g/mL. Following this, 3 μ L of the shRNA lentivirus was added and the well contents were mixed gently. The plates were then spun at 2250 rpm for 30 min at 25°C. The media was then removed and replaced with fresh media (50 μ L). Puromycin (2 μ g/ml) was added after an additional 24 h incubation at 37°C/5%CO₂. Four days post-infection, target cells were fixed with 4% paraformaldehyde for 15 min, washed with PBS, permeabilized with PBS containing 0.2% Triton X-100 for 15 min, washed with blocking buffer (PBS/0.25% BSA) and incubated with primary antibody solution (1:200 in blocking buffer) recognizing phosphorylated histone H3 (Santa Cruz Biotechnology; SC-8656) for 1 h at room temperature. The cells were washed with blocking buffer and incubated with blocking buffer containing 1:2000 dilution of goat anti-rabbit conjugated Alexa Fluor 488 (Molecular Probes; A11008), 1:1000 dilution of rhodamine-conjugated phalloidin (Molecular Probes; R415) and 1:2000 dilution of 10mg/mL Hoechst (Molecular Probes). The secondary incubation proceeded for 1 h in the dark at room temperature. The cells were then washed 2 times with blocking buffer and stored in PBS.

Image Acquisition and Data Analysis. Stained 384-well plates of target cells were imaged using a certified Arrayscan HCS Reader (Cellomics) at the Whitehead/MIT Biolmaging Center. Images were acquired at 10X magnification in standard camera acquisition mode with intra-well autofocus intervals every 2 fields. Scan limits were set at 6 fields per well. Channel 1 (Hoechst) was used as the focus channel and image analysis was carried out during image acquisition 'on the fly' with the TargetActivation assay algorithm. A secondary virtual scan was performed on all the images collected with the MitoticIndex assay algorithm to obtain CellCount and MitoticIndex measurements. MitoticIndex is defined as the percentage of cells in mitosis at a given time under certain conditions.

Parameters for each assay algorithm were optimized with test plates of images prior to screening with the sub-library (TRCs1) in order to ensure consistency and accuracy

between image analysis algorithms. For example, primary object (i.e. nuclei) segmentation parameters were optimized with the TargetActivation assay protocol and ValidObjectCount (# primary objects) was compared to CellCount (# primary objects obtained from MitoticIndex assay algorithm) and the correlation coefficient found to be $\rho=0.992$. Images and plate data were stored on separate servers and accessible through Cellomics software in plate format based on relational models. Data was extracted from plates and compiled in a database for hit identification and statistical analyses.

Data for each lentiviral sample were rejected unless images were obtained both with and without puromycin selection, and the ratio of cell counts under +/- puromycin conditions exceeded 0.25. MI values were only computed for composite images that yielded >100 cells (this corresponded to ~300 cells/well). When data for both + and - puromycin conditions were available, the MI values were averaged.

For DNA content histograms, primary screening images from the Arrayscan HCS (Cellomics) were exported and nuclei from the Hoechst channel were segmented and the integrated nuclear intensity for each segmented object was determined using CellProfiler Software (www.cellprofiler.org). DNA content histograms extracted from 50 control images were mutually consistent and agreed with cell cycle FACS profiles obtained using a BD FACScan machine (data not shown).

Lentiviral Production and Infections for MI Hit Follow-up Experiments. DNA for selected hairpins was prepared using mini- or maxi-prep kits (Qiagen). Packaging cells (293T) were seeded onto 60 mm dishes at a density of 8×10^5 cells 24 h prior to transfection. A mixture containing 90 μ L OptiMEM (GIBCO), 0.1 μ g pMDG, 0.9 μ g pCMV Δ R.89 and 6 μ L FUGENE (Roche) was added to 1 μ g of hairpin DNA in a 1.5 mL Eppendorf tube and incubated for 15 min at room temperature. This transfection mixture was then transferred to 60 mm dishes containing packaging cells and incubated at 37°C/5% CO₂. At 36 hours post-transfection, lentiviral supernatants were removed from plates of producer cells. These supernatants were stored at 4°C and 5 mL of fresh media (DME/10% IFS/penstrep/glutamine) was added and the dishes were incubated for an additional 12 h followed by a second lentiviral supernatant collection. The 36 and 48 hour lentiviral supernatants were pooled and stored at -20°C until required.

For infections, target cells (10^6 HT29 cells or 2.5×10^5 BJ-hTERT fibroblasts) were seeded onto 60 mm dishes and allowed to grow at 37°C/5%CO₂ for 24 hours. Lentiviral supernatants were gently transferred to dishes containing the target cells, polybrene (Sigma) was added to the dishes to a final concentration of 8 μ g/mL, and the cells were incubated 4-6 h at 37°C/5%CO₂. The lentiviral supernatants were then removed and fresh media (DME/10% IFS/penstrep/glutamine) was placed on the target cells. The target cells were grown at 37°C/5%CO₂ for 12-24 h prior to being split into two 60 mm dishes. Puromycin was added 24 h after splitting to a final concentration of 2 μ g/mL and cells were incubated for 2 additional days at 37°C/5%CO₂. The total incubation time post-infection was 4 d.

Immunoblot Analyses. Cells were rinsed twice with phosphate buffered saline (PBS), collected by scraping and then harvested by centrifugation (1250 rpm/4 minutes/25°C). Cell pellets were then resuspended in 200 μ L of chilled lysis buffer [50mM Tris pH8.0,

150 mM NaCl, 1% NP-40, 0.5% sodium deoxycholate, 0.1% SDS, 1 mM Na₃VO₄, 25 mM NaF, 5 mM sodium pyrophosphate, 5mM sodium β-glycerophosphate and a cocktail of protease inhibitors (Roche)], transferred to 1.5 mL Eppendorf tubes, vortexed 5 sec 3 times then incubated on ice for 30 min. Cell lysates were then centrifuged at 16000 x g (10 min/4°C) and supernatants transferred to a fresh 1.5 mL tube. Protein concentrations were determined by Bradford assay (BioRad). Protein extracts were separated by SDS-PAGE and immunoblotting was performed with the following antibodies as recommended by the manufacturers: AurkB (BD Biosciences), Cdk2 (Upstate 05-596), c-Met (Cell Signaling 3127), Polo (Abcam 12210), Rock1 (Santa Cruz sc-17794), Tie1 (Santa Cruz sc-342), Yes1 (Santa Cruz sc-8403), α-tubulin (Sigma T-5168), phospho-histone H3 (Santa Cruz sc-8656), goat anti-rabbit IgG-HRP (Santa Cruz sc-2054), goat anti-mouse IgG-HRP (Santa Cruz sc-2055). Immunoblots were developed using the ECL detection system (Amersham).

Quantitative RT-PCR. Total RNA was harvested from cells in 6 cm tissue culture plates using Trizol (Invitrogen). For infections in 96-well plates, mRNA was harvested using GenePlateHybridization (RNAure). Reverse transcription reactions were carried out using a SuperScript II RT Kit (Invitrogen). Quantitative PCR reactions were performed using Assays-on-Demand FAM-MGB primer/probe sets and TaqMan Universal PCR Master Mix on an ABI Prism 7900HT Real-Time PCR machine (Applied Biosystems). Quantification of GAPDH levels in the same cDNA samples measured in separate qPCR reactions served as an endogenous control. All qPCR reactions were run in triplicate, and the average C_t (cycles to threshold) were used in the comparative C_t method (ABI User Bulletin #2) for relative quantification of target gene expression. Control infections using either an shRNA targeting lamin or an shRNA not targeting any human gene were used to define 100% expression.

Titering Assay. Viruses were titered using NIH3T3 fibroblasts, plated in 6 well dishes at 10⁵ cells per well. The next day, cells were infected with 10 μl of highly diluted virus (1:50-1:50,000) using a standard spin infection protocol with 8 μg/ml polybrene. 24 hours post infection, media was replaced with media containing 2 μg/ml puromycin. Colonies were allowed to form for 9-11 days, changing media as needed, then fixed with ethanol and stained with crystal violet.

pLKO.1 Lentiviral Infections of Other Cell Types. Mouse embryonic stem cells were infected in suspension and then plated onto 10 cm dishes containing mitotically inactivated mouse embryonic fibroblast feeders. Standard ES cell media was used to re-feed the ES cell colonies for 5 consecutive days. Mouse embryonic stem cells were photographed 5 d post-infection and FACS analysis was performed using a BD FACScan.

MEFs and human HCN1A cortical neurons were grown in standard DME with 10% fetal bovine serum and antibiotics and infected as described above for follow up assays. Human SHSY5Y neuroblastoma cells were grown in 1:1 Eagle's modified medium: HAMS F-12 with 10% fetal bovine serum and antibiotics and infected as described above for follow up assays. Cells were photographed 4-7 d post-infection.

Neonatal rat cardiomyocytes were isolated as previously described (Matsui et al., 1999) from 1 d old rats and plated in 12 well plates. Lentiviral infection was performed with the addition of 0.5 ml of viral supernatant (obtained from production in a 6 cm dish) and polybrene (final concentration of 4 μ g/ml). Incubation with virus was performed for a minimum of 24 h and GFP expression was assessed 4 days after infection. GFP+ cardiomyocytes that were actively beating in the dish were photographed 5 days after infection.

Tests for Interferon Induction. Lentiviral production and infection followed the same protocol as for MI hit follow-up experiments. Interferon gene expression levels were quantified with quantitative RT-PCR as described, except that an uninfected HT29 sample was used to define 100% expression.

Sequence of pLKO.1 (with 1.9 kb Stuffer Shown in Capital Letters)

pLKO.1 is a replication-incompetent lentiviral vector that contains the human U6 pol-III promoter, a stem-loop cassette followed by a cPPT termination signal, a puromycin resistance gene (puroR) driven by the human phosphoglycerate kinase promoter (hPGK), two bacterial origins of replication (f1 ori and pUC ori), and an ampicillin resistance gene (ampR).

```
ttgggggttgcgccctttccaaggcagccctggggttgcgcgagggacgaggctgctctggg
cgtgggttccgggaaacgcagcggcgccgaccctggggtctcgcacattcttcacgtccgtt
cgcagcgtcaccgggatcttcgcccgtacccttgtggggcccccgggcgacgcttctgct
ccgccccctaagtccgggaaggttcccttgccggttcgcccggctgcccggacgtgacaaacggaa
gccgcacgtctcactagtaccctcgcagacggacagcggccagggagcaatggcagcgcgc
cgaccgcgatgggctgtggccaatagcggctgctcagcagggcgcgccgagagcagcggc
cgggaagggggcggtgccccgagggcggggtgtggggcggtagtgtggggccctgttccctgcc
gcccgggtgttccgcattctgcaagcctccggagcgcacgtcggcagtcggctccctcgtt
gaccgaatcaccgacctctctccccagggggatccaccggagcttaccatgaccgagtac
aagcccacgggtgcccctcgccaccgcgacgacgtccccagggccgtacgcaccctcgcc
gccgcgttcgcccgaactccccgccacgcgccacaccgtcgatccggaccgccacatcgag
cgggtcaccgagctgcaagaactcttctcaccgcgcgtcgggctcgacatcggcaaggtg
tgggtcgcggacgacggcgcccgcggtggcggtctggaccacgcggagagcgtcgaagcg
ggggcggtgttcgcccagatcggcccgcgctggcccgagttgagcgggttccccggctggcc
gcccagcaacagatggaaggcctcctggcgccgacccggcccaaggagcccgcggtggttc
ctggccaccgtcggcgtctcgcccgaccaccagggcaaggggtctgggcagcgcctcgtg
ctccccggagtggaggcgccgagcgcgcgggggtgcccgccttctggagacctccgcg
ccccgcaacctccccctctacgagcggctcggcttaccgctcaccgcccagcgtcgaggtg
cccgaaggaccgcccacctgggtgcatgaccgcaagccgggtgctgacgcccgccccac
gaccgcgagcggccgaccgaaaggagcgcacgacccccatgcatcggtacctttaagacca
atgacttacaaggcagctgtagatcttagccactttttaaagaaaaggggggactggaa
gggctaattcactcccaacgaagacaagatctgctttttgcttgtactgggtctctctgg
ttagaccagatctgagcctgggagctctctggctaactagggaaaccactgcttaagcct
caataaagcttgcccttgagtgcttcaagtagtggtgcccgtctggtgtgtgactctgggt
aactagagatccctcagacccttttagtcagtggtggaaaatctctagcagtagtagttca
tgtcatcttattattcagtatattataacttgcaagaaatgaatatcagagagtgagagg
aacttgtttattgcagcttataatggttacaaataaagcaatagcattacaaaatttcaca
aataaagcatttttttctactgacttctagttgtgggtttgtccaaactcatcaatgtatct
tatcatgtctggctctagctatcccccccctaactccgcccatacccccccctaactccgc
ccagttccgcccattctccgcccataggctgactaattttttttatattatgcagaggccg
aggccgcctcggcctctgagctattccagaagtagtgaggaggcttttttggaggcctag
ggacgtaccaaatccgcccataagtagtcgtattacgcgcgctcactggccgctcgtttt
```


acaacgtcgtgactgggaaaaccctggcggttacccaacttaatcgccctgcagcacatcc
ccctttcgccagctggcgtaatagcgaagaggcccgaccgatcgcccttcccaacagtt
gcgagcctgaatggcgaatgggacgcgcctgtagcggcgcat taagcgcggcgggtgt
ggtggttacgcgcagcgtgaccgctacacttgccagcgccttagcgcgccgctcctttcgc
tttcttcccttcccttctcgccacggttcgcccggctttccccgtcaagctctaaatcgggg
gctcccttttagggttccgatttagtgctttacggcacctcgacccccaaaaaacttgatta
gggtgatgggtcacgtagtgggcatcgccctgatagacgggtttttcgcccttgacggt
ggagtccacgttctttaatagtgactcttggttccaaactggaacaacactcaaccctat
ctcggctctattcttttgatttataagggattttgcccgatttcggcctattgggttaaaaa
tgagctgatttaacaaaaat ttaacgcgaat t ttaacaaaaatattaacgcttacaat tta
ggtggcacttttcggggaaatgtgcgcggaaccctatttggttatttttctaatacat
tcaaatagtatccgctcatgagacaataaccctgataaatgcttcaataatattgaaa
aggaagagtatgagtatcaacatttccggtgcgccttattcccttttttgccgcat t
tgccttccgtttttgctcaccagaaacgctgggtgaaagtaaaagatgctgaagatcag
ttgggtgcacgagtggttacatcgaactggatctcaacagcggtaagatccttgagagt
tttcgccccgaagaacggtttccaatgatgagcacttttaagttctgctatgtggcgcg
gtattatcccgtattgacgcgggcaagagcaactcggctgcgcgcatacactattctcag
aatgacttgggttgagtactcaccagtcacagaaaagcatcttacggatggcatgacagta
agagaattatgcagtgctgccataaccatgagtgataaacactgcccgaacttacttctg
acaacgatcggaggaccgaaggagctaacgcttttttgcaacatgggggatcatgta
actcgccttgatcgttgggaaccggagctgaatgaagccataccaaacgacgagcgtgac
accacgatgcctgtagcaatggcaacaacgcttgcgcaaacctattaactggcgaactactt
actctagcttcccggcaacaattaatagactggatggaggcggataaagttgcaggacca
cttctgcgctcggcccttccggctggctgggtttattgctgataaatctggagccggtgag
cgtgggtctcgcggtatcattgcagcactggggccagatggtaagccctcccgtatcgta
gttatctacacgacggggagt caggcaactatggatgaacgaaatagacagatcgctgag
ataggtgcctcactgattaaagcattggtaactgtcagaccaagtttactcatatatactt
tagattgatttaaaacttcat ttttaatttaaaaggatctaggtgaagatcctttttgat
aatctcatgacccaaaatcccttaacgtgagtttccgttccactgagcgtcagaccccgta
gaaaagatcaaaggatcttcttgagatccttttttctgcgcgtaaatctgctgcttgcaa
acaaaaaacaccgcctaccagcgggtgggtttgcttgcggatcaagagctaccaactctt
tttccgaaggtaactggcttccagcagagcgcagataccaaatactgttcttctagtgtag
ccgtagttaggccaccacttcaagaactctgtagcaccgcctacatacctcgctctgcta
atcctgttaccagtggtgctgcccagtgggcgataagtcgtgcttaccgggttggaactca
agacgatagttaccggataaggcgcagcgggtcgggctgaacgggggggttcgtgcacacag
cccagcttggagcgaacgacctacaccgaactgagatacctacagcgtgagctatgagaa
agcgcacgcttcccgaaggagaaaggcggacaggtatccggtaagcggcaggggtcgga
acaggagagcgcacgagggagcttccagggggaaacgcctggatctttatagtcctgtc
gggtttcgccacctctgacttgagcgtcgat ttttgatgctcgtcagggggggcggagc
ctatggaaaaacgccagcaacgcggccttttacgggttccctggccttttgctggcctttt
gctcacatgttcttctcgtgcttaccctgattctgtggataaccgattaccgccttt
gagtgagctgataaccgctcgccgcagccgaacgaccgagcgcagcagtgagtgagcag
gaagcggaaagagcgcaccaatacgcacaaccgctctccccgcgcgcttggccgattcattaa
tgcagctggcagcagaggtttcccgactggaaagcgggagtgagcgcgaacgcaat taat
gtgagttagctcactcattagggaccccaggctttacactttatgcttccggctcgtatg
ttgtgtggaattgtgagcggataaacaat ttcacacaggaacagctatgacctgattac
gccaagcgcgcaat taaccctcactaaagggaaacaaaagctggagctgcaagcttaatgt
agtcttatgcaataactctgtagtcttgcaacatggtaacgatgagttagcaacatgcct
tacaaggagagaaaaagcaccgctgcatgcccgat tgggtggaagttaaggtggtagcgtg
ccttattaggaaggcaacagacgggtctgacatggattggacgaaccactgaattgccgc
attgcagagatattgtatttaagtgcctagctcgatacataaacgggtctctctgggttag
accagatctgagcctgggagctctctggctaaactagggaaaccactgcttaagcctcaat
aaagcttgccttgagtgcttcaagtagtggtgcccgtctgttggtgactctggtaact
agagatccctcagacccttttagtcagtggtgaaaatctctagcagtgggcggccgaacag
ggacttgaaagcgaagggaaccagaggagctctctgcagcaggactcggcttgctga
agcgcgcacggcaagaggcagggggcggcgactgggtgagtagccaaaaat tttgactag
cggaggctagaaggagagagatgggtgagagagcgtcagtat taagcgggggagaat tag

atcgcgatgggaaaaaatttcggttaagggccagggggaaagaaaaatataaattaaaaca
tatagtatgggcaagcagggagctagaacgatttcgcagttaatcctggcctgttagaac
atcagaaggctgtagacaaatactgggacagctacaaccatcccttcagacaggatcaga
agaacttagatcattatataatacagtagcaaccctctatttgtgtgcatcaaaggataga
gataaaagacaccaaggaagcttttagacaagatagaggaagagcaaaacaaaagtaagac
caccgcacagcaagcggccgctgatcttcagacctggaggaggagatatgagggacaatt
ggagaagtgaattatataaataataaagtagtaaaaaattgaaccattaggagtagcacca
ccaaggcaagagaagagtgggtgcagagagaaaaagagcagtggggaataggagctttgt
tccttgggttcttggggagcagcaggaagcactatggggcgcagcgtcaatgacgctgacgg
tacagggccagacaattatttgtctgggtatagtgcagcagcagaacaatttgtctgagggcta
ttgagggcgaacagcatctgttgcaactcacagctctggggcatcaagcagctccaggcaa
gaatcctggctgtggaaagatacctaaaggatcaacagctcctggggatttgggggtgtct
ctggaaaactcatttgcaccactgctgtgccttgggaatgctagtggagtaataaatctc
tggaaacagatttgggaatcacacgacctggatggagtgggacagagaaattaacaattaca
caagcttaatacactccttaattgaagaatcgaaaaccagcaagaaaagaatgaacaag
aattattggaattagataaatgggcaagtttgtggaattgggttaacataacaaattggc
tgtggtatataaaattattcataatgatagtaggaggcttggtaggtttaagaatagttt
ttgctgtactttctatagtgaatagagtttaggcagggatattcaccattatcgtttcaga
cccacctcccaacccccgagggggaccgcagggccgaaggaatagaagaagaaggtggag
agagagacagagacagatccattcgattagtgaacggatctcgacggatcgatcacgag
actagcctcgagcggccgcccccttcaccgagggcctatttcccatgatctctcatatt
tgcataacagatacaaggctgttagagagataattggaattaatttgactgtaaacacaa
agatatttagtacaaaatacgtgacgtagaaagtaataatttcttgggtagtttgcagttt
taaaattatgttttaaaatggactatcatatgcttaccgtaacttgaaagtatttgcatt
tcttggctttatataatcttgtggaaaggacgaaacaccggTGTGTTGTAAATGAGCACAC
AAAATACACATGCTAAAATATTATATTCTATGACCTTTATAAAATCAACCAAAATCTTCT
TTTTAATAACTTTAGTATCAATAATTAGAATTTTTATGTTCTTTTTGCAAACTTTTAAT
AAAAATGAGCAAAAATAAAAAACGCTAGTTTTAGTAACTCGCGTTGTTTTCTTCACSTTT
AATAATAGCTACTCCACCATTGTTCTTAAGCGGTGAGCTCCTGCTTCAATCATTTTTTG
AGCATCTTCAAATGTTCTAACTCCACCAGCTGCTTTAACTAAAGCATTGTCTTTAAACAAC
TGACTTCATTAGTTTAAACATCTTCAAATGTTGCACCTGATTTTTGAAAATCCTGTTGATGT
TTTTAACAAATTCTAATCCAGCTTCAACAGCTATTTTACAAGCTTTTCATGATTTCTTCTTT
TGTTAATAACAATTTTCCATAATACATTTAAACAACATGTGATCCAGCTGCTTTTTTTAC
AGCTTTTCATGTCTTCTAAACTAATTCATAATTTTTGTCTTTTAAATGCACCAATATTTAA
TACCATATCAATTTCTGTTGCACCATCTTTAATTGCTTCAGAAACTTCGAATGCTTTTTGT
AGCTGTTGTGCATGCACCTAGAGGAAAACCTACAACATTTGTTATTCTACATTTGTGCC
TTTTAATAAATTTTACAATAGCTTGTTCATATGAATTAACACAAACTGTTGCAAAATC
AAATTCATTTGCTTCATCACATAATTGTTTAAATTTTCACTTTTCGTAGCATCTTGTTTTAA
TAATGTGTGATCTATATATTTGTTTAGTTTTCAATTTTTCTCTATATATTCAATTTTTAAT
TTTTAATTTTAAATAATTTTCGTCTACTTTAACTTTAGCGTTTTGAACAGATTCCACCAACA
CCTATAAAATAAATTTTTAGTTTAGGTTTCACTTGGGCGAACAGCAAATCATGAC
TTATCTTCAAATAAAATTTTAGTAAGTCTTGTCTTGGCATATTATACATTCCATCGATG
TAGTCTTCAACATTAACAACCTTTAAGTCCAGCAATTTGAGTTAAGGGTGTGCTCTCAAT
GATTTCAATTAATGGTTCAATTTTTAATTTCTTTTCTTCTGTTTTAAATTCAGTTTAAA
GTGAAAGTGTAATATGCACCCATTTCTTTAAATAAATCTTCTAAATAGTCTACTAATGTT
TTATTTTGTTTTTTATAAAATCAAGCAGCCTCTGCTATTAATATAGAAGCTTGATTCCA
TCTTTATCTCTAGCTGAGTCATCAATTACATATCCATAACTTTCTTCTATAAGCAAAAACA
AAATTTAATCCGTTATCTTCTTCTTTAGCAATTTCTCTACCCATTCAATTTAATCCAGTT
AAAGTTTTTACAATATTAACCTCATATTTTTTTCATGAGCGATTCTATCACCCAAATCACTT
GTTACAAAACCTGAATATAGAGCCGGATTTTTTGGGAATGCTATTTAAGCGTTTTAGATTT
GATAATTTTCAATCAATTAATAATTTGGTCTGTTTGTATTCCATCTAATCTTACAAAATGA
CCATCATGTTTTATTGCCATTCCAAATCTGTCAGCATCTGGGTCAATTCATAATAATAATA
TCTGCATCATGTTTAAATACCATATTCAAGCGGTATTTTTTTCATGCAGGATCAAATTTCTGGA
TTTTGGATTTACAACATTTTTTAAATGTTTTCATCTTCAAATGCATGCTCTTCAACCTCAATA
ACGTTATATCCTGATTCACGTAATATTTTTTGGGGTAAATTTAGTTTCTGTTCCATTAACCT
GCGCTAAAATAAATTTTTTAAATCTTTTTTAGCTTCTTGTCTTTTTTTGTAGAATTctcga
cctcgagacaaatggcagttatccacaatttttaaaagaaaaggggggattgggggggt

acagtgcaggggaaagaatagtagacataatagcaacagacatacaaaactaaagaattac
aaaaaaaattacaaaaattcaaaattttcgggtttattacagggacagcagagatccac
ttggccgcggtcgagggg

Supplemental References

Johannessen, C. M., Reczek, E. E., James, M. F., Brems, H., Legius, E., and Cichowski, K. (2005). The NF1 tumor suppressor critically regulates TSC2 and mTOR. *Proc Natl Acad Sci U S A* *102*, 8573-8578.

