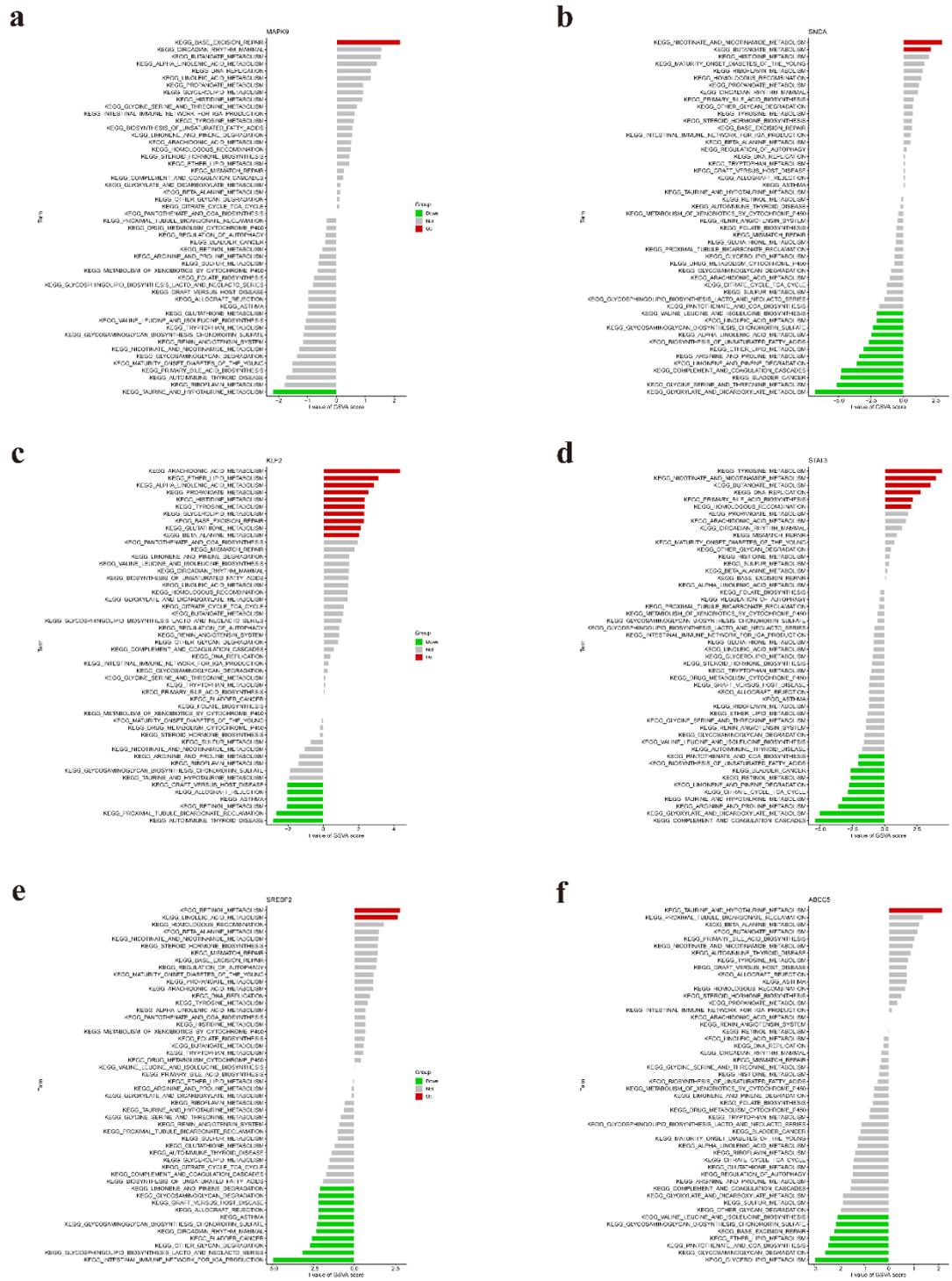


Supplementary Figure S1a-d. Single-gene GSEA-KEGG pathway analysis in ABCC5 (a), EGR1 (b), SRE8F2 (c), STAT3 (d).



