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Basic Science

Bioinformatic Analysis of the Possible Regulative Network of miR-30a/e in Cardiomyocytes 2 Days Post Myocardial Infarction

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Background: Both miR-30a and miR-30e are significantly downregulated in cardiomyocytes (CMs) 2 days (d) post myocardial infarction (MI). This study aimed to identify their possible regulative network in CMs 2d post-MI.
Methods: The dysregulated mRNAs in left ventricle tissues 2d post-MI in mice model were retrieved from one previous publication. The verified target genes of miR-30a/e and the predicted targets (upregulated 2d post-MI) were subjected to analysis of the involvement in biological processes according to their enrichment in gene ontology (GO) terms.
Results: The known targets of miR-30a/e can regulate cellular responses to glucose starvation via targeting *TP53*, *BECH1* and *HSPA5*, and also control cardiac epithelial to mesenchymal transition via targeting ETS-related gene (ERG), *SNAI1* and *NOTCH1*. Bioinformatic prediction further showed that miR-30a might regulate some biological processes related to CM responses to MI via some other potential targets, such as platelet aggregation (possibly via *ITGB3* and *STXBP1*), regulation of intrinsic apoptotic signaling pathway in response to deoxyribonucleic acid damage (possibly via *SNAI1*) and positive regulation of tyrosine phosphorylation of Stat3 protein (possibly via *LYN*, *SOCS3* and *SLCF1*).
Conclusions: Considering the importance of these genes in cellular responses to MI, it is meaningful to further investigate the regulative effect of miR-30a/e on their expression, as well as their regulative network in CMs.

Key Words: Bioinformatic analysis • miR-30a • miR-30e • Myocardial infarction

INTRODUCTION

MicroRNAs (miRNAs) are a group of endogenous, conserved and small non-coding RNA which negatively regulates gene expression via binding to the 3' or 5' of the untranslated region of target genes.[1] Several recent studies show that miRNAs might be key regulators in cardiovascular biology, both in embryonic cardiovascular development and in cardiovascular diseases such as hypertrophy, end-stage heart failure, dilated and ischemic cardiomyopathy, and aortic stenosis.[2-5] In addition, the expression of genes, including mRNA, lncRNA and miRNAs is quite dynamic during the pathological development of cardiovascular diseases.[6,7] Several recent studies have reported that the expression of miRNAs at different time points post-myocardial infarction (MI) vary significantly,[8-10] suggesting that their regulation may be time dependent. Temporal changes (2 days) in miRNA and gene expression in response to MI connect the heart transitions from an acute response to the loss of muscle mass and further to a more compensated, remodeled phenotype.[10] Therefore, a clear understanding of the regulative network involving critical miRNAs during this stage is helpful to illustrate the molecular pathology of MI.

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The miR-30 family includes miR-30a, miR-30c-2, miR-30b and miR-30d, miR-30e, and miR-30c-1 (http://www.mirbase.org). Several miR-30 family members including miR-30a, miR-30b and miR-30e, may have protective effects on cardiomyocytes (CMs) from ischemia/ reperfusion injury, apoptosis and necrotic cell death.[11-13] However, one recent study reported that silencing the whole miR-30 family can protect cardiac cells against hypoxic injury by elevating cystathionine-c-lyase (CSE) and hydrogen sulfide (H_2S) levels.[14] They authors suggested that inhibition of the miR-30 family after MI injury offers potential therapeutic value.[14] These findings suggest that there is controversy over the role of the miR-30 family members in MI.

miR-30a and miR-30e have also been reported to be significantly downregulated in CMs 2 days post-MI.[8-10] However, their downstream regulative network in this temporal period is not clearly understood. In this study, we tried to identify the possible regulative network of miR-30a/e in cardiomyocytes 2 days post-MI via bioinformatic analysis.

MATERIALS AND METHODS

Bioinformatic analysis of verified targets of miR-30a/e and their involvement in biological processes

Verified targets of miR-30a/e were identified using ClueGO in CytoScape, with data from mirTarBase. validated. miRNAs_15.06.2016. The genes were then subjected to analysis of the involvement in biological processes according to their enrichment in gene ontology (GO) terms. Only pathways with a p value < 0.05 were included.

Bioinformatic analysis of the possible targets of miR-30a/e 2d post-MI

The raw data of upregulated and downregulated genes 2 days post-MI were obtained from a previous study (shown in Supplementary Table 1).[10] The possible targets of miR-30a/e were predicted using TargetScan 7.1. The overlapping subsets of the upregulated genes and the predicted targets were identified. The genes were then loaded into ClueGO to predict their involvement in biological processes according to their enrichment in GO terms. Only pathways with a p value < 0.05 were included.

RESULTS

Involvement of the known targets of miR-30a and miR-30e in biological processes

Both miR-30a and miR-30e were significantly downregulated in CMs 2 days post-MI.[10] Via bioinformatic analysis, we identified the involvement in molecular processes of known targets of miR-30a/e according to their enrichment in GO terms. The results indicated that their targets were involved in several important processes related to post-MI pathology including cellular responses to glucose starvation (via *TP53*, *BECH1* and *HSPA5*) and cardiac epithelial to mesenchymal transition (EMT) (via *ERG*, *SNAI1* and *NOTCH1*) (Figure 1).

Bioinformatic analysis of the possible targets of miR-30a/e 2 days post-MI

An miRNA can usually target multiple genes and modulate multiple signaling pathways. To support the future exploration of the functional roles of miR-30a/e, we then tried to predict the possible targets of miR-30a/ e in CMs 2 days post-MI and analyzed their involvement in possible biological processes. One previous study measured the temporal expression of mRNAs in a mouse model of MI and identified the genes dysregulated 2 days post-MI (N = 1682).[10] Using TargetScan 7.1, we identified the predicted targets of miR-30a/e, and then determined their overlapping subsets. The results indicated that among 430 predicted targets of miR-30a, 50 genes were significantly upregulated 2 days post-MI (Figure 2), while among 425 predicted targets of miR-30e, 57 genes were significantly upregulated 2 days post-MI (Figure 2).

Involvement of the possible targets of miR-30a 2d post-MI in biological processes

Bioinformatic analysis showed that the predicted targets of miR-30a that were significantly upregulated 2 days post-MI were significantly enriched in platelet aggregation, positive regulation of neural precursor cell proliferation, regulation of erythrocyte differentiation, cell differentiation involved in embryonic placenta development, cell differentiation involved in embryonic placenta development, trophoblast giant cell differentiation, cell surface receptor signaling pathway involved in heart development, Notch signaling involved in heart development, regulation of intrinsic apoptotic signaling pathway in response to deoxyri-

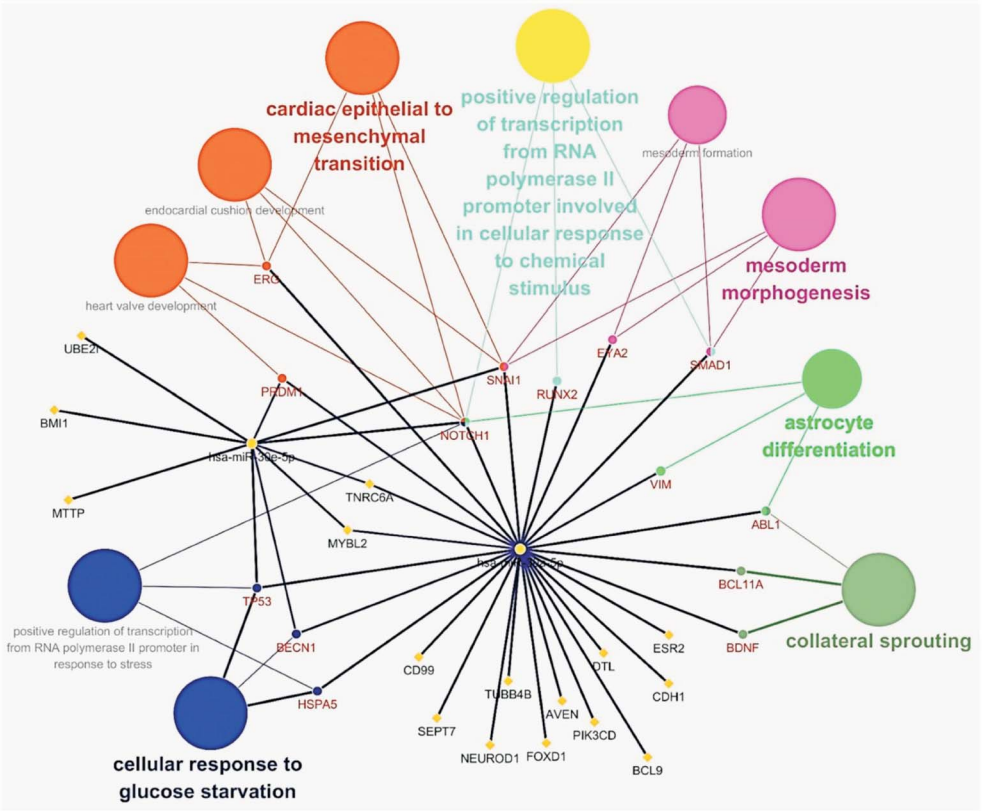

Figure 1. *The involvement of the known targets of miR-30a and miR-30e in biological processes. ABL1, ABL proto-oncogene 1; AVEN, apoptosis and caspase activation inhibitor; BCL9, B cell CLL/lymphoma 9; BCL11A, B cell CLL/lymphoma 11A; BDNF, brain derived neurotrophic factor; BECN1, Beclin-1; BMI1, B cell-specific Moloney murine leukemia virus integration site 1; CDH1, cadherin-1; DTL, denticleless E3 ubiquitin protein ligase homolog; ERG, ETS-related gene; ESR2, estrogen receptor 2; EYA2, EYA transcriptional coactivator and phosphatase 2; FOXD1, forkhead box D1; HSPA5, heat shock protein family A (Hsp70) member 5; MTTP, microsomal triglyceride transfer protein; MYBL2, MYB proto-oncogene like 2; NEUROD1, neurogenic differentiation 1; NOTCH1, notch homolog 1; PIK3CD, phosphatidylinositol-4,5-bisphosphate 3-kinase catalytic subunit delta; PRDM1, PR domain zinc finger protein 1; RUNX2, runt related transcription factor 2; SMAD1, SMAD family member 1; SEPT7, septin 7; SNAI1, snail family transcriptional repressor 1; TNRC6A, trinucleotide repeat containing 6A; TP53, tumor protein p53; TUBB4B, tubulin beta 4B class IVb; UBE2I, SUMO-conjugating enzyme UBC9; VIM, vimentin.*

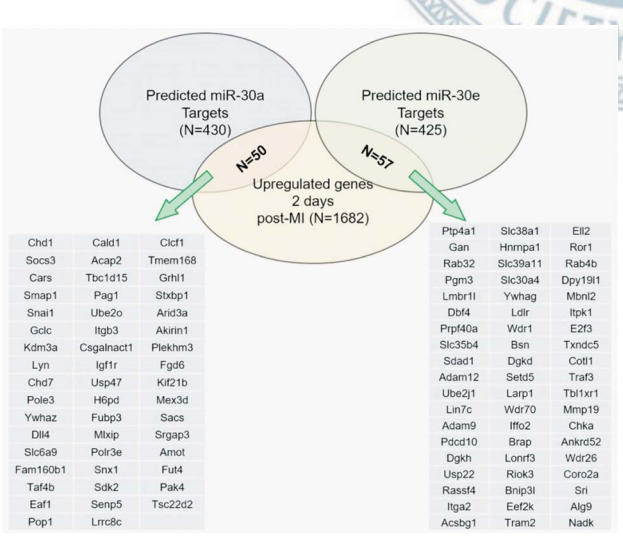

Figure 2. *Bioinformatic analysis of the possible targets of miR-30a/e 2d post-MI.*

bonucleic acid (DNA) damage, negative regulation of intrinsic apoptotic signaling pathway in response to DNA damage, heart trabecula morphogenesis, ventricular cardiac muscle tissue morphogenesis, ventricular trabecula myocardium morphogenesis, aorta morphogenesis, regulation of tyrosine phosphorylation of Stat3 protein, positive regulation of tyrosine phosphorylation of Stat3 protein, tolerance induction, tyrosine phosphorylation of Stat3 protein, regulation of tyrosine phosphorylation of STAT protein and positive regulation of tyrosine phosphorylation of STAT protein (Figure 3 and Table 1).

