Supplementary Information

miR-128a acts as a regulator in early cardiac development by modulating differentiation of cardiac progenitor cell populations

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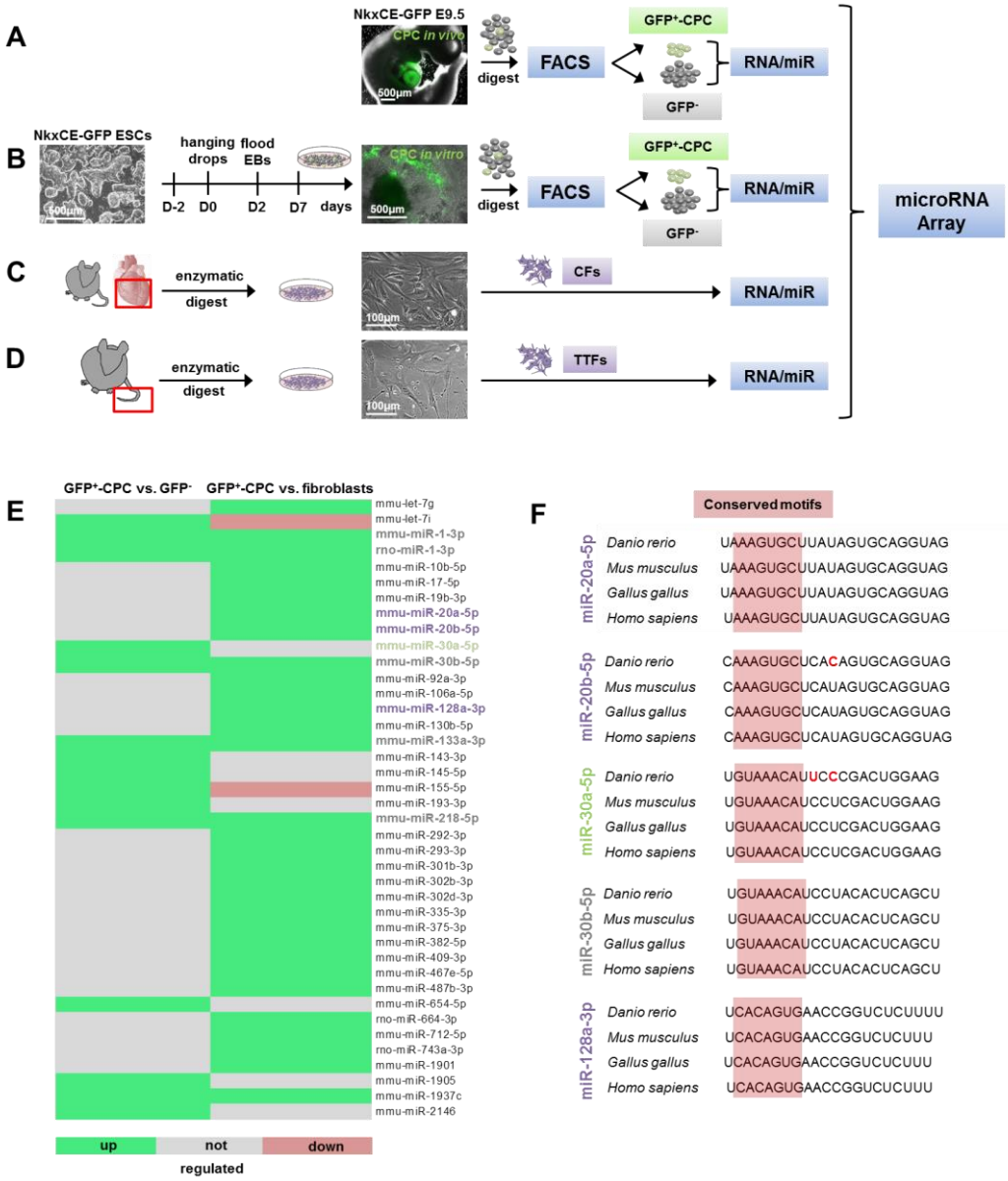
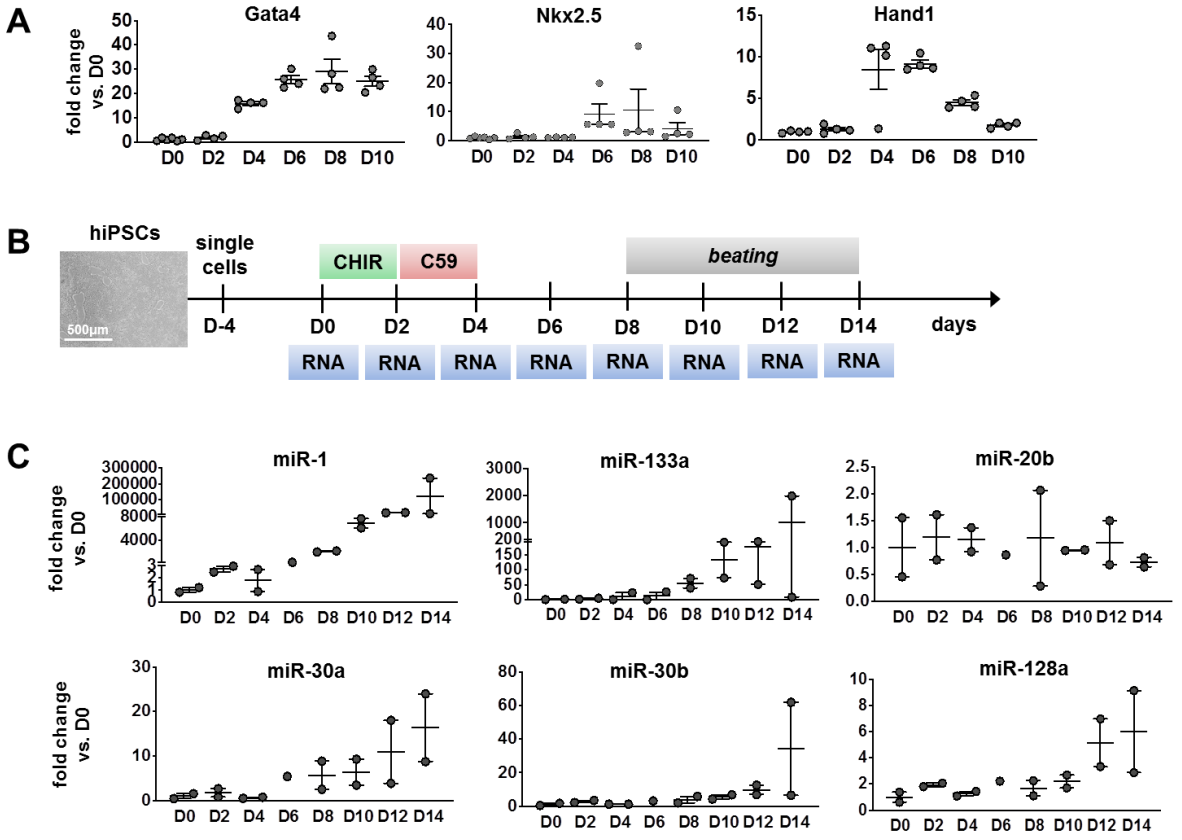
1. Supplementary Figures and Figure Legends



Suppl. Figure S1. Identification of candidate miRs during cardiac development.