Supplementary Figure S2a-f. Differentially activated pathways between the high- and low-expression groups based on the expression levels of each gene biomarkers. GSEA-KEGG pathway analysis in MAPK9 (a), SNCA (b), KLF2 (c), STAT3 (d), SRE8F2 (e) and ABCC5 (f).

Supplementary Table S1. 348 FRGs were pre-prepared and obtained from the FerrDb database.

RCD	Symbol	HGNCID
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	AKR1C1	HGNC:384
Ferroptosis	AKR1C2	HGNC:385
Ferroptosis	AKR1C3	HGNC:386
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	RB1	HGNC:9884
Ferroptosis	HSPB1	HGNC:5246
Ferroptosis	HSF1	HGNC:5224
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	GCLC	HGNC:4311
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	SQSTM1	HGNC:11280
Ferroptosis	NQO1	HGNC:2874
Ferroptosis	HMOX1	HGNC:5013
Ferroptosis	FTH1	HGNC:3976
Ferroptosis	MUC1	HGNC:7508
Ferroptosis	SLC3A2	HGNC:11026
Ferroptosis	MT1G	HGNC:7399
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	SLC40A1	HGNC:10909
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	CISD1	HGNC:30880
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	FANCD2	HGNC:3585
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	FTMT	HGNC:17345
Ferroptosis	HSPA5	HGNC:5238
Ferroptosis	ATF4	HGNC:786
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	HMOX1	HGNC:5013
Ferroptosis	ATF4	HGNC:786
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	TP53	HGNC:11998
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	HELLS	HGNC:4861

Ferroptosis	SCD	HGNC:10571
Ferroptosis	FADS2	HGNC:3575
Ferroptosis	SRC	HGNC:11283
Ferroptosis	STAT3	HGNC:11364
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	PML	HGNC:9113
Ferroptosis	MTOR	HGNC:3942
Ferroptosis	NFS1	HGNC:15910
Ferroptosis	TP63	HGNC:15979
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	TP53	HGNC:11998
Ferroptosis	CDKN1A	HGNC:1784
Ferroptosis	MIR137	HGNC:31523
Ferroptosis	SLC40A1	HGNC:10909
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	ENPP2	HGNC:3357
Ferroptosis	VDAC2	HGNC:12672
Ferroptosis	FH	HGNC:3700
Ferroptosis	CISD2	HGNC:24212
Ferroptosis	SLC40A1	HGNC:10909
Ferroptosis	MIR9-1	HGNC:31641
Ferroptosis	MIR9-2	HGNC:31642
Ferroptosis	MIR9-3	HGNC:31646
Ferroptosis	CBS	HGNC:1550
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	SQSTM1	HGNC:11280
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	ISCU	HGNC:29882
Ferroptosis	FTH1	HGNC:3976
Ferroptosis	ACSL3	HGNC:3570
Ferroptosis	OTUB1	HGNC:23077
Ferroptosis	CD44	HGNC:1681
Ferroptosis	LINC00336	HGNC:33813
Ferroptosis	STAT3	HGNC:11364
Ferroptosis	BRD4	HGNC:13575
Ferroptosis	PRDX6	HGNC:16753
Ferroptosis	MIR17	HGNC:31547
Ferroptosis	SCD	HGNC:10571
Ferroptosis	SESN2	HGNC:20746
Ferroptosis	NF2	HGNC:7773
Ferroptosis	ARNTL	HGNC:701
Ferroptosis	HIF1A	HGNC:4910
Ferroptosis	JUN	HGNC:6204