Involvement of the possible targets of miR-30e 2d post-MI in biological processes

Bioinformatic analysis showed that the predicted targets of miR-30e that were significantly upregulated 2

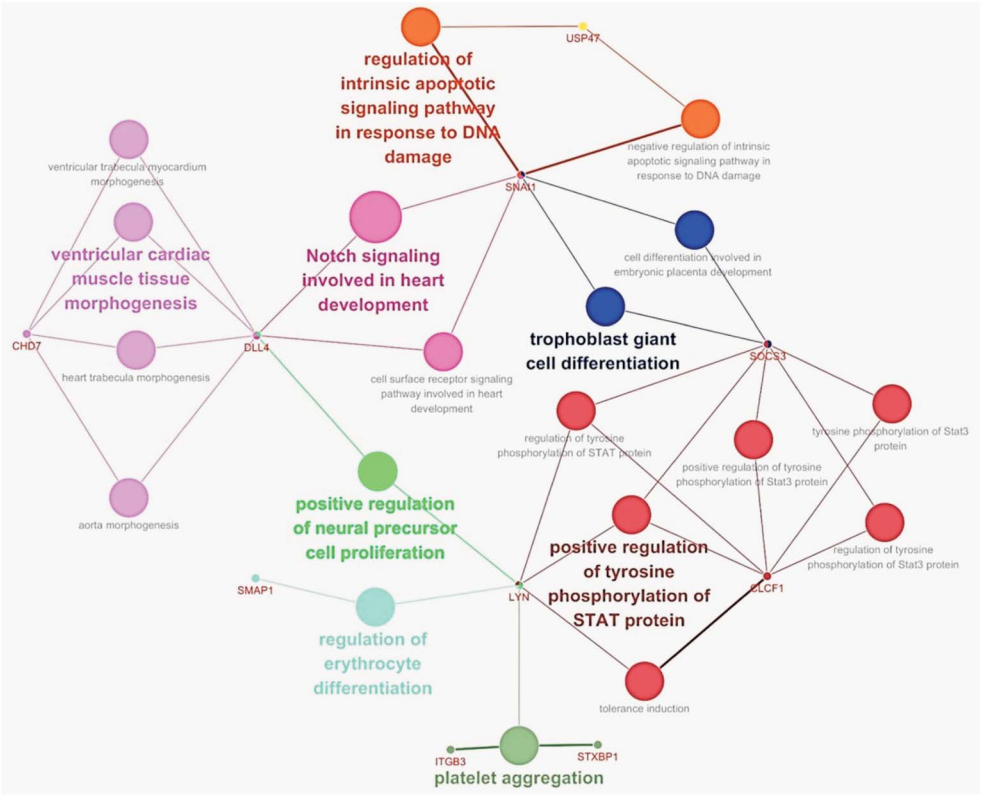

Figure 3. *The involvement of the possible targets of miR-30a 2d post-MI in biological processes. CHD7, chromodomain helicase DNA binding protein 7; CLCF1, cardiotrophin like cytokine factor 1; DLL4, delta like canonical Notch ligand 4; ITGB3, integrin subunit beta 3; LYN, LYN proto-oncogene; SMAP1, small ArfGAP 1; SOCS3, suppressor of cytokine signaling 3; STXBP1, syntaxin binding protein 1; USP47, ubiquitin specific peptidase 47.*

Table 1. The involvement in molecular processes of possible targets of miR-30a 2 days post-MI

GO ID	GO term	Term p value	% Associated genes	Nr. genes	Associated genes found
GO:0070527	Platelet aggregation	430.0E-6	5.36	3.00	[ITGB3, LYN, STXBP1]
GO:2000179	Positive regulation of neural precursor cell proliferation	6.8E-3	4.26	2.00	[DLL4, LYN]
GO:0045646	Regulation of erythrocyte differentiation	5.7E-3	4.65	2.00	[LYN, SMAP1]
GO:0060706	Cell differentiation involved in embryonic placenta development	2.8E-3	6.67	2.00	[SNAI1, SOCS3]
GO:0060707	Trophoblast giant cell differentiation	610.0E-6	14.29	2.00	[SNAI1, SOCS3]
GO:0061311	Cell surface receptor signaling pathway involved in heart development	2.3E-3	7.41	2.00	[DLL4, SNAI1]
GO:0061314	Notch signaling involved in heart development	240.0E-6	22.22	2.00	[DLL4, SNAI1]
GO:1902229	Regulation of intrinsic apoptotic signaling pathway in response to DNA damage	5.7E-3	4.65	2.00	[SNAI1, USP47]
GO:1902230	Negative regulation of intrinsic apoptotic signaling pathway in response to DNA damage	3.6E-3	5.88	2.00	[SNAI1, USP47]
GO:0061384	Heart trabecula morphogenesis	4.3E-3	5.41	2.00	[CHD7, DLL4]
GO:0055010	Ventricular cardiac muscle tissue morphogenesis	7.4E-3	4.08	2.00	[CHD7, DLL4]
GO:0003222	Ventricular trabecula myocardium morphogenesis	900.0E-6	11.76	2.00	[CHD7, DLL4]
GO:0035909	Aorta morphogenesis	3.0E-3	6.45	2.00	[CHD7, DLL4]
GO:0042516	Regulation of tyrosine phosphorylation of Stat3 protein	6.8E-3	4.26	2.00	[CLCF1, SOCS3]
GO:0042517	Positive regulation of tyrosine phosphorylation of Stat3 protein	4.5E-3	5.26	2.00	[CLCF1, SOCS3]
GO:0002507	Tolerance induction	2.6E-3	6.90	2.00	[CLCF1, LYN]
GO:0042503	Tyrosine phosphorylation of Stat3 protein	7.1E-3	4.17	2.00	[CLCF1, SOCS3]
GO:0042509	Regulation of tyrosine phosphorylation of STAT protein	980.0E-6	4.05	3.00	[CLCF1, LYN, SOCS3]
GO:0042531	Positive regulation of tyrosine phosphorylation of STAT protein	640.0E-6	4.69	3.00	[CLCF1, LYN, SOCS3]

days post-MI were significantly enriched in regulation of alternative mRNA splicing via spliceosome, protein kinase C-activating G-protein coupled receptor signaling pathway, collagen biosynthetic process, regulation of triglyceride metabolic process, negative regulation of transcription regulatory region DNA binding, zinc II ion transport, zinc II ion transmembrane transport, maintenance of apical/basal cell polarity, establishment or maintenance of epithelial cell apical/basal polarity and maintenance of epithelial cell apical/basal polarity (Figure 4 and Table 2).

DISCUSSION

Dysregulated miR-30 family members are closely related to the responses of CMs to MI. The inhibition of miR-30a can augment autophagy of CMs after hypoxia.[12] MiR-30b can suppress the translation of cyclophilin D,

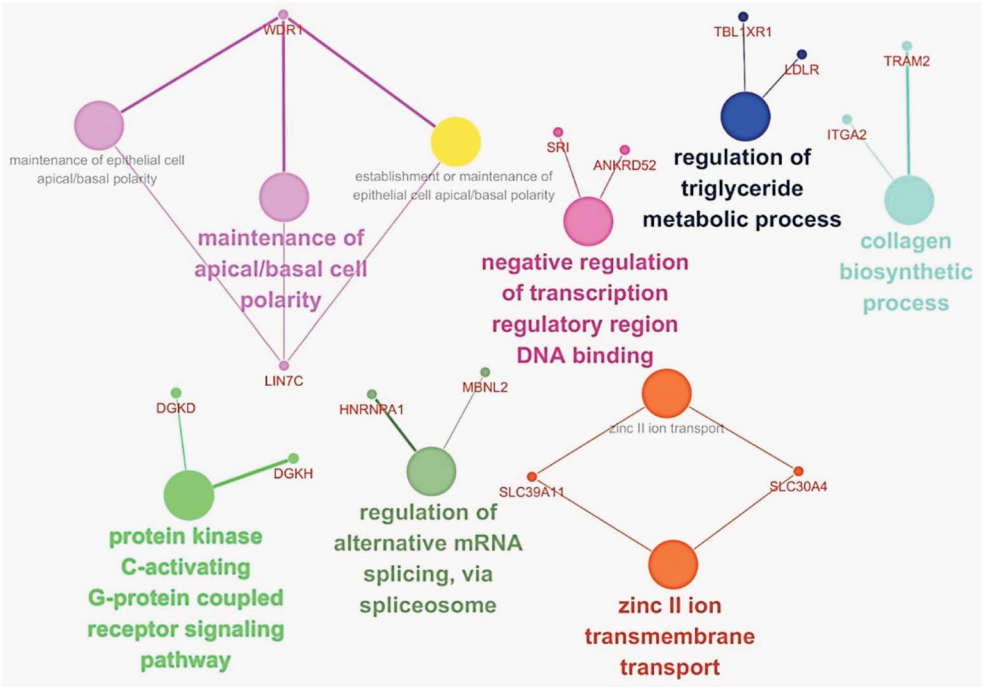

Figure 4. *The involvement of the possible targets of miR-30e 2d post-MI in biological processes. ANKRD52, ankyrin repeat domain 52; DGKD, diacylglycerol kinase delta; DGKH, diacylglycerol kinase eta; HNRNPA1, heterogeneous nuclear ribonucleoprotein A1; ITGA2, integrin subunit alpha 2; LDLR, low density lipoprotein receptor; LIN7C, lin-7 homolog C; MBNL2, muscleblind like splicing factor 2; SLC30A4, solute carrier family 30 member 4; SLC39A11, solute carrier family 39 member 11; SRI, sorcin; TBL1XR1, transducin beta like 1 X-linked receptor 1; TRAM2, translocation associated membrane protein 2; WDR1, WD repeat domain 1.*