Khvorova, A., Reynolds, A., and Jayasena, S. D. (2003). Functional siRNAs and miRNAs exhibit strand bias. *Cell* *115*, 209-216.

Matsui, T., Li, L., del Monte, F., Fukui, Y., Franke, T. F., Hajjar, R. J., and Rosenzweig, A. (1999). Adenoviral gene transfer of activated phosphatidylinositol 3'-kinase and Akt inhibits apoptosis of hypoxic cardiomyocytes in vitro. *Circulation* *100*, 2373-2379.

Sarbassov, D. D., Guertin, D. A., Ali, S. M., and Sabatini, D. M. (2005). Phosphorylation and regulation of Akt/PKB by the rictor-mTOR complex. *Science* *307*, 1098-1101.

Schwarz, D. S., Hutvagner, G., Du, T., Xu, Z., Aronin, N., and Zamore, P. D. (2003). Asymmetry in the assembly of the RNAi enzyme complex. *Cell* *115*, 199-208.

Supplemental Tables

Table S1. Cell Types that Have Been Infected by pLKO.1-Based Lentiviruses

| Cells | Cell type | Infection & Knockdown | Reference |
|------------------------|-------------------------------|-----------------------|----------------------------|
| Cell Lines | | | |
| (human) | | | |
| HEK293 | embryonic kidney cells | both | (Sarbassov et al., 2005) |
| HeLa | cervical adenocarcinoma | both | (Sarbassov et al., 2005) |
| A549 | lung adenocarcinoma | both | this study |
| HT29-D4 | colon carcinoma | both | this study |
| MCF7 | breast carcinoma | both | this study |
| MCF10A | breast carcinoma | both | SY Kim, unpublished |
| PC3 | prostate carcinoma | both | (Sarbassov et al., 2005) |
| DU145 | prostate carcinoma | both | (Sarbassov et al., 2005) |
| A431 | epidermal carcinoma | both | (Sarbassov et al., 2005) |
| THP1 | monocytic cells | both | N. Hacoheh, PC |
| RAW264.7 | macrophage cells | both | N. Hacoheh, PC |
| SH-SY5Y | brain neuroblastoma | infection | this study |
| HCN-1A | brain cortical neuron | infection | this study |
| SupT1 | T cells | both | A Luster, PC |
| BJ-TERT | diploid fibroblasts | both | this study |
| (mouse) | | | |
| NIH3T3 | fibroblasts | both | this study |
| Primary Cells | | | |
| (human) | | | |
| C3H10T1/2 | mesenchymal | both | L. Glimcher, PC |
| dendritic cells | immature dendritic cells | both | N. Hacoheh, unpublished |
| T cells | lymphocytes | both | D. Hafler, PC |
| epithelial cells | prostate | both | WC Hahn, unpublished |
| fibroblasts | primary mammary | both | A. Orimo & R. Weinberg, PC |
| (other species) | | | |
| ESC | mouse embryonic stem cells | both | this study |
| fibroblasts | mouse embryonic fibroblasts | both | (Johannessen et al., 2005) |
| MC3T3-E1 | primary calvarial osteoblasts | both | L. Glimcher, PC. |
| dendritic cells | mouse bone marrow derived | both | N. Hacoheh, unpublished. |
| cardiomyocytes | rat neonatal cardiomyocytes | infection | this study |

PC = personal communication.

Table S2. List of Genes Included in the Screening Collection

| NCBI Gene ID | Official Symbol | Gene Description |
|---------------------|------------------------|--|
| 22848 | AAK1 | AP2 associated kinase 1 |
| 9625 | AATK | apoptosis-associated tyrosine kinase |
| 25 | ABL1 | v-abl Abelson murine leukemia viral oncogene homolog 1 |
| 27 | ABL2 | v-abl Abelson murine leukemia viral oncogene homolog 2 (arg, Abelson-related gene) |
| 32 | ACACB | acetyl-Coenzyme A carboxylase beta |
| 10188 | ACK1 | activated Cdc42-associated kinase 1 |
| 52 | ACP1 | acid phosphatase 1, soluble |
| 55 | ACPP | acid phosphatase, prostate |
| 90 | ACVR1 | activin A receptor, type I |
| 91 | ACVR1B | activin A receptor, type IB |
| 130399 | ACVR1C | activin A receptor, type IC |
| 92 | ACVR2 | activin A receptor, type II |
| 93 | ACVR2B | activin A receptor, type IIB |
| 94 | ACVRL1 | activin A receptor type II-like 1 |
| 57143 | ADCK1 | aarF domain containing kinase 1 |
| 90956 | ADCK2 | aarF domain containing kinase 2 |
| 79934 | ADCK4 | aarF domain containing kinase 4 |
| 203054 | ADCK5 | aarF domain containing kinase 5 |
| 132 | ADK | adenosine kinase |
| 156 | ADRBK1 | adrenergic, beta, receptor kinase 1 |
| 157 | ADRBK2 | adrenergic, beta, receptor kinase 2 |
| 186 | AGTR2 | angiotensin II receptor, type 2 |
| 203 | AK1 | adenylate kinase 1 |
| 50808 | AK3L1 | adenylate kinase 3 like 1 |
| 26289 | AK5 | adenylate kinase 5 |
| 11215 | AKAP11 | A kinase (PRKA) anchor protein 11 |
| 9495 | AKAP5 | A kinase (PRKA) anchor protein 5 |
| 207 | AKT1 | v-akt murine thymoma viral oncogene homolog 1 |
| 208 | AKT2 | v-akt murine thymoma viral oncogene homolog 2 |
| 10000 | AKT3 | v-akt murine thymoma viral oncogene homolog 3 (protein kinase B, gamma) |
| 238 | ALK | anaplastic lymphoma kinase (Ki-1) |
| 80216 | ALPK1 | alpha-kinase 1 |
| 115701 | ALPK2 | alpha-kinase 2 |
| 57538 | ALPK3 | alpha-kinase 3 |
| 55437 | ALS2CR2 | amyotrophic lateral sclerosis 2 (juvenile) chromosome region, candidate 2 |
| 65061 | ALS2CR7 | amyotrophic lateral sclerosis 2 (juvenile) chromosome region, candidate 7 |
| 267 | AMFR | autocrine motility factor receptor |
| 269 | AMHR2 | anti-Mullerian hormone receptor, type II |
| 255239 | ANKK1 | ankyrin repeat and kinase domain containing 1 |
| 324 | APC | adenomatosis polyposis coli |
| 338 | APOB | apolipoprotein B (including Ag(x) antigen) |
| 369 | ARAF1 | v-raf murine sarcoma 3611 viral oncogene homolog 1 |
| 375 | ARF1 | ADP-ribosylation factor 1 |
| 9181 | ARHGEF2 | rho/rac guanine nucleotide exchange factor (GEF) 2 |
| 9891 | ARK5 | AMP-activated protein kinase family member 5 |
| 472 | ATM | ataxia telangiectasia mutated (includes complementation groups A, C and D) |

| | | |
|--------|----------|--|
| 545 | ATR | ataxia telangiectasia and Rad3 related |
| 6310 | ATXN1 | ataxin 1 |
| 9212 | AURKB | aurora kinase B |
| 6795 | AURKC | aurora kinase C |
| 558 | AXL | AXL receptor tyrosine kinase |
| 23621 | BACE1 | beta-site APP-cleaving enzyme 1 |
| 580 | BARD1 | BRCA1 associated RING domain 1 |
| 10295 | BCKDK | branched chain alpha-ketoacid dehydrogenase kinase |
| 596 | BCL2 | B-cell CLL/lymphoma 2 |
| 10018 | BCL2L11 | BCL2-like 11 (apoptosis facilitator) |
| 613 | BCR | breakpoint cluster region |
| 329 | BIRC2 | baculoviral IAP repeat-containing 2 |
| 330 | BIRC3 | baculoviral IAP repeat-containing 3 |
| 331 | BIRC4 | baculoviral IAP repeat-containing 4 |
| 640 | BLK | B lymphoid tyrosine kinase |
| 55839 | BM039 | uncharacterized bone marrow protein BM039 |
| 55589 | BMP2K | BMP2 inducible kinase |
| 657 | BMPR1A | bone morphogenetic protein receptor, type IA |
| 658 | BMPR1B | bone morphogenetic protein receptor, type IB |
| 659 | BMPR2 | bone morphogenetic protein receptor, type II (serine/threonine kinase) |
| 660 | BMX | BMX non-receptor tyrosine kinase |
| 673 | BRAF | v-raf murine sarcoma viral oncogene homolog B1 |
| 672 | BRCA1 | breast cancer 1, early onset |
| 675 | BRCA2 | breast cancer 2, early onset |
| 6046 | BRD2 | bromodomain containing 2 |
| 8019 | BRD3 | bromodomain containing 3 |
| 23476 | BRD4 | bromodomain containing 4 |
| 676 | BRDT | bromodomain, testis-specific |
| 695 | BTK | Bruton agammaglobulinemia tyrosine kinase |
| 699 | BUB1 | BUB1 budding uninhibited by benzimidazoles 1 homolog (yeast) |
| 701 | BUB1B | BUB1 budding uninhibited by benzimidazoles 1 homolog beta (yeast) |
| 283629 | C14orf20 | chromosome 14 open reading frame 20 |
| 23293 | C17orf31 | chromosome 17 open reading frame 31 |
| 94104 | C21orf66 | chromosome 21 open reading frame 66 |
| 8563 | C22orf19 | chromosome 22 open reading frame 19 |
| 10842 | C7orf16 | chromosome 7 open reading frame 16 |
| 56997 | CABC1 | chaperone, ABC1 activity of bc1 complex like (S. pombe) |
| 8536 | CAMK1 | calcium/calmodulin-dependent protein kinase I |
| 57118 | CAMK1D | calcium/calmodulin-dependent protein kinase ID |
| 57172 | CAMK1G | calcium/calmodulin-dependent protein kinase IG |
| 815 | CAMK2A | calcium/calmodulin-dependent protein kinase (CaM kinase) II alpha |
| 816 | CAMK2B | calcium/calmodulin-dependent protein kinase (CaM kinase) II beta |
| 817 | CAMK2D | calcium/calmodulin-dependent protein kinase (CaM kinase) II delta |
| 818 | CAMK2G | calcium/calmodulin-dependent protein kinase (CaM kinase) II gamma |
| 814 | CAMK4 | calcium/calmodulin-dependent protein kinase IV |
| 84254 | CAMKK1 | calcium/calmodulin-dependent protein kinase kinase 1, alpha |
| 10645 | CAMKK2 | calcium/calmodulin-dependent protein kinase kinase 2, beta |
| 79012 | CAMKV | CaM kinase-like vesicle-associated |
| 23729 | CARKL | carbohydrate kinase-like |

| | | |
|--------|----------|---|
| 8573 | CASK | calcium/calmodulin-dependent serine protein kinase (MAGUK family) |
| 867 | CBL | Cas-Br-M (murine) ecotropic retroviral transforming sequence |
| 868 | CBLB | Cas-Br-M (murine) ecotropic retroviral transforming sequence b |
| 595 | CCND1 | cyclin D1 (PRAD1: parathyroid adenomatosis 1) |
| 1231 | CCR2 | chemokine (C-C motif) receptor 2 |
| 12772 | Ccr2 | chemokine (C-C motif) receptor 2 |
| 23552 | CCRK | cell cycle related kinase |
| 25819 | CCRN4L | CCR4 carbon catabolite repression 4-like (<i>S. cerevisiae</i>) |
| 8556 | CDC14A | CDC14 cell division cycle 14 homolog A (<i>S. cerevisiae</i>) |
| 983 | CDC2 | cell division cycle 2, G1 to S and G2 to M |
| 991 | CDC20 | CDC20 cell division cycle 20 homolog (<i>S. cerevisiae</i>) |
| 993 | CDC25A | cell division cycle 25A |
| 994 | CDC25B | cell division cycle 25B |
| 995 | CDC25C | cell division cycle 25C |
| 984 | CDC2L1 | cell division cycle 2-like 1 (PITSLRE proteins) |
| 8621 | CDC2L5 | cell division cycle 2-like 5 (cholinesterase-related cell division controller) |
| 23097 | CDC2L6 | cell division cycle 2-like 6 (CDK8-like) |
| 51362 | CDC40 | cell division cycle 40 homolog (yeast) |
| 8476 | CDC42BPA | CDC42 binding protein kinase alpha (DMPK-like) |
| 9578 | CDC42BPB | CDC42 binding protein kinase beta (DMPK-like) |
| 55561 | CDC42BPG | CDC42 binding protein kinase gamma (DMPK-like) |
| 8317 | CDC7 | CDC7 cell division cycle 7 (<i>S. cerevisiae</i>) |
| 999 | CDH1 | cadherin 1, type 1, E-cadherin (epithelial) |
| 8558 | CDK10 | cyclin-dependent kinase (CDC2-like) 10 |
| 1017 | CDK2 | cyclin-dependent kinase 2 |
| 1018 | CDK3 | cyclin-dependent kinase 3 |
| 1019 | CDK4 | cyclin-dependent kinase 4 |
| 1020 | CDK5 | cyclin-dependent kinase 5 |
| 8851 | CDK5R1 | cyclin-dependent kinase 5, regulatory subunit 1 (p35) |
| 1021 | CDK6 | cyclin-dependent kinase 6 |
| 1022 | CDK7 | cyclin-dependent kinase 7 (MO15 homolog, <i>Xenopus laevis</i> , cdk-activating kinase) |
| 1024 | CDK8 | cyclin-dependent kinase 8 |
| 1025 | CDK9 | cyclin-dependent kinase 9 (CDC2-related kinase) |
| 8814 | CDKL1 | cyclin-dependent kinase-like 1 (CDC2-related kinase) |
| 8999 | CDKL2 | cyclin-dependent kinase-like 2 (CDC2-related kinase) |
| 51265 | CDKL3 | cyclin-dependent kinase-like 3 |
| 344387 | CDKL4 | cyclin-dependent kinase-like 4 |
| 6792 | CDKL5 | cyclin-dependent kinase-like 5 |
| 1026 | CDKN1A | cyclin-dependent kinase inhibitor 1A (p21, Cip1) |
| 1027 | CDKN1B | cyclin-dependent kinase inhibitor 1B (p27, Kip1) |
| 1028 | CDKN1C | cyclin-dependent kinase inhibitor 1C (p57, Kip2) |
| 1029 | CDKN2A | cyclin-dependent kinase inhibitor 2A (melanoma, p16, inhibits CDK4) |
| 1033 | CDKN3 | cyclin-dependent kinase inhibitor 3 (CDK2-associated dual specificity phosphatase) |
| 1111 | CHEK1 | CHK1 checkpoint homolog (<i>S. pombe</i>) |
| 11200 | CHEK2 | CHK2 checkpoint homolog (<i>S. pombe</i>) |
| 55790 | ChGn | chondroitin beta1,4 N-acetylgalactosaminyltransferase |
| 1119 | CHKA | choline kinase alpha |
| 1147 | CHUK | conserved helix-loop-helix ubiquitous kinase |
| 10518 | CIB2 | calcium and integrin binding family member 2 |

| | | |
|--------|----------|--|
| 8483 | CILP | cartilage intermediate layer protein, nucleotide pyrophosphohydrolase |
| 11113 | CIT | citron (rho-interacting, serine/threonine kinase 21) |
| 1152 | CKB | creatine kinase, brain |
| 1158 | CKM | creatine kinase, muscle |
| 1159 | CKMT1 | creatine kinase, mitochondrial 1 (ubiquitous) |
| 1160 | CKMT2 | creatine kinase, mitochondrial 2 (sarcomeric) |
| 1195 | CLK1 | CDC-like kinase 1 |
| 1196 | CLK2 | CDC-like kinase 2 |
| 1198 | CLK3 | CDC-like kinase 3 |
| 57396 | CLK4 | CDC-like kinase 4 |
| 1267 | CNP | 2',3'-cyclic nucleotide 3' phosphodiesterase |
| 1281 | COL3A1 | collagen, type III, alpha 1 (Ehlers-Danlos syndrome type IV, autosomal dominant) |
| 221184 | CPNE2 | copine II |
| 8895 | CPNE3 | copine III |
| 29894 | CPSF1 | cleavage and polyadenylation specific factor 1, 160kDa |
| 11051 | CPSF5 | cleavage and polyadenylation specific factor 5, 25 kDa |
| 11052 | CPSF6 | cleavage and polyadenylation specific factor 6, 68kDa |
| 1376 | CPT2 | carnitine palmitoyltransferase II |
| 51755 | CRK7 | CDC2-related protein kinase 7 |
| 1436 | CSF1R | colony stimulating factor 1 receptor, formerly McDonough feline sarcoma viral (v-fms) oncogene homolog |
| 1445 | CSK | c-src tyrosine kinase |
| 1452 | CSNK1A1 | casein kinase 1, alpha 1 |
| 122011 | CSNK1A1L | casein kinase 1, alpha 1-like |
| 1453 | CSNK1D | casein kinase 1, delta |
| 1454 | CSNK1E | casein kinase 1, epsilon |
| 53944 | CSNK1G1 | casein kinase 1, gamma 1 |
| 1456 | CSNK1G3 | casein kinase 1, gamma 3 |
| 1457 | CSNK2A1 | casein kinase 2, alpha 1 polypeptide |
| 1459 | CSNK2A2 | casein kinase 2, alpha prime polypeptide |
| 1460 | CSNK2B | casein kinase 2, beta polypeptide |
| 9150 | CTDP1 | CTD (carboxy-terminal domain, RNA polymerase II, polypeptide A) phosphatase, subunit 1 |
| 10106 | CTDSP2 | CTD (carboxy-terminal domain, RNA polymerase II, polypeptide A) small phosphatase 2 |
| 10217 | CTDSPL | CTD (carboxy-terminal domain, RNA polymerase II, polypeptide A) small phosphatase-like |
| 6387 | CXCL12 | chemokine (C-X-C motif) ligand 12 (stromal cell-derived factor 1) |
| 1540 | CYLD | cylindromatosis (turban tumor syndrome) |
| 153090 | DAB2IP | DAB2 interacting protein |
| 1612 | DAPK1 | death-associated protein kinase 1 |
| 23604 | DAPK2 | death-associated protein kinase 2 |
| 1613 | DAPK3 | death-associated protein kinase 3 |
| 27071 | DAPP1 | dual adaptor of phosphotyrosine and 3-phosphoinositides |
| 1616 | DAXX | death-associated protein 6 |
| 9201 | DCAMKL1 | doublecortin and CaM kinase-like 1 |
| 1630 | DCC | deleted in colorectal carcinoma |
| 1633 | DCK | deoxycytidine kinase |
| 780 | DDR1 | discoidin domain receptor family, member 1 |
| 4921 | DDR2 | discoidin domain receptor family, member 2 |
| 1654 | DDX3X | DEAD (Asp-Glu-Ala-Asp) box polypeptide 3, X-linked |
| 8653 | DDX3Y | DEAD (Asp-Glu-Ala-Asp) box polypeptide 3, Y-linked |
| 9879 | DDX46 | DEAD (Asp-Glu-Ala-Asp) box polypeptide 46 |