A.-D. Generation of cell samples for microRNA Array. E9.5 Nkx2.5 cardiac enhancer eGFP (NkxCE-GFP) embryos were collected and enzymatically digested. GFP-positive CPCs and the correspondent GFP-negative fractions were subsequently sorted using flow cytometry (FACS) (A). Differentiated (hanging drop method) NkxCE-GFP ESCs were harvested and enzymatically digested after 7 days (D7), FACS sorted and RNA/miR was isolated of GFP^+ and GFP^- cells. (B). Cardiac fibroblasts (CFs) (C) and tail tip fibroblasts (TTFs) (D) were *in vitro* cultivated after enzymatic digestion from hearts or tailtips of adult NkxCE-GFP mice. RNA/miR was isolated from low passage cells (C). Isolated miR was then used for microRNA Arrays. **E.** Heat map of 41 upregulated miRs ($p < 0.05$) of the microRNA Array. All together

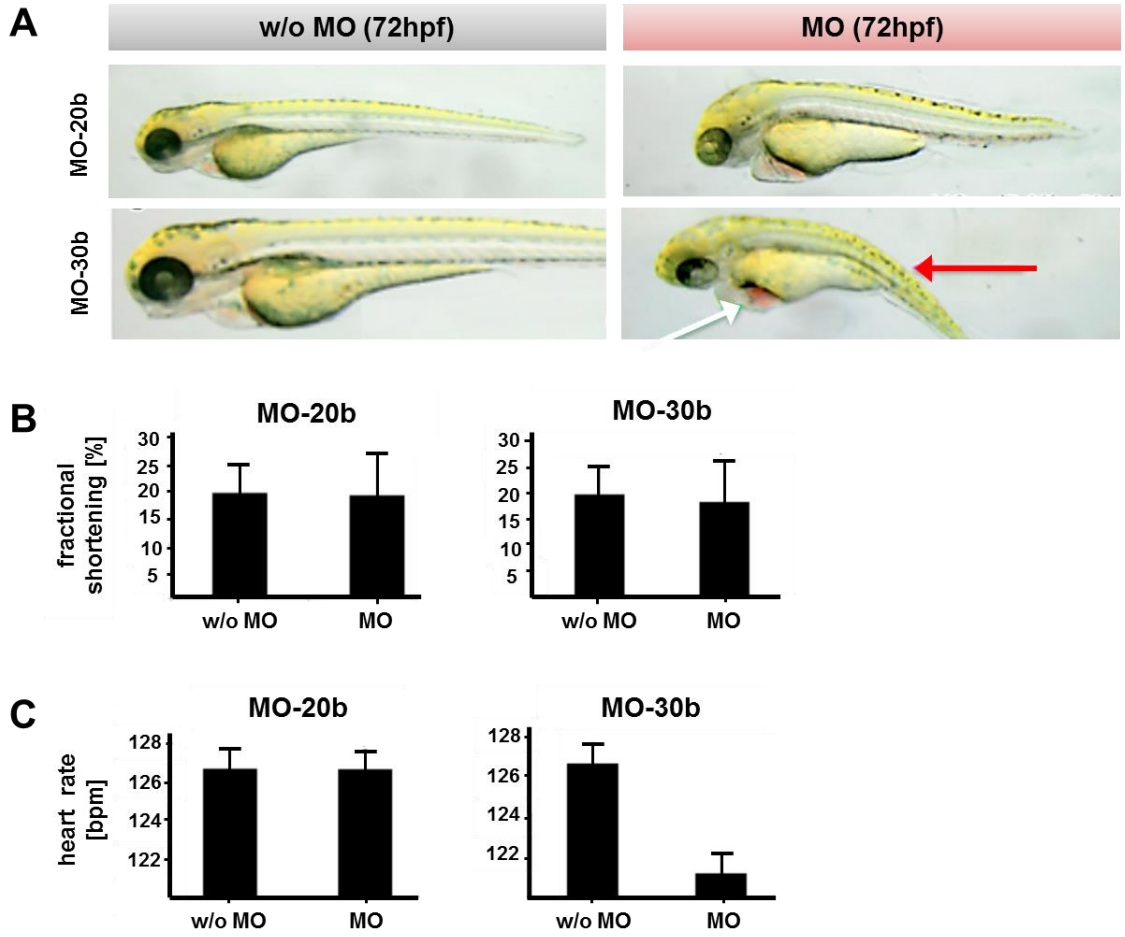
about 800 miRs were evaluated. **F**. Sequences of miR-20a-5p, miR-20b-5p, miR-30a-5p, miR-30b-5p and miR-128a-3p are highly conserved between species, including zebrafish (*danio rerio*), mouse (*mus musculus*), chicken (*gallus gallus*) and human (*homo sapiens*). Red bases represent non-homologous bases compared to human miR-sequences.



Suppl. Figure S2: Identification of candidate miRs during cardiac development.

A. Expression kinetics of *Gata4*, *Nkx2.5* and *Hand1* (early cardiac transcription factors) during *in vitro* differentiation of NkxCE-GFP ESCs. Gene expression starts to elevate on day 4 (D4) to 6 (D6). **B.** huiPSCs were *in vitro* differentiated for two weeks. Wnt-signaling was activated from day 0 (D0) until day two (D2) using CHIR99021 (GSK3 inhibitor) followed by a treatment with Wnt-C59 (Wnt-signaling inhibitor) for two days. Total RNA was isolated every other day to evaluate microRNA kinetics. **C.** Kinetics of miR candidates during *in vitro* differentiation of huiPS. Expressions of miR-1 and -133a followed a typical course by rising upon the beginning of cardiomyogenesis (around day 8-10). MiR-30a, -30b and -128a also elevated around day 8 (D8) to 10 (D10). However, miR-20b showed no recognizable trend of upregulation during differentiation.