Table 2. The involvement in molecular processes of possible targets of miR-30e 2 days post-MI

GO ID	GO term	Term p value	% Associated genes	Nr. genes	Associated genes found
GO:0000381	Regulation of alternative mRNA splicing, via spliceosome	5.9E-3	5.26	2.00	[HNRNPA1, MBNL2]
GO:0007205	Protein kinase C-activating G-protein coupled receptor signaling pathway	4.2E-3	6.25	2.00	[DGKD, DGKH]
GO:0032964	Collagen biosynthetic process	6.2E-3	5.13	2.00	[ITGA2, TRAM2]
GO:0090207	Regulation of triglyceride metabolic process	4.5E-3	6.06	2.00	[LDLR, TBL1XR1]
GO:2000678	Negative regulation of transcription regulatory region DNA binding	2.0E-3	9.09	2.00	[ANKRD52, SRI]
GO:0006829	Zinc II ion transport	3.2E-3	7.14	2.00	[SLC30A4, SLC39A11]
GO:0071577	Zinc II ion transmembrane transport	2.6E-3	8.00	2.00	[SLC30A4, SLC39A11]
GO:0035090	Maintenance of apical/basal cell polarity	590.0E-6	16.67	2.00	[LIN7C, WDR1]
GO:0045197	Establishment or maintenance of epithelial cell apical/basal polarity	4.8E-3	5.88	2.00	[LIN7C, WDR1]
GO:0045199	Maintenance of epithelial cell apical/basal polarity	590.0E-6	16.67	2.00	[LIN7C, WDR1]

thereby inhibiting cyclophilin D-mediated necrotic cell death in CMs. Cardiac-specific miR-30b transgenic mice have also been reported to exhibit reduced necrosis and myocardial infarct size upon ischemia/reperfusion (I/R) injury.[15] However, one recent study reported that delivery of miR-30b in mice greatly aggravated MI injury. Mechanistically, they showed that miR-30 can directly target CSE, which catalyzes the formation of H_2S that is predominantly derived from L-cysteine.[14] These findings suggest that the functional role of the miR-30 family members in MI is still controversial. In addition, previous studies have reported that the downregulation of miR-30a and upregulation of miR-30c/d can enhance myocardial hypertrophy,[16,17] suggesting that the different members of the miR-30 family may have distinct regulative effects on CMs.

Both miR-30a and miR-30e have been reported to be significantly downregulated in CMs 2 days post-MI.[8-10] Maintenance of miR-30a expression in the cardiac area at risk after I/R injury helps to reduce the expression of p53 protein and subsequent Bax expression, thereby limiting mitochondrial membrane impairment and decreasing apoptosis and necrosis.[18] MiR-30e mimic-based treatment can suppress the expression of Beclin-1 and protect primary cardiomyocytes against doxorubicin-induced apoptosis.[19] In addition, miR-30e was also shown to exhibit a cardiac protective effect on human coronary artery endothelial cells through targeting the 3'UTR of *ITGA4* and *PLCG1* in an atherosclerosis model.[20] These findings suggest that miR-30a and miR-30e may be cardiac protective miRNAs. Therefore, it is meaningful to further investigate their downstream regulation after MI.

Our bioinformatic analysis showed that both miR-30a and miR-30e could regulate cellular responses to glucose starvation via targeting *TP53*, *BECH1* and *HSPA5*, and also regulate cardiac EMT via targeting ETS-related gene (ERG), *SNAI1* and *NOTCH1*. Our bioinformatic prediction further showed that miR-30a/e may regulate some biological processes related to CM responses to MI via other potential targets. For example, miR-30a might regulate MI-related biological processes such as platelet aggregation (possibly via *ITGB3* and *STXBP1*), regulation of the intrinsic apoptotic signaling pathway in response to DNA damage (possibly via *SNAI1*), and positive regulation of tyrosine phosphorylation of Stat3 protein (possibly via *LYN*, *SOCS3* and *SLCF1*). ITGB3 plays a key role in platelet aggregation, and its elevation results in significantly increased thrombus formation and MI after coronary artery bypass graft surgery.[21] In a mice model of MI, Snail1 expression in mRNA and protein levels were significantly increased in the infarcted area. Moreover, all Snail1-positive cells were able to express periostin, suggesting that it is involved in *de novo* cardiac fibrosis after MI.[22] The cardiac-specific deletion of *SOCS3* has also been reported to prevent the development of left ventricular remodeling and myocardial ischemia reperfusion injury after acute MI by enhancing multiple cardio-protective signaling pathways, including STAT3, AKT, and extracellular signal-regulated kinase (ERK)-1/2.[23,24] In comparison, the association between MI and the biological processes regulated by potential targets of miR-30e is far less understood. Only a few studies have reported an association between missense alleles of *LDLR* and the early-onset of MI,[25] and the association between *ITGA2* genetic polymorphisms and the risk of acute MI.[26,27]

One major limitation of this study is the absence of data at the protein level. Although we identified dysregulated genes at the RNA level from previous arrays, it is the protein that exerts the predicted biological regulations. Another limitation is that part of the functional prediction was based on the putative targets of miR-30a/e, which were not verified in this study. Therefore, future studies are necessary to confirm the predicted targets and their *in vivo* regulative network in MI.

CONCLUSIONS

The currently known targets of miR-30/e can regulate MI-related biological processes such as cellular responses to glucose starvation and cardiac EMT. MiR-30a may regulate other MI-related processes such as platelet aggregation, regulation of intrinsic apoptotic signaling pathway in response to DNA damage and positively regulate tyrosine phosphorylation of the Stat3 protein, although further studies are needed to validate this hypothesis.

CONFLICT OF INTEREST

None of the authors has any potential financial conflict of interest related to this manuscript.

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Supplement Table 1. The upregulated and downregulated genes 2d post-MI

Uniquely up-regulated genes 2 days post-MI		Uniquely down-regulated genes 2 days post-MI	
A4galt	Mmp8	Aadacl1	Meis2
Aacs	Mmp9	Aars2	Meox2
Aars	Mobkl1a	Aarsd1	Mepce
Aatf	Mogs	Aasdhppt	Mett11d1
Abca7	Morc2a	Abca1	Mett5d1
Abcc1	Morf4l2	Abca12	Mettl3
Abcc3	Mospd4	Abca2	Mettl4
Abce1	Mpg	Abca6	Mff
Abhd2	Mphosph10	Abca8a	Mfn1
Abl2	Mphosph6	Abca8b	Mfn2
Acaca	Mrps18b	Abca9	Mfsd11
Acap2	Mrto4	Abcb4	Mfsd6
Acbd3	Ms4a15	Abcb7	Mfsd7c
Acer2	Ms4a4a	Abcb8	Mfsd8
Acin1	Ms4a8a	Abcc5	Mgat4b
Acly	Msr1	Abcc9	Mgea5
Acot10	Mt1	Abcd1	Mgl2
Acot4	Mt2	Abhd10	Mgst3
Acot9	Mtbp	Abhd12	Mib2
Acp5	Mthfd1l	Abhd14a	Mid1ip1
Acr	Mthfd2	Abhd3	Mier3
Acsbg1	Mthfr	Abhd8	Mill2
Acsl4	Mtmr12	Ablim1	Mitf
Acsl5	Mtmr9	Ablim3	Mkks
Actb	Mtpn	Abtb1	Mkrn2
Actn1	Muc1	Acaa1a	Mlec
Actn4	Mvp	Acacb	Mlf1
Actr2	Mxd1	Acad11	Mlh1
Actr3	Myadm	Acad8	Mlh3
Ada	Mybbp1a	Acad9	Mll1
Adam12	Myd116	Acadl	Mll3
Adam15	Myd88	Acadm	Mllt3
Adam8	Myo1c	Acads	Mllt6
Adam9	Myo1h	Acadsb	Mmachc
Adamts4	Myo9b	Acadvl	Mmgt1
Adamts6	Myoz1	Acat1	Mmp15
Adat2	Myst2	Aco2	Mn1
Adc	Nacc1	Acot11	Morn2
Adck4	Nadk	Acot13	Mosc2
Adcyap1r1	Naip1	Acrbp	Mospd1
Adfp	Naip2	Acsl1	Mov10l1
Adm	Nans	Acsl6	Mpa2l
Adnp2	Napsa	Acss1	Mpdz
Adora3	Nars	Acss2	Mpi
Adpgk	Nat10	Actr3b	Mpnd
Adrb2	Nav2	Actr6	Mpped2
Adss	Ncdn	Actr8	Mpv17
Aebp1	Ncf1	Acvr2a	Mpv17l2
Aff1	Ncf2	Acy3	Mr1
Agpat4	Ncf4	Acyp1	Mras
Ahctf1	Nckap1	Adal	Mreg
Ahi1	Ncl	Adam4	Mrp63
Ahnak	Ncor2	Adamts10	Mrpl1
Aida	Ndrg1	Adamts3	Mrpl11
Aim2	Ndst1	Adamts5	Mrpl12
Ak3l1	Nfam1	Adcy5	Mrpl14
Akap12	Nfe2l2	Adcy6	Mrpl15

Supplement Table 1. Continued

Akirin1	Nfil3	Adcy9	Mrpl16
Akna	Nfkb2	Add3	Mrpl18
Akr1b8	Nhedc2	Adh1	Mrpl19
Alas2	Nhp2	Adhfe1	Mrpl21
Alcam	Ninj1	Adprhl1	Mrpl24
Aldh1a2	Nip7	Adra1a	Mrpl27
Aldh3b1	Nkrf	Aes	Mrpl28
Aldoc	Nlrp3	Aga	Mrpl3
Alg5	Nob1	Agl	Mrpl30
Alg9	Noc3l	Agpat1	Mrpl34
Alkbh1	Nol10	Agtr1a	Mrpl35
Alkbh2	Nol12	Ahdc1	Mrpl36
Alox15	Nol6	Ahsa2	Mrpl38
Alox5ap	Nol9	Ak1	Mrpl39
Aloxe3	Nolc1	Ak3	Mrpl41
Ambra1	Nop14	Akap1	Mrpl44
Amica1	Nop16	Akap6	Mrpl46
Ammecr1	Nop2	Akap7	Mrpl47
Amot	Nop56	Akap8l	Mrpl48
Amotl1	Nop58	Akr1b3	Mrpl49
Ampd2	Nos2	Akr1c14	Mrpl54
Ampd3	Notch2	Akr1e1	Mrpl55
Angpt2	Notch4	Akt2	Mrps14
Angptl4	Npm1	Aktip	Mrps15
Ankib1	Npy	Alas1	Mrps17
Ankrd10	Nr2c2ap	Aldh2	Mrps18a
Ankrd13a	Nras	Aldh4a1	Mrps21
Ankrd2	Nrgn	Aldh5a1	Mrps23
Ankrd27	Nrm	Aldh6a1	Mrps24
Ankrd28	Nsf	Aldh7a1	Mrps25
Ankrd37	Nsun2	Alg6	Mrps27
Ankrd52	Nt5c	Alox5	Mrps28
Anp32b	Nts	Alpk2	Mrps30
Ap2b1	Nudcd1	Alpk3	Mrps31
Apbb1ip	Nudcd2	Amd1	Mrps36
Apex1	Nufip1	Amigo1	Mrps5
Apln	Nup107	Amz2	Mrps6
Apob48r	Nup153	Anapc5	Mrs2
Apoc2	Nup205	Angpt1	Msh2
Aprt	Nup210l	Angptl3	Msh3
Arc	Nup43	Ank	Msl3
Arf1	Nup50	Ank2	Msrb2
Arf2	Nup54	Ankmy2	Mtap4
Arf3	Nup93	Ankrd12	Mtap7d1
Arfgap1	Nup98	Ankrd29	Mtch2
Arg1	Nupl1	Ankrd32	Mtcp1
Arg2	Nxn	Ankrd40	Mterfd1
Arhgap1	Oas3	Anks1	Mterfd3
Arhgap27	Obfc2a	Ankzf1	Mtfr1
Arhgap30	Odc1	Ano1	Mtif2
Arhgap9	Olfr161	Ano8	Mtif3
Arhgdia	Olfr920	Antxr2	Mto1
Arhgef1	Olr1	Aof1	Mtr
Arhgef5	Orc2l	Aox1	Mtrf1
Arid3a	Orc6l	Ap4m1	Mtrf1l
Arih1	Osbpl10	Ap4s1	Mtss1
Arih2	Osbpl5	Apba3	Mtus1
Arl11	Osgin1	Apbb1	Mus81
Arl8a	Ostc	Apeh	Mut
Armc7	Ostf1	Apex2	Muted
Arpc2	Otub1	Apip	Myadml2