| | | |
|--------|----------|--|
| 1655 | DDX5 | DEAD (Asp-Glu-Ala-Asp) box polypeptide 5 |
| 1606 | DGKA | diacylglycerol kinase, alpha 80kDa |
| 1607 | DGKB | diacylglycerol kinase, beta 90kDa |
| 8527 | DGKD | diacylglycerol kinase, delta 130kDa |
| 8526 | DGKE | diacylglycerol kinase, epsilon 64kDa |
| 1608 | DGKG | diacylglycerol kinase, gamma 90kDa |
| 160851 | DGKH | diacylglycerol kinase, eta |
| 9162 | DGKI | diacylglycerol kinase, iota |
| 1609 | DGKQ | diacylglycerol kinase, theta 110kDa |
| 8525 | DGKZ | diacylglycerol kinase, zeta 104kDa |
| 1665 | DHX15 | DEAH (Asp-Glu-Ala-His) box polypeptide 15 |
| 8449 | DHX16 | DEAH (Asp-Glu-Ala-His) box polypeptide 16 |
| 9785 | DHX38 | DEAH (Asp-Glu-Ala-His) box polypeptide 38 |
| 1659 | DHX8 | DEAH (Asp-Glu-Ala-His) box polypeptide 8 |
| 1660 | DHX9 | DEAH (Asp-Glu-Ala-His) box polypeptide 9 |
| 1736 | DKC1 | dyskeratosis congenita 1, dyskerin |
| 152926 | DKFZ | hypothetical protein DKFZp761G058 |
| 1760 | DMPK | dystrophia myotonica-protein kinase |
| 1763 | DNA2L | DNA2 DNA replication helicase 2-like (yeast) |
| 9829 | DNAJC6 | DnaJ (Hsp40) homolog, subfamily C, member 6 |
| 10059 | DNM1L | dynamamin 1-like |
| 1794 | DOCK2 | dedicator of cytokinesis 2 |
| 9732 | DOCK4 | dedicator of cytokinesis 4 |
| 1841 | DTYMK | deoxythymidylate kinase (thymidylate kinase) |
| 1843 | DUSP1 | dual specificity phosphatase 1 |
| 11221 | DUSP10 | dual specificity phosphatase 10 |
| 8446 | DUSP11 | dual specificity phosphatase 11 (RNA/RNP complex 1-interacting) |
| 11266 | DUSP12 | dual specificity phosphatase 12 |
| 51207 | DUSP13 | dual specificity phosphatase 13 |
| 11072 | DUSP14 | dual specificity phosphatase 14 |
| 128853 | DUSP15 | dual specificity phosphatase-like 15 |
| 150290 | DUSP18 | dual specificity phosphatase 18 |
| 142679 | DUSP19 | dual specificity phosphatase 19 |
| 1847 | DUSP5 | dual specificity phosphatase 5 |
| 1848 | DUSP6 | dual specificity phosphatase 6 |
| 1852 | DUSP9 | dual specificity phosphatase 9 |
| 1859 | DYRK1A | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 1A |
| 9149 | DYRK1B | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 1B |
| 8445 | DYRK2 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 2 |
| 8444 | DYRK3 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 3 |
| 8798 | DYRK4 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 4 |
| 8291 | DYSF | dysferlin, limb girdle muscular dystrophy 2B (autosomal recessive) |
| 1869 | E2F1 | E2F transcription factor 1 |
| 29904 | EEF2K | eukaryotic elongation factor-2 kinase |
| 1956 | EGFR | epidermal growth factor receptor (erythroblastic leukemia viral (v-erb-b) oncogene homolog, avian) |
| 54583 | EGLN1 | egl nine homolog 1 (C. elegans) |
| 112399 | EGLN3 | egl nine homolog 3 (C. elegans) |
| 9451 | EIF2AK3 | eukaryotic translation initiation factor 2-alpha kinase 3 |
| 1978 | EIF4EBP1 | eukaryotic translation initiation factor 4E binding protein 1 |

| | | |
|--------|--------|--|
| 2021 | ENDOG | endonuclease G |
| 5167 | ENPP1 | ectonucleotide pyrophosphatase/phosphodiesterase 1 |
| 339221 | ENPP7 | ectonucleotide pyrophosphatase/phosphodiesterase 7 |
| 2033 | EP300 | E1A binding protein p300 |
| 2041 | EPHA1 | EPH receptor A1 |
| 284656 | EPHA10 | EPH receptor A10 |
| 1969 | EPHA2 | EPH receptor A2 |
| 2042 | EPHA3 | EPH receptor A3 |
| 2043 | EPHA4 | EPH receptor A4 |
| 2044 | EPHA5 | EPH receptor A5 |
| 285220 | EPHA6 | EPH receptor A6 |
| 285220 | EPHA6 | EPH receptor |
| 2045 | EPHA7 | EPH receptor A7 |
| 2046 | EPHA8 | EPH receptor A8 |
| 2047 | EPHB1 | EPH receptor B1 |
| 2048 | EPHB2 | EPH receptor B2 |
| 2049 | EPHB3 | EPH receptor B3 |
| 2050 | EPHB4 | EPH receptor B4 |
| 2051 | EPHB6 | EPH receptor B6 |
| 7957 | EPM2A | epilepsy, progressive myoclonus type 2A, Lafora disease (laforin) |
| 2064 | ERBB2 | v-erb-b2 erythroblastic leukemia viral oncogene homolog 2, neuro/glioblastoma derived oncogene homolog (avian) |
| 2065 | ERBB3 | v-erb-b2 erythroblastic leukemia viral oncogene homolog 3 (avian) |
| 2066 | ERBB4 | v-erb-a erythroblastic leukemia viral oncogene homolog 4 (avian) |
| 1161 | ERCC8 | excision repair cross-complementing rodent repair deficiency, complementation group 8 |
| 2069 | EREG | epiregulin |
| 225689 | ERK8 | extracellular signal-regulated kinase 8 |
| 2081 | ERN1 | endoplasmic reticulum to nucleus signalling 1 |
| 10595 | ERN2 | endoplasmic reticulum to nucleus signalling 2 |
| 2099 | ESR1 | estrogen receptor 1 |
| 2100 | ESR2 | estrogen receptor 2 (ER beta) |
| 55500 | ETNK1 | ethanolamine kinase 1 |
| 2122 | EVI1 | ecotropic viral integration site 1 |
| 2130 | EWSR1 | Ewing sarcoma breakpoint region 1 |
| 9156 | EXO1 | exonuclease 1 |
| 2131 | EXT1 | exostoses (multiple) 1 |
| 2132 | EXT2 | exostoses (multiple) 2 |
| 2145 | EZH1 | enhancer of zeste homolog 1 (Drosophila) |
| 2146 | EZH2 | enhancer of zeste homolog 2 (Drosophila) |
| 2194 | FASN | fatty acid synthase |
| 10922 | FASTK | FAST kinase |
| 2241 | FER | fer (fps/fes related) tyrosine kinase (phosphoprotein NCP94) |
| 26509 | FER1L3 | fer-1-like 3, myoferlin (C. elegans) |
| 2242 | FES | feline sarcoma oncogene |
| 2247 | FGF2 | fibroblast growth factor 2 (basic) |
| 2260 | FGFR1 | fibroblast growth factor receptor 1 (fms-related tyrosine kinase 2, Pfeiffer syndrome) |
| 2263 | FGFR2 | fibroblast growth factor receptor 2 (bacteria-expressed kinase, keratinocyte growth factor receptor, craniofacial dysostosis 1, Crouzon syndrome, Pfeiffer syndrome, Jackson-Weiss syndrome) |
| 2261 | FGFR3 | fibroblast growth factor receptor 3 (achondroplasia, thanatophoric dwarfism) |

| | | |
|--------|----------|--|
| 2264 | FGFR4 | fibroblast growth factor receptor 4 |
| 2268 | FGR | Gardner-Rasheed feline sarcoma viral (v-fgr) oncogene homolog |
| 55137 | FIGN | fidgetin |
| 2289 | FKBP5 | FK506 binding protein 5 |
| 23770 | FKBP8 | FK506 binding protein 8, 38kDa |
| 55681 | FLJ10074 | hypothetical protein FLJ10074 |
| 55135 | FLJ10385 | hypothetical protein FLJ10385 |
| 54862 | FLJ20241 | putative NFkB activating protein |
| 64419 | FLJ22405 | hypothetical protein FLJ22405 |
| 80122 | FLJ23074 | hypothetical protein FLJ23074 |
| 84197 | FLJ23356 | hypothetical protein FLJ23356 |
| 124923 | FLJ25006 | hypothetical protein FLJ25006 |
| 132160 | FLJ32332 | likely ortholog of mouse protein phosphatase 2C eta |
| 152110 | FLJ32685 | hypothetical protein FLJ32685 |
| 197259 | FLJ34389 | hypothetical protein FLJ34389 |
| 147699 | FLJ40125 | hypothetical protein FLJ40125 |
| 2321 | FLT1 | fms-related tyrosine kinase 1 (vascular endothelial growth factor/vascular permeability factor receptor) |
| 2322 | FLT3 | fms-related tyrosine kinase 3 |
| 2324 | FLT4 | fms-related tyrosine kinase 4 |
| 2308 | FOXO1A | forkhead box O1A (rhabdomyosarcoma) |
| 2309 | FOXO3A | forkhead box O3A |
| 2475 | FRAP1 | FK506 binding protein 12-rapamycin associated protein 1 |
| 2444 | FRK | fyn-related kinase |
| 2492 | FSHR | follicle stimulating hormone receptor |
| 2521 | FUS | fusion (involved in t(12;16) in malignant liposarcoma) |
| 2534 | FYN | FYN oncogene related to SRC, FGR, YES |
| 2547 | G22P1 | thyroid autoantigen 70kDa (Ku antigen) |
| 14394 | Gabra1 | gamma-aminobutyric acid (GABA-A) receptor, subunit alpha 1 |
| 14395 | Gabra2 | gamma-aminobutyric acid (GABA-A) receptor, subunit alpha 2 |
| 14396 | Gabra3 | gamma-aminobutyric acid (GABA-A) receptor, subunit alpha 3 |
| 110886 | Gabra5 | gamma-aminobutyric acid (GABA-A) receptor, subunit alpha 5 |
| 2580 | GAK | cyclin G associated kinase |
| 2584 | GALK1 | galactokinase 1 |
| 2585 | GALK2 | galactokinase 2 |
| 64223 | GBL | G protein beta subunit-like |
| 2645 | GCK | glucokinase (hexokinase 4, maturity onset diabetes of the young 2) |
| 115557 | GEFT | RAC/CDC42 exchange factor |
| 2686 | GGTL3 | gamma-glutamyltransferase-like 3 |
| 2764 | GMFB | glia maturation factor, beta |
| 9535 | GMFG | glia maturation factor, gamma |
| 10020 | GNE | glucosamine (UDP-N-acetyl)-2-epimerase/N-acetylmannosamine kinase |
| 27232 | GNMT | glycine N-methyltransferase |
| 338442 | GPR109A | G protein-coupled receptor 109A |
| 80885 | Gpr109b | G protein-coupled receptor 109B |
| 14738 | Gpr12 | G-protein coupled receptor 12 |
| 9687 | GREB1 | GREB1 protein |
| 6011 | GRK1 | G protein-coupled receptor kinase 1 |
| 2868 | GRK4 | G protein-coupled receptor kinase 4 |
| 2869 | GRK5 | G protein-coupled receptor kinase 5 |

| | | |
|--------|----------|---|
| 2870 | GRK6 | G protein-coupled receptor kinase 6 |
| 131890 | GRK7 | G protein-coupled receptor kinase 7 |
| 145258 | GSC | goosecoid |
| 83903 | GSG2 | haspin |
| 2931 | GSK3A | glycogen synthase kinase 3 alpha |
| 2932 | GSK3B | glycogen synthase kinase 3 beta |
| 2984 | GUCY2C | guanylate cyclase 2C (heat stable enterotoxin receptor) |
| 3000 | GUCY2D | guanylate cyclase 2D, membrane (retina-specific) |
| 2986 | GUCY2F | guanylate cyclase 2F, retinal |
| 2987 | GUK1 | guanylate kinase 1 |
| 3055 | HCK | hemopoietic cell kinase |
| 23072 | HECW1 | HECT, C2 and WW domain containing E3 ubiquitin protein ligase 1 |
| 3070 | HELLS | helicase, lymphoid-specific |
| 8916 | HERC3 | hect domain and RLD 3 |
| 3081 | HGD | homogentisate 1,2-dioxygenase (homogentisate oxidase) |
| 3082 | HGF | hepatocyte growth factor (hepapoietin A; scatter factor) |
| 204851 | HIPK1 | homeodomain interacting protein kinase 1 |
| 28996 | HIPK2 | homeodomain interacting protein kinase 2 |
| 10114 | HIPK3 | homeodomain interacting protein kinase 3 |
| 147746 | HIPK4 | homeodomain interacting protein kinase 4 |
| 3181 | HNRPA2B1 | heterogeneous nuclear ribonucleoprotein A2/B1 |
| 10151 | HNRPA3P1 | heterogeneous nuclear ribonucleoprotein A3 pseudogene 1 |
| 3185 | HNRPF | heterogeneous nuclear ribonucleoprotein F |
| 10236 | HNRPR | heterogeneous nuclear ribonucleoprotein R |
| 3248 | HPGD | hydroxyprostaglandin dehydrogenase 15-(NAD) |
| 3265 | HRAS | v-Ha-ras Harvey rat sarcoma viral oncogene homolog |
| 57110 | HRASLS | HRAS-like suppressor |
| 27102 | HRI | heme-regulated initiation factor 2-alpha kinase |
| 3309 | HSPA5 | heat shock 70kDa protein 5 (glucose-regulated protein, 78kDa) |
| 26353 | HSPB8 | heat shock 22kDa protein 8 |
| 3320 | HSPCA | heat shock 90kDa protein 1, alpha |
| 30811 | HUNK | hormonally upregulated Neu-associated kinase |
| 29072 | HYPB | huntingtin interacting protein B |
| 22858 | ICK | intestinal cell (MAK-like) kinase |
| 3416 | IDE | insulin-degrading enzyme |
| 3476 | IGBP1 | immunoglobulin (CD79A) binding protein 1 |
| 3479 | IGF1 | insulin-like growth factor 1 (somatomedin C) |
| 3480 | IGF1R | insulin-like growth factor 1 receptor |
| 9641 | IKBKE | inhibitor of kappa light polypeptide gene enhancer in B-cells, kinase epsilon |
| 3611 | ILK | integrin-linked kinase |
| 80895 | ILKAP | integrin-linked kinase-associated serine/threonine phosphatase 2C |
| 10994 | ILVBL | ilvB (bacterial acetolactate synthase)-like |
| 3631 | INPP4A | inositol polyphosphate-4-phosphatase, type I, 107kDa |
| 3635 | INPP5D | inositol polyphosphate-5-phosphatase, 145kDa |
| 3643 | INSR | insulin receptor |
| 3645 | INSRR | insulin receptor-related receptor |
| 3654 | IRAK1 | interleukin-1 receptor-associated kinase 1 |
| 3656 | IRAK2 | interleukin-1 receptor-associated kinase 2 |
| 11213 | IRAK3 | interleukin-1 receptor-associated kinase 3 |

| | | |
|--------|-----------|---|
| 51135 | IRAK4 | interleukin-1 receptor-associated kinase 4 |
| 3667 | IRS1 | insulin receptor substrate 1 |
| 83737 | ITCH | itchy homolog E3 ubiquitin protein ligase (mouse) |
| 3685 | ITGAV | integrin, alpha V (vitronectin receptor, alpha polypeptide, antigen CD51) |
| 3690 | ITGB3 | integrin, beta 3 (platelet glycoprotein IIIa, antigen CD61) |
| 3702 | ITK | IL2-inducible T-cell kinase |
| 6453 | ITSN1 | intersectin 1 (SH3 domain protein) |
| 50618 | ITSN2 | intersectin 2 |
| 3716 | JAK1 | Janus kinase 1 (a protein tyrosine kinase) |
| 3717 | JAK2 | Janus kinase 2 (a protein tyrosine kinase) |
| 3718 | JAK3 | Janus kinase 3 (a protein tyrosine kinase, leukocyte) |
| 3725 | JUN | v-jun sarcoma virus 17 oncogene homolog (avian) |
| 3778 | KCNMA1 | potassium large conductance calcium-activated channel, subfamily M, alpha member 1 |
| 3791 | KDR | kinase insert domain receptor (a type III receptor tyrosine kinase) |
| 10657 | KHDRBS1 | KH domain containing, RNA binding, signal transduction associated 1 |
| 23398 | KIAA0073 | KIAA0073 protein |
| 9711 | KIAA0226 | KIAA0226 gene product |
| 80820 | KIAA1706 | KIAA1706 protein |
| 85443 | KIAA1765 | KIAA1765 protein |
| 84451 | KIAA1804 | mixed lineage kinase 4 |
| 84446 | KIAA1811 | KIAA1811 protein |
| 3833 | KIFC1 | kinesin family member C1 |
| 22944 | KIN | KIN, antigenic determinant of recA protein homolog (mouse) |
| 3815 | KIT | v-kit Hardy-Zuckerman 4 feline sarcoma viral oncogene homolog |
| 3845 | KRAS2 | v-Ki-ras2 Kirsten rat sarcoma 2 viral oncogene homolog |
| 283455 | KSR2 | kinase suppressor of Ras-2 |
| 9113 | LATS1 | LATS, large tumor suppressor, homolog 1 (Drosophila) |
| 26524 | LATS2 | LATS, large tumor suppressor, homolog 2 (Drosophila) |
| 3932 | LCK | lymphocyte-specific protein tyrosine kinase |
| 3981 | LIG4 | ligase IV, DNA, ATP-dependent |
| 3984 | LIMK1 | LIM domain kinase 1 |
| 3985 | LIMK2 | LIM domain kinase 2 |
| 22853 | LMTK2 | lemur tyrosine kinase 2 |
| 114783 | LMTK3 | lemur tyrosine kinase 3 |
| 151649 | LOC151649 | hypothetical protein MGC27069 |
| 283155 | LOC283155 | similar to bone morphogenetic protein receptor, type IA precursor; activin A receptor, type II-like kinase 3 |
| 339263 | LOC339263 | hypothetical protein LOC339263 |
| 340371 | LOC340371 | hypothetical protein LOC340371 |
| 387934 | LOC387934 | similar to Fatty acid-binding protein, epidermal (E-FABP) (Psoriasis-associated fatty acid-binding protein homolog) (PA-FABP) |
| 401313 | LOC401313 | similar to ATP-binding cassette sub-family E member 1 (RNase L inhibitor) (Ribonuclease 4 inhibitor) (RNS4I) |
| 51760 | LOC51760 | B/K protein |
| 91807 | LOC91807 | myosin light chain kinase (MLCK) |
| 10128 | LRPPRC | leucine-rich PPR-motif containing |
| 79705 | LRRK1 | leucine-rich repeat kinase 1 |
| 120892 | LRRK2 | leucine-rich repeat kinase 2 |
| 4058 | LTK | leukocyte tyrosine kinase |
| 55692 | LUC7L | LUC7-like (S. cerevisiae) |
| 51631 | LUC7L2 | LUC7-like 2 (S. cerevisiae) |

| | | |
|--------|-----------|--|
| 92335 | LYK5 | protein kinase LYK5 |
| 4067 | LYN | v-yes-1 Yamaguchi sarcoma viral related oncogene homolog |
| 4094 | MAF | v-maf musculoaponeurotic fibrosarcoma oncogene homolog (avian) |
| 4117 | MAK | male germ cell-associated kinase |
| 9794 | MAML1 | mastermind-like 1 (Drosophila) |
| 5604 | MAP2K1 | mitogen-activated protein kinase kinase 1 |
| 5605 | MAP2K2 | mitogen-activated protein kinase kinase 2 |
| 5606 | MAP2K3 | mitogen-activated protein kinase kinase 3 |
| 6416 | MAP2K4 | mitogen-activated protein kinase kinase 4 |
| 5607 | MAP2K5 | mitogen-activated protein kinase kinase 5 |
| 5608 | MAP2K6 | mitogen-activated protein kinase kinase 6 |
| 5609 | MAP2K7 | mitogen-activated protein kinase kinase 7 |
| 4294 | MAP3K10 | mitogen-activated protein kinase kinase kinase 10 |
| 4296 | MAP3K11 | mitogen-activated protein kinase kinase kinase 11 |
| 7786 | MAP3K12 | mitogen-activated protein kinase kinase kinase 12 |
| 9175 | MAP3K13 | mitogen-activated protein kinase kinase kinase 13 |
| 9020 | MAP3K14 | mitogen-activated protein kinase kinase kinase 14 |
| 389840 | MAP3K15 | mitogen-activated protein kinase kinase kinase 15 |
| 10746 | MAP3K2 | mitogen-activated protein kinase kinase kinase 2 |
| 4215 | MAP3K3 | mitogen-activated protein kinase kinase kinase 3 |
| 4216 | MAP3K4 | mitogen-activated protein kinase kinase kinase 4 |
| 4217 | MAP3K5 | mitogen-activated protein kinase kinase kinase 5 |
| 9064 | MAP3K6 | mitogen-activated protein kinase kinase kinase 6 |
| 6885 | MAP3K7 | mitogen-activated protein kinase kinase kinase 7 |
| 10454 | MAP3K7IP1 | mitogen-activated protein kinase kinase kinase 7 interacting protein 1 |
| 1326 | MAP3K8 | mitogen-activated protein kinase kinase kinase 8 |
| 4293 | MAP3K9 | mitogen-activated protein kinase kinase kinase 9 |
| 11184 | MAP4K1 | mitogen-activated protein kinase kinase kinase kinase 1 |
| 5871 | MAP4K2 | mitogen-activated protein kinase kinase kinase kinase 2 |
| 8491 | MAP4K3 | mitogen-activated protein kinase kinase kinase kinase 3 |
| 9448 | MAP4K4 | mitogen-activated protein kinase kinase kinase kinase 4 |
| 11183 | MAP4K5 | mitogen-activated protein kinase kinase kinase kinase 5 |
| 5594 | MAPK1 | mitogen-activated protein kinase 1 |
| 5602 | MAPK10 | mitogen-activated protein kinase 10 |
| 5600 | MAPK11 | mitogen-activated protein kinase 11 |
| 6300 | MAPK12 | mitogen-activated protein kinase 12 |
| 5603 | MAPK13 | mitogen-activated protein kinase 13 |
| 1432 | MAPK14 | mitogen-activated protein kinase 14 |
| 5596 | MAPK4 | mitogen-activated protein kinase 4 |
| 5597 | MAPK6 | mitogen-activated protein kinase 6 |
| 5598 | MAPK7 | mitogen-activated protein kinase 7 |
| 5599 | MAPK8 | mitogen-activated protein kinase 8 |
| 9479 | MAPK8IP1 | mitogen-activated protein kinase 8 interacting protein 1 |
| 5601 | MAPK9 | mitogen-activated protein kinase 9 |
| 79109 | MAPKAP1 | mitogen-activated protein kinase associated protein 1 |
| 9261 | MAPKAPK2 | mitogen-activated protein kinase-activated protein kinase 2 |
| 7867 | MAPKAPK3 | mitogen-activated protein kinase-activated protein kinase 3 |
| 8550 | MAPKAPK5 | mitogen-activated protein kinase-activated protein kinase 5 |
| 4139 | MARK1 | MAP/microtubule affinity-regulating kinase 1 |