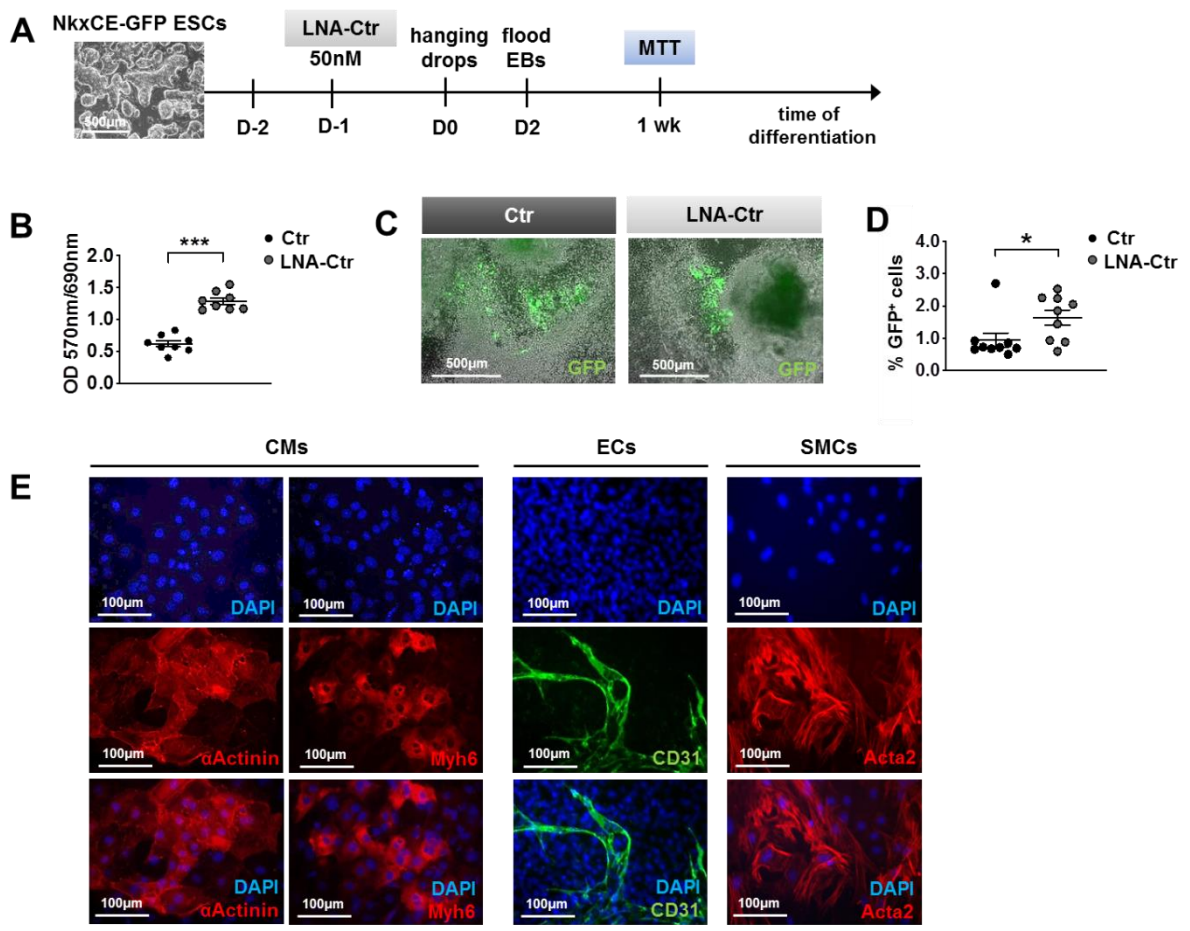
Data are represented as means ± SEM.



Suppl. Figure S3: Evaluation of candidate miR function during zebrafish development.

A. Morphological changes of morpholino oligo (MO)-treated zebrafish larvae at 72 hpf. MO-20b morphants showed decreased body size compared to controls (w/o MO) (upper panels). MO-30b morphants exhibited extreme blood stasis (white arrow) and crimped tails (red arrow) (lower panels). **B.** MO-20b and MO-30b treated larvae showed no difference in fractional shortening compared to control larvae (w/o MO) at 72hpf. **C.** Knockdown of miR-20b or -30b had no significant effects on heart rate in zebrafish morphants at 72 hpf compared to controls (w/o MO).

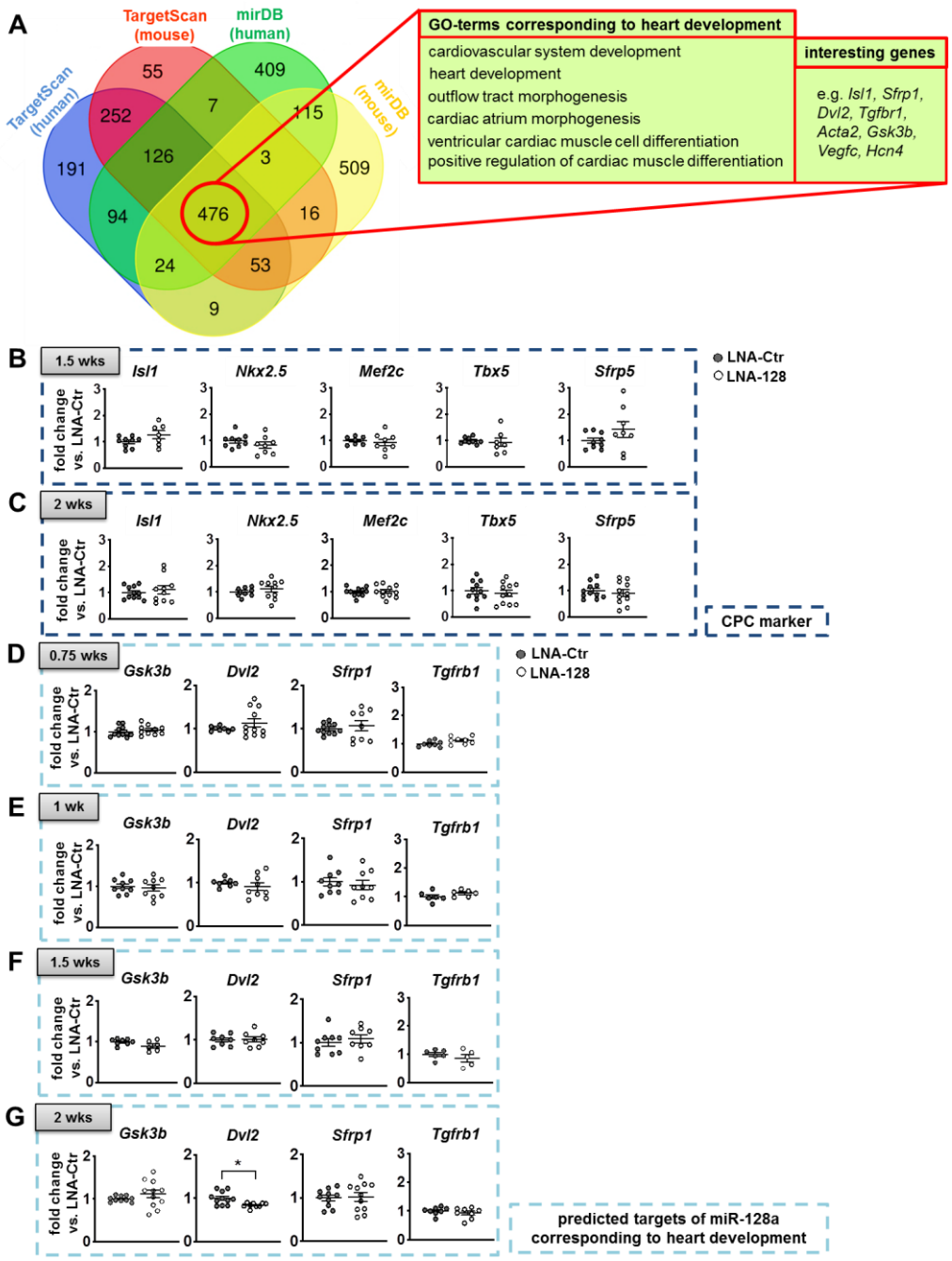
Data are represented as means ± SEM.