Supplement Table 1. Continued

Arpc3	Otx1	Aplnr	Mybpc2
Arpc4	Oxsr1	Aplp2	Mybpc3
Arpc5	P2ry13	Apoa1bp	Myeov2
Arrb1	P4hb	Apobec2	Myh11
Arrb2	Pa2g4	Apoe	Myh14
Arrdc4	Pabpc1l	Apol10b	Myh6
Arsg	Pafah1b3	Apoo-ps	Myh7
Arv1	Pag1	Appl2	Myl1
Ascc2	Pak1	Aqp1	Myl2
Ascc3	Pak1ip1	Aqp11	Myl3
Asns	Pak2	Aqp4	Mylip
Asprv1	Pak3	Aqp8	Mylk3
Aspscr1	Pak4	Ar	Mylk4
Ass1	Pak6	Araf	Myo18a
Atf4	Papss1	Arap2	Myo6
Atic	Pard6b	Arfrp1	Myoc
Atn1	Parvb	Arhgap12	Myom1
Atoh1	Parvg	Arhgap20	Myom2
Atp13a3	Pask	Arhgap24	Myoz2
Atp1a3	Pcbp3	Arhgap26	Myst1
Atp6v1h	Pcdhb17	Arhgef15	Myst4
Atp8b4	Pcna	Arhgef17	N6amt2
Atxn10	Pcnxl3	Arhgef19	Naaa
Atxn1l	Pctk3	Arhgef6	Nagpa
Atxn2l	Pdcd10	Arhgef9	Napa
Atxn7l2	Pdcd11	Arl5b	Narf
Atxn7l3	Pdcd6ip	Arl6ip6	Narfl
B3gnt3	Pde1a	Armc1	Nars2
B3gnt7	Pde1b	Armcx3	Nat15
B4galnt1	Pdgfra	Armetl1	Nat6
Baiap2	Pdia4	Arpc5l	Nat9
Basp1	Pdia5	Arsk	Nbas
Bat1a	Pdk4	Art1	Nbea
Bax	Pdpk1	Art4	Nbeal1
Bcar1	Pdpn	As3mt	Ncald
Bcat1	Pdzrn3	Asah2	Ncapd3
Bcl10	Pecam1	Asap3	Ncbp2
Bcl2a1a	Per2	Asb10	Ncoa1
Bcl2a1b	Pes1	Asb11	Ncoa2
Bcl2a1c	Pex14	Asb13	Ncrna00153
Bcl2a1d	Pf4	Asb14	Ndrg2
Bcr	Pfkfb3	Asb2	Ndrg4
Bdkrb2	Pfkfb4	Asb3	Ndufa10
Bet1l	Pfn1	Asb5	Ndufa12
Bhlhe40	Pgd	Asb8	Ndufa13
Bin1	Pgf	Ascc1	Ndufa2
Bin2	Pgk1	Asna1	Ndufa3
Bin3	Pglyrp1	Asnsd1	Ndufa4
Birc1f	Pgm3	Asph	Ndufa6
Birc3	Pgrmc1	Asrgl1	Ndufa7
Blk	Pgs1	Atad1	Ndufa8
Blm	Phactr4	Atf7ip	Ndufa9
Bmf	Phf20	Atg10	Ndufab1
Bmp2	Phlda3	Atg2a	Ndufaf1
Bnip3	Pi15	Atg4c	Ndufaf2
Bnip3l	Pi4k2a	Atm	Ndufaf3
Bok	Pi4k2b	Atp11a	Ndufb10
Bop1	Pik3c2a	Atp1a2	Ndufb11
Bpgm	Pik3cd	Atp1b2	Ndufb5
Brap	Pik3r5	Atp2a2	Ndufb6

Supplement Table 1. Continued

Brd2	Pilra	Atp2c1	Ndufb7
Brp16	Pion	Atp5a1	Ndufb8
Brpf1	Pip5k1a	Atp5b	Ndufb9
Bsn	Pira2	Atp5c1	Ndufc1
Bst1	Pira3	Atp5d	Ndufc2
Btbd10	Pitpna	Atp5e	Ndufs1
Btbd12	Pitpnm1	Atp5g1	Ndufs2
Btg1	Pkm2	Atp5g2	Ndufs3
Btg3	Pkmyt1	Atp5g3	Ndufs4
Bub1b	Pkn2	Atp5h	Ndufs5
Bxdc1	Pknox1	Atp5j	Ndufs6
Bxdc2	Pla2g4a	Atp5j2	Ndufs7
Bysl	Pla2g7	Atp5k	Ndufs8
Bzw1	Plac8	Atp5l	Ndufv1
C1qtnf6	Plau	Atp5o	Ndufv2
C5ar1	Plcxd2	Atp5s	Nebl
Cacna1d	Plek	Atp5sl	Nedd1
Cad	Plekha1	Atp6v0b	Nedd4
Cald1	Plekha2	Atp6v1d	Nek1
Calm1	Plekhg1	Atp6v1e1	Neo1
Camsap1l1	Plekhm3	Atp6v1f	Nepn
Capn2	Plekho2	Atp6v1g2	Nexn
Car13	Plod3	Atp8a1	Nfatc2
Car9	Plscr3	Atp8a2	Nfia
Cars	Plvap	Atp9a	Nfib
Casp3	Plxna2	Atpaf1	Nfix
Casp8	Pmepa1	Atpaf2	Nfu1
Cast	Pnp1	Atpif1	Nfyc
Cbl	Pola2	Atxn1	Nhlrc2
Cblb	Pold4	Atxn2	Nhsl1
Ccbp2	Pole3	Auh	Nicn1
Ccdc109b	Polh	Auts2	Nipa1
Ccdc134	Polr1b	B3galnt2	Nipal3
Ccdc50	Polr2a	B3galt2	Nit2
Ccdc6	Polr3e	B3gat3	Nkx2-5
Ccdc86	Pols	B4galt4	Nlk
Cchcr1	Pom121	Bag1	Nlrp10
Ccl17	Pop1	Bag4	Nme2
Ccl3	Pop4	Bahcc1	Nme3
Ccl6	Por	Bak1	Nme5
Ccl9	Ppan	Bambi	Nme6
Ccnl1	Ppapdc1b	Banp	Nmnat1
Ccr1	Ppbp	Bat5	Nnt
Cct2	Ppfibp1	Baz1b	Nod1
Cct3	Pphln1	Bbs2	Nos1ap
Cct4	Ppib	Bbs7	Notch3
Cct6a	Ppm1j	Bbs9	Npepl1
Cct8	Ppme1	Bcam	Nphp1
Cd14	Ppp1r14b	Bcas3	Npr1
Cd177	Ppp1r15b	Bcat2	Npr2
Cd244	Ppp1r2	Bche	Nqo2
Cd24a	Ppp2cb	Bckdha	Nr0b2
Cd300a	Ppp2r1b	Bckdk	Nr1d2
Cd300lf	Ppp2r2a	Bcs1l	Nr2f6
Cd37	Ppp4c	Bhlhb9	Nrbp2
Cd52	Ppp4r1	Blnk	Nrd1
Cd63	Pram1	Bloc1s1	Nrip2
Cd84	Prdm4	Bphl	Nrp1
Cd97	Prdx6	Brd7	Nrxn1
Cda	Prep	Brd9	Nsmaf
Cdc16	Prg4	Bri3bp	Nsmce4a

Supplement Table 1. Continued

Cdc42	Prkaa1	Brms1l	Nsun4
Cdc42bpb	Prkab2	Brp44	Nt5c1a
Cdca4	Prkar2b	Brp44l	Nt5c3
Cdca7l	Prkcd	Brwd2	Ntf3
Cdgap	Prkx	Bscl2	Ntn1
Cdh1	Prmt1	Btnl9	Ntn4
Cdk6	Prnp	Btrc	Ntsr2
Cdk9	Procr	Bves	Nub1
Cdkn2aipnl	Prpf31	C1qtnf7	Nudt12
Cdr2l	Prpf40a	C1qtnf9	Nudt13
Cdsn	Prr3	C1s	Nudt14
Cdt1	Prrc1	C2cd3	Nudt19
Cdv3	Psat1	C3	Nudt2
Cebpb	Psd4	C7	Nudt22
Cenpc1	Psma3	C87436	Nudt3
Cenpt	Psma5	Cab39l	Nudt6
Cfl1	Psmc1	Cabc1	Nudt7
Cfl2	Psmc4	Cables1	Nudt8
Cgref1	Psmd11	Cacna1c	Numa1
Chaf1b	Psmd14	Cacna1g	Nxt2
Chd1	Psmd3	Cacna2d1	Oat
Chd7	Psmd8	Cacnb2	Oaz1
Chd9	Psmg3	Calcoco1	Obscn
Chi3l1	Pstpip1	Camk2n1	Obsl1
Chi3l3	Ptbp1	Camta1	Ogdh
Chi3l4	Ptbp2	Cand2	Ogdhl
Chic2	Ptk2	Canx	Ogn
Chka	Ptk2b	Cap2	Opa1
Chmp4b	Ptk7	Capn3	Oplah
Chmp4c	Ptma	Capn7	Optn
Chrnb1	Ptp4a1	Car14	Ormdl1
Chst11	Ptpn22	Card10	Osbp
Chsy1	Ptpn23	Card6	Osbpl1a
Cirh1a	Ptpre	Carf	Osbpl2
Ckap4	Ptrh1	Casd1	Osbpl6
Cks2	Ptx3	Casp1	Osbpl8
Clca1	Purb	Casq2	Osgep
Clcf1	Pus1	Cbfa2t3	Osgepl1
Clcn5	Pus7	Cbr1	Ostm1
Cldn15	Pus7l	Cbr2	Otud6b
Clec4d	Pusl1	Cbr4	Oxa1l
Clec4e	Pvr	Cbx1	Oxct1
Clec5a	Pvrl1	Cbx8	Oxnad1
Clic4	Pwp2	Ccbl1	Oxsm
Clic5	Pxn	Ccbl2	P2rx4
Cltb	Pycr1	Ccdc117	P2rx6
Cltc	Pycr2	Ccdc21	P2ry14
Cmpk1	Pygl	Ccdc28a	P4htm
Cndp2	Pyhin1	Ccdc44	Pabpc4
Cnih2	Rab11fip5	Ccdc45	Pafah2
Cnksr1	Rab32	Ccdc46	Paics
Cnn2	Rab34	Ccdc47	Paip1
Cog3	Rab35	Ccdc51	Paip2
Col18a1	Rab3gap2	Ccdc52	Palld
Copb1	Rab44	Ccdc56	Palm
Copg	Rab4b	Ccdc66	Pank4
Coro1a	Rabgef1	Ccdc69	Papln
Coro1b	Rac2	Ccdc72	Papolg
Coro2a	Rad18	Ccdc75	Paqr4
Cotl1	Rad23b	Ccdc85a	Paqr7