| | | |
|--------|----------|--|
| 2011 | MARK2 | MAP/microtubule affinity-regulating kinase 2 |
| 4140 | MARK3 | MAP/microtubule affinity-regulating kinase 3 |
| 57787 | MARK4 | MAP/microtubule affinity-regulating kinase 4 |
| 22983 | MAST1 | microtubule associated serine/threonine kinase 1 |
| 23139 | MAST2 | microtubule associated serine/threonine kinase 2 |
| 23031 | MAST3 | microtubule associated serine/threonine kinase 3 |
| 23227 | MAST4 | microtubule associated serine/threonine kinase family member 4 |
| 84930 | MASTL | microtubule associated serine/threonine kinase-like |
| 4145 | MATK | megakaryocyte-associated tyrosine kinase |
| 4149 | MAX | MAX protein |
| 23344 | MBC2 | likely ortholog of mouse membrane bound C2 domain containing protein |
| 51562 | MBIP | MAP3K12 binding inhibitory protein 1 |
| 4174 | MCM5 | MCM5 minichromosome maintenance deficient 5, cell division cycle 46 (<i>S. cerevisiae</i>) |
| 79772 | MCTP1 | multiple C2-domains with two transmembrane regions 1 |
| 4193 | MDM2 | Mdm2, transformed 3T3 cell double minute 2, p53 binding protein (mouse) |
| 9833 | MELK | maternal embryonic leucine zipper kinase |
| 4221 | MEN1 | multiple endocrine neoplasia I |
| 10461 | MERTK | c-mer proto-oncogene tyrosine kinase |
| 4233 | MET | met proto-oncogene (hepatocyte growth factor receptor) |
| 78986 | MGC1136 | hypothetical protein MGC1136 |
| 93627 | MGC16169 | hypothetical protein MGC16169 |
| 168448 | MGC26484 | hypothetical protein MGC26484 |
| 167359 | MGC42105 | hypothetical protein MGC42105 |
| 166614 | MGC45428 | hypothetical protein MGC45428 |
| 83931 | MGC4796 | Ser/Thr-like kinase |
| 341676 | MGC75495 | similar to Serine/threonine-protein kinase Nek1 (NimA-related protein kinase 1) |
| 50488 | MINK | misshapen/NIK-related kinase |
| 8569 | MKNK1 | MAP kinase interacting serine/threonine kinase 1 |
| 2872 | MKNK2 | MAP kinase interacting serine/threonine kinase 2 |
| 51657 | MK-STYX | map kinase phosphatase-like protein MK-STYX |
| 4292 | MLH1 | mutL homolog 1, colon cancer, nonpolyposis type 2 (<i>E. coli</i>) |
| 4303 | MLLT7 | myeloid/lymphoid or mixed-lineage leukemia (trithorax homolog, <i>Drosophila</i>); translocated to, 7 |
| 4312 | MMP1 | matrix metalloproteinase 1 (interstitial collagenase) |
| 4314 | MMP3 | matrix metalloproteinase 3 (stromelysin 1, progelatinase) |
| 27136 | MORC | microrchidia homolog (mouse) |
| 4342 | MOS | v-mos Moloney murine sarcoma viral oncogene homolog |
| 51678 | MPP6 | membrane protein, palmitoylated 6 (MAGUK p53 subfamily member 6) |
| 4361 | MRE11A | MRE11 meiotic recombination 11 homolog A (<i>S. cerevisiae</i>) |
| 4436 | MSH2 | mutS homolog 2, colon cancer, nonpolyposis type 1 (<i>E. coli</i>) |
| 4439 | MSH5 | mutS homolog 5 (<i>E. coli</i>) |
| 4486 | MST1R | macrophage stimulating 1 receptor (c-met-related tyrosine kinase) |
| 51765 | MST4 | Mst3 and SOK1-related kinase |
| 4534 | MTM1 | myotubularin 1 |
| 8776 | MTMR1 | myotubularin related protein 1 |
| 8898 | MTMR2 | myotubularin related protein 2 |
| 8897 | MTMR3 | myotubularin related protein 3 |
| 9110 | MTMR4 | myotubularin related protein 4 |
| 55613 | MTMR8 | myotubularin related protein 8 |
| 4593 | MUSK | muscle, skeletal, receptor tyrosine kinase |

| | | |
|--------|--------|--|
| 4598 | MVK | mevalonate kinase (mevalonic aciduria) |
| 4602 | MYB | v-myb myeloblastosis viral oncogene homolog (avian) |
| 4609 | MYC | v-myc myelocytomatosis viral oncogene homolog (avian) |
| 4638 | MYLK | myosin, light polypeptide kinase |
| 85366 | MYLK2 | myosin light chain kinase 2, skeletal muscle |
| 53904 | MYO3A | myosin IIIA |
| 140469 | MYO3B | myosin IIIB |
| 11143 | MYST2 | MYST histone acetyltransferase 2 |
| 4683 | NBS1 | Nijmegen breakage syndrome 1 (nibrin) |
| 23327 | NEDD4L | neural precursor cell expressed, developmentally down-regulated 4-like |
| 4750 | NEK1 | NIMA (never in mitosis gene a)-related kinase 1 |
| 79858 | NEK11 | NIMA (never in mitosis gene a)- related kinase 11 |
| 4751 | NEK2 | NIMA (never in mitosis gene a)-related kinase 2 |
| 4752 | NEK3 | NIMA (never in mitosis gene a)-related kinase 3 |
| 6787 | NEK4 | NIMA (never in mitosis gene a)-related kinase 4 |
| 10783 | NEK6 | NIMA (never in mitosis gene a)-related kinase 6 |
| 140609 | NEK7 | NIMA (never in mitosis gene a)-related kinase 7 |
| 284086 | NEK8 | NIMA (never in mitosis gene a)- related kinase 8 |
| 91754 | NEK9 | NIMA (never in mitosis gene a)- related kinase 9 |
| 4763 | NF1 | neurofibromin 1 (neurofibromatosis, von Recklinghausen disease, Watson disease) |
| 4771 | NF2 | neurofibromin 2 (bilateral acoustic neuroma) |
| 4824 | NKX3-1 | NK3 transcription factor related, locus 1 (Drosophila) |
| 51701 | NLK | nemo like kinase |
| 4830 | NME1 | non-metastatic cells 1, protein (NM23A) expressed in |
| 4831 | NME2 | non-metastatic cells 2, protein (NM23B) expressed in |
| 4833 | NME4 | non-metastatic cells 4, protein expressed in |
| 10201 | NME6 | non-metastatic cells 6, protein expressed in (nucleoside-diphosphate kinase) |
| 29922 | NME7 | non-metastatic cells 7, protein expressed in (nucleoside-diphosphate kinase) |
| 4843 | NOS2A | nitric oxide synthase 2A (inducible, hepatocytes) |
| 4851 | NOTCH1 | Notch homolog 1, translocation-associated (Drosophila) |
| 4857 | NOVA1 | neuro-oncological ventral antigen 1 |
| 4881 | NPR1 | natriuretic peptide receptor A/guanylate cyclase A (atriuretic peptide receptor A) |
| 4882 | NPR2 | natriuretic peptide receptor B/guanylate cyclase B (atriuretic peptide receptor B) |
| 1728 | NQO1 | NAD(P)H dehydrogenase, quinone 1 |
| 9971 | NR1H4 | nuclear receptor subfamily 1, group H, member 4 |
| 8856 | NR1I2 | nuclear receptor subfamily 1, group I, member 2 |
| 9970 | NR1I3 | nuclear receptor subfamily 1, group I, member 3 |
| 29959 | NRBP | nuclear receptor binding protein |
| 4914 | NTRK1 | neurotrophic tyrosine kinase, receptor, type 1 |
| 4915 | NTRK2 | neurotrophic tyrosine kinase, receptor, type 2 |
| 4916 | NTRK3 | neurotrophic tyrosine kinase, receptor, type 3 |
| 84033 | OBSCN | obscurin, cytoskeletal calmodulin and titin-interacting RhoGEF |
| 9943 | OXS1 | oxidative-stress responsive 1 |
| 55197 | P15RS | hypothetical protein FLJ10656 |
| 8106 | PABPN1 | poly(A) binding protein, nuclear 1 |
| 57147 | PACE-1 | ezrin-binding partner PACE-1 |
| 5058 | PAK1 | p21/Cdc42/Rac1-activated kinase 1 (STE20 homolog, yeast) |
| 5062 | PAK2 | p21 (CDKN1A)-activated kinase 2 |
| 5063 | PAK3 | p21 (CDKN1A)-activated kinase 3 |

| | | |
|--------|---------|---|
| 10298 | PAK4 | p21(CDKN1A)-activated kinase 4 |
| 56924 | PAK6 | p21(CDKN1A)-activated kinase 6 |
| 57144 | PAK7 | p21(CDKN1A)-activated kinase 7 |
| 9061 | PAPSS1 | 3'-phosphoadenosine 5'-phosphosulfate synthase 1 |
| 9411 | PARG1 | PTPL1-associated RhoGAP 1 |
| 5071 | PARK2 | Parkinson disease (autosomal recessive, juvenile) 2, parkin |
| 23178 | PASK | PAS domain containing serine/threonine kinase |
| 5127 | PCK1 | PCTAIRE protein kinase 1 |
| 5128 | PCK2 | PCTAIRE protein kinase 2 |
| 5155 | PDGFB | platelet-derived growth factor beta polypeptide (simian sarcoma viral (v-sis) oncogene homolog) |
| 5156 | PDGFRA | platelet-derived growth factor receptor, alpha polypeptide |
| 5159 | PDGFRB | platelet-derived growth factor receptor, beta polypeptide |
| 149420 | PDIK1L | PDLIM1 interacting kinase 1 like |
| 64714 | PDIP | protein disulfide isomerase, pancreatic |
| 5163 | PDK1 | pyruvate dehydrogenase kinase, isoenzyme 1 |
| 5164 | PDK2 | pyruvate dehydrogenase kinase, isoenzyme 2 |
| 5165 | PDK3 | pyruvate dehydrogenase kinase, isoenzyme 3 |
| 5166 | PDK4 | pyruvate dehydrogenase kinase, isoenzyme 4 |
| 5170 | PDPK1 | 3-phosphoinositide dependent protein kinase-1 |
| 8566 | PDXK | pyridoxal (pyridoxine, vitamin B6) kinase |
| 5211 | PFKL | phosphofructokinase, liver |
| 5218 | PFTK1 | PFTAIRE protein kinase 1 |
| 5230 | PGK1 | phosphoglycerate kinase 1 |
| 5241 | PGR | progesterone receptor |
| 5260 | PHKG1 | phosphorylase kinase, gamma 1 (muscle) |
| 5261 | PHKG2 | phosphorylase kinase, gamma 2 (testis) |
| 5286 | PIK3C2A | phosphoinositide-3-kinase, class 2, alpha polypeptide |
| 5287 | PIK3C2B | phosphoinositide-3-kinase, class 2, beta polypeptide |
| 5288 | PIK3C2G | phosphoinositide-3-kinase, class 2, gamma polypeptide |
| 5290 | PIK3CA | phosphoinositide-3-kinase, catalytic, alpha polypeptide |
| 5291 | PIK3CB | phosphoinositide-3-kinase, catalytic, beta polypeptide |
| 5296 | PIK3R2 | phosphoinositide-3-kinase, regulatory subunit 2 (p85 beta) |
| 30849 | PIK3R4 | phosphoinositide-3-kinase, regulatory subunit 4, p150 |
| 5292 | PIM1 | pim-1 oncogene |
| 11040 | PIM2 | pim-2 oncogene |
| 5300 | PIN1 | protein (peptidyl-prolyl cis/trans isomerase) NIMA-interacting 1 |
| 65018 | PINK1 | PTEN induced putative kinase 1 |
| 8394 | PIP5K1A | phosphatidylinositol-4-phosphate 5-kinase, type I, alpha |
| 5305 | PIP5K2A | phosphatidylinositol-4-phosphate 5-kinase, type II, alpha |
| 8396 | PIP5K2B | phosphatidylinositol-4-phosphate 5-kinase, type II, beta |
| 5569 | PKIA | protein kinase (cAMP-dependent, catalytic) inhibitor alpha |
| 5570 | PKIB | protein kinase (cAMP-dependent, catalytic) inhibitor beta |
| 5313 | PKLR | pyruvate kinase, liver and RBC |
| 9088 | PKMYT1 | membrane-associated tyrosine- and threonine-specific cdc2-inhibitory kinase |
| 5585 | PKN1 | protein kinase N1 |
| 5586 | PKN2 | protein kinase N2 |
| 29941 | PKN3 | protein kinase N3 |
| 5330 | PLCB2 | phospholipase C, beta 2 |
| 5331 | PLCB3 | phospholipase C, beta 3 (phosphatidylinositol-specific) |

| | | |
|--------|----------|---|
| 5333 | PLCD1 | phospholipase C, delta 1 |
| 5336 | PLCG2 | phospholipase C, gamma 2 (phosphatidylinositol-specific) |
| 5334 | PLCL1 | phospholipase C-like 1 |
| 23228 | PLCL2 | phospholipase C-like 2 |
| 89869 | PLCZ1 | phospholipase C, zeta 1 |
| 5337 | PLD1 | phospholipase D1, phosphatidylcholine-specific |
| 5347 | PLK1 | polo-like kinase 1 (Drosophila) |
| 10769 | PLK2 | polo-like kinase 2 (Drosophila) |
| 1263 | PLK3 | polo-like kinase 3 (Drosophila) |
| 10733 | PLK4 | polo-like kinase 4 (Drosophila) |
| 51400 | PME-1 | protein phosphatase methylesterase-1 |
| 5378 | PMS1 | PMS1 postmeiotic segregation increased 1 (S. cerevisiae) |
| 10654 | PMVK | phosphomevalonate kinase |
| 139728 | PNCK | pregnancy upregulated non-ubiquitously expressed CaM kinase |
| 25913 | POT1 | POT1 protection of telomeres 1 homolog (S. pombe) |
| 8611 | PPAP2A | phosphatidic acid phosphatase type 2A |
| 8612 | PPAP2C | phosphatidic acid phosphatase type 2C |
| 5465 | PPARA | peroxisome proliferative activated receptor, alpha |
| 5467 | PPARD | peroxisome proliferative activated receptor, delta |
| 5468 | PPARG | peroxisome proliferative activated receptor, gamma |
| 19016 | Pparg | peroxisome proliferator activated receptor gamma |
| 10891 | PPARGC1A | peroxisome proliferative activated receptor, gamma, coactivator 1, alpha |
| 5475 | PPEF1 | protein phosphatase, EF hand calcium-binding domain 1 |
| 5470 | PPEF2 | protein phosphatase, EF hand calcium-binding domain 2 |
| 8500 | PPFIA1 | protein tyrosine phosphatase, receptor type, f polypeptide (PTPRF), interacting protein (liprin), alpha 1 |
| 8499 | PPFIA2 | protein tyrosine phosphatase, receptor type, f polypeptide (PTPRF), interacting protein (liprin), alpha 2 |
| 8541 | PPFIA3 | protein tyrosine phosphatase, receptor type, f polypeptide (PTPRF), interacting protein (liprin), alpha 3 |
| 8496 | PPFIBP1 | PTPRF interacting protein, binding protein 1 (liprin beta 1) |
| 51645 | PPIL1 | peptidylprolyl isomerase (cyclophilin)-like 1 |
| 23759 | PPIL2 | peptidylprolyl isomerase (cyclophilin)-like 2 |
| 53938 | PPIL3 | peptidylprolyl isomerase (cyclophilin)-like 3 |
| 5494 | PPM1A | protein phosphatase 1A (formerly 2C), magnesium-dependent, alpha isoform |
| 5495 | PPM1B | protein phosphatase 1B (formerly 2C), magnesium-dependent, beta isoform |
| 8493 | PPM1D | protein phosphatase 1D magnesium-dependent, delta isoform |
| 22843 | PPM1E | protein phosphatase 1E (PP2C domain containing) |
| 9647 | PPM1F | protein phosphatase 1F (PP2C domain containing) |
| 5496 | PPM1G | protein phosphatase 1G (formerly 2C), magnesium-dependent, gamma isoform |
| 151742 | PPM1L | protein phosphatase 1 (formerly 2C)-like |
| 54704 | PPM2C | protein phosphatase 2C, magnesium-dependent, catalytic subunit |
| 5499 | PPP1CA | protein phosphatase 1, catalytic subunit, alpha isoform |
| 5500 | PPP1CB | protein phosphatase 1, catalytic subunit, beta isoform |
| 5501 | PPP1CC | protein phosphatase 1, catalytic subunit, gamma isoform |
| 5514 | PPP1R10 | protein phosphatase 1, regulatory subunit 10 |
| 6992 | PPP1R11 | protein phosphatase 1, regulatory (inhibitor) subunit 11 |
| 4659 | PPP1R12A | protein phosphatase 1, regulatory (inhibitor) subunit 12A |
| 54776 | PPP1R12C | protein phosphatase 1, regulatory (inhibitor) subunit 12C |
| 23368 | PPP1R13B | protein phosphatase 1, regulatory (inhibitor) subunit 13B |
| 81706 | PPP1R14C | protein phosphatase 1, regulatory (inhibitor) subunit 14C |

| | | |
|-------|----------|---|
| 54866 | PPP1R14D | protein phosphatase 1, regulatory (inhibitor) subunit 14D |
| 23645 | PPP1R15A | protein phosphatase 1, regulatory (inhibitor) subunit 15A |
| 84919 | PPP1R15B | protein phosphatase 1, regulatory (inhibitor) subunit 15B |
| 84988 | PPP1R16A | protein phosphatase 1, regulatory (inhibitor) subunit 16A |
| 5502 | PPP1R1A | protein phosphatase 1, regulatory (inhibitor) subunit 1A |
| 80316 | PPP1R2P9 | protein phosphatase 1, regulatory (inhibitor) subunit 2 pseudogene 9 |
| 79660 | PPP1R3B | protein phosphatase 1, regulatory (inhibitor) subunit 3B |
| 5507 | PPP1R3C | protein phosphatase 1, regulatory (inhibitor) subunit 3C |
| 5510 | PPP1R7 | protein phosphatase 1, regulatory subunit 7 |
| 5511 | PPP1R8 | protein phosphatase 1, regulatory (inhibitor) subunit 8 |
| 84687 | PPP1R9B | protein phosphatase 1, regulatory subunit 9B, spinophilin |
| 5515 | PPP2CA | protein phosphatase 2 (formerly 2A), catalytic subunit, alpha isoform |
| 5516 | PPP2CB | protein phosphatase 2 (formerly 2A), catalytic subunit, beta isoform |
| 5518 | PPP2R1A | protein phosphatase 2 (formerly 2A), regulatory subunit A (PR 65), alpha isoform |
| 5519 | PPP2R1B | protein phosphatase 2 (formerly 2A), regulatory subunit A (PR 65), beta isoform |
| 5520 | PPP2R2A | protein phosphatase 2 (formerly 2A), regulatory subunit B (PR 52), alpha isoform |
| 5521 | PPP2R2B | protein phosphatase 2 (formerly 2A), regulatory subunit B (PR 52), beta isoform |
| 5522 | PPP2R2C | protein phosphatase 2 (formerly 2A), regulatory subunit B (PR 52), gamma isoform |
| 5524 | PPP2R4 | protein phosphatase 2A, regulatory subunit B' (PR 53) |
| 5525 | PPP2R5A | protein phosphatase 2, regulatory subunit B (B56), alpha isoform |
| 5526 | PPP2R5B | protein phosphatase 2, regulatory subunit B (B56), beta isoform |
| 5527 | PPP2R5C | protein phosphatase 2, regulatory subunit B (B56), gamma isoform |
| 5528 | PPP2R5D | protein phosphatase 2, regulatory subunit B (B56), delta isoform |
| 5529 | PPP2R5E | protein phosphatase 2, regulatory subunit B (B56), epsilon isoform |
| 5530 | PPP3CA | protein phosphatase 3 (formerly 2B), catalytic subunit, alpha isoform (calcineurin A alpha) |
| 5532 | PPP3CB | protein phosphatase 3 (formerly 2B), catalytic subunit, beta isoform (calcineurin A beta) |
| 5534 | PPP3R1 | protein phosphatase 3 (formerly 2B), regulatory subunit B, 19kDa, alpha isoform (calcineurin B, type I) |
| 5531 | PPP4C | protein phosphatase 4 (formerly X), catalytic subunit |
| 5536 | PPP5C | protein phosphatase 5, catalytic subunit |
| 5537 | PPP6C | protein phosphatase 6, catalytic subunit |
| 5558 | PRIM2A | primase, polypeptide 2A, 58kDa |
| 5562 | PRKAA1 | protein kinase, AMP-activated, alpha 1 catalytic subunit |
| 5563 | PRKAA2 | protein kinase, AMP-activated, alpha 2 catalytic subunit |
| 5565 | PRKAB2 | protein kinase, AMP-activated, beta 2 non-catalytic subunit |
| 5566 | PRKACA | protein kinase, cAMP-dependent, catalytic, alpha |
| 5567 | PRKACB | protein kinase, cAMP-dependent, catalytic, beta |
| 5571 | PRKAG1 | protein kinase, AMP-activated, gamma 1 non-catalytic subunit |
| 51422 | PRKAG2 | protein kinase, AMP-activated, gamma 2 non-catalytic subunit |
| 5573 | PRKAR1A | protein kinase, cAMP-dependent, regulatory, type I, alpha (tissue specific extinguisher 1) |
| 5578 | PRKCA | protein kinase C, alpha |
| 5579 | PRKCB1 | protein kinase C, beta 1 |
| 5580 | PRKCD | protein kinase C, delta |
| 5581 | PRKCE | protein kinase C, epsilon |
| 5582 | PRKCG | protein kinase C, gamma |
| 5583 | PRKCH | protein kinase C, eta |
| 5584 | PRKCI | protein kinase C, iota |
| 5588 | PRKCQ | protein kinase C, theta |
| 5590 | PRKCZ | protein kinase C, zeta |
| 5587 | PRKD1 | protein kinase D1 |