Ferroptosis	CA9	HGNC:1383
Ferroptosis	HSPA5	HGNC:5238
Ferroptosis	TMBIM4	HGNC:24257
Ferroptosis	HSPA5	HGNC:5238
Ferroptosis	PLIN2	HGNC:248
Ferroptosis	MIR212	HGNC:31589
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Ferroptosis	AIFM2	HGNC:21411
Ferroptosis	AIFM2	HGNC:21411
Ferroptosis	LAMP2	HGNC:6501
Ferroptosis	ZFP36	HGNC:12862
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	PROM2	HGNC:20685
Ferroptosis	CHMP5	HGNC:26942
Ferroptosis	CHMP6	HGNC:25675
Ferroptosis	AKR1C1	HGNC:384
Ferroptosis	AKR1C2	HGNC:385
Ferroptosis	AKR1C3	HGNC:386
Ferroptosis	CBS	HGNC:1550
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	CAV1	HGNC:1527
Ferroptosis	GCH1	HGNC:4193
Ferroptosis	SIRT3	HGNC:14931
Ferroptosis	DAZAP1	HGNC:2683
Ferroptosis	PIR	HGNC:30048
Ferroptosis	GCLC	HGNC:4311
Ferroptosis	FTL	HGNC:3999
Ferroptosis	HCAR1	HGNC:4532
Ferroptosis	SLC16A1	HGNC:10922
Ferroptosis	RRM2	HGNC:10452
Ferroptosis	SCD	HGNC:10571
Ferroptosis	NR4A1	HGNC:7980
Ferroptosis	PIK3CA	HGNC:8975
Ferroptosis	RPTOR	HGNC:30287
Ferroptosis	SREBF1	HGNC:11289
Ferroptosis	SREBF2	HGNC:11290
Ferroptosis	FZD7	HGNC:4045
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	P4HB	HGNC:8548
Ferroptosis	NT5DC2	HGNC:25717
Ferroptosis	BCAT2	HGNC:977
Ferroptosis	HSF1	HGNC:5224
Ferroptosis	PLA2G6	HGNC:9039

Ferroptosis	MIR424	HGNC:31881
Ferroptosis	PARK7	HGNC:16369
Ferroptosis	FXN	HGNC:3951
Ferroptosis	SUV39H1	HGNC:11479
Ferroptosis	ATF2	HGNC:784
Ferroptosis	CDKN1A	HGNC:1784
Ferroptosis	FTH1	HGNC:3976
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	STAT3	HGNC:11364
Ferroptosis	ACOT1	HGNC:33128
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	ALDH3A2	HGNC:403
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	STK11	HGNC:11389
Ferroptosis	FNDC5	HGNC:20240
Ferroptosis	CircIL4R	_NA_
Ferroptosis	CDH1	HGNC:1748
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	MIR214	HGNC:31591
Ferroptosis	NEDD4L	HGNC:7728
Ferroptosis	SQSTM1	HGNC:11280
Ferroptosis	TF	HGNC:11740
Ferroptosis	FTMT	HGNC:17345
Ferroptosis	BRD2	HGNC:1103
Ferroptosis	BRD3	HGNC:1104
Ferroptosis	BRD4	HGNC:13575
Ferroptosis	BRDT	HGNC:1105
Ferroptosis	SCD	HGNC:10571
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	DECR1	HGNC:2753
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	GLRX5	HGNC:20134
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	NCOA3	HGNC:7670
Ferroptosis	NR5A2	HGNC:7984
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	MTOR	HGNC:3942
Ferroptosis	PANX2	HGNC:8600
Ferroptosis	RHEBP1	HGNC:10010
Ferroptosis	TFAP2A	HGNC:11742
Ferroptosis	CP	HGNC:2295

Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	ARF6	HGNC:659
Ferroptosis	GDF15	HGNC:30142
Ferroptosis	ABHD12	HGNC:15868
Ferroptosis	PPP1R13L	HGNC:18838
Ferroptosis	TFAM	HGNC:11741
Ferroptosis	KDM3B	HGNC:1337
Ferroptosis	RNF113A	HGNC:12974
Ferroptosis	PARK7	HGNC:16369
Ferroptosis	AHCY	HGNC:343
Ferroptosis	FXN	HGNC:3951
Ferroptosis	circ-TTBK2	HGNC:19141
Ferroptosis	MIR522	HGNC:32127
Ferroptosis	IDH2	HGNC:5383
Ferroptosis	PPARA	HGNC:9232
Ferroptosis	NOS2	HGNC:7873
Ferroptosis	SIAH2	HGNC:10858
Ferroptosis	RELA	HGNC:9955
Ferroptosis	PRKAA2	HGNC:9377
Ferroptosis	VDR	HGNC:12679
Ferroptosis	NEDD4	HGNC:7727
Ferroptosis	FXN	HGNC:3951
Ferroptosis	AIFM2	HGNC:21411
Ferroptosis	PRDX1	HGNC:9352
Ferroptosis	AR	HGNC:644
Ferroptosis	CBS	HGNC:1550
Ferroptosis	NFE2L2	HGNC:7782
Ferroptosis	CHMP5	HGNC:26942
Ferroptosis	CHMP6	HGNC:25675
Ferroptosis	HMOX1	HGNC:5013
Ferroptosis	ZFP36	HGNC:12862
Ferroptosis	LAMP2	HGNC:6501
Ferroptosis	MTF1	HGNC:7428
Ferroptosis	COPZ1	HGNC:2243
Ferroptosis	NUPR1	HGNC:29990
Ferroptosis	USP35	HGNC:20061
Ferroptosis	HSF1	HGNC:5224
Ferroptosis	PROM2	HGNC:20685
Ferroptosis	PLA2G6	HGNC:9039
Ferroptosis	HIF1A	HGNC:4910
Ferroptosis	NEAT1	HGNC:30815
Ferroptosis	RRM2	HGNC:10452
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	FTMT	HGNC:17345

Ferroptosis	PARP1	HGNC:270
Ferroptosis	PARP2	HGNC:272
Ferroptosis	PARP3	HGNC:273
Ferroptosis	PARP4	HGNC:271
Ferroptosis	PARP6	HGNC:26921
Ferroptosis	PARP8	HGNC:26124
Ferroptosis	PARP9	HGNC:24118
Ferroptosis	PARP10	HGNC:25895
Ferroptosis	PARP11	HGNC:1186
Ferroptosis	PARP12	HGNC:21919
Ferroptosis	PARP14	HGNC:29232
Ferroptosis	PARP15	HGNC:26876
Ferroptosis	PARP16	HGNC:26040
Ferroptosis	PDSS2	HGNC:23041
Ferroptosis	TXN	HGNC:12435
Ferroptosis	SENP1	HGNC:17927
Ferroptosis	PLA2G6	HGNC:9039
Ferroptosis	OIP5-AS1	HGNC:43563
Ferroptosis	MIR190A	HGNC:31560
Ferroptosis	FGF21	HGNC:3678
Ferroptosis	CREB1	HGNC:2345
Ferroptosis	CREB3	HGNC:2347
Ferroptosis	CREB5	HGNC:16844
Ferroptosis	FTMT	HGNC:17345
Ferroptosis	GOT1	HGNC:4432
Ferroptosis	TFRC	HGNC:11763
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	MIR130B	HGNC:31515
Ferroptosis	BEX1	HGNC:1036
Ferroptosis	ASAH2	HGNC:18860
Ferroptosis	SCD	HGNC:10571
Ferroptosis	FABP4	HGNC:3559
Ferroptosis	AKT1S1	HGNC:28426
Ferroptosis	MLST8	HGNC:24825
Ferroptosis	MTOR	HGNC:3942
Ferroptosis	RPTOR	HGNC:30287
Ferroptosis	CDH1	HGNC:1748
Ferroptosis	SIRT1	HGNC:14929
Ferroptosis	TYRO3	HGNC:12446
Ferroptosis	SIRT6	HGNC:14934
Ferroptosis	TMSB4X	HGNC:11881
Ferroptosis	TMSB4Y	HGNC:11882
Ferroptosis	KIF20A	HGNC:9787
Ferroptosis	ECH1	HGNC:3149