Supplement Table 1. Continued

Cox18	Rad54l2	Ccdc91	Paqr9
Cpne1	Ralb	Ccl11	Pard3b
Cpne2	Ran	Ccl19	Parp1
Cpsf2	Ranbp1	Ccl21a	Patz1
Cpsf7	Rapgef1	Ccl8	Pbx1
Cpt1a	Raph1	Ccnd2	Pbxip1
Creb3	Rara	Ccng1	Pcbd2
Creb3l1	Rarres2	Ccni	Pcca
Creb5	Rars	Ccnt2	Pccb
Creld2	Rasip1	Ccpg1	Pcdh18
Crk	Rasl11b	Ccrl2	Pcdh19
Crkrs	Rassf1	Cd28	Pcdh7
Crlf2	Rassf4	Cd300lg	Pcdhga12
Crmp1	Rassf5	Cd46	Pcmtd1
Crtc2	Rassf7	Cd55	Pcmtd2
Cry1	Rbm19	Cd59b	Pcnt
Cryab	Rbm34	Cd74	Pcolce2
Csf2rb	Rbm47	Cd81	Pcp4l1
Csf2rb2	Rbms1	Cd83	Pcsk6
Csf3r	Rbmx2	Cdadc1	Pcyox1
Csgalnact1	Rbmxrt	Cdan1	Pdcd4
Csnk1d	Rbp7	Cdc123	Pde1c
Csrp1	Rbpj	Cdc14b	Pde3a
Cstb	Rbpms	Cdc23	Pde4c
Cstf2	Rcc1	Cdc2l6	Pde4dip
Ctdp1	Rcc2	Cdc37	Pde6d
Ctla2b	Rcl1	Cdc37l1	Pde7b
Ctps	Rdh10	Cdh23	Pdgfd
Cttn	Rdh11	Cdk10	Pdha1
Cul2	Rdh12	Cdk5	Pdhb
Cwf19l1	Rdh9	Cdk5rap1	Pdhx
Cxcl2	Reep3	Cdkal1	Pdk2
Cxcl3	Relb	Cdkl5	Pdlim4
Cxcr6	Rell1	Cdkn1c	Pds5b
Cyfip1	Relt	Ceacam1	Pdss2
Cyp1b1	Retnlg	Cecr2	Pdxk
Cyp20a1	Rfc3	Cenpa	Pdzd2
Cyp4f18	Rgnef	Cenpf	Pebp1
Cyr61	Rgs11	Cenpq	Pepd
Cytip	Rgs12	Cenpv	Per3
Dbf4	Rgs16	Cep63	Pet112l
Dck	Rgs18	Cep68	Pex1
Dclre1b	Rgs19	Cep70	Pex12
Dcpp1	Rhbdd1	Cep97	Pex19
Dctd	Rhbdf2	Cgrrf1	Pex26
Dcun1d3	Rhod	Chchd10	Pfkfb1
Dda1	Ric8	Chchd2	Pfkfb2
Ddr1	Rin1	Chchd3	Pfkm
Ddx10	Riok1	Chchd8	Pfn2
Ddx19a	Riok3	Chd6	Pfn4
Ddx19b	Ripk2	Chek2	Pgam2
Ddx21	Ripk3	Chid1	Pgap1
Ddx24	Rlim	Chordc1	Pgcp
Ddx27	Rnaseh1	Chpt1	Pgm5
Ddx31	Rnd1	Chrac1	Pgpep1
Ddx39	Rnf103	Chtf8	Phactr2
Ddx50	Rnf125	Ciao1	Phb
Ddx54	Rnf126	Cideb	Phf1
Ddx56	Rnf149	Cisd1	Phf17
Defb13	Rnf160	Cish	Phf20l1
Degs1	Rnf19a	Cited4	Phkb

Supplement Table 1. Continued

Dera	Rnf19b	Ckm	Phlpp
Dgkd	Rnf39	Ckmt2	Phospho2
Dgkh	Rnf4	Clasp1	Phpt1
Dhcr24	Rnf41	Clasp2	Phtf2
Dhrs9	Rnh1	Clcc1	Phyh
Dhx32	Rnmt	Clcn4-2	Phyhd1
Dhx37	Rnps1	Clec3b	Phyhip
Dhx38	Rnu3b1	Clip1	Pibf1
Dhx8	Ror1	Clip4	Pick1
Dhx9	Rpl12	Clptm1	Pigg
Diap1	Rpl13	Clpx	Pigs
Dicer1	Rpl14	Clstn1	Pigy
Dimt1	Rpl17	Clu	Pih1d1
Dis3	Rpl23	Clybl	Pik3c2b
Dkc1	Rpl27	Cmah	Pik3r2
Dlg5	Rpl27a	Cmbl	Pik3r4
Dlgap4	Rpl30	Cmc1	Pip5k1b
Dll4	Rpl34	Cmya5	Pitpnc1
Dnajb9	Rpl36a	Cnnm2	Pja1
Dnajc5	Rpl36al	Cnnm3	Pkdcc
Dnm2	Rpl37	Cnot4	Pkig
Dnttip2	Rpl7	Cnot8	Pknox2
Dock2	Rpl7l1	Cntn5	Pla2g16
Dock4	Rpn1	Cog4	Pla2g4e
Dock5	Rps12	Cog5	Pla2g5
Dok1	Rps15a	Cog6	Plag1
Dok3	Rps18	Cog7	Plbd1
Dpep2	Rps19	Col14a1	Plcb1
Dpep3	Rps25	Colec11	Plce1
Dph2	Rps27a	Colq	Pld3
Dph5	Rps6	Commd3	Plekha5
Dpy19l1	Rps6ka1	Commd6	Plekha6
Dtl	Rps6ka3	Commd9	Plekhb2
Dusp26	Rps6ka4	Copg2	Plekhh3
Dusp4	Rraga	Cops3	Pln
Dusp5	Rras	Copz2	Plscr4
E2f3	Rras2	Coq10a	Pltp
E2f7	Rrbp1	Coq2	Plxdc1
Eaf1	Rrp15	Coq5	Plxdc2
Ear2	Rrp1b	Coq6	Pm20d1
Ece1	Rrp8	Coq9	Pm20d2
Ecm1	Rtn4	Corin	Pmpcb
Ecscr	Rtn4rl2	Coro6	Pnkd
Edn1	Runx2	Cox10	Pnpla7
Eef1b2	Rusc2	Cox11	Pnpla8
Eef1e1	Ruvbl1	Cox15	Pnrc2
Eef1g	Rxfp3	Cox17	Podn
Eef2k	S100a10	Cox4i1	Podxl
Efna5	S100a16	Cox5a	Pogz
Eftud1	S100a4	Cox5b	Polb
Eftud2	S100a6	Cox6a2	Poldip2
Egln3	S100a8	Cox6b1	Polg
Eid3	S100a9	Cox6c	Poll
Eif2ak3	S1pr1	Cox7a1	Polr2e
Eif2b3	Saa3	Cox7a2	Polr2j
Eif2c2	Sacs	Cox7a2l	Polr3gl
Eif2s1	Samsn1	Cox7b	Polrmt
Eif2s2	Sap30	Cox8a	Pon3
Eif3b	Sars	Cox8b	Pot1a
Eif3d	Sat1	Cpa3	Ppa2
Eif4a1	Sav1	Cpe	Ppapdc3

Supplement Table 1. Continued

Eif4ebp1	Sc4mol	Cpne3	Ppara
Eif5	Scn5a	Cpped1	Ppargc1a
Eif5a2	Scyl2	Cpt1b	Ppfibp2
Eif6	Scyl3	Cpxm2	Ppid
Elavl1	Sdad1	Cradd	Ppif
Elk4	Sdc1	Crat	Ppil1
Ell	Sdcbp	Creb1	Ppm1k
Ell2	Sdcbp2	Crebbp	Ppm2c
Elmo2	Sdk2	Crebl2	Ppox
Elovl1	Sebox	Creld1	Ppp1r14c
Elovl6	Sec23b	Crhr2	Ppp1r16a
Emb	Sec24a	Crip2	Ppp1r3a
Emilin1	Sec24b	Crot	Ppp1r3c
Eml3	Seh1l	Crybg3	Ppp1r9a
Emp2	Sell	Cryz	Ppp2r5a
Eno1	Selp	Cryzl1	Ppp2r5d
Entpd3	Selplg	Cs	Ppp3cb
Entpd7	Sema3a	Csad	Ppp3cc
Epb4.1l1	Sema4a	Csdc2	Ppp5c
Epha2	Senp5	Csde1	Ppt2
Eps8	Serinc2	Csprs	Pptc7
Erbb2ip	Serpina3m	Cst3	Prcc
Ercc1	Serpinb2	Ctcf	Prdm16
Ercc6l	Sertad1	Ctdsp1	Prdx2
Erh	Sertad2	Ctla4	Prdx3
Erlin1	Sertad3	Ctnna3	Prei4
Ero1l	Sesn2	Ctnnal1	Prelp
Esd	Set	Ctns	Prepl
Etf1	Setd1a	Ctsa	Prex2
Etv4	Setd5	Ctsd	Prickle3
Evi1	Sf3b4	Ctsf	Prkaca
Evi5	Sfpi1	Ctso	Prkag1
Exoc1	Sfrs9	Cugbp2	Prkce
Exoc5	Sft2d1	Cul4a	Prkcq
Exosc1	Sfxn1	Cul9	Prkcsh
Exosc2	Sfxn5	Cuta	Prkd1
F10	Sgpl1	Cx3cr1	Prkdc
F13a1	Sgtb	Cxcl16	Prkra
F5	Sh2b2	Cxx1b	Prpf19
F7	Sh2d5	Cxx1c	Prps2
Fads3	Sh3bgrl2	Cxxc5	Prpsap1
Fam105b	Sh3bgrl3	Cyb5d1	Prpsap2
Fam107b	Sh3pxd2b	Cyb5rl	Psap
Fam117b	Shb	Cyc1	Psd3
Fam13b	Shc1	Cycs	Psmb10
Fam160a2	Shcbp1	Cyfip2	Psmb9
Fam160b1	She	Cyhr1	Psme1
Fam167a	Shisa5	Cyp27a1	Psme2
Fam169b	Shkbp1	Cyp2j6	Psme4
Fam20c	Shoc2	Cyp2j9	Psmg1
Fam38a	Shq1	Cyp39a1	Ptcd1
Fam40a	Shroom2	Cyth1	Ptcd2
Fam46b	Shroom3	Cytl1	Ptcd3
Fam46c	Siah1a	D2hgdh	Ptdss1
Fam49b	Siglec1	Daam1	Ptdss2
Fam57a	Siglece	Dach1	Pter
Fam60a	Sigmar1	Dalrd3	Ptges2
Fam71f2	Sipa1l3	Dapk2	Ptgr2
Farp1	Sirpb1	Dars2	Ptov1
Farsa	Skap2	Dbp	Ptpn14
Fbl	Sla	Dbt	Ptpn2