| | | |
|--------|---------|--|
| 25865 | PRKD2 | protein kinase D2 |
| 23683 | PRKD3 | protein kinase D3 |
| 5591 | PRKDC | protein kinase, DNA-activated, catalytic polypeptide |
| 5592 | PRKG1 | protein kinase, cGMP-dependent, type I |
| 5593 | PRKG2 | protein kinase, cGMP-dependent, type II |
| 5610 | PRKR | protein kinase, interferon-inducible double stranded RNA dependent |
| 65125 | PRKWNK1 | protein kinase, lysine deficient 1 |
| 65268 | PRKWNK2 | protein kinase, lysine deficient 2 |
| 65267 | PRKWNK3 | protein kinase, lysine deficient 3 |
| 65266 | PRKWNK4 | protein kinase, lysine deficient 4 |
| 5613 | PRKX | protein kinase, X-linked |
| 5616 | PRKY | protein kinase, Y-linked |
| 8559 | PRPF18 | PRP18 pre-mRNA processing factor 18 homolog (yeast) |
| 26121 | PRPF31 | PRP31 pre-mRNA processing factor 31 homolog (yeast) |
| 8899 | PRPF4B | PRP4 pre-mRNA processing factor 4 homolog B (yeast) |
| 5631 | PRPS1 | phosphoribosyl pyrophosphate synthetase 1 |
| 5634 | PRPS2 | phosphoribosyl pyrophosphate synthetase 2 |
| 5651 | PRSS7 | protease, serine, 7 (enterokinase) |
| 5681 | PSKH1 | protein serine kinase H1 |
| 85481 | PSKH2 | protein serine kinase H2 |
| 5723 | PSPH | phosphoserine phosphatase |
| 9051 | PSTPIP1 | proline-serine-threonine phosphatase interacting protein 1 |
| 9050 | PSTPIP2 | proline-serine-threonine phosphatase interacting protein 2 |
| 5725 | PTBP1 | polypyrimidine tract binding protein 1 |
| 58155 | PTBP2 | polypyrimidine tract binding protein 2 |
| 5727 | PTCH | patched homolog (Drosophila) |
| 5728 | PTEN | phosphatase and tensin homolog (mutated in multiple advanced cancers 1) |
| 5734 | PTGER4 | prostaglandin E receptor 4 (subtype EP4) |
| 5745 | PTH1R | parathyroid hormone receptor 1 |
| 5747 | PTK2 | PTK2 protein tyrosine kinase 2 |
| 2185 | PTK2B | PTK2B protein tyrosine kinase 2 beta |
| 5753 | PTK6 | PTK6 protein tyrosine kinase 6 |
| 5754 | PTK7 | PTK7 protein tyrosine kinase 7 |
| 5756 | PTK9 | PTK9 protein tyrosine kinase 9 |
| 11344 | PTK9L | PTK9L protein tyrosine kinase 9-like (A6-related protein) |
| 5764 | PTN | pleiotrophin (heparin binding growth factor 8, neurite growth-promoting factor 1) |
| 7803 | PTP4A1 | protein tyrosine phosphatase type IVA, member 1 |
| 8073 | PTP4A2 | protein tyrosine phosphatase type IVA, member 2 |
| 11156 | PTP4A3 | protein tyrosine phosphatase type IVA, member 3 |
| 138639 | PTPDC1 | protein tyrosine phosphatase domain containing 1 |
| 9200 | PTPLA | protein tyrosine phosphatase-like (proline instead of catalytic arginine), member a |
| 5770 | PTPN1 | protein tyrosine phosphatase, non-receptor type 1 |
| 5782 | PTPN12 | protein tyrosine phosphatase, non-receptor type 12 |
| 5783 | PTPN13 | protein tyrosine phosphatase, non-receptor type 13 (APO-1/CD95 (Fas)-associated phosphatase) |
| 26469 | PTPN18 | protein tyrosine phosphatase, non-receptor type 18 (brain-derived) |
| 5771 | PTPN2 | protein tyrosine phosphatase, non-receptor type 2 |
| 11099 | PTPN21 | protein tyrosine phosphatase, non-receptor type 21 |
| 26191 | PTPN22 | protein tyrosine phosphatase, non-receptor type 22 (lymphoid) |
| 25930 | PTPN23 | protein tyrosine phosphatase, non-receptor type 23 |

| | | |
|--------|----------|---|
| 5774 | PTPN3 | protein tyrosine phosphatase, non-receptor type 3 |
| 5775 | PTPN4 | protein tyrosine phosphatase, non-receptor type 4 (megakaryocyte) |
| 84867 | PTPN5 | protein tyrosine phosphatase, non-receptor type 5 (striatum-enriched) |
| 5778 | PTPN7 | protein tyrosine phosphatase, non-receptor type 7 |
| 5780 | PTPN9 | protein tyrosine phosphatase, non-receptor type 9 |
| 140885 | PTPNS1 | protein tyrosine phosphatase, non-receptor type substrate 1 |
| 128646 | PTPNS1L2 | protein tyrosine phosphatase, non-receptor type substrate 1-like 2 |
| 5786 | PTPRA | protein tyrosine phosphatase, receptor type, A |
| 5787 | PTPRB | protein tyrosine phosphatase, receptor type, B |
| 5788 | PTPRC | protein tyrosine phosphatase, receptor type, C |
| 5789 | PTPRD | protein tyrosine phosphatase, receptor type, D |
| 5791 | PTPRE | protein tyrosine phosphatase, receptor type, E |
| 5792 | PTPRF | protein tyrosine phosphatase, receptor type, F |
| 5793 | PTPRG | protein tyrosine phosphatase, receptor type, G |
| 5794 | PTPRH | protein tyrosine phosphatase, receptor type, H |
| 5795 | PTPRJ | protein tyrosine phosphatase, receptor type, J |
| 5796 | PTPRK | protein tyrosine phosphatase, receptor type, K |
| 5797 | PTPRM | protein tyrosine phosphatase, receptor type, M |
| 5798 | PTPRN | protein tyrosine phosphatase, receptor type, N |
| 5799 | PTPRN2 | protein tyrosine phosphatase, receptor type, N polypeptide 2 |
| 5800 | PTPRO | protein tyrosine phosphatase, receptor type, O |
| 5801 | PTPRR | protein tyrosine phosphatase, receptor type, R |
| 5802 | PTPRS | protein tyrosine phosphatase, receptor type, S |
| 11122 | PTPRT | protein tyrosine phosphatase, receptor type, T |
| 10076 | PTPRU | protein tyrosine phosphatase, receptor type, U |
| 5803 | PTPRZ1 | protein tyrosine phosphatase, receptor-type, Z polypeptide 1 |
| 54899 | PXK | PX domain containing serine/threonine kinase |
| 65263 | PYCRL | pyrroline-5-carboxylate reductase-like |
| 5865 | RAB3B | RAB3B, member RAS oncogene family |
| 10111 | RAD50 | RAD50 homolog (<i>S. cerevisiae</i>) |
| 8438 | RAD54L | RAD54-like (<i>S. cerevisiae</i>) |
| 5894 | RAF1 | v-raf-1 murine leukemia viral oncogene homolog 1 |
| 5891 | RAGE | renal tumor antigen |
| 57521 | raptor | raptor |
| 5922 | RASA2 | RAS p21 protein activator 2 |
| 22821 | RASA3 | RAS p21 protein activator 3 |
| 9462 | RASAL2 | RAS protein activator like 2 |
| 83593 | RASSF5 | Ras association (RalGDS/AF-6) domain family 5 |
| 5925 | RB1 | retinoblastoma 1 (including osteosarcoma) |
| 64080 | RBKS | ribokinase |
| 5933 | RBL1 | retinoblastoma-like 1 (p107) |
| 5934 | RBL2 | retinoblastoma-like 2 (p130) |
| 84991 | RBM17 | RNA binding motif protein 17 |
| 5966 | REL | v-rel reticuloendotheliosis viral oncogene homolog (avian) |
| 5979 | RET | ret proto-oncogene (multiple endocrine neoplasia and medullary thyroid carcinoma 1, Hirschsprung disease) |
| 5997 | RGS2 | regulator of G-protein signalling 2, 24kDa |
| 5998 | RGS3 | regulator of G-protein signalling 3 |
| 6009 | RHEB | Ras homolog enriched in brain |
| 6010 | RHO | rhodopsin (opsin 2, rod pigment) (retinitis pigmentosa 4, autosomal dominant) |

| | | |
|-------|----------|--|
| 22999 | RIMS1 | regulating synaptic membrane exocytosis 1 |
| 8737 | RIPK1 | receptor (TNFRSF)-interacting serine-threonine kinase 1 |
| 8767 | RIPK2 | receptor-interacting serine-threonine kinase 2 |
| 11035 | RIPK3 | receptor-interacting serine-threonine kinase 3 |
| 54101 | RIPK4 | receptor-interacting serine-threonine kinase 4 |
| 6041 | RNASEL | ribonuclease L (2',5'-oligoadenylate synthetase-dependent) |
| 8732 | RNGTT | RNA guanylyltransferase and 5'-phosphatase |
| 10921 | RNPS1 | RNA binding protein S1, serine-rich domain |
| 6093 | ROCK1 | Rho-associated, coiled-coil containing protein kinase 1 |
| 9475 | ROCK2 | Rho-associated, coiled-coil containing protein kinase 2 |
| 4919 | ROR1 | receptor tyrosine kinase-like orphan receptor 1 |
| 4920 | ROR2 | receptor tyrosine kinase-like orphan receptor 2 |
| 6098 | ROS1 | v-ros UR2 sarcoma virus oncogene homolog 1 (avian) |
| 57096 | RPGRIP1 | retinitis pigmentosa GTPase regulator interacting protein 1 |
| 6194 | RPS6 | ribosomal protein S6 |
| 6195 | RPS6KA1 | ribosomal protein S6 kinase, 90kDa, polypeptide 1 |
| 6196 | RPS6KA2 | ribosomal protein S6 kinase, 90kDa, polypeptide 2 |
| 6197 | RPS6KA3 | ribosomal protein S6 kinase, 90kDa, polypeptide 3 |
| 8986 | RPS6KA4 | ribosomal protein S6 kinase, 90kDa, polypeptide 4 |
| 9252 | RPS6KA5 | ribosomal protein S6 kinase, 90kDa, polypeptide 5 |
| 27330 | RPS6KA6 | ribosomal protein S6 kinase, 90kDa, polypeptide 6 |
| 6198 | RPS6KB1 | ribosomal protein S6 kinase, 70kDa, polypeptide 1 |
| 6199 | RPS6KB2 | ribosomal protein S6 kinase, 70kDa, polypeptide 2 |
| 26750 | RPS6KC1 | ribosomal protein S6 kinase, 52kDa, polypeptide 1 |
| 83694 | RPS6KL1 | ribosomal protein S6 kinase-like 1 |
| 6248 | RSC1A1 | regulatory solute carrier protein, family 1, member 1 |
| 6256 | RXRA | retinoid X receptor, alpha |
| 6257 | RXRB | retinoid X receptor, beta |
| 6258 | RXRG | retinoid X receptor, gamma |
| 6259 | RYK | RYK receptor-like tyrosine kinase |
| 6295 | SAG | S-antigen; retina and pineal gland (arrestin) |
| 9092 | SART1 | squamous cell carcinoma antigen recognised by T cells |
| 57410 | SCYL1 | SCY1-like 1 (S. cerevisiae) |
| 10283 | SDCCAG10 | serologically defined colon cancer antigen 10 |
| 6392 | SDHD | succinate dehydrogenase complex, subunit D, integral membrane protein |
| 7536 | SF1 | splicing factor 1 |
| 8175 | SF3A2 | splicing factor 3a, subunit 2, 66kDa |
| 10946 | SF3A3 | splicing factor 3a, subunit 3, 60kDa |
| 23451 | SF3B1 | splicing factor 3b, subunit 1, 155kDa |
| 23450 | SF3B3 | splicing factor 3b, subunit 3, 130kDa |
| 10262 | SF3B4 | splicing factor 3b, subunit 4, 49kDa |
| 2810 | SFN | stratifin |
| 6421 | SFPQ | splicing factor proline/glutamine rich (polypyrimidine tract binding protein associated) |
| 6426 | SFRS1 | splicing factor, arginine/serine-rich 1 (splicing factor 2, alternate splicing factor) |
| 6434 | SFRS10 | splicing factor, arginine/serine-rich 10 (transformer 2 homolog, Drosophila) |
| 9295 | SFRS11 | splicing factor, arginine/serine-rich 11 |
| 6427 | SFRS2 | splicing factor, arginine/serine-rich 2 |
| 6428 | SFRS3 | splicing factor, arginine/serine-rich 3 |
| 6430 | SFRS5 | splicing factor, arginine/serine-rich 5 |

| | | |
|--------|---------|---|
| 6432 | SFRS7 | splicing factor, arginine/serine-rich 7, 35kDa |
| 6446 | SGK | serum/glucocorticoid regulated kinase |
| 10110 | SGK2 | serum/glucocorticoid regulated kinase 2 |
| 23678 | SGK3 | serum/glucocorticoid regulated kinase family, member 3 |
| 6464 | SHC1 | SHC (Src homology 2 domain containing) transforming protein 1 |
| 22933 | SIRT2 | sirtuin (silent mating type information regulation 2 homolog) 2 (S. cerevisiae) |
| 6497 | SKI | v-ski sarcoma viral oncogene homolog (avian) |
| 22938 | SKIIP | SKI interacting protein |
| 20512 | Slc1a3 | solute carrier family 1 (glial high affinity glutamate transporter), member 3 |
| 320718 | Slc26a9 | solute carrier family 26, member 9 |
| 9748 | SLK | STE20-like kinase (yeast) |
| 10569 | SLU7 | step II splicing factor SLU7 |
| 4087 | SMAD2 | SMAD, mothers against DPP homolog 2 (Drosophila) |
| 4089 | SMAD4 | SMAD, mothers against DPP homolog 4 (Drosophila) |
| 6598 | SMARCB1 | SWI/SNF related, matrix associated, actin dependent regulator of chromatin, subfamily b, member 1 |
| 10285 | SMNDC1 | survival motor neuron domain containing 1 |
| 81788 | SNARK | likely ortholog of rat SNF1/AMP-activated protein kinase |
| 6622 | SNCA | synuclein, alpha (non A4 component of amyloid precursor) |
| 150094 | SNF1LK | SNF1-like kinase |
| 54861 | SNRK | SNF-1 related kinase |
| 6625 | SNRP70 | small nuclear ribonucleoprotein 70kDa polypeptide (RNP antigen) |
| 9655 | SOCS5 | suppressor of cytokine signaling 5 |
| 6647 | SOD1 | superoxide dismutase 1, soluble (amyotrophic lateral sclerosis 1 (adult)) |
| 6657 | SOX2 | SRY (sex determining region Y)-box 2 |
| 6725 | SRMS | src-related kinase lacking C-terminal regulatory tyrosine and N-terminal myristylation sites |
| 6732 | SRPK1 | SFRS protein kinase 1 |
| 10250 | SRRM1 | serine/arginine repetitive matrix 1 |
| 23524 | SRRM2 | serine/arginine repetitive matrix 2 |
| 54434 | SSH1 | slingshot homolog 1 (Drosophila) |
| 54961 | SSH3 | slingshot homolog 3 (Drosophila) |
| 246329 | STAC3 | SH3 and cysteine rich domain 3 |
| 6793 | STK10 | serine/threonine kinase 10 |
| 6794 | STK11 | serine/threonine kinase 11 (Peutz-Jeghers syndrome) |
| 8576 | STK16 | serine/threonine kinase 16 |
| 9263 | STK17A | serine/threonine kinase 17a (apoptosis-inducing) |
| 9262 | STK17B | serine/threonine kinase 17b (apoptosis-inducing) |
| 8859 | STK19 | serine/threonine kinase 19 |
| 23617 | STK22B | serine/threonine kinase 22B (spermiogenesis associated) |
| 81629 | STK22C | serine/threonine kinase 22C (spermiogenesis associated) |
| 26576 | STK23 | serine/threonine kinase 23 |
| 8428 | STK24 | serine/threonine kinase 24 (STE20 homolog, yeast) |
| 10494 | STK25 | serine/threonine kinase 25 (STE20 homolog, yeast) |
| 9024 | STK29 | serine/threonine kinase 29 |
| 6788 | STK3 | serine/threonine kinase 3 (STE20 homolog, yeast) |
| 56164 | STK31 | serine/threonine kinase 31 |
| 55351 | STK32B | serine/threonine kinase 32B |
| 282974 | STK32C | serine/threonine kinase 32C |
| 65975 | STK33 | serine/threonine kinase 33 |
| 140901 | STK35 | serine/threonine kinase 35 |

| | | |
|--------|-----------|---|
| 27148 | STK36 | serine/threonine kinase 36 (fused homolog, Drosophila) |
| 11329 | STK38 | serine/threonine kinase 38 |
| 23012 | STK38L | serine/threonine kinase 38 like |
| 27347 | STK39 | serine threonine kinase 39 (STE20/SPS1 homolog, yeast) |
| 6789 | STK4 | serine/threonine kinase 4 |
| 6790 | STK6 | serine/threonine kinase 6 |
| 55359 | STYK1 | protein kinase STYK1 |
| 6850 | SYK | spleen tyrosine kinase |
| 23208 | SYT11 | synaptotagmin XI |
| 255928 | SYT14 | synaptotagmin XIV |
| 83851 | SYT14L | synaptotagmin XIV-like |
| 127833 | SYT2 | synaptotagmin II |
| 6860 | SYT4 | synaptotagmin IV |
| 6861 | SYT5 | synaptotagmin V |
| 94122 | SYTL5 | synaptotagmin-like 5 |
| 9344 | TAOK2 | TAO kinase 2 |
| 9344 | TAOK2 | TAO kinase 2 |
| 51347 | TAOK3 | TAO kinase 3 |
| 160760 | TA-PP2C | T-cell activation protein phosphatase 2C |
| 29110 | TBK1 | TANK-binding kinase 1 |
| 7006 | TEC | tec protein tyrosine kinase |
| 7010 | TEK | TEK tyrosine kinase, endothelial (venous malformations, multiple cutaneous and mucosal) |
| 23371 | TENC1 | tensin like C1 domain containing phosphatase |
| 64759 | TENS1 | tensin-like SH2 domain containing 1 |
| 7011 | TEP1 | telomerase-associated protein 1 |
| 7013 | TERF1 | telomeric repeat binding factor (NIMA-interacting) 1 |
| 54386 | TERF2IP | telomeric repeat binding factor 2, interacting protein |
| 7016 | TESK1 | testis-specific kinase 1 |
| 10420 | TESK2 | testis-specific kinase 2 |
| 7040 | TGFB1 | transforming growth factor, beta 1 (Camurati-Engelmann disease) |
| 7046 | TGFBR1 | transforming growth factor, beta receptor I (activin A receptor type II-like kinase, 53kDa) |
| 7048 | TGFBR2 | transforming growth factor, beta receptor II (70/80kDa) |
| 7052 | TGM2 | transglutaminase 2 (C polypeptide, protein-glutamine-gamma-glutamyltransferase) |
| 7057 | THBS1 | thrombospondin 1 |
| 9984 | THOC1 | THO complex 1 |
| 10189 | THOC4 | THO complex 4 |
| 7074 | TIAM1 | T-cell lymphoma invasion and metastasis 1 |
| 7075 | TIE1 | tyrosine kinase with immunoglobulin-like and EGF-like domains 1 |
| 26277 | TINF2 | TERF1 (TRF1)-interacting nuclear factor 2 |
| 7083 | TK1 | thymidine kinase 1, soluble |
| 7084 | TK2 | thymidine kinase 2, mitochondrial |
| 9874 | TLK1 | tousled-like kinase 1 |
| 11011 | TLK2 | tousled-like kinase 2 |
| 4071 | TM4SF1 | transmembrane 4 superfamily member 1 |
| 56937 | TMEPAI | transmembrane, prostate androgen induced RNA |
| 7113 | TMPRSS2 | transmembrane protease, serine 2 |
| 7124 | TNF | tumor necrosis factor (TNF superfamily, member 2) |
| 8792 | TNFRSF11A | tumor necrosis factor receptor superfamily, member 11a, activator of NFKB |
| 7133 | TNFRSF1B | tumor necrosis factor receptor superfamily, member 1B |

| | | |
|--------|----------|---|
| 8600 | TNFSF11 | tumor necrosis factor (ligand) superfamily, member 11 |
| 8711 | TNK1 | tyrosine kinase, non-receptor, 1 |
| 8658 | TNKS | tankyrase, TRF1-interacting ankyrin-related ADP-ribose polymerase |
| 51086 | TNNI3K | TNNI3 interacting kinase |
| 7145 | TNS | tensin |
| 55872 | TOPK | T-LAK cell-originated protein kinase |
| 7157 | TP53 | tumor protein p53 (Li-Fraumeni syndrome) |
| 93492 | TPTE2 | transmembrane phosphoinositide 3-phosphatase and tensin homolog 2 |
| 11139 | TRAD | serine/threonine kinase with Dbl- and pleckstrin homology domains |
| 10221 | TRIB1 | tribbles homolog 1 (Drosophila) |
| 28951 | TRIB2 | tribbles homolog 2 (Drosophila) |
| 7204 | TRIO | triple functional domain (PTPRF interacting) |
| 140803 | TRPM6 | transient receptor potential cation channel, subfamily M, member 6 |
| 54822 | TRPM7 | transient receptor potential cation channel, subfamily M, member 7 |
| 56302 | TRPV5 | transient receptor potential cation channel, subfamily V, member 5 |
| 55503 | TRPV6 | transient receptor potential cation channel, subfamily V, member 6 |
| 7248 | TSC1 | tuberous sclerosis 1 |
| 7249 | TSC2 | tuberous sclerosis 2 |
| 146057 | TTBK2 | tau tubulin kinase 2 |
| 7272 | TTK | TTK protein kinase |
| 51567 | TTRAP | TRAF and TNF receptor associated protein |
| 7294 | TXK | TXK tyrosine kinase |
| 7297 | TYK2 | tyrosine kinase 2 |
| 7301 | TYRO3 | TYRO3 protein tyrosine kinase |
| 7307 | U2AF1 | U2(RNU2) small nuclear RNA auxiliary factor 1 |
| 11338 | U2AF2 | U2 (RNU2) small nuclear RNA auxiliary factor 2 |
| 7321 | UBE2D1 | ubiquitin-conjugating enzyme E2D 1 (UBC4/5 homolog, yeast) |
| 7322 | UBE2D2 | ubiquitin-conjugating enzyme E2D 2 (UBC4/5 homolog, yeast) |
| 7337 | UBE3A | ubiquitin protein ligase E3A (human papilloma virus E6-associated protein, Angelman syndrome) |
| 127933 | UHMK1 | U2AF homology motif (UHM) kinase 1 |
| 8408 | ULK1 | unc-51-like kinase 1 (C. elegans) |
| 9706 | ULK2 | unc-51-like kinase 2 (C. elegans) |
| 54986 | ULK4 | unc-51-like kinase 4 (C. elegans) |
| 51727 | UMP-CMPK | UMP-CMP kinase |
| 10497 | UNC13B | unc-13 homolog B (C. elegans) |
| 10713 | USP39 | ubiquitin specific protease 39 |
| 7409 | VAV1 | vav 1 oncogene |
| 7422 | VEGF | vascular endothelial growth factor |
| 7428 | VHL | von Hippel-Lindau tumor suppressor |
| 7443 | VRK1 | vaccinia related kinase 1 |
| 7444 | VRK2 | vaccinia related kinase 2 |
| 51231 | VRK3 | vaccinia related kinase 3 |
| 7465 | WEE1 | WEE1 homolog (S. pombe) |
| 7471 | WNT1 | wingless-type MMTV integration site family, member 1 |
| 7490 | WT1 | Wilms tumor 1 |
| 9589 | WTAP | Wilms tumor 1 associated protein |
| 11060 | WWP2 | WW domain containing E3 ubiquitin protein ligase 2 |
| 7518 | XRCC4 | X-ray repair complementing defective repair in Chinese hamster cells 4 |
| 7520 | XRCC5 | X-ray repair complementing defective repair in Chinese hamster cells 5 (double-strand-break |

| | | |
|--------|--------|--|
| | | rejoining; Ku autoantigen, 80kDa) |
| 7525 | YES1 | v-yes-1 Yamaguchi sarcoma viral oncogene homolog 1 |
| 51776 | ZAK | sterile alpha motif and leucine zipper containing kinase AZK |
| 7535 | ZAP70 | zeta-chain (TCR) associated protein kinase 70kDa |
| 65986 | ZBTB10 | zinc finger and BTB domain containing 10 |
| 23515 | ZCWCC3 | zinc finger, CW type with coiled-coil domain 3 |
| 153527 | ZMAT2 | zinc finger, matrin type 2 |