Ferroptosis	circRHOT1	_NA_
Ferroptosis	ETV4	HGNC:3493
Ferroptosis	MEG8	HGNC:14574
Ferroptosis	VCP	HGNC:12666
Ferroptosis	circ_0007142	_NA_
Ferroptosis	ENPP2	HGNC:3357
Ferroptosis	RBMS1	HGNC:9907
Ferroptosis	KDM4A	HGNC:22978
Ferroptosis	CBS	HGNC:1550
Ferroptosis	MGST1	HGNC:7061
Ferroptosis	circKIF4A	_NA_
Ferroptosis	miR-7-5p	_NA_
Ferroptosis	PRDX6	HGNC:16753
Ferroptosis	circ_0067934	_NA_
Ferroptosis	MPC1	HGNC:21606
Ferroptosis	CHMP1A	HGNC:8740
Ferroptosis	CAMKK2	HGNC:1470
Ferroptosis	SOX2	HGNC:11195
Ferroptosis	SRSF9	HGNC:10791
Ferroptosis	PROK2	HGNC:18455
Ferroptosis	MIR4443	HGNC:41830
Ferroptosis	SIRT2	HGNC:10886
Ferroptosis	circRNA1615	_NA_
Ferroptosis	MIR27A	HGNC:31613
Ferroptosis	MIR670	HGNC:37304
Ferroptosis	MEF2C	HGNC:6996
Ferroptosis	NF2	HGNC:7773
Ferroptosis	CDH1	HGNC:1748
Ferroptosis	HSPB1	HGNC:5246
Ferroptosis	EZH2	HGNC:3527
Ferroptosis	PEDS1	HGNC:16735
Ferroptosis	SMPD1	HGNC:11120
Ferroptosis	ADAMTS13	HGNC:1366
Ferroptosis	CDC25A	HGNC:1725
Ferroptosis	G6PD	HGNC:4057
Ferroptosis	SRSF9	HGNC:10791
Ferroptosis	CAV1	HGNC:1527
Ferroptosis	CircFNDC3B	_NA_
Ferroptosis	PPARD	HGNC:9235
Ferroptosis	CISD2	HGNC:24212
Ferroptosis	ENO3	HGNC:3354
Ferroptosis	SESN2	HGNC:20746
Ferroptosis	LCN2	HGNC:6526
Ferroptosis	MARCHF5	HGNC:26025

Ferroptosis	TRIB2	HGNC:30809
Ferroptosis	DHODH	HGNC:2867
Ferroptosis	SLC7A11	HGNC:11059
Ferroptosis	MIR545	HGNC:32531
Ferroptosis	OTUB1	HGNC:23077
Ferroptosis	PDK4	HGNC:8812
Ferroptosis	CircPVT1	_NA_
Ferroptosis	MIR9-3HG	HGNC:27388
Ferroptosis	ADIPOQ	HGNC:13633
Ferroptosis	circDTL	_NA_
Ferroptosis	GPX4	HGNC:4556
Ferroptosis	mmu_circRNA_0000309	_NA_
Ferroptosis	IL6	HGNC:6018
Ferroptosis	PTPN18	HGNC:9649
Ferroptosis	FTH1	HGNC:3976
Ferroptosis	FTH1	HGNC:3976
Ferroptosis	FTL	HGNC:3999
Ferroptosis	LCN2	HGNC:6526
Ferroptosis	ABCC5	HGNC:56
Ferroptosis	CISD3	HGNC:27578
Ferroptosis	MS4A15	HGNC:28573
Ferroptosis	LCN2	HGNC:6526
Ferroptosis	FURIN	HGNC:8568
Ferroptosis	circRHBG	_NA_
Ferroptosis	GALNT14	HGNC:22946
Ferroptosis	KLHDC3	HGNC:20704
Ferroptosis	LINC01833	HGNC:52644
Ferroptosis	circGFRA1	_NA_
Ferroptosis	MAPKAP1	HGNC:18752
Ferroptosis	MLST8	HGNC:24825
Ferroptosis	MTOR	HGNC:3942
Ferroptosis	PRR5	HGNC:31682
Ferroptosis	RICTOR	HGNC:28611
Ferroptosis	GSTM1	HGNC:4632
Ferroptosis	TERT	HGNC:11730
Ferroptosis	circ0097009	_NA_
Ferroptosis	TMEM161B-DT	HGNC:43839
Ferroptosis	circEPSTI1	_NA_
Ferroptosis	MIR18A	HGNC:31548
Ferroptosis	RARRES2	HGNC:9868
Ferroptosis	USP11	HGNC:12609