Supplement Table 1. Continued

Fbxl5	Slc10a3	Dci	Ptpn3
Fbxo38	Slc10a7	Dclre1a	Ptprd
Fbxw10	Slc11a1	Dcn	Ptprm
Fbxw11	Slc12a4	Dcps	Ptprs
Fbxw9	Slc15a3	Dctn3	Pwwp2b
Fcgr1	Slc16a3	Dcun1d4	Pxmp3
Fcgr2b	Slc19a1	Dcxr	Pxmp4
Fcgr4	Slc1a1	Ddb2	Pycrl
Fcrlb	Slc1a4	Ddo	Pygb
Fem1c	Slc22a15	Ddt	Pygm
Fen1	Slc23a2	Deb1	Pyroxd1
Fermt2	Slc25a1	Decr1	Qdpr
Fermt3	Slc25a17	Decr2	Qpct
Fes	Slc25a37	Def8	Qser1
Fgd3	Slc2a1	Dennd1a	R3hdm2
Fgd6	Slc2a3	Dennd5b	RP23-195K8.6
Fgf23	Slc30a4	Depdc5	RP23-357I14.1
Fgr	Slc30a7	Det1	Rab12
Fhl1	Slc35b1	Dexi	Rab1b
Fhl3	Slc35b3	Dgat2	Rab22a
Fhod1	Slc35b4	Dgcr6	Rab28
Fjx1	Slc35d2	Dgka	Rab3a
Fkbp10	Slc35e4	Dgkb	Rab3d
Fkbp11	Slc36a4	Dguok	Rab7
Fkbp14	Slc38a1	Dhodh	Rab9
Fkbp1a	Slc39a11	Dhrs1	Rabac1
Flna	Slc39a13	Dhrs11	Rad1
Flt4	Slc39a14	Dhrs3	Rad23a
Fmn1	Slc39a7	Dhrs7	Rad51l3
Fmnl2	Slc3a2	Dhrs7b	Rad9b
Fmr1	Slc43a2	Dhrs7c	Raf1
Fnbp4	Slc45a3	Diablo	Rai2
Fosb	Slc4a1	Diras2	Ralgps2
Fosl1	Slc6a12	Dirc2	Rangrf
Foxn2	Slc6a9	Dis3l	Rapgef2
Fpgs	Slc7a11	Disp1	Rapgef4
Fpr1	Slc7a2	Dixdc1	Rasgrf2
Fpr3	Slc7a5	Dlat	Rasgrp2
Freq	Slc9a3r1	Dld	Rasgrp3
Frmd4a	Slc9a7	Dlg1	Raver2
Fscn1	Slco2a1	Dlst	Rbbp9
Fstl3	Slco4a1	Dmpk	Rbl2
Ftsj3	Slfn1	Dmxl1	Rbm10
Fubp3	Slfn10	Dnaja2	Rbm20
Furin	Slfn4	Dnaja4	Rbm38
Fut4	Slpi	Dnajb5	Rbpj
Fxyd5	Smad7	Dnajc15	Rc3h1
G6pd2	Smap1	Dnajc18	Rcan2
G6pdx	Smarcb1	Dnajc19	Rcbtb2
Gabarapl2	Smg1	Dnajc24	Rcn2
Gabre	Smg7	Dnajc4	Rcor3
Gadd45b	Smn1	Dnajc9	Rcsd1
Gak	Smpdl3b	Dnalc4	Rdh13
Gale	Smurf1	Dnmt3a	Rdh5
Galk1	Smyd5	Doc2g	Rdm1
Galns	Snai1	Dock6	Reep1
Galnt6	Snca	Dok4	Rfc1
Galntl1	Snhg1	Dpf2	Rfesd
Gan	Snora61	Dpf3	Rfk
Gapt	Snora62	Dpm1	Rfwd3

Supplement Table 1. Continued

Gar1	Snora65	Dpt	Rgl3
Gars	Snora70	Dpy30	Rgma
Gas2l1	Snora7a	Dpyd	Rgmb
Gas7	Snord115	Dpysl4	Rgs2
Gatad2a	Snord116	Dsc2	Rgs5
Gba	Snord34	Dsp	Rgs6
Gbe1	Snord49a	Dtd1	Rhd
Gclc	Snord53	Dtnbp1	Rhob
Gclm	Snord96a	Dtx3	Rhobtb2
Gcnt1	Snrpa1	Dtx3l	Rhobtb3
Gcnt2	Snrpd1	Dtymk	Rhot1
Gda	Snx1	Dus4l	Rhot2
Gdf6	Snx10	Dusp19	Ric8b
Gdi2	Snx18	Dusp28	Rilp
Gemin5	Snx24	Dusp7	Ring1
Gemin6	Snx7	Dym	Rmi1
Gfod1	Snx9	Dyrk1b	Rmnd5a
Gfpt1	Soat2	Dzip3	Rnaseh2a
Gimap7	Socs3	E2f6	Rnasek
Gins2	Sorbs2	Ebf2	Rnasen
Gipc1	Spata13	Ebf3	Rnaset2a
Gipr	Spatc1	Ech1	Rnf10
Gjc1	Spcs3	Echdc1	Rnf114
Glipr2	Spg21	Echdc2	Rnf123
Glis3	Sphk1	Echdc3	Rnf13
Glrx	Spint1	Echs1	Rnf135
Glt8d3	Spp1	Ecm2	Rnf14
Glul	Spred3	Ecsit	Rnf146
Gm1862	Sprr2a	Edf1	Rnf150
Gm1964	Spry2	Ednra	Rnf166
Gm22	Spryd3	Eepd1	Rnf167
Gm340	Sqle	Efcab2	Rnf187
Gm672	Src	Efha1	Rnf207
Gm885	Srebf2	Egflam	Rnf34
Gmds	Srgap1	Ehbp1	Rnf8
Gmeb2	Srgap3	Ehhadh	Rnls
Gmfb	Srgn	Eif1	Rnpep
Gmfg	Sri	Eif2b4	Robld3
Gmip	Srxn1	Eif4e	Rogdi
Gna13	Ssb	Elf2	Romo1
Gnai3	Ssh1	Elmod2	Rora
Gnb1	Ssr1	Elp4	Rpa1
Gnb2l1	Ssr2	Eml1	Rpa3
Gng12	Ssrp1	Endog	Rpap3
Gngt2	Stam	Eno3	Rpgr
Gnl3	Star	Enox2	Rpl31
Gnpnat1	Stat3	Enpep	Rpl3l
Golt1b	Steap1	Enpp3	Rpp40
Gorab	Steap2	Enpp5	Rprd1a
Gorasp2	Stfa2l1	Entpd2	Rpusd4
Gosr2	Stk3	Entpd4	Rrad
Gpatch4	Stk4	Entpd5	Rragb
Gpd1	Stk40	Epb4.1l3	Rragd
Gpihbp1	Strm	Epb4.1l5	Rreb1
Gpn2	Strn	Epha7	Rrm2b
Gpr141	Strn4	Ephb3	Rsbn1l
Gpr172b	Stt3a	Ephx1	Rshl2a
Gpr35	Stx12	Ephx2	Rsl1
Gpr39	Stxbp1	Epm2a	Rtf1
Gpr64	Stxbp2	Epn3	Rtn2
Gpr97	Supt6h	Eps8l1	Rtn3

Supplement Table 1. Continued

Gprc5a	Surf4	Erap1	Rtn4ip1
Gpx1	Sv2b	Erbb4	Rtp3
Grap	Syk	Ergic3	Rttn
Grhl1	Syncrip	Eri3	Rufy1
Grk6	Synj1	Esco1	Rxra
Grwd1	Taf1d	Esrrb	Rxrg
Grxcr1	Taf4b	Etfa	Ryr2
Gsr	Taf9	Etfb	S100a1
Gss	Tal2	Etfdh	Samd12
Gsta1	Taldo1	Ethe1	Sars2
Gsta2	Tapt1	Etl4	Sbk2
Gstcd	Tardbp	Etv1	Scand1
Gtf2f1	Tars	Exd2	Scaper
Gtf2f2	Tas2r126	Exoc3	Scarna17
Gtpbp4	Tas2r135	Exoc4	Sccpdh
Gtpbp6	Tas2r143	Exoc8	Schip1
H13	Tatdn2	Extl3	Scin
H2-M10.3	Tbc1d1	Eya3	Sclt1
H2-Q10	Tbc1d10b	Ezh1	Scly
H3f3b	Tbc1d15	F3	Scmh1
H6pd	Tbc1d9	Faf1	Scn7a
Hars	Tbcd	Fahd1	Sco1
Haus6	Tbk1	Fam110b	Scp2
Haus7	Tbl1xr1	Fam114a2	Scrn1
Havcr2	Tbl2	Fam118b	Scrn3
Hax1	Tbl3	Fam120b	Scube2
Hba-a1	Tbrg1	Fam120c	Sdf2
Hba-a2	Tbrg3	Fam126a	Sdha
Hbb-b1	Tcerg1	Fam128b	Sdhb
Hcls1	Tcfec	Fam132a	Sdhd
Hdac1	Tdg	Fam13a	Sdpr
Hdac6	Tead2	Fam149b	Sec14l1
Hdc	Tead4	Fam160a1	Selenbp1
Heatr1	Tes	Fam161b	Selk
Hells	Tex10	Fam173a	Sema6a
Hgs	Tfpi2	Fam173b	Sema6c
Hipk1	Tgfb1i1	Fam174a	Senp7
Hk1	Tgfbi	Fam174b	Senp8
Hk3	Tgm1	Fam175a	Sepp1
Hmg1l1	Thoc4	Fam179a	Sepw1
Hmga1	Thumpd3	Fam20b	Serac1
Hmgb1	Tiam2	Fam40b	Serf1
Hmgb2	Tifa	Fam53b	Serf2
Hmgcr	Tigd2	Fam54b	Serinc5
Hmgn1	Tinagl1	Fam55d	Serpinb9
Hmha1	Tipin	Fam59a	Serping1
Hnrnpa0	Tjap1	Fam69b	Serpini1
Hnrnpa1	Tjp2	Fam70b	Sesn1
Hnrnpa1l2	Tkt	Fam73b	Sesn3
Hnrnpa3	Tll1	Fam78a	Setbp1
Hnrnpk	Tln1	Fam81a	Setd3
Hp	Tlr13	Fam82a1	Setd8
Hps3	Tm4sf19	Fam82a2	Sfrs12ip1
Hpse	Tmbim1	Fam82b	Sfrs18
Hrct1	Tmed5	Fam92a	Sft2d3
Hsd17b11	Tmed9	Fam96a	Sfxn4
Hsd3b4	Tmem120a	Fam96b	Sgca
Hspa13	Tmem128	Fancl	Sgcb
Hspb1	Tmem154	Fars2	Sgcd
Hspb2	Tmem165	Fastk	Sgce
Htr2a	Tmem167	Fastkd1	Sgcg