Suppl. Figure S4: LNA probes during *in vitro* differentiation of murine NkxCE-GFP ES cells.

A. NkxCE-GFP ESCs were differentiated using the hanging drop method and transfected with 50nM LNA-Ctr probes at day-1 (D-1). After one week, (wk) MTT assay was performed and compared to non-transfected, equally differentiated NkCE-GFP ESCs (Ctr). **B.** MTT Assay: After one week of differentiation NkxCE-GFP ESCs transfected with LNA-Ctr probes showed a significant upregulation of proliferation capacity ($p < 0.001$) when compared to non-tranfected NkxCE-GFP ESCs. **C.** GFP-positive NkxCE CPCs after one week of differentiation in non-transfected NkxCE-GFP embryoid bodies (EBs) and LNA-Ctr-transfected NkxCE-GFP EBs. Images are an overlay between phase contrast and fluorescent microscopic pictures. **D.** Frequency of GFP-positive NkxCE CPCs after one week of differentiation was significantly enhanced in LNA-Ctr-transfected NkxCE-GFP EBs compared to non-transfected NkxCE-GFP EBs. **E.** Immunofluorescent stainings showed that after two to three weeks of differentiation NkxCE-GFP ESCs differentiated into the three major cardiac cell types including cardiomyocytes (α-Actinin, α-Myosin Heavy Chain (Myh6)), endothelial cells (CD31), and smooth muscle cells (Smooth Muscle Actin (Acta2)).

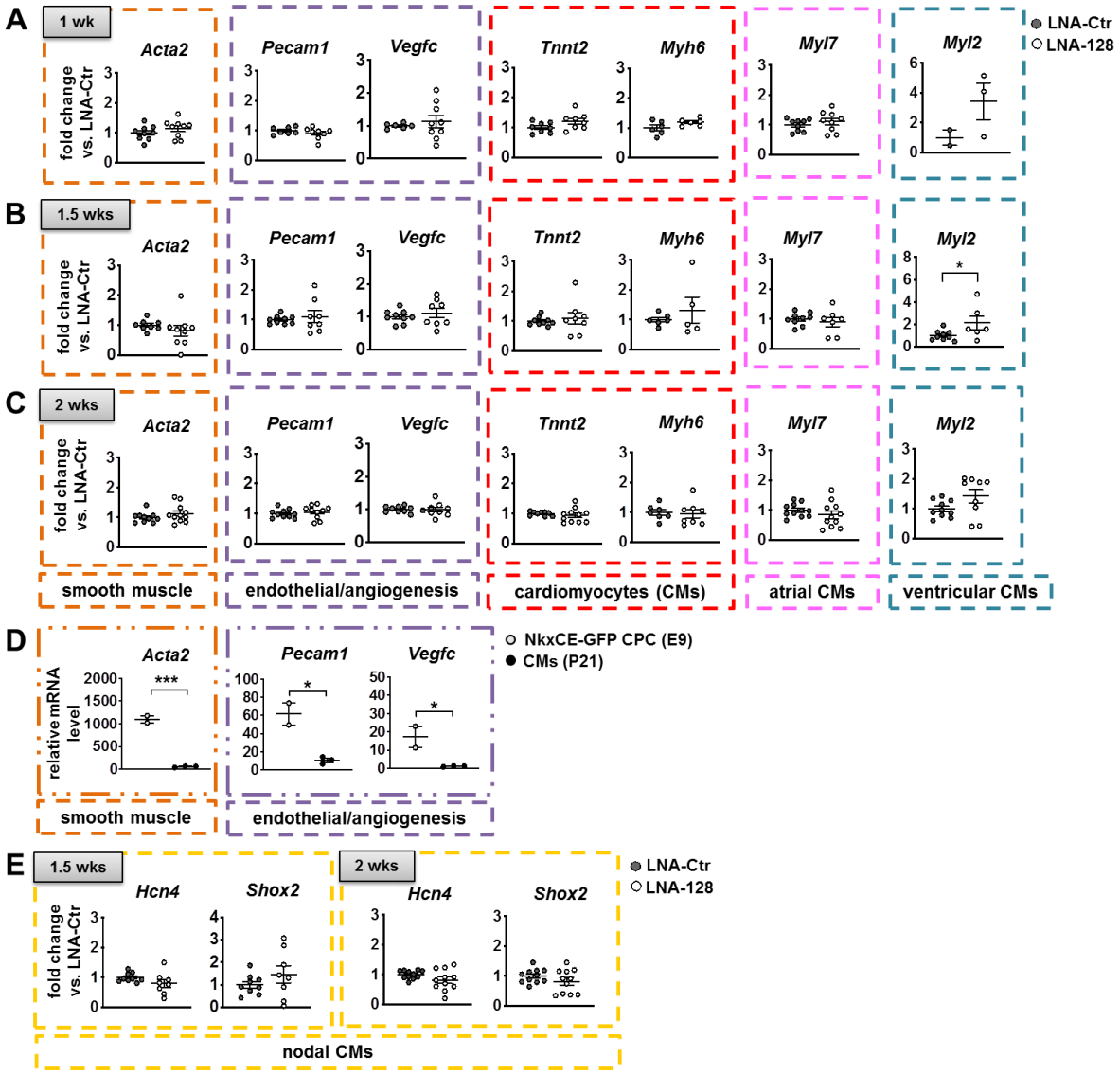
Data are represented as means ± SEM. * $p \leq 0.05$, *** $p \leq 0.001$.



Suppl. Figure S5: Predicted target genes of miR-128a and gene expression data after knockdown of miR-128a during *in vitro* differentiation of murine NkxCE-GFP ESCs.

A. Venn diagram analysis of predicted miR-128a target genes (human and murine) from Target Scan version 7.2 (http://www.targetscan.org) and miRDB (http://mirdb.org). 476 genes were found to be included in all four lists. **B-C.** Panels show the expression of early CPC markers after 1.5 weeks (wks) (B.) and after 2 wks (C.). **D-G.** The expression of *Gsk3b*, *Dvl2* and *Sfrp1* (Wnt signaling) as well as *Tgfbr1* was not influenced (0.75-2 wks) by a knockdown of miR128-a during the differentiation of NkxCE-GFP-ESCs.