Table S3A. Genes and shRNAs that Induce Mitotic Indices Greater Than 14

| Gene ID | Symbol | Hairpin Name | Average MI | Description |
|---------|-----------------|----------------|------------|---|
| 5778 | PTPN7 | shPTPN7-222 | 51.5 | protein tyrosine phosphatase, non-receptor type 7 |
| 7443 | VRK1 | shVRK1-1070 | 47.4 | vaccinia related kinase 1 |
| 7145 | TNS | shTNS-6197 | 43.0 | tensin |
| 4920 | ROR2 | shROR2-2071 | 39.1 | receptor tyrosine kinase-like orphan receptor 2 |
| | | shROR2-3357 | 14.5 | |
| 4915 | NTRK2 | shNTRK2-2123 | 34.1 | neurotrophic tyrosine kinase, receptor, type 2 |
| | | shNTRK2-1968 | 15.6 | |
| 23228 | PLCL2 | shPLCL2-3402 | 33.0 | phospholipase C-like 2 |
| 5520 | PPP2R2A | shPPP2R2A-363 | 32.6 | protein phosphatase 2 (formerly 2A), regulatory subunit B (PR 52), alpha isoform |
| 54899 | PXK | shPXK-1318 | 31.4 | PX domain containing serine/threonine kinase |
| 11338 | U2AF2 | shU2AF2-606 | 31.2 | U2 (RNU2) small nuclear RNA auxiliary factor 2 |
| 5563 | PRKAA2 | shPRKAA2-1028 | 31.0 | protein kinase, AMP-activated, alpha 2 catalytic subunit |
| 5347 | PLK1 | shPLK1-513 | 30.8 | polo-like kinase 1 (Drosophila) |
| 5159 | PDGFRB | shPDGFRB-2371 | 30.6 | platelet-derived growth factor receptor, beta polypeptide |
| | | shPDGFRB-1985 | 16.1 | |
| 3055 | HCK | shHCK-261 | 30.4 | hemopoietic cell kinase |
| 5591 | PRKDC | shPRKDC-12460 | 30.4 | protein kinase, DNA-activated, catalytic polypeptide |
| 1017 | CDK2 | shCDK2-923 | 29.5 | cyclin-dependent kinase 2 |
| 4089 | SMAD4 | shSMAD4-2493 | 29.1 | SMAD, mothers against DPP homolog 4 (Drosophila) |
| 5522 | PPP2R2C | shPPP2R2C-481 | 29.0 | protein phosphatase 2 (formerly 2A), regulatory subunit B (PR 52), gamma isoform |
| 7294 | TXK | shTXK-408 | 28.8 | TXK tyrosine kinase |
| 5333 | PLCD1 | shPLCD1-406 | 28.5 | phospholipase C, delta 1 |
| 5218 | PFTK1 | shPFTK1-1042 | 28.4 | PFTAIRE protein kinase 1 |
| 8737 | RIPK1 | shRIPK1-1674 | 28.3 | receptor (TNFRSF)-interacting serine-threonine kinase 1 |
| | | shRIPK1-432 | 14.6 | |
| 2268 | FGR | shFGR-385 | 28.1 | Gardner-Rasheed feline sarcoma viral (v-fgr) oncogene homolog |
| | | shFGR-460 | 26.1 | |
| 4638 | MYLK | shMYLK-479 | 27.8 | myosin, light polypeptide kinase |
| 112399 | EGLN3 | shEGLN3-2244 | 27.6 | egl nine homolog 3 (C. elegans) |
| 51562 | MBIP | shMBIP-853 | 27.5 | MAP3K12 binding inhibitory protein 1 |
| 7010 | TEK | shTEK-520 | 27.0 | TEK tyrosine kinase, endothelial (venous malformations, multiple cutaneous and mucosal) |
| 6416 | MAP2K4 | shMAP2K4-3471 | 26.8 | mitogen-activated protein kinase kinase 4 |
| 6792 | CDKL5 | shCDKL5-2750 | 26.8 | cyclin-dependent kinase-like 5 |
| 83851 | SYT14L | shSYT14L-652 | 26.3 | synaptotagmin XIV-like |
| 79012 | MGC8407 | shMGC8407-623 | 25.8 | hypothetical protein MGC8407 |
| 1978 | EIF4EBP1 | shEIF4EBP1-694 | 25.8 | eukaryotic translation initiation factor 4E binding protein 1 |
| 10250 | SRRM1 | shSRRM1-3369 | 25.6 | serine/arginine repetitive matrix 1 |
| 5997 | RGS2 | shRGS2-510 | 25.6 | regulator of G-protein signalling 2, 24kDa |
| | | shRGS2-508 | 20.9 | |
| 7525 | YES1 | shYES1-905 | 25.4 | v-yes-1 Yamaguchi sarcoma viral oncogene homolog 1 |
| | | shYES1-1338 | 19.8 | |
| 5334 | PLCL1 | shPLCL1-3211 | 25.3 | phospholipase C-like 1 |
| 9156 | EXO1 | shEXO1-1586 | 25.2 | exonuclease 1 |
| 4303 | MLLT7 | shMLLT7-1975 | 24.8 | myeloid/lymphoid or mixed-lineage leukemia (trithorax |

| | | | | |
|--------|-----------------|-----------------|------|---|
| | | | | homolog, <i>Drosophila</i>) |
| 3181 | HNRPA2B1 | shHNRPA2B1-1196 | 24.7 | heterogeneous nuclear ribonucleoprotein A2/B1 |
| 23524 | SRRM2 | shSRRM2-2974 | 24.6 | serine/arginine repetitive matrix 2 |
| 7075 | TIE1 | shTIE1-3795 | 24.5 | tyrosine kinase with immunoglobulin-like and EGF-like domains 1 |
| 5582 | PRKCG | shPRKCG-395 | 24.2 | protein kinase C, gamma |
| 780 | DDR1 | shDDR1-1857 | 24.1 | discoidin domain receptor family, member 1 |
| 2069 | EREG | shEREG-703 | 24.0 | epiregulin |
| 5571 | PRKAG1 | shPRKAG1-157 | 24.0 | protein kinase, AMP-activated, gamma 1 non-catalytic subunit |
| | | shPRKAG1-565 | 23.4 | |
| | | shPRKAG1-1269 | 15.4 | |
| 6197 | RPS6KA3 | shRPS6KA3-982 | 23.9 | ribosomal protein S6 kinase, 90kDa, polypeptide 3 |
| 11035 | RIPK3 | shRIPK3-612 | 23.9 | receptor-interacting serine-threonine kinase 3 |
| 4233 | MET | shMET-1651 | 23.8 | met proto-oncogene (hepatocyte growth factor receptor) |
| 815 | CAMK2A | shCAMK2A-394 | 23.7 | calcium/calmodulin-dependent protein kinase (CaM kinase) II alpha |
| 5922 | RASA2 | shRASA2-572 | 23.6 | RAS p21 protein activator 2 |
| | | shRASA2-1607 | 14.0 | |
| 11183 | MAP4K5 | shMAP4K5-2826 | 23.6 | mitogen-activated protein kinase kinase kinase kinase 5 |
| 138639 | PTPDC1 | shPTPDC1-1613 | 23.5 | protein tyrosine phosphatase domain containing 1 |
| 84867 | PTPN5 | shPTPN5-937 | 23.5 | protein tyrosine phosphatase, non-receptor type 5 (striatum-enriched) |
| 5597 | MAPK6 | shMAPK6-3734 | 23.3 | mitogen-activated protein kinase 6 |
| 3611 | ILK | shILK-1688 | 23.2 | integrin-linked kinase |
| 10000 | AKT3 | shAKT3-361 | 23.2 | v-akt murine thymoma viral oncogene homolog 3 (protein kinase B, gamma) |
| | | shAKT3-1307 | 15.7 | |
| 10283 | SDCCAG10 | shSDCCAG10-641 | 22.8 | serologically defined colon cancer antigen 10 |
| 4683 | NBS1 | shNBS1-440 | 22.8 | Nijmegen breakage syndrome 1 (nibrin) |
| 150290 | DUSP18 | shDUSP18-1046 | 22.7 | dual specificity phosphatase 18 |
| 1659 | DHX8 | shDHX8-3626 | 22.5 | DEAH (Asp-Glu-Ala-His) box polypeptide 8 |
| 2869 | GRK5 | shGRK5-526 | 22.5 | G protein-coupled receptor kinase 5 |
| | | shGRK5-356 | 14.5 | |
| 4921 | DDR2 | shDDR2-1694 | 21.9 | discoidin domain receptor family, member 2 |
| 3645 | INSRR | shINSRR-3960 | 21.7 | insulin receptor-related receptor |
| 3981 | LIG4 | shLIG4-1633 | 21.7 | ligase IV, DNA, ATP-dependent |
| 4830 | NME1 | shNME1-99 | 21.6 | non-metastatic cells 1, protein (NM23A) expressed in |
| 55137 | FIGN | shFIGN-1661 | 21.3 | fidgetin |
| | | shFIGN-1450 | 18.6 | |
| 5651 | PRSS7 | shPRSS7-1306 | 21.2 | protease, serine, 7 (enterokinase) |
| | | shPRSS7-2651 | 21.2 | |
| 8536 | CAMK1 | shCAMK1-553 | 21.0 | calcium/calmodulin-dependent protein kinase I |
| 7046 | TGFBR1 | shTGFBR1-1493 | 21.0 | transforming growth factor, beta receptor I (activin A receptor type II-like kinase, 53kDa) |
| 10217 | CTDSPL | shCTDSPL-456 | 20.9 | CTD (carboxy-terminal domain, RNA polymerase II, polypeptide A) small phosphatase-like |
| 8986 | RPS6KA4 | shRPS6KA4-683 | 20.9 | ribosomal protein S6 kinase, 90kDa, polypeptide 4 |
| 657 | BMPR1A | shBMPR1A-1777 | 20.9 | bone morphogenetic protein receptor, type IA |
| 6625 | SNRP70 | shSNRP70-637 | 20.8 | small nuclear ribonucleoprotein 70kDa polypeptide (RNP antigen) |
| 5601 | MAPK9 | shMAPK9-812 | 20.6 | mitogen-activated protein kinase 9 |

| | | | | |
|--------|-----------------|----------------|------|--|
| | | shMAPK9-997 | 14.1 | |
| 140469 | MYO3B | shMYO3B-177 | 20.5 | myosin IIIB |
| 5789 | PTPRD | shPTPRD-1729 | 20.4 | protein tyrosine phosphatase, receptor type, D |
| 14395 | Gabra2 | shGabra2-775 | 20.4 | gamma-aminobutyric acid (GABA-A) receptor, subunit alpha 2 |
| 613 | BCR | shBCR-3023 | 20.3 | breakpoint cluster region |
| 91 | ACVR1B | shACVR1B-318 | 20.2 | activin A receptor, type IB |
| 6392 | SDHD | shSDHD-266 | 20.1 | succinate dehydrogenase complex, subunit D, integral membrane protein |
| 57144 | PAK7 | shPAK7-1918 | 19.8 | p21(CDKN1A)-activated kinase 7 |
| | | shPAK7-616 | 14.4 | |
| 10921 | RNPS1 | shRNPS1-872 | 19.7 | RNA binding protein S1, serine-rich domain |
| 8798 | DYRK4 | shDYRK4-1292 | 19.5 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 4 |
| 8491 | MAP4K3 | shMAP4K3-1824 | 19.4 | mitogen-activated protein kinase kinase kinase kinase 3 |
| 1633 | DCK | shDCK-440 | 19.4 | deoxycytidine kinase |
| 8175 | SF3A2 | shSF3A2-208 | 19.2 | splicing factor 3a, subunit 2, 66kDa |
| 558 | AXL | shAXL-4548 | 19.2 | AXL receptor tyrosine kinase |
| 27 | ABL2 | shABL2-3279 | 19.0 | v-abl Abelson murine leukemia viral oncogene homolog 2 (arg, Abelson-related gene) |
| 5754 | PTK7 | shPTK7-2544 | 19.0 | PTK7 protein tyrosine kinase 7 |
| 10733 | PLK4 | shPLK4-433 | 18.8 | polo-like kinase 4 (Drosophila) |
| | | shPLK4-1377 | 15.6 | |
| 3248 | HPGD | shHPGD-403 | 18.7 | hydroxyprostaglandin dehydrogenase 15-(NAD) |
| | | shHPGD-1794 | 14.1 | |
| 5596 | MAPK4 | shMAPK4-1017 | 18.7 | mitogen-activated protein kinase 4 |
| 2046 | EPHA8 | shEPHA8-2771 | 18.5 | EPH receptor A8 |
| 25930 | PTPN23 | shPTPN23-4994 | 18.5 | protein tyrosine phosphatase, non-receptor type 23 |
| 1847 | DUSP5 | shDUSP5-1014 | 18.3 | dual specificity phosphatase 5 |
| 8776 | MTMR1 | shMTMR1-1051 | 18.1 | myotubularin related protein 1 |
| 1608 | DGKG | shDGKG-2779 | 18.1 | diacylglycerol kinase, gamma 90kDa |
| 4058 | LTK | shLTK-2132 | 18.0 | leukocyte tyrosine kinase |
| 65061 | ALS2CR7 | shALS2CR7-314 | 18.0 | amyotrophic lateral sclerosis 2 (juvenile) chromosome region, candidate 7 |
| | | shALS2CR7-283 | 16.8 | |
| 1028 | CDKN1C | shCDKN1C-431 | 17.9 | cyclin-dependent kinase inhibitor 1C (p57, Kip2) |
| | | shCDKN1C-285 | 16.1 | |
| 1445 | CSK | shCSK-835 | 17.9 | c-src tyrosine kinase |
| 3320 | HSPCA | shHSPCA-867 | 17.8 | heat shock 90kDa protein 1, alpha |
| 151649 | FLJ25449 | shFLJ25449-950 | 17.3 | hypothetical protein MGC27069 |
| 282974 | STK32C | shSTK32C-795 | 17.2 | serine/threonine kinase 32C |
| 1540 | CYLD | shCYLD-5274 | 17.1 | cylindromatosis (turban tumor syndrome) |
| | | shCYLD-3218 | 17.1 | |
| 5287 | PIK3C2B | shPIK3C2B-2993 | 17.0 | phosphoinositide-3-kinase, class 2, beta polypeptide |
| 6861 | SYT5 | shSYT5-1333 | 17.0 | synaptotagmin V |
| 5933 | RBL1 | shRBL1-302 | 17.0 | retinoblastoma-like 1 (p107) |
| 4771 | NF2 | shNF2-473 | 16.9 | neurofibromin 2 (bilateral acoustic neuroma) |
| 6093 | ROCK1 | shROCK1-1885 | 16.7 | Rho-associated, coiled-coil containing protein kinase 1 |
| 5378 | PMS1 | shPMS1-276 | 16.6 | PMS1 postmeiotic segregation increased 1 (S. cerevisiae) |
| 3984 | LIMK1 | shLIMK1-3140 | 16.5 | LIM domain kinase 1 |

| | | | | |
|--------|-----------------|-----------------|------|--|
| 26121 | PRPF31 | shPRPF31-986 | 16.5 | PRP31 pre-mRNA processing factor 31 homolog (yeast) |
| 156 | ADRBK1 | shADRBK1-1546 | 16.5 | adrenergic, beta, receptor kinase 1 |
| 5581 | PRKCE | shPRKCE-1288 | 16.5 | protein kinase C, epsilon |
| 5598 | MAPK7 | shMAPK7-993 | 16.4 | mitogen-activated protein kinase 7 |
| 9050 | PSTPIP2 | shPSTPIP2-943 | 16.3 | proline-serine-threonine phosphatase interacting protein 2 |
| 2324 | FLT4 | shFLT4-2503 | 16.3 | fms-related tyrosine kinase 4 |
| 1454 | CSNK1E | shCSNK1E-794 | 16.3 | casein kinase 1, epsilon |
| 10769 | PLK2 | shPLK2-2005 | 16.3 | polo-like kinase 2 (Drosophila) |
| 6794 | STK11 | shSTK11-514 | 16.3 | serine/threonine kinase 11 (Peutz-Jeghers syndrome) |
| 10111 | RAD50 | shRAD50-3846 | 16.2 | RAD50 homolog (<i>S. cerevisiae</i>) |
| 5127 | PCTK1 | shPCTK1-1623 | 16.1 | PCTAIRE protein kinase 1 |
| 1111 | CHEK1 | shCHEK1-1609 | 16.0 | CHK1 checkpoint homolog (<i>S. pombe</i>) |
| 5681 | PSKH1 | shPSKH1-1231 | 16.0 | protein serine kinase H1 |
| 93 | ACVR2B | shACVR2B-1312 | 15.9 | activin A receptor, type IIB |
| 11266 | DUSP12 | shDUSP12-751 | 15.9 | dual specificity phosphatase 12 |
| 1859 | DYRK1A | shDYRK1A-3947 | 15.9 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 1A |
| 65125 | PRKWINK1 | shPRKWINK1-1456 | 15.8 | protein kinase, lysine deficient 1 |
| 8621 | CDC2L5 | shCDC2L5-5160 | 15.7 | cell division cycle 2-like 5 (cholinesterase-related cell division controller) |
| 1969 | EPHA2 | shEPHA2-716 | 15.6 | EPH receptor A2 |
| 8566 | PDXK | shPDXK-889 | 15.6 | pyridoxal (pyridoxine, vitamin B6) kinase |
| 208 | AKT2 | shAKT2-633 | 15.6 | v-akt murine thymoma viral oncogene homolog 2 |
| 695 | BTK | shBTK-591 | 15.6 | Bruton agammaglobulinemia tyrosine kinase |
| 4436 | MSH2 | shMSH2-2550 | 15.6 | mutS homolog 2, colon cancer, nonpolyposis type 1 (<i>E. coli</i>) |
| 4087 | SMAD2 | shSMAD2-1543 | 15.5 | SMAD, mothers against DPP homolog 2 (<i>Drosophila</i>) |
| | | shSMAD2-415 | 15.0 | |
| 818 | CAMK2G | shCAMK2G-2251 | 15.5 | calcium/calmodulin-dependent protein kinase (CaM kinase) II gamma |
| 150094 | SNF1LK | shSNF1LK-1104 | 15.5 | SNF1-like kinase |
| 8576 | STK16 | shSTK16-1331 | 15.5 | serine/threonine kinase 16 |
| 5599 | MAPK8 | shMAPK8-864 | 15.4 | mitogen-activated protein kinase 8 |
| 23208 | SYT11 | shSYT11-608 | 15.4 | synaptotagmin XI |
| 7083 | TK1 | shTK1-610 | 15.4 | thymidine kinase 1, soluble |
| 4916 | NTRK3 | shNTRK3-1263 | 15.4 | neurotrophic tyrosine kinase, receptor, type 3 |
| 867 | CBL | shCBL-2991 | 15.4 | Cas-Br-M (murine) ecotropic retroviral transforming sequence |
| 255928 | SYT14 | shSYT14-1753 | 15.2 | synaptotagmin XIV |
| 10946 | SF3A3 | shSF3A3-177 | 15.1 | splicing factor 3a, subunit 3, 60kDa |
| 25 | ABL1 | shABL1-1234 | 15.1 | v-abl Abelson murine leukemia viral oncogene homolog 1 |
| 5167 | ENPP1 | shENPP1-3435 | 15.0 | ectonucleotide pyrophosphatase/phosphodiesterase 1 |
| 1456 | CSNK1G3 | shCSNK1G3-530 | 15.0 | casein kinase 1, gamma 3 |
| 5979 | RET | shRET-6955 | 15.0 | ret proto-oncogene |
| 5587 | PRKD1 | shPRKD1-2270 | 14.9 | protein kinase D1 |
| 7048 | TGFBR2 | shTGFBR2-1093 | 14.9 | transforming growth factor, beta receptor II (70/80kDa) |
| 2264 | FGFR4 | shFGFR4-1739 | 14.7 | fibroblast growth factor receptor 4 |
| 6885 | MAP3K7 | shMAP3K7-601 | 14.7 | mitogen-activated protein kinase kinase kinase 7 |
| 5300 | PIN1 | shPIN1-420 | 14.7 | protein (peptidyl-prolyl cis/trans isomerase) NIMA-interacting 1 |
| 2868 | GRK4 | shGRK4-1116 | 14.6 | G protein-coupled receptor kinase 4 |