Supplement Table 1. Continued

Htt	Tmem168	Fastkd2	Sgol2
Hyou1	Tmem183a	Fat4	Sgsm2
Ibtk	Tmem184b	Fblim1	Sgta
Id2	Tmem189	Fbln1	Sh3bgr
Iffo2	Tmem202	Fbxl20	Sh3glb2
Ifi30	Tmem214	Fbxl22	Siae
Ifitm1	Tmem22	Fbxo18	Sin3b
Ifitm6	Tmem39a	Fbxo21	Sipa1l2
Ifrd1	Tmem43	Fbxo22	Sirt1
Igf1r	Tmem49	Fbxo25	Sirt2
Igf2bp2	Tmem87b	Fbxo3	Sirt3
Igsf2	Tnc	Fbxo31	Sirt4
Igsf6	Tnfaip1	Fbxo32	Sirt5
Ikbke	Tnfaip3	Fbxo40	Six4
Ikzf1	Tnfaip6	Fbxo44	Six5
Il11	Tnfaip8l2	Fbxo8	Slc16a7
Il17ra	Tnfrsf10b	Fbxw4	Slc16a9
Il18rap	Tnfrsf1b	Fbxw5	Slc25a10
Il1f9	Tnfrsf22	Fbxw7	Slc25a11
Il1r2	Tnfrsf23	Fcgrt	Slc25a12
Il1rap	Tnfrsf26	Fchsd2	Slc25a13
Il20rb	Tnfrsf9	Fcrls	Slc25a15
Il4ra	Tnfsf9	Fdx1	Slc25a17
Il8rb	Tnpo2	Fgd4	Slc25a19
Ilk	Tomm20	Fgf13	Slc25a23
Impdh1	Tomm70a	Fgf14	Slc25a27
Impdh2	Topbp1	Fgf16	Slc25a3
Inhba	Tpbg	Fgf9	Slc25a33
Inhbb	Tpcn2	Fggy	Slc25a36
Ino80	Tpd52	Fh1	Slc25a39
Ino80c	Tpp2	Fhl2	Slc25a4
Ip6k2	Tpt1	Fhod3	Slc26a10
Ipo4	Tra2b	Fig4	Slc27a1
Ipo7	Traf3	Fign	Slc28a2
Ippk	Traf6	Filip1	Slc29a1
Irak3	Traf7	Filip1l	Slc2a12
Irak4	Tram1	Fis1	Slc2a8
Irf8	Tram2	Fitm1	Slc30a9
Irg1	Trappc5	Fkbp3	Slc31a2
Irs2	Trem1	Fktn	Slc35a1
Itga2	Treml2	Flot1	Slc36a2
Itga2b	Trib3	Flt3l	Slc37a1
Itga3	Trim27	Fmc1	Slc37a4
Itga7	Trim41	Fmo1	Slc38a11
Itgal	Trip13	Fmo5	Slc38a3
Itgam	Trmt6	Fn3krp	Slc38a7
Itgb1bp3	Trmt61a	Fnbp1	Slc38a9
Itgb2	Trove2	Fndc5	Slc41a1
Itgb3	Trp53	Fnip1	Slc41a3
Itgb7	Trp53i11	Fnta	Slc46a1
Itpk1	Trp53i13	Folr2	Slc47a1
Itpkc	Trpc6	Foxj2	Slc9a3r2
Itpr3	Trpm2	Foxn3	Slc9a6
Jmjd6	Trpv2	Foxo3	Slc9a9
Jtv1	Tsc22d2	Foxred1	Slco2b1
Jub	Tshz1	Frag1	Slco3a1
Kbtbd10	Tsku	Frem2	Slfn5
Kcne3	Tspan5	Frmd5	Smarca2
Kcne4	Tsr1	Frs2	Smarcal1
Kcnn4	Tssc4	Fsd2	Smarcd3
Kctd17	Ttc37	Fuca2	Smpd1

Supplement Table 1. Continued

Kctd18	Ttc9	Fundc1	Smpd2
Kctd5	Ttll11	Fundc2	Smpdl3a
Kdm3a	Tuba1c	Fut8	Smtnl2
Kdm5c	Tubb1	Fv1	Smyd1
Khdrbs1	Tuft1	Fxyd1	Smyd3
Kif21b	Tulp4	Fyco1	Snai2
Kif3b	Twist1	Fzd6	Snapc1
Klf10	Twistnb	G0s2	Snapc5
Klf16	Txlna	G6pc3	Snapin
Klf6	Txn1	Gaa	Sned1
Klhdc4	Txndc11	Gab1	Snrnp27
Klhl2	Txndc5	Gabarap	Snx16
Klhl6	Txnrd1	Gadd45gip1	Snx21
Klra2	U2af1	Gal3st2	Snx27
Kpnb1	Uba2	Galnt11	Snx32
Kri1	Ubash3b	Galt	Snx33
Krt19	Ube2e2	Gamt	Sobp
Krt8	Ube2j1	Garnl1	Socs2
Krt80	Ube2o	Gas6	Sod2
Lamc2	Ube2z	Gatc	Sorbs1
Larp1	Ubqln1	Gatsl2	Sorcs2
Lasp1	Ubxn4	Gbas	Sord
Lass2	Ucp2	Gbp4	Sox6
Lass3	Ufm1	Gbp6	Sp100
Lass6	Ugcgl2	Gca	Sp4
Lats1	Ugt1a9	Gcdh	Spa17
Lcn2	Uhrf1	Gck	Spag7
Lcp2	Uhrf1bp1l	Gcom1	Spata1
Ldb2	Unc5b	Gdap10	Spc24
Ldlr	Urb1	Gdpd1	Spna1
Ldlrap1	Urb2	Gdpd5	Spnb1
Lgals1	Uso1	Gfm1	Spns1
Lig3	Usp1	Gfm2	Sqrdl
Lilrb3	Usp20	Gfra4	Srd5a2l2
Limd1	Usp22	Ggcx	Srl
Limk1	Usp31	Ghdc	Srpk2
Lin7c	Usp39	Ghitm	Srpk3
Lipg	Usp47	Ghr	Srpx
Llph	Usp53	Gins4	Srr
Lmbr1l	Usp6nl	Gja1	Ssbp1
Lmnb1	Usp7	Gja3	Ssbp2
Lonrf3	Uspl1	Gkap1	Sspn
Lox	Utp14a	Glb1	St3gal3
Loxl4	Utp15	Glcci1	St3gal4
Lpcat3	Utp18	Glo1	St3gal5
Lpcat4	Utp20	Glrx2	St3gal6
Lpxn	Uxs1	Glrx5	St5
Lrp10	Vars	Glt25d2	St6galnac2
Lrrc32	Vasp	Glt8d1	St6galnac6
Lrrc49	Vav1	Gm1614	St7l
Lrrc58	Vcl	Gm166	Stard3
Lrrc59	Vmn2r9	Gm239	Stard8
Lrrc8c	Vps37b	Gm428	Stard9
Lrrc8d	Vps4b	Gm561	Stat5b
Lrrfip1	Wasf2	Gm572	Stau2
Lsg1	Wdfy1	Gm826	Stc2
Lss	Wdhd1	Gmnn	Steap3
Ltbr	Wdr1	Gmpr	Steap4
Ltv1	Wdr12	Gna12	Stk11
Ly6g	Wdr26	Gnb5	Stk16
Lyn	Wdr3	Gnmt	Stk39

Supplement Table 1. Continued

Lypd1	Wdr4	Gnpat	Stmn1
Magi1	Wdr43	Gnpda1	Stom
Mak16	Wdr45l	Gnptab	Stradb
Mal	Wdr46	Gnptg	Strbp
Mall	Wdr62	Golga4	Stub1
Malt1	Wdr70	Gorasp1	Stx17
Mamld1	Wdr73	Got1	Stxbp4
Manbal	Wdr74	Got2	Stxbp6
Map2k1	Wdr75	Gpam	Sucla2
Map2k3	Wdr77	Gpatch8	Suds3
Map2k4	Wdsof1	Gpbp1l1	Suox
Map4k4	Whamm	Gpc1	Supv3l1
Map4k5	Whsc1	Gpd1l	Surf1
Mapk11	Wipf1	Gpld1	Svil
Mapk6	Wnt9a	Gpn3	Svip
Mapk7	Wwc2	Gpr108	Syde2
Mast4	Xbp1	Gpr125	Sympk
Mbc2	Xirp2	Gpr137b	Sync
Mbd1	Xpnpep1	Gpr175	Syne1
Mbnl2	Xpo6	Gpr22	Syne2
Mboat2	Xpot	Gpr89	Syngr1
Mcm3	Xylt1	Gprasp1	Syngr2
Mcm4	Yars	Gprc5c	Synj2
Mcm9	Yipf5	Gpsm1	Synpo2
Mctp2	Ykt6	Gpsn2	Tac1
Mdfi	Ypel5	Gpt2	Tada2l
Mdn1	Yrdc	Gpx4	Taf12
Me2	Ythdf2	Gramd1b	Taf4a
Med13l	Ywhab	Gramd4	Taf6
Med14	Ywhag	Grb14	Tars2
Med8	Ywhah	Grhpr	Taz
Mertk	Ywhaz	Grinl1a	Tbc1d17
Met	Zbp1	Grm1	Tbc1d19
Mettl1	Zbtb22	Grsf1	Tbc1d22a
Mettl13	Zc3h12d	Gsn	Tbc1d4
Mettl9	Zc3h7a	Gstk1	Tbc1d7
Mex3d	Zcchc9	Gstm1	Tbccd1
Mfsd10	Zdhhc12	Gstm2	Tbx20
Mfsd7b	Zdhhc21	Gstm3	Tbx3
Mical1	Zdhhc9	Gstm4	Tbx5
Mical2	Zfp120	Gstm5	Tcap
Micall1	Zfp13	Gstm7	Tcea3
Micall2	Zfp408	Gstp1	Tceal1
Midn	Zfp52	Gstp2	Tcf21
Mif	Zfp593	Gstt1	Tcfcp2
Mirhg1	Zfp9	Gstz1	Tcfeb
Mki67ip	Zfr	Gtf2h2	Tcn2
Mkrn1	Zmat3	Gtf2i	Tcp11l2
Mlxip	Zmiz1	Gtf3c1	Tcta
Mmadhc	Zmynd19	Gtpbp8	Tctn3
Mmp12	Znrf2	Gucy1a2	Tec
Mmp19	Zscan4-ps2	Gucy1a3	Tef
Mmp25	Zswim4	Gucy1b3	Tek
Mmp3	Zwilch	Gypc	Tesc
	Zwint	Gzmm	Tesk2
		H2-Eb1	Tex261
		H2-Ke6	Tfb2m
		H2-T24	Tfpi
		H2afv	Tgfbr3
		Hacl1	Tha1
		Hadh	Thap4