Supplementary Table S2. 41 DE-FRGs were obtained from training set.

Gene	Con-Mean	Treat-Mean	p-value	Type
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TFRC	9.432887257	9.723546605	0.001931625	Up
CYBB	9.3956784	9.843263833	0.000452172	Up
SLC38A1	11.04436597	10.33627473	4.20E-11	Down
ATG7	8.3139024	8.665556926	0.000157497	Up
BID	9.142455257	9.376133928	0.002505987	Up
MAPK9	8.305138857	8.422574553	0.004751003	Up
ELAVL1	7.034856686	6.82536272	0.00505943	Down
TLR4	7.627897914	8.154877315	0.000351632	Up
IDH1	7.491380486	7.850648219	0.001223754	Up
FBXW7	7.958634171	8.124892454	0.012215809	Up
PANX1	6.798570229	6.940310425	0.031497767	Up
BACH1	6.867012257	7.322351586	0.000467213	Up
CTSB	10.07117197	10.41897664	0.000542704	Up
AGPAT3	7.719606714	7.978381313	0.002277351	Up
MMD	10.23368569	10.5214645	0.032885401	Up
AGPS	7.630691686	7.854475764	0.004882281	Up
CDCA3	4.1815338	4.775006954	0.004625124	Up
PHF21A	9.440150429	9.59296278	0.018485219	Up
GSK3B	8.786448057	8.97156778	0.01777986	Up
BRD7	9.043054343	8.906184898	0.025262028	Down
SNCA	7.414779	8.875593592	1.10E-10	Up
MDM4	7.649657514	7.187703685	0.004302043	Down
DLD	8.932773257	9.190319796	0.001312675	Up
KLF2	13.12547409	12.60258911	3.04E-09	Down
CIRBP	11.52547883	11.13075074	0.000144861	Down
EGR1	8.963959314	10.56256334	6.72E-08	Up
CFL1	13.44021203	13.65179526	1.36E-05	Up
SQSTM1	8.238273543	8.565810668	0.001199154	Up
STAT3	9.331379314	9.615812134	4.43E-06	Up
LAMP2	9.138018486	9.548683285	5.83E-06	Up
SREBF2	7.806847057	8.221168046	1.58E-07	Up
FXN	6.134659971	5.791937289	0.030153593	Down
NEDD4L	5.1458622	5.538794842	0.000560941	Up
MTF1	8.346153743	8.585861347	0.003890929	Up
CREB1	8.558812286	8.351908064	0.006042829	Down
FABP4	4.092150886	3.493526236	0.005386726	Down
RBMS1	8.826648886	8.966913392	0.009609621	Up
ADAMTS13	4.871982686	5.246578055	0.013466344	Up
ENO3	6.634002629	6.365253973	0.037393167	Down
ABCC5	8.029049629	7.791799286	0.000166874	Down
MAPKAP1	7.5480524	7.710214034	0.003749648	Up

Supplementary Table S3. Diagnostic characteristics in training and validation sets.

Group	AUC value	Sensitivity	Specificity	Positive predictive value (PPV)	Negative predictive value (NPV)
Training set	0.993	100%	94.29%	97.6992	100
Validation set	0.864	79.49%	81.82	79.4973	81.8134