| | | | | |
|-------|-----------------|-----------------|------|--|
| 6725 | SRMS | shSRMS-1235 | 14.6 | src-related kinase lacking C-terminal regulatory tyrosine and N-terminal myristylation sites |
| 3716 | JAK1 | shJAK1-898 | 14.6 | Janus kinase 1 (a protein tyrosine kinase) |
| 54986 | FLJ20574 | shFLJ20574-422 | 14.6 | hypothetical protein FLJ20574 |
| 20512 | Slc1a3 | shSlc1a3-909 | 14.6 | solute carrier family 1 (glial high affinity glutamate transporter), member 3 |
| 11213 | IRAK3 | shIRAK3-1030 | 14.6 | interleukin-1 receptor-associated kinase 3 |
| 5603 | MAPK13 | shMAPK13-1254 | 14.6 | mitogen-activated protein kinase 13 |
| 1607 | DGKB | shDGKB-1895 | 14.6 | diacylglycerol kinase, beta 90kDa |
| 5516 | PPP2CB | shPPP2CB-490 | 14.6 | protein phosphatase 2 (formerly 2A), catalytic subunit, beta isoform |
| 7074 | TIAM1 | shTIAM1-918 | 14.5 | T-cell lymphoma invasion and metastasis 1 |
| 8438 | RAD54L | shRAD54L-2027 | 14.5 | RAD54-like (<i>S. cerevisiae</i>) |
| 7297 | TYK2 | shTYK2-2906 | 14.5 | tyrosine kinase 2 |
| 8476 | CDC42BPA | shCDC42BPA-6823 | 14.5 | CDC42 binding protein kinase alpha (DMPK-like) |
| 32 | ACACB | shACACB-6613 | 14.4 | acetyl-Coenzyme A carboxylase beta |
| 55839 | BM039 | shBM039-1162 | 14.4 | uncharacterized bone marrow protein BM039 |
| 4882 | NPR2 | shNPR2-3036 | 14.3 | natriuretic peptide receptor B/guanylate cyclase B (atriuretic peptide receptor B) |
| 2047 | EPHB1 | shEPHB1-712 | 14.3 | EPH receptor B1 |
| 5894 | RAF1 | shRAF1-1764 | 14.3 | v-raf-1 murine leukemia viral oncogene homolog 1 |
| 8428 | STK24 | shSTK24-606 | 14.2 | serine/threonine kinase 24 (STE20 homolog, yeast) |
| 51776 | ZAK | shZAK-549 | 14.2 | sterile alpha motif and leucine zipper containing kinase AZK |
| 5602 | MAPK10 | shMAPK10-494 | 14.2 | mitogen-activated protein kinase 10 |
| 1021 | CDK6 | shCDK6-921 | 14.1 | cyclin-dependent kinase 6 |
| 1198 | CLK3 | shCLK3-707 | 14.1 | CDC-like kinase 3 |
| 3654 | IRAK1 | shIRAK1-1257 | 14.1 | interleukin-1 receptor-associated kinase 1 |
| 5514 | PPP1R10 | shPPP1R10-2361 | 14.1 | protein phosphatase 1, regulatory subunit 10 |
| 6011 | GRK1 | shGRK1-1344 | 14.1 | G protein-coupled receptor kinase 1 |
| 11184 | MAP4K1 | shMAP4K1-2707 | 14.1 | mitogen-activated protein kinase kinase kinase kinase 1 |
| 2764 | GMFB | shGMFB-1321 | 14.1 | glia maturation factor, beta |
| 1655 | DDX5 | shDDX5-631 | 14.1 | DEAD (Asp-Glu-Ala-Asp) box polypeptide 5 |

Table S3B. Genes and shRNAs that Induce Mitotic Indices Less than 0.3

| Gene ID | Symbol | Hairpin Name | Average MI | Description |
|---------|----------|----------------|------------|--|
| 79012 | MGC8407 | shMGC8407-346 | 0 | hypothetical protein MGC8407 |
| 1608 | DGKG | shDGKG-1685 | 0 | diacylglycerol kinase, gamma 90kDa |
| 57096 | RPGRIP1 | shRPGRIP1-565 | 0 | retinitis pigmentosa GTPase regulator interacting protein 1 |
| 701 | BUB1B | shBUB1B-1822 | 0 | BUB1 budding uninhibited by benzimidazoles 1 homolog beta (yeast) |
| 5778 | PTPN7 | shPTPN7-803 | 0 | protein tyrosine phosphatase, non-receptor type 7 |
| 5502 | PPP1R1A | shPPP1R1A-612 | 0 | protein phosphatase 1, regulatory (inhibitor) subunit 1A |
| 3656 | IRAK2 | shIRAK2-1563 | 0 | interleukin-1 receptor-associated kinase 2 |
| 7525 | YES1 | shYES1-427 | 0 | v-yes-1 Yamaguchi sarcoma viral oncogene homolog 1 |
| 1794 | DOCK2 | shDOCK2-5761 | 0 | dedicator of cytokinesis 2 |
| 51678 | MPP6 | shMPP6-617 | 0 | membrane protein, palmitoylated 6 (MAGUK p55 subfamily member 6) |
| 23031 | MAST3 | shMAST3-2357 | 0 | microtubule associated serine/threonine kinase 3 |
| 4824 | NKX3-1 | shNKX3-1-471 | 0 | NK3 transcription factor related, locus 1 (Drosophila) |
| 10298 | PAK4 | shPAK4-285 | 0 | p21(CDKN1A)-activated kinase 4 |
| 5966 | REL | shREL-598 | 0 | v-rel reticuloendotheliosis viral oncogene homolog (avian) |
| 2932 | GSK3B | shGSK3B-867 | 0 | glycogen synthase kinase 3 beta |
| 6248 | RSC1A1 | shRSC1A1-1720 | 0.1 | regulatory solute carrier protein, family 1, member 1 |
| 23293 | C17orf31 | shC17orf31-132 | 0.1 | chromosome 17 open reading frame 31 |
| 140901 | STK35 | shSTK35-814 | 0.1 | serine/threonine kinase 35 |
| 51231 | VRK3 | shVRK3-753 | 0.1 | vaccinia related kinase 3 |
| 55500 | ETNK1 | shETNK1-394 | 0.1 | ethanolamine kinase 1 |
| 53904 | MYO3A | shMYO3A-4214 | 0.1 | myosin IIIA |
| 1021 | CDK6 | shCDK6-1000 | 0.1 | cyclin-dependent kinase 6 |
| 1267 | CNP | shCNP-1010 | 0.1 | 2',3'-cyclic nucleotide 3' phosphodiesterase |
| 6793 | STK10 | shSTK10-860 | 0.1 | serine/threonine kinase 10 |
| 10262 | SF3B4 | shSF3B4-375 | 0.1 | splicing factor 3b, subunit 4, 49kDa |
| 2585 | GALK2 | shGALK2-1330 | 0.2 | galactokinase 2 |
| 1859 | DYRK1A | shDYRK1A-3947 | 0.2 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 1A |
| 22938 | SKIIP | shSKIIP-1594 | 0.2 | SKI interacting protein |
| 699 | BUB1 | shBUB1-281 | 0.2 | BUB1 budding uninhibited by benzimidazoles 1 homolog (yeast) |
| 5496 | PPM1G | shPPM1G-432 | 0.2 | protein phosphatase 1G (formerly 2C), magnesium-dependent, gamma isoform |
| 4215 | MAP3K3 | shMAP3K3-1313 | 0.2 | mitogen-activated protein kinase kinase kinase 3 |
| 1454 | CSNK1E | shCSNK1E-766 | 0.2 | casein kinase 1, epsilon |
| 7048 | TGFBR2 | shTGFBR2-1692 | 0.2 | transforming growth factor, beta receptor II (70/80kDa) |
| 5261 | PHKG2 | shPHKG2-211 | 0.2 | phosphorylase kinase, gamma 2 (testis) |
| 8445 | DYRK2 | shDYRK2-2863 | 0.2 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 2 |
| 7535 | ZAP70 | shZAP70-2393 | 0.2 | zeta-chain (TCR) associated protein kinase 70kDa |
| 23678 | SGK3 | shSGK3-1386 | 0.3 | serum/glucocorticoid regulated kinase-like |
| 8916 | HERC3 | shHERC3-1556 | 0.3 | hect domain and RLD 3 |
| 55351 | STK32B | shSTK32B-554 | 0.3 | serine/threonine kinase 32B |
| 5563 | PRKAA2 | shPRKAA2-820 | 0.3 | protein kinase, AMP-activated, alpha 2 catalytic subunit |
| 2049 | EPHB3 | shEPHB3-3611 | 0.3 | EPH receptor B3 |

Table S4. Full Table of Gene Targets for which Two or More shRNAs Induced High Mitotic Index

| Gene ID | Symbol | Hairpin Name | Average MI | Description |
|---------|--------|---------------|------------|---|
| 7145 | TNS | shTNS-6197 | 43.0 | tensin |
| | | shTNS-5263 | 13.4 | |
| 2268 | FGR | shFGR-385 | 28.1 | Gardner-Rasheed feline sarcoma viral (v-fgr) oncogene homolog |
| | | shFGR-460 | 26.1 | |
| | | shFGR-339 | 9.7 | |
| 4920 | ROR2 | shROR2-2071 | 39.1 | receptor tyrosine kinase-like orphan receptor 2 |
| | | shROR2-3357 | 14.5 | |
| 5159 | PDGFRB | shPDGFRB-2371 | 30.6 | platelet-derived growth factor receptor, beta polypeptide |
| | | shPDGFRB-1985 | 16.1 | |
| 3055 | HCK | shHCK-261 | 30.4 | hemopoietic cell kinase |
| | | shHCK-412 | 11.0 | |
| 4915 | NTRK2 | shNTRK2-2123 | 34.1 | neurotrophic tyrosine kinase, receptor, type 2 |
| | | shNTRK2-1968 | 15.6 | |
| 7525 | YES1 | shYES1-905 | 25.4 | v-yes-1 Yamaguchi sarcoma viral oncogene homolog 1 |
| | | shYES1-1338 | 19.8 | |
| 7075 | TIE1 | shTIE1-3795 | 24.5 | tyrosine kinase with immunoglobulin-like and EGF-like domains 1 |
| | | shTIE1-3206 | 12.4 | |
| 5571 | PRKAG1 | shPRKAG1-157 | 24.0 | protein kinase, AMP-activated, gamma 1 non-catalytic subunit |
| | | shPRKAG1-565 | 23.4 | |
| | | shPRKAG1-1269 | 15.4 | |
| 5997 | RGS2 | shRGS2-510 | 25.6 | regulator of G-protein signalling 2, 24kDa |
| | | shRGS2-508 | 20.9 | |
| | | shRGS2-158 | 13.6 | |
| 5597 | MAPK6 | shMAPK6-3734 | 23.3 | mitogen-activated protein kinase 6 |
| | | shMAPK6-798 | 9.4 | |
| 6416 | MAP2K4 | shMAP2K4-3471 | 26.8 | mitogen-activated protein kinase kinase 4 |
| | | shMAP2K4-401 | 12.0 | |
| 11183 | MAP4K5 | shMAP4K5-2826 | 23.6 | mitogen-activated protein kinase kinase kinase kinase 5 |
| | | shMAP4K5-2158 | 13.5 | |
| 11338 | U2AF2 | shU2AF2-606 | 31.2 | U2 (RNU2) small nuclear RNA auxiliary factor 2 |
| | | shU2AF2-289 | 12.9 | |
| 5563 | PRKAA2 | shPRKAA2-1028 | 31.0 | protein kinase, AMP-activated, alpha 2 catalytic subunit |
| | | shPRKAA2-2127 | 13.0 | |
| 8737 | RIPK1 | shRIPK1-1674 | 28.3 | receptor (TNFRSF)-interacting serine-threonine kinase 1 |
| | | shRIPK1-432 | 14.6 | |
| 5651 | PRSS7 | shPRSS7-1306 | 21.2 | protease, serine, 7 (enterokinase) |
| | | shPRSS7-2651 | 21.2 | |
| 7010 | TEK | shTEK-520 | 27.0 | TEK tyrosine kinase, endothelial (venous malformations, multiple cutaneous and mucosal) |
| | | shTEK-1275 | 11.2 | |
| | | shTEK-1276 | 9.6 | |
| 4089 | SMAD4 | shSMAD4-2493 | 29.1 | SMAD, mothers against DPP homolog 4 (Drosophila) |
| | | shSMAD4-458 | 13.1 | |
| | | shSMAD4-1735 | 9.4 | |
| 55137 | FIGN | shFIGN-1661 | 21.3 | fidgetin |
| | | shFIGN-1450 | 18.6 | |
| 10000 | AKT3 | shAKT3-361 | 23.2 | v-akt murine thymoma viral oncogene homolog 3 (protein kinase B, gamma) |
| | | shAKT3-1307 | 15.7 | |

| | | | | |
|--------------|----------------|-----------------------|-------------|--|
| | | shAKT3-1222 | 12.8 | |
| | | shAKT3-200 | 12.2 | |
| | | shAKT3-770 | 11.0 | |
| 11035 | RIPK3 | shRIPK3-612 | 23.9 | receptor-interacting serine-threonine kinase 3 |
| | | shRIPK3-1041 | 13.8 | |
| 5922 | RASA2 | shRASA2-572 | 23.6 | RAS p21 protein activator 2 |
| | | shRASA2-1607 | 14.0 | |
| 2869 | GRK5 | shGRK5-526 | 22.5 | G protein-coupled receptor kinase 5 |
| | | shGRK5-356 | 14.5 | |
| 4233 | MET | shMET-1651 | 23.8 | met proto-oncogene (hepatocyte growth factor receptor) |
| | | shMET-1374 | 9.1 | |
| 3645 | INSRR | shINSRR-3960 | 21.7 | insulin receptor-related receptor |
| | | shINSRR-2789 | 11.1 | |
| 27 | ABL2 | shABL2-3279 | 19.0 | v-abl Abelson murine leukemia viral oncogene homolog 2 (arg, Abelson-related gene) |
| | | shABL2-156 | 11.7 | |
| 9156 | EXO1 | shEXO1-1586 | 25.2 | exonuclease 1 |
| | | shEXO1-2736 | 10.9 | |
| 6197 | RPS6KA3 | shRPS6KA3-982 | 23.9 | ribosomal protein S6 kinase, 90kDa, polypeptide 3 |
| | | shRPS6KA3-2052 | 12.0 | |
| 65061 | ALS2CR7 | shALS2CR7-314 | 18.0 | amyotrophic lateral sclerosis 2 (juvenile) chromosome region, candidate 7 |
| | | shALS2CR7-283 | 16.8 | |
| 5601 | MAPK9 | shMAPK9-812 | 20.6 | mitogen-activated protein kinase 9 |
| | | shMAPK9-997 | 14.1 | |
| 10733 | PLK4 | shPLK4-433 | 18.8 | polo-like kinase 4 (Drosophila) |
| | | shPLK4-1377 | 15.6 | |
| 1540 | CYLD | shCYLD-5274 | 17.1 | cylindromatosis (turban tumor syndrome) |
| | | shCYLD-3218 | 17.1 | |
| | | shCYLD-896 | 9.6 | |
| 23524 | SRRM2 | shSRRM2-2974 | 24.6 | serine/arginine repetitive matrix 2 |
| | | shSRRM2-2687 | 9.6 | |
| 57144 | PAK7 | shPAK7-1918 | 19.8 | p21(CDKN1A)-activated kinase 7 |
| | | shPAK7-616 | 14.4 | |
| 1028 | CDKN1C | shCDKN1C-431 | 17.9 | cyclin-dependent kinase inhibitor 1C (p57, Kip2) |
| | | shCDKN1C-285 | 16.1 | |
| 3611 | ILK | shILK-1688 | 23.2 | integrin-linked kinase |
| | | shILK-700 | 10.8 | |
| 10921 | RNPS1 | shRNPS1-872 | 19.7 | RNA binding protein S1, serine-rich domain |
| | | shRNPS1-1243 | 13.4 | |
| | | shRNPS1-1148 | 9.9 | |
| 657 | BMPR1A | shBMPR1A-1777 | 20.9 | bone morphogenetic protein receptor, type IA |
| | | shBMPR1A-880 | 12.1 | |
| 3248 | HPGD | shHPGD-403 | 18.7 | hydroxyprostaglandin dehydrogenase 15-(NAD) |
| | | shHPGD-1794 | 14.1 | |
| 8491 | MAP4K3 | shMAP4K3-1824 | 19.4 | mitogen-activated protein kinase kinase kinase kinase 3 |
| | | shMAP4K3-965 | 9.4 | |
| 4830 | NME1 | shNME1-99 | 21.6 | non-metastatic cells 1, protein (NM23A) expressed in |
| | | shNME1-270 | 10.9 | |
| 10283 | SDCCAG10 | shSDCCAG10-641 | 22.8 | serologically defined colon cancer antigen 10 |
| | | shSDCCAG10-1015 | 9.2 | |
| 6794 | STK11 | shSTK11-514 | 16.3 | serine/threonine kinase 11 (Peutz-Jeghers syndrome) |

| | | | | |
|-------------|-------------|--------------------|-------------|---|
| 8175 | SF3A2 | shSTK11-1351 | 12.6 | |
| | | shSF3A2-208 | 19.2 | splicing factor 3a, subunit 2, 66kDa |
| | | shSF3A2-443 | 12.0 | |
| | | shSF3A2-617 | 11.0 | |
| 2324 | FLT4 | shFLT4-2503 | 16.3 | fms-related tyrosine kinase 4 |
| | | shFLT4-3875 | 13.6 | |
| | | shFLT4-1694 | 10.4 | |
| 5596 | MAPK4 | shMAPK4-1017 | 18.7 | mitogen-activated protein kinase 4 |
| | | shMAPK4-1105 | 12.4 | |
| 1445 | CSK | shCSK-835 | 17.9 | c-src tyrosine kinase |
| | | shCSK-633 | 13.2 | |
| | | shCSK-1280 | 10.7 | |
| | | shCSK-903 | 10.0 | |
| 10217 | CTDSPL | shCTDSPL-456 | 20.9 | CTD (carboxy-terminal domain, RNA polymerase II, polypeptide A) small phosphatase-like |
| | | shCTDSPL-693 | 10.0 | |
| 4087 | SMAD2 | shSMAD2-1543 | 15.5 | SMAD, mothers against DPP homolog 2 (Drosophila) |
| | | shSMAD2-415 | 15.0 | |
| 4058 | LTK | shLTK-2132 | 18.0 | leukocyte tyrosine kinase |
| | | shLTK-1509 | 12.3 | |
| 6392 | SDHD | shSDHD-266 | 20.1 | succinate dehydrogenase complex, subunit D, integral membrane protein |
| | | shSDHD-671 | 10.2 | |
| 558 | AXL | shAXL-4548 | 19.2 | AXL receptor tyrosine kinase |
| | | shAXL-2909 | 10.2 | |
| 5754 | PTK7 | shPTK7-2544 | 19.0 | PTK7 protein tyrosine kinase 7 |
| | | shPTK7-2361 | 10.2 | |
| 1111 | CHEK1 | shCHEK1-1609 | 16.0 | CHK1 checkpoint homolog (S. pombe) |
| | | shCHEK1-1317 | 13.0 | |
| | | shCHEK1-438 | 12.9 | |
| 8798 | DYRK4 | shDYRK4-1292 | 19.5 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 4 |
| | | shDYRK4-949 | 9.6 | |
| 11213 | IRAK3 | shIRAK3-1030 | 14.6 | interleukin-1 receptor-associated kinase 3 |
| | | shIRAK3-1348 | 13.9 | |
| 7048 | TGFBR2 | shTGFBR2-1093 | 14.9 | transforming growth factor, beta receptor II (70/80kDa) |
| | | shTGFBR2-890 | 13.1 | |
| 156 | ADRBK1 | shADRBK1-1546 | 16.5 | adrenergic, beta, receptor kinase 1 |
| | | shADRBK1-587 | 11.4 | |
| 1655 | DDX5 | shDDX5-631 | 14.1 | DEAD (Asp-Glu-Ala-Asp) box polypeptide 5 |
| | | shDDX5-2264 | 13.7 | |
| 5894 | RAF1 | shRAF1-1764 | 14.3 | v-raf-1 murine leukemia viral oncogene homolog 1 |
| | | shRAF1-1529 | 13.4 | |
| | | shRAF1-1236 | 10.1 | |
| 695 | BTK | shBTK-591 | 15.6 | Bruton agammaglobulinemia tyrosine kinase |
| | | shBTK-508 | 10.2 | |
| 6725 | SRMS | shSRMS-1235 | 14.6 | src-related kinase lacking C-terminal regulatory tyrosine and N-terminal myristylation sites |
| | | shSRMS-1231 | 12.6 | |
| | | shSRMS-814 | 12.0 | |
| 3984 | LIMK1 | shLIMK1-3140 | 16.5 | LIM domain kinase 1 |
| | | shLIMK1-874 | 10.7 | |
| 51776 | ZAK | shZAK-549 | 14.2 | sterile alpha motif and leucine zipper containing kinase AZK |
| | | shZAK-743 | 13.0 | |

| | | | | |
|--------|----------|-----------------|------|---|
| | | shZAK-331 | 11.0 | |
| 1859 | DYRK1A | shDYRK1A-3947 | 15.9 | dual-specificity tyrosine-(Y)-phosphorylation regulated kinase 1A |
| | | shDYRK1A-472 | 11.2 | |
| 5603 | MAPK13 | shMAPK13-1254 | 14.6 | mitogen-activated protein kinase 13 |
| | | shMAPK13-720 | 12.4 | |
| 5599 | MAPK8 | shMAPK8-864 | 15.4 | mitogen-activated protein kinase 8 |
| | | shMAPK8-984 | 11.6 | |
| 255928 | SYT14 | shSYT14-1753 | 15.2 | synaptotagmin XIV |
| | | shSYT14-319 | 11.6 | |
| 5581 | PRKCE | shPRKCE-1288 | 16.5 | protein kinase C, epsilon |
| | | shPRKCE-741 | 10.3 | |
| 151649 | FLJ25449 | shFLJ25449-950 | 17.3 | hypothetical protein MGC27069 |
| | | shFLJ25449-1016 | 9.3 | |
| 1969 | EPHA2 | shEPHA2-716 | 15.6 | EPH receptor A2 |
| | | shEPHA2-2881 | 10.9 | |
| 7297 | TYK2 | shTYK2-2906 | 14.5 | tyrosine kinase 2 |
| | | shTYK2-3209 | 9.2 | |
| 9050 | PSTPIP2 | shPSTPIP2-943 | 16.3 | proline-serine-threonine phosphatase interacting protein 2 |
| | | shPSTPIP2-562 | 9.9 | |
| 5979 | RET | shRET-6955 | 15.0 | ret proto-oncogene (multiple endocrine neoplasia and medullary thyroid carcinoma 1, Hirschsprung disease) |
| | | shRET-441 | 11.1 | |
| | | shRET-3874 | 9.3 | |
| 6861 | SYT5 | shSYT5-1333 | 17.0 | synaptotagmin V |
| | | shSYT5-1844 | 9.2 | |
| 8621 | CDC2L5 | shCDC2L5-5160 | 15.7 | cell division cycle 2-like 5 (cholinesterase-related cell division controller) |
| | | shCDC2L5-1981 | 10.3 | |
| 7083 | TK1 | shTK1-610 | 15.4 | thymidine kinase 1, soluble |
| | | shTK1-224 | 10.2 | |
| 10946 | SF3A3 | shSF3A3-177 | 15.1 | splicing factor 3a, subunit 3, 60kDa |
| | | shSF3A3-942 | 10.3 | |
| 8476 | CDC42BPA | shCDC42BPA-6823 | 14.5 | CDC42 binding protein kinase alpha (DMPK-like) |
| | | shCDC42BPA-7066 | 10.8 | |
| 2047 | EPHB1 | shEPHB1-712 | 14.3 | EPH receptor B1 |
| | | shEPHB1-260 | 10.9 | |
| | | shEPHB1-1610 | 10.5 | |
| | | shEPHB1-3623 | 9.2 | |
| 208 | AKT2 | shAKT2-633 | 15.6 | v-akt murine thymoma viral oncogene homolog 2 |
| | | shAKT2-1510 | 9.2 | |
| 4882 | NPR2 | shNPR2-3036 | 14.3 | natriuretic peptide receptor B/guanylate cyclase B (atrionatriuretic peptide receptor B) |
| | | shNPR2-1801 | 10.3 | |
| 4916 | NTRK3 | shNTRK3-1263 | 15.4 | neurotrophic tyrosine kinase, receptor, type 3 |
| | | shNTRK3-1748 | 9.1 | |
| 5587 | PRKD1 | shPRKD1-2270 | 14.9 | protein kinase D1 |
| | | shPRKD1-2978 | 9.0 | |
| 3654 | IRAK1 | shIRAK1-1257 | 14.1 | interleukin-1 receptor-associated kinase 1 |
| | | shIRAK1-2656 | 9.8 | |
| 1021 | CDK6 | shCDK6-921 | 14.1 | cyclin-dependent kinase 6 |
| | | shCDK6-468 | 9.3 | |

At least one shRNA induced MI > 14 and at least one additional shRNA elicited MI > 9. Genes in bold print are included in Table 1 in the main text.