Supplement Table 1. Continued

Hadha	Thap6
Hadhb	Thoc7
Hagh	Thra
Hars2	Tiaf2
Haus1	Tie1
Haus5	Timm17b
Haus8	Timm22
Hbp1	Timm23
Hbs1l	Timm44
Hbxip	Timm8b
Hccs	Timp2
Hcfc1r1	Tlcd1
Hcn2	Tle2
Hcn4	Tln2
Hdac10	Tm7sf3
Hdac2	Tm9sf2
Hdac5	Tmbim4
Hdac8	Tmc7
Hdac9	Tmco1
Hddc3	Tmco3
Hdhd2	Tmed1
Heatr5b	Tmem106b
Helz	Tmem106c
Hemk1	Tmem109
Herpud1	Tmem116
Hes6	Tmem117
Hexa	Tmem126a
Hexim1	Tmem126b
Hfe	Tmem129
Hfe2	Tmem135
Hhatl	Tmem140
Hibadh	Tmem141
Hibch	Tmem143
Hif1an	Tmem147
Higd2a	Tmem175
Hint2	Tmem195
Hint3	Tmem201
Hisppd1	Tmem204
Hist1h1e	Tmem205
Hist1h2bc	Tmem218
Hist1h4h	Tmem223
Hist2h2be	Tmem25
Hist3h2a	Tmem35
Hlf	Tmem42
Hltf	Tmem44
Hmbs	Tmem47
Hmgb3	Tmem48
Hmgcs2	Tmem50a
Hmgn2	Tmem50b
Hnmt	Tmem56
Homer2	Tmem59
Hopx	Tmem63b
Hp1bp3	Tmem64
Hpgd	Tmem65
Hps4	Tmem69
Hrasls	Tmem70
Hrsp12	Tmem77
Hs1bp3	Tmem80
Hs3st5	Tmem82
Hsbp1	Tmem85
Hscb	Tmem98

Supplement Table 1. Continued

Hsf1	Tmod1
Hspa4l	Tmod4
Hspa9	Tmtc1
Hspb3	Tmtc2
Hspbp1	Tnfaip8
Htatip2	Tnip3
Htatsf1	Tnni3
Htra1	Tnni3k
Htra3	Tnrc6b
Htra4	Tnrc6c
Hyal1	Tnxb
Hyls1	Tob2
Iars2	Tom1l1
Ica1	Tom1l2
Ict1	Tomm34
Idh2	Tomm40l
Idh3a	Tomm5
Idh3b	Tpcn1
Idh3g	Tpmt
Ids	Tpp1
Ifi203	Tppp
Ifi205	Tppp3
Ifngr2	Tprgl
Ift140	Tra2a
Ift172	Traf3ip1
Ift20	Trak1
Ift80	Trap1
Ift81	Trappc2
Igbp1	Trappc2l
Igdcc4	Trappc9
Igf2	Trib2
Igf2r	Trim12
Igfals	Trim32
Igfbp4	Trim55
Igfbp5	Trim63
Igfbp6	Trim65
Iigp1	Trim68
Ikzf2	Trim72
Il10rb	Trmt2b
Il11ra1	Trmt5
Il15	Trmu
Il15ra	Trnt1
Il17rd	Trp53inp2
Immp1l	Trpc1
Immt	Trpc2
Inadl	Trpc3
Inca1	Trpm4
Ing4	Trpt1
Inpp4a	Tsc1
Inpp5a	Tsc2
Inpp5e	Tsc22d4
Inpp5j	Tsen34
Inpp5k	Tsfm
Inppl1	Tsga10ip
Insig2	Tspan12
Ints10	Tspan13
Intu	Tspan3
Ip6k3	Tspan7
Ipo8	Tspyl4
Ipp	Ttc12
Iqcb1	Ttc19

Supplement Table 1. Continued

Iqcc	Ttc21b
Iqwd1	Ttc3
Irak1bp1	Ttc30a2
Irf2bp1	Ttc30b
Irgm2	Ttc32
Irs1	Ttc35
Irx3	Ttll1
Irx4	Ttll5
Isca1	Ttn
Isca2	Tubd1
Islr	Tubg1
Isoc1	Tufm
Isyna1	Tusc4
Itfg1	Twf2
Itfg2	Twsg1
Itfg3	Txlnb
Itga1	Txn2
Itgb1bp2	Txndc14
Itgb6	Txndc15
Itih5	Txndc16
Itm2a	U2af1l4
Itm2b	Uba52
Itpa	Ube1y1
Itpkb	Ube2a
Itpr1	Ube2b
Itsn1	Ube2d1
Ivd	Ube2e3
Ivns1abp	Ube2l3
Jam2	Ube2r2
Jarid2	Ube2v2
Jmjd8	Ubl4
Jmy	Ubl5
Josd1	Ubl7
Jtb	Ubr7
Kank2	Ubxn2b
Kank3	Ubxn6
Katnal1	Uckl1
Kbtbd4	Uhrf2
Kbtbd7	Ulk1
Kcna5	Ulk2
Kcna7	Unc84a
Kcnb1	Uqcc
Kcnd3	Uqcr
Kcng2	Uqcrb
Kcnh2	Uqcrc1
Kcnip2	Uqcrc2
Kcnj11	Uqcrfs1
Kcnj12	Uqcrh
Kcnn2	Uqcrq
Kcnq1	Urod
Kcnt2	Use1
Kctd1	Usf2
Kctd2	Ushbp1
Kctd21	Usmg5
Kdelc2	Usp11
Kdm2b	Usp13
Kdm5d	Usp15
Kdr	Usp2
Khdrbs3	Usp21
Kif13a	Usp24
Kif13b	Usp46

Supplement Table 1. Continued

Kif16b	Uty
Kif1c	V1rd20
Kif21a	Vdac1
Kif3c	Vdac3
Kif7	Vegfb
Kifap3	Vezt
Kifc2	Vit
Kifc3	Vldlr
Klc2	Vmn2r111
Klc4	Vps13a
Klf12	Vps13c
Klf15	Vps13d
Klf2	Vps25
Klhdc2	Vps28
Klhdc8a	Vps52
Klhl13	Vps72
Klhl22	Vrk2
Klhl23	Vtn
Klhl24	Wbp1
Klhl30	Wbscr16
Klhl31	Wbscr17
Klhl32	Wdr18
Klhl7	Wdr21
Klhl8	Wdr23
Krba1	Wdr24
Krt222	Wdr35
Ktn1	Wdr41
Ky	Wdr45
L2hgdh	Wdr48
Lactb	Wdr53
Lage3	Wdr6
Lama2	Wdr67
Lamb2	Wdr7
Lamp2	Wdr92
Lancl1	Wdsub1
Laptm4a	Wdyhv1
Laptm4b	Wfdc6a
Lars2	Whrn
Lass4	Wipf3
Lcmt1	Wnk1
Ldb3	Wnk2
Ldhb	Wnk4
Ldhd	Wrap53
Letm1	Wrb
Letm2	Wwp1
Lgi1	Xdh
Lgtn	Xpo7
Lifr	Xrcc1
Limch1	Xrcc4
Lims1	Xrcc5
Lims2	Xrcc6
Lix1	Ybx1
Lman2l	Yif1a
Lmbr1	Yipf2
Lmbrd1	Yipf3
Lmod2	Yipf7
Lmtk2	Ypel3
Lonp1	Zbtb20
Lonp2	Zbtb4
Lonrf2	Zc3h7b
Lpgat1	Zcchc17

Supplement Table 1. Continued

Lphn2	Zdhhc1
Lpin1	Zdhhc17
Lpl	Zer1
Lrba	Zfand1
Lrp4	Zfand6
Lrp6	Zfp106
Lrpprc	Zfp110
Lrrc1	Zfp113
Lrrc10	Zfp128
Lrrc2	Zfp148
Lrrc20	Zfp157
Lrrc39	Zfp160
Lrrc48	Zfp161
Lrrc52	Zfp180
Lrrc57	Zfp187
Lrrc68	Zfp189
Lrrcc1	Zfp191
Lrrfip2	Zfp219
Lrrk2	Zfp229
Lsm10	Zfp235
Lsmd1	Zfp251
Ltbp1	Zfp260
Lum	Zfp27
Ly96	Zfp30
Lynx1	Zfp319
Lyrm2	Zfp329
Lyrm5	Zfp358
Lyrm7	Zfp366
Lysmd4	Zfp386
Lzic	Zfp422-rs1
Lztfl1	Zfp426
Lzts2	Zfp438
M6prbp1	Zfp442
Macrod1	Zfp46
Magi2	Zfp512
Magi3	Zfp521
Magix	Zfp563
Mak10	Zfp58
Man2a2	Zfp60
Manba	Zfp606
Maob	Zfp617
Map1lc3a	Zfp62
Map1lc3b	Zfp652
Map2k2	Zfp704
Map2k5	Zfp706
Map3k5	Zfp715
Map3k7ip1	Zfp72
Map4k2	Zfp759
Mapk10	Zfp763
Mapk1ip1	Zfp768
Mapkap1	Zfp771
Mapkapk3	Zfp788
Mapksp1	Zfp799
Mapre2	Zfp82
Mapt	Zfp825
Marveld1	Zfp826
Mat2b	Zfp827
Matn2	Zfp839
Mavs	Zfp84
Mb	Zfp87
Mcc	Zfpm2

Supplement Table 1. Continued

Mccc1	Zgpat
Mccc2	Zh2c2
Mcee	Zhx2
Mchr1	Zkscan3
Mcoln1	Zmat1
Mcrs1	Zmat5
Mdh1	Zmym3
Mdh2	Zmym6
Me3	Zmynd11
Mecr	Zmynd15
Med12l	Zranb3
Med16	Zrsr1
Med24	Zswim1
Med31	Zyg11b
Mef2a	l7Rn6
Mef2c	rp9