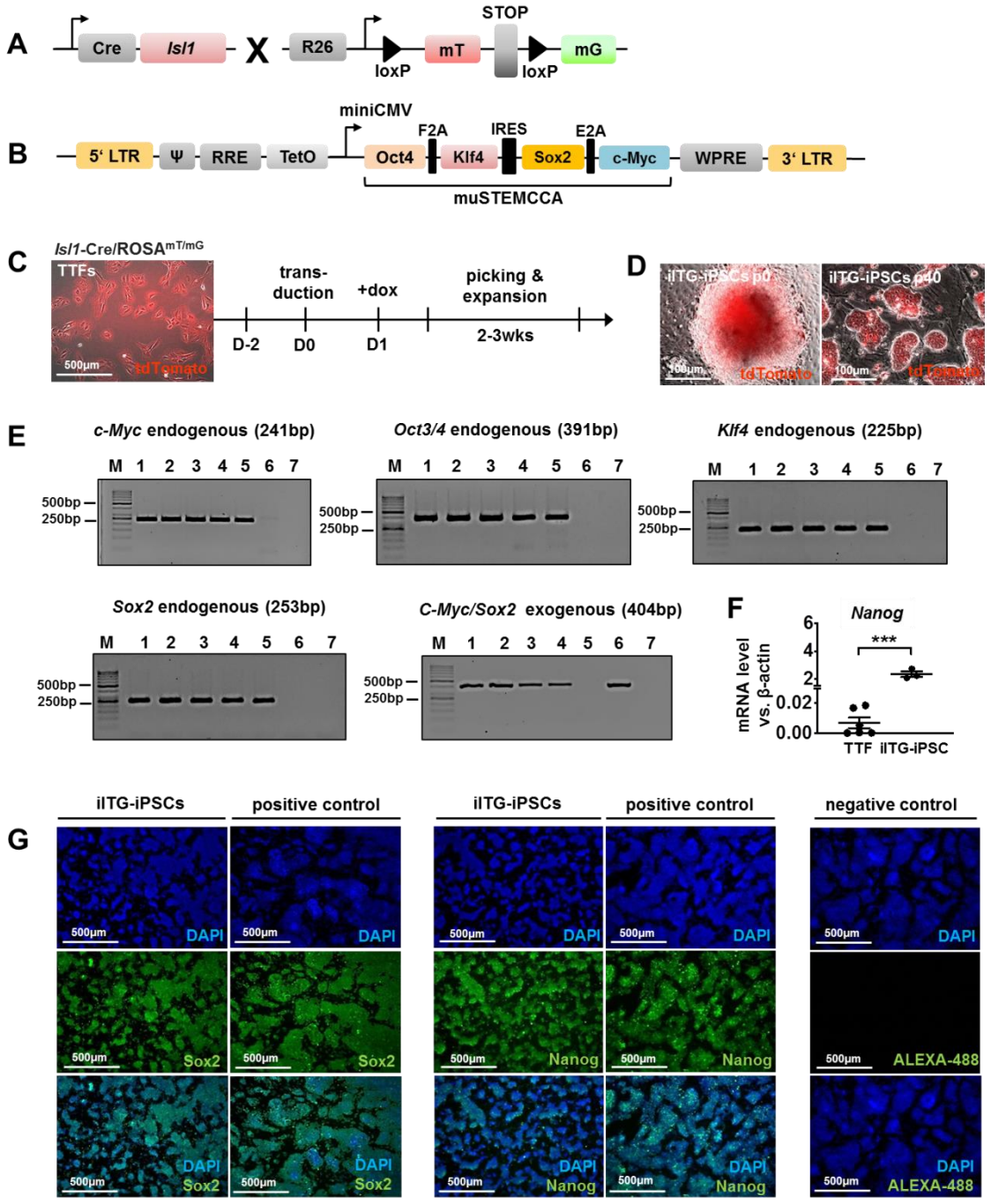
Data are represented as means ± SEM. * $p \leq 0.05$.



Suppl. Figure S6: Gene expression data after knockdown of miR-128a during *in vitro* differentiation of murine NkxCE-GFP ESCs.

A-C. The expression of *Acta2* (smooth muscle cell marker), *Pecam 1* (endothelial cell marker), *Vegfc* (angiogenesis marker) as well as general cardiomyocyte (CM) marker (*Tnnt2, Myh6*), atrial CM (*Myl7*) and ventricular CM marker (*Myl2*) are shown from 1 wk to 2 wks. **D.** RNA sequencing data depict that NkxCE-GFP-positive cells from embryonic hearts (embryonic day 9, E9) expressed high levels of *Acta2, Pecam1* and *Vegfc* compared to cardiomyocytes from adult mouse hearts (postnatal day 21, P21). **G.** Nodal CM markers (*Hcn4, Shox2*) were not differentially regulated during differentiation of NkxCE-GFP ESCs transfected with LNA-128 or LNA-Ctr probes (panels after 1.5 and 2 wks are shown).

Data are represented as means ± SEM. * $p \leq 0.05$, *** $p \leq 0.001$.