Supplemental Figures

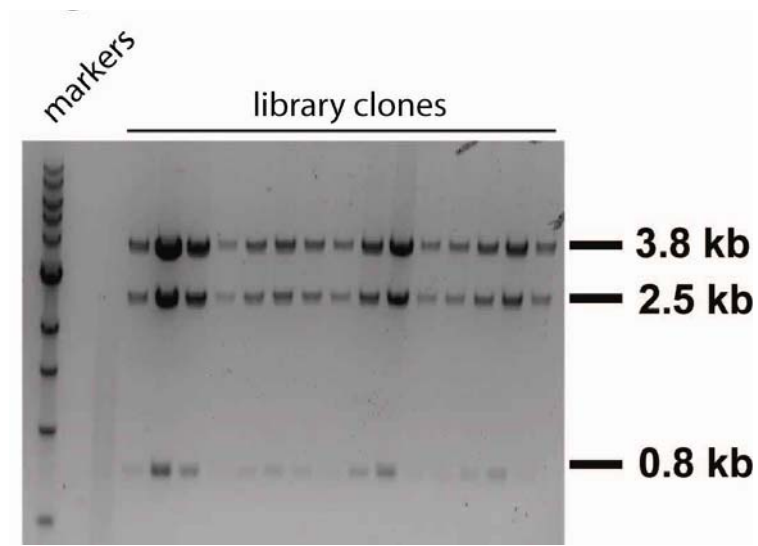


Figure S1. pLKO.1 Stability Assessed by Diagnostic Restriction Digestion

Digestion of pLKO.1 library constructs by PvuII produces 3 fragments of 3.8 kb, 2.5 kb and 0.8 kb. PvuII digestions of 244 library clones in pLKO.1 were performed following ten rounds of sequential copying and regrowth. No evidence of recombination was observed. A representative digestion gel from a fraction of wells in a library plate from a 10th generation copy is shown.

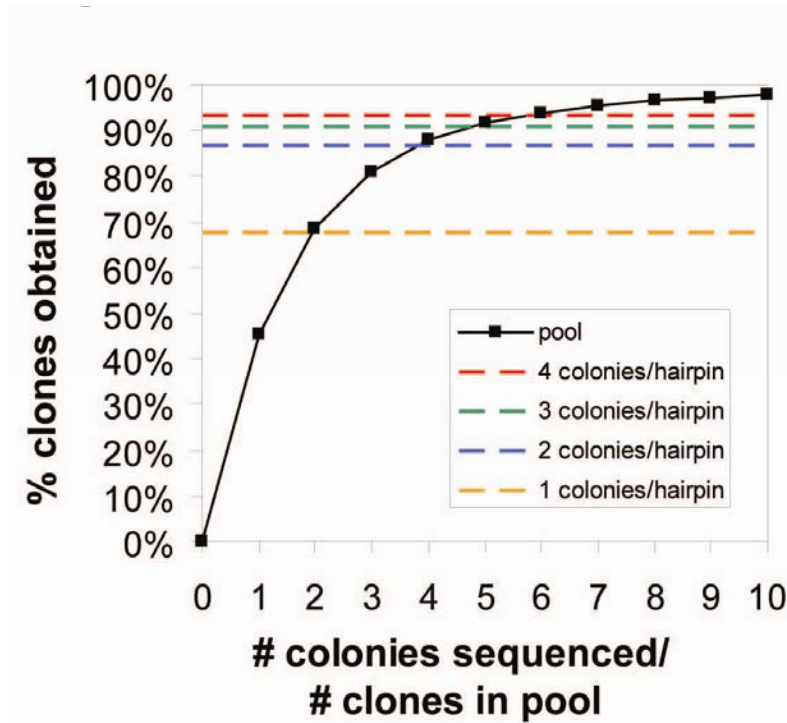


Figure S2. Library Cloning Success Rates by Sequencing Transformant Pools

Transformations from 90 individual ligations were pooled and plated onto a single 9 inch by 9 inch LB-agar plate. Colonies were picked randomly and clones were sequence-verified. The percentage of unique clones obtained is plotted versus the number of colonies sequenced from the plate (solid black line). For reference, a second method was employed in which each transformant was plated onto an LB-agar plate and four colonies were sequenced. The 4 dashed lines in the graph show the cloning success rates when 1(yellow), 2(blue), 3(green), or 4(red) colonies were picked from individual LB-agar plates, respectively. For example, 6-fold sequencing coverage from the transformant pool gives the same clone recovery rate as picking four single colonies from 90 separate plates of transformants. In our library production process, we perform 7-fold oversequencing of colonies from the pool, with a 94% cloning success rate.

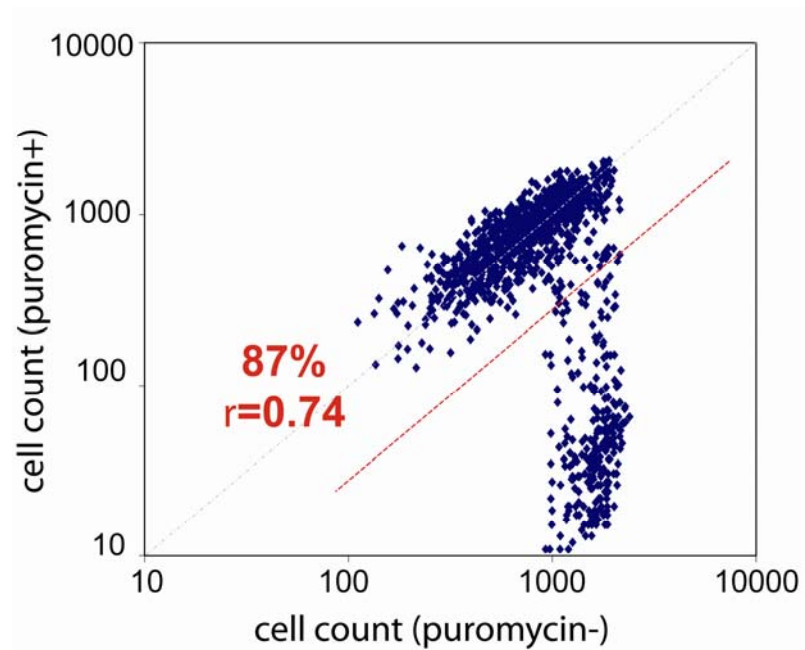
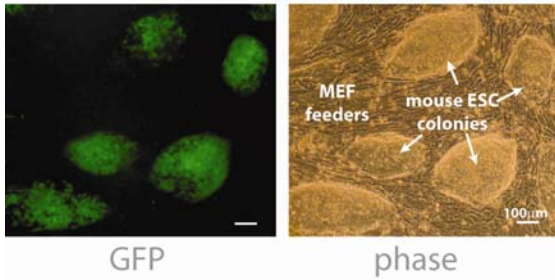


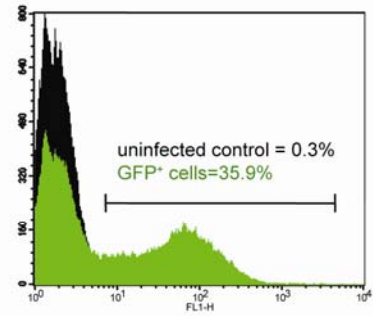
Figure S3. Infection Rates for HT-Generated Virus in A549 Cells

Analysis of infection rates presented as a scatter plot comparing the number of cells in a well in the presence (Y-axis) or absence (X-axis) of puromycin selection with 1,500 viruses.

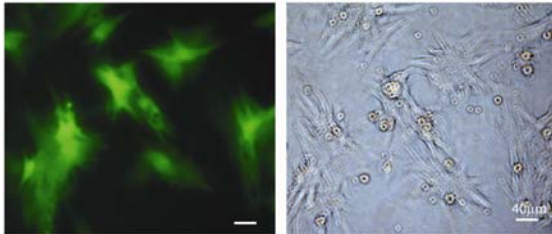
A mouse ES cells (on feeders)



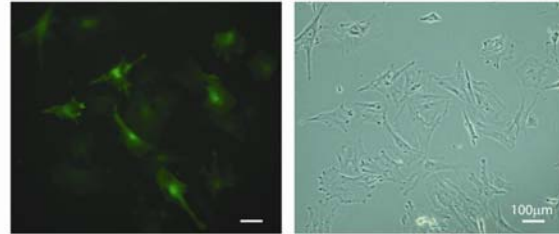
B



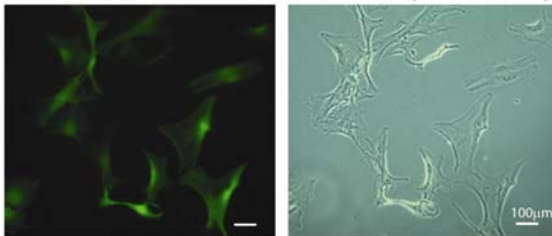
C rat neonatal cardiomyocytes



D mouse embryonic fibroblasts



E human cortical neurons (HCN-1A)



F human neuroblastoma (SH-SY5Y)

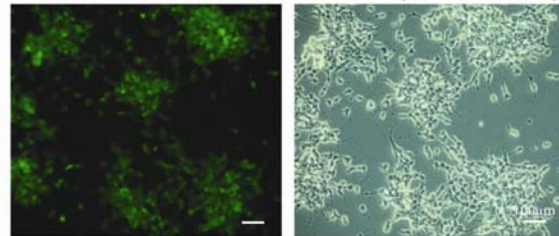


Figure S4. Various Cell Types Infected with pLKO.1 Lentiviruses

A number of cell types were infected with GFP expressing lentiviruses and photographed post-infection including (A and B) mouse embryonic stem cells, (C) rat neonatal cardiomyocytes, (D) mouse embryonic fibroblasts, (E) human HCN1A cortical neurons, and (F) human SHSY5Y neuroblastoma cells. Mouse embryonic stem cells infected with GFP expressing lentiviruses were analyzed by FACS as shown in (B). Results from a control infection are shown in black.

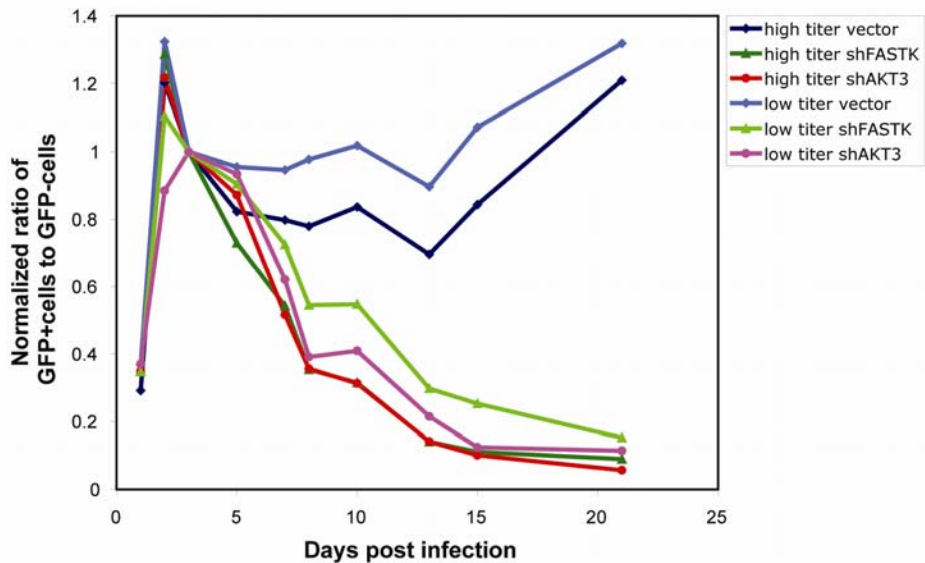


Figure S5. Killing of HT29 Cells by Low-Titer shFASTK and shAKT3 Viruses

The puromycin resistant gene in LKO.1 was replaced by EGFP to create LKO-EGFP. The hairpins for human FASTK and AKT3 were cloned into LKO-EGFP to create shFASTK-186 and shAKT3-403. HT29 cells were infected with the indicated amount of virus and the percentage of infected, GFP positive cells, among the total propidium iodide negative live cells was measured by FACS at various times after infection. The ratio of GFP-positive to GFP-negative cells normalized to the ratio at 3 days post infection is plotted versus time post infection. The percentages of GFP-expressing cells at 3 days post infection for control vector, shFASTK-186, and shAKT3-403 viruses are 88%, 65% and 56% respectively for high titers and 15%, 7% and 6% respectively, for low titers.

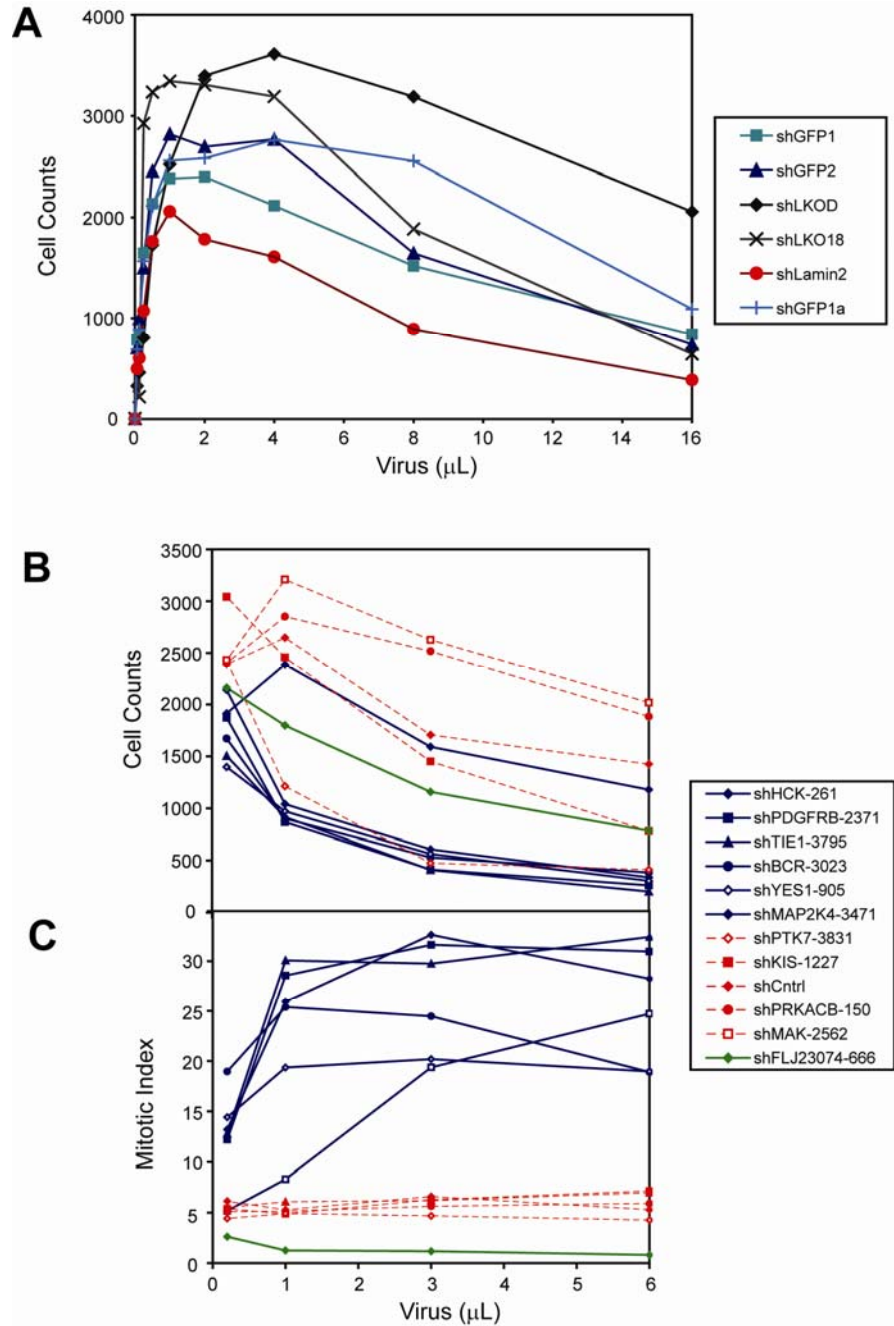


Figure S6. Dose-Response Effects on Cell Number and Mitotic Index

(A) Viral dose titration of lentiviruses for control shRNAs. Cell counts determined by automated image analysis following puromycin selection are plotted versus the volume of virus used in the infection.

(B and C) A selection of shRNAs from the primary mitotic index screen in HT29 cells, some of which caused an increase in mitotic index, were used to assess the effect of viral dose on (B) cell counts and (C) mitotic index.

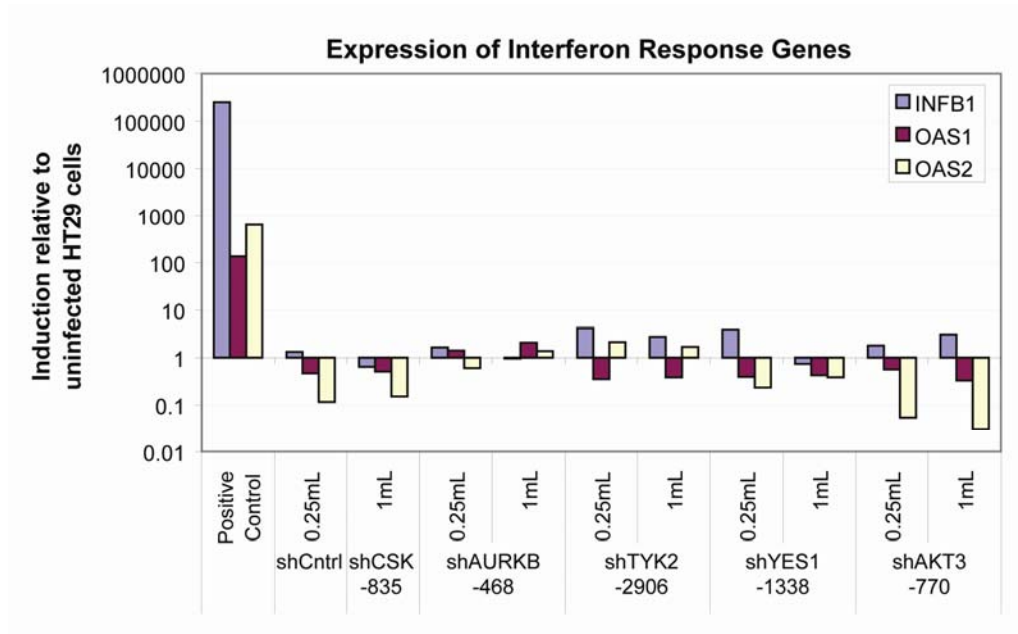


Figure S7. Test Interferon Induction by Selected Hits from Primary Screen

The expression levels of several interferon response genes (IFNB1, OAS1, and OAS2) were quantified following transduction of HT29 cells with shRNA-expressing lentivirus. Levels of interferon response gene expression were scaled to an uninfected HT29 control sample (expression = 1). Induction of interferon response genes is clearly observed in the positive control sample (primary dendritic cells infected with influenza virus), but is not seen following transduction with shRNA-lentivirus. HT29 cells were transduced in 60 mm plates with 0.25 mL or 1 mL lentivirus containing shRNA expression constructs that showed high MI in the screen, or with a control shRNA lentivirus (shCntrl).