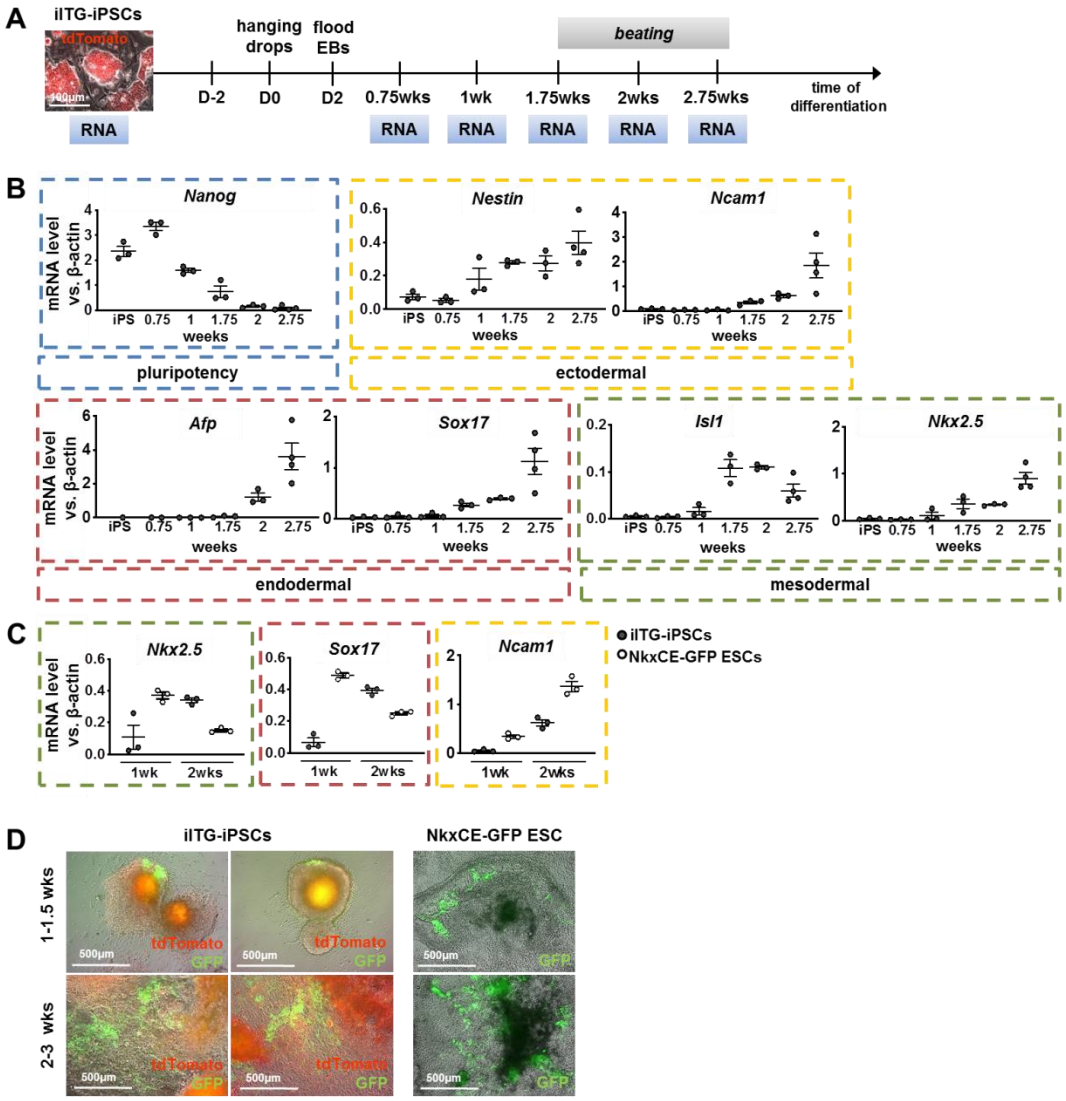


Suppl. Figure S7: Generation and verification of murine Isl1-Cre/Rosa26^{mTmG} iPSCs (iITG-iPSCs).

A. Isl1-Cre/Rosa26^{mTmG} (ITG) transgenic construct: ubiquitous expression of dtTomato and labeling of Isl1 expressing cells by GFP after Cre-mediated excision of dtTomato. **B.** Doxycycline(dox)-inducible polycistronic lentiviral vector for reprogramming of transgenic ITG fibroblasts into iPSCs (iITG-iPSCs). It contains the four "Yamanaka factors" Oct4, Klf4, Sox2 and c-Myc (OKSM, "stem cell cassette"; murine STEMCCA) separated by self-cleaving 2A peptides and IRES (internal ribosomal entry site) sequences. *Abbreviations: LTR, long terminal repeats; RRE, Reverse Response Element; TetO, tetracycline operator, CMV,*

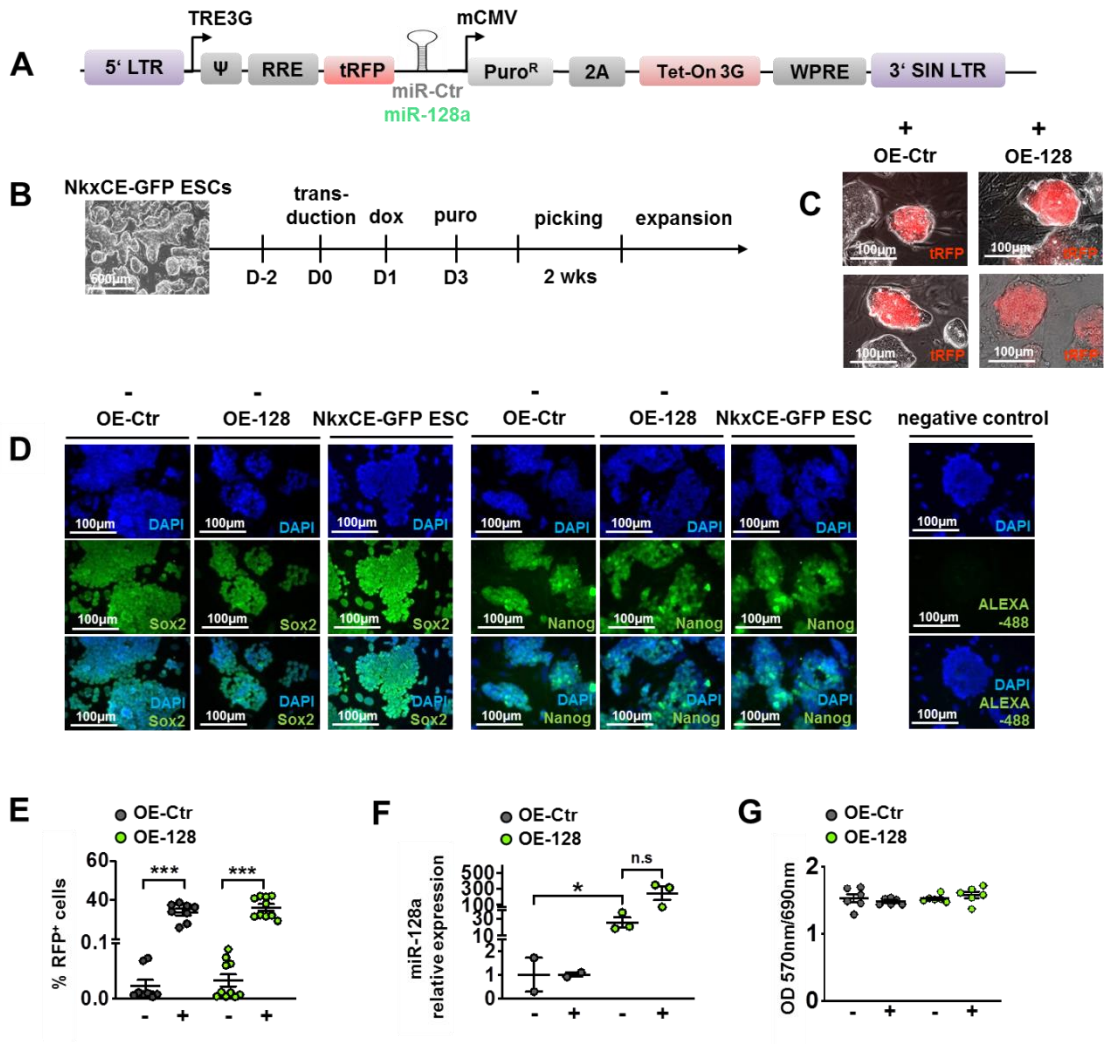
Cytomegalovirus Promoter; WPRE, Woodchuck Hepatitis Posttranscriptional Regulatory Element. **C.** Isl1-Cre/Rosa26^{mTmG} tail tip fibroblasts (ITG-TTFs) were transduced with lentiviral dox-inducible muSTEMCCA particles and lentiviral particles containing a reverse tetracyclin transactivator (rtTA). Expression of the "Yamanaka factors" was induced one day (D1) after transduction. IPSC colonies were picked two to three weeks after transduction and further expanded. **D.** Microscopic images of an iPSC colony before picking and expanded iPSCs after 40 passages. Images are an overlay between phase contrast and fluorescent microscopic pictures. **E.** Different passages of generated iITG-iPSCs endogenously expressed all four "Yamanaka factors" (c-Myc, Oct3/4, Klf4 and Sox2) at similar levels than ESCs (NkxCE-GFP ESCs) (Block Cycler PCRs). With increasing passages, generated iPSCs showed declining expression of exogenous c-Myc/Sox2 (polycistronic vector construct). *(M) marker; (1) iITG-iPSC p1; (2*) *iITG-iPSC p3; (3) iITG-iPSC p13*; *(4) iITG-iPSC p18; (5) NkxCE-GFP ESCs p28 (control 1); (6) muSTEMCCA (control 2); (7) H_2O (control 3).* **F.** Generated iPSCs expressed significant higher levels of the pluripotency marker *Nanog* when compared to tail tip fibroblasts (qRT-PCR). **G.** iITG-iPSCs expressed the pluripotency markers Sox2 (left panel) and Nanog (right panel) like ESCs (NkxCE-GFP ESCs) (immunofluorescent stainings with anti-Sox2 and anti-Nanog antibodies).

Data are represented as means ± SEM. *** $p \leq 0.001$.



Suppl. Figure S8: *In vitro* differentiation of murine Isl1-Cre/Rosa26^{mTmG} iPSCs (iITG-iPSCs) for verification of differentiation capability into all three germ layers.

A. iITG iPSCs were differentiated using the hanging drop method. RNA for qRT-PCR analysis was isolated at respective timepoints. Differentiated iPSCs started beating after 1.75 to 2 weeks (wks) of differentiation. **B.** Kinetics of pluripotency and germ layer markers during iITG iPSC *in vitro* differentiation. The expression of pluripotency marker *Nanog* decreased throughout differentiation whereas the expression of all three germ layer markers rose (ectodermal: *Nestin, Ncam1*, endodermal: *Afp, Sox17*, mesodermal: *Isl1, Nkx2.5*). **C.** Throughout *in vitro* differentiation, the generated iITG-iPSCs started to express meso-, endo- and ectodermal markers approximately one week later than ESCs (NkxCE-GFP ESCs). **D.** Microscopic images of Isl1-GFP-positive CPCs of iITG-iPSCs differentiated for 1-1.5 wks (upper left panels) or 2-3 wks (lower left panels). Timepoint-matched NkxCE-GFP-positive CPCs as comparison (right panels). Images are an overlay between phase contrast and fluorescent microscopic pictures. Images show that iITG-iPSCs differentiated slower than corresponding NkxCE ESCs.

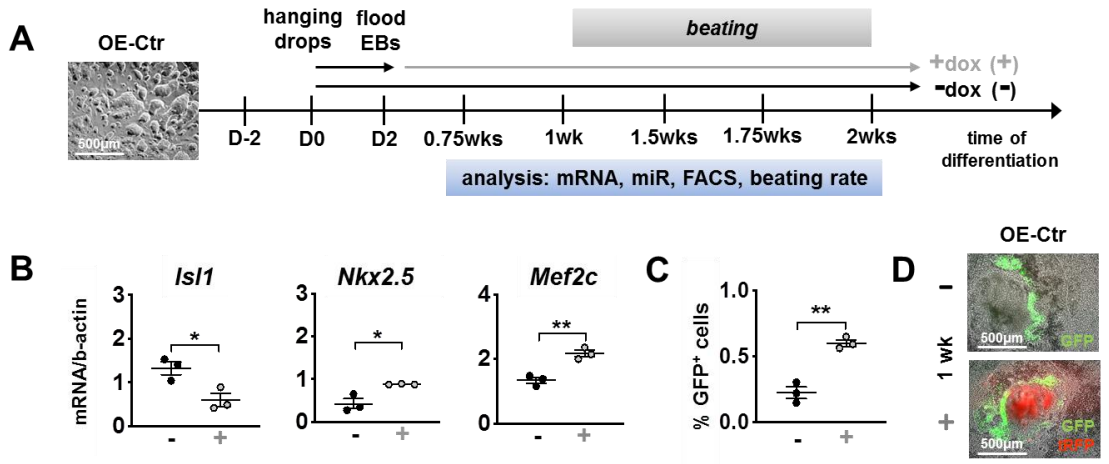


Suppl. Figure S9: Generation and verification of miR overexpressing murine NkxCE-GFP ESCs (OE-128, OE-Ctr).

A. Lentiviral miR overexpression (OE) vector for transduction of NkxCE-GFP ESCs: the vector is doxycycline inducible (tet-on 3G), carries an ubiquitous puromycine resistence ($Puro^R$) and turbo Red Fluorescent Protein (tRFP) is expressed in front of the respective miR to be overexpressed, either miR-128a (OE-128) or a non-targeting control miR (miR-Ctr, OE-Ctr). *Abbreviations: LTR, long terminal repeats; TRE3G, Tetracycline Response Element 3G; RRE, Reverse Response Element; mCMV, murine Cytomegalovirus Promoter; 2A, 2A peptide; WPRE, Woodchuck Hepatitis Posttranscriptional Regulatory Element; SIN LTR, Self-inactivating Long Terminal Repeats*. **B.** NkxCE ESCs were transduced with either OE-Ctr or OE-128 lentiviral particles (day 0, D0). tRFP and miR expression was induced at D1 by adding doxycycline (dox) and transduced ESCs were selected by Puro from day D3. RFP-positive clones were picked after one to two weeks of selection and further expanded**. C.** Microscopic images of RFP-positive OE-Ctr and OE-128 colonies before picking. Images are an overlay between phase contrast and fluorescent microscopic pictures. **D.** OE-Ctr as well as OE-128 ESCs expressed the pluripotency markers Sox2 (left panel) and Nanog (right

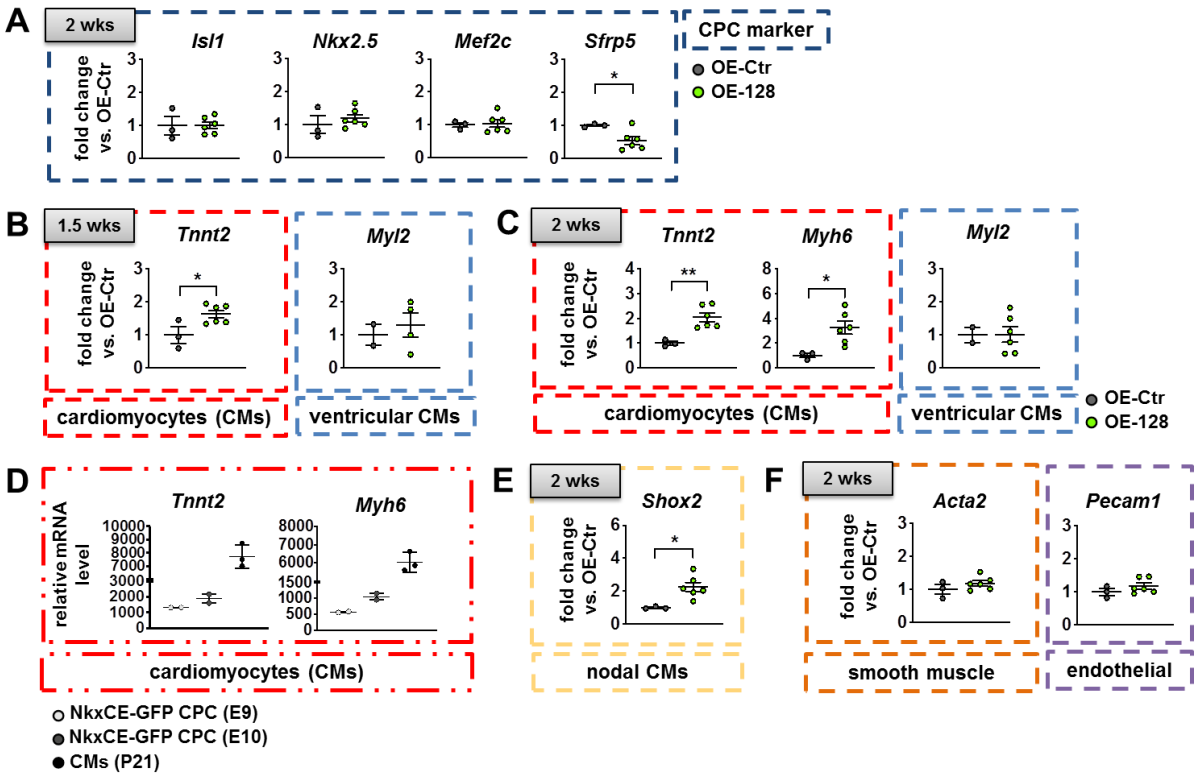
panel) like the originating ESCs (NkxCE-GFP ESCs) (immunofluorescent stainings with anti-Sox2 and anti-Nanog antibodies). Experiments were performed without dox-induction of miRs. **E.** Doxycycline (+) significantly induced tRFP in OE-Ctr and OE-128 ESCs ($p<0.001$) compared to their counterparts without doxycycline (-) (% RFP+ cells was evaluated by flow cytometry). **F.** No miR-128a expression was induced upon dox-addition in OE-Ctr ESCs. However, OE-128 ESCs showed a significantly elevated miR128a-expression level even without dox compared to OE-Ctr ESCs. Unfortunately, by adding dox (2µg/ml) to OE-128 ESCs no further upregulation of miR128a could be achieved. **G.** MTT Assay: No significant differences concerning proliferation capacity were observed in OE-Ctr and OE-128 ESCs cultivated with or without dox.

Data are represented as means ± SEM. * $p \leq 0.05$, ** $p \leq 0.01$ and *** $p \leq 0.001$.



Suppl. Figure S10: *In vitro* differentiation of murine OE-Ctr NkxCE-GFP ESCs (OE-Ctr) to evaluate doxycycline related effects.

A. OE-Ctr ESCs were differentiated using the hanging drop method for two weeks (wks) either with (+dox,+) or without (-dox,-) doxycycline. Analysis was performed on respective timepoints between 0.75 and 2 wks of differentiation. *Abbreviations: EB: embryoid bodies; FACS: flow cytometry*; **B.** Gene expression of early CPC markers *Isl1*, *Nkx2.5* and *Mef2c* was significantly different between OE-Ctr EBs with (+) or without (-) dox after 1.5 to 2 wks of differentiation. **C.** Frequency of NkxCE-GFP-positive CPCs was significantly upregulated upon dox-addition (+) in OE-Ctr EBs compared to OE-Ctr EBs without dox (-) after 2 wks of differentiation. **D.** Upon dox-addition (+) (lower panel) more NkxCE-GFP-positive CPCs developped in OE-Ctr EBs compared to OE-Ctr EBs without dox (-) (upper panel) after 1 wk of differentiation. Images are an overlay between phase contrast and fluorescent microscopic pictures.



Suppl. Figure S11: Gene expression data after overexpression of miR-128a during *in vitro* differentiation of murine OE-128 and OE-Ctr NkxCE-GFP ESCs.

A. Panels show the expression of early CPC markers (*Isl1, Nkx2.5, Mef2c, Sfrp5*) after 2 weeks (wks) of differentiation. **B.-C.** General cardiomyocyte (CM) markers (*Tnnt2, Myh6*), and ventricular CM marker *Myl2* are shown from 1.5 to 2 wks. **D.** RNA sequencing data depict that NkxCE-GFP-positive cells from embryonic hearts (embryonic day 9 and 11, E9 and E11) already expressed high levels of *Tnnt2* and *Myh6* whereas not as high as cardiomyocytes from adult mouse hearts (postnatal day 21, P21). **E.** Nodal CM marker *Shox2* was upregulated upon miR-128a OE after 2 wks. **F.** *Acta2* (smooth muscle cell marker) and *Pecam 1* (endothelial cell marker) were not differentially regulated after 2 wks.

Data are represented as means ± SEM. * $p \leq 0.05$.

2. Supplementary Video Legends

Videos are not real-time but assembled from single pictures photographed in a time series. Therefore beating frequency is an artifact of exposure time. Each video displays 70-80 images. Magnification is 100x.

Video V1-V3. *In vitro* differentiation of *Nkx*CE-GFP ESCs treated with LNA-probes (LNACtr or LNA128) from day 3.5 led to GFP-positive beating areas similar to *Nkx*CE-GFP ESCs not treated with LNA-probes (w/o LNA). V1. Time-lapse imaging of *Nkx*CE-GFP EBs not treated with LNA probes after one week of *in vitro* differentiation. **V2.** Time-lapse imaging of *Nkx*CE-GFP EBs treated with LNACtr probes after one week of *in vitro* differentiation. **V3.** Time-lapse imaging of *Nkx*CE-GFP EBs treated with LNA128 probes after one week of *in vitro* differentiation.

Video V4-V5. *In vitro* differentiation of iITG-iPSCs treated with LNA-probes (LNACtr or LNA128) from day 5 led to GFP-positive beating areas. V4. Time-lapse imaging of iITG-iPSC EBs treated with LNACtr probes after two weeks of *in vitro* differentiation. **V5.** Time-lapse imaging of iITG-iPSC EBs treated with LNA128 probes after two weeks of *in vitro* differentiation.

3. Supplementary Tables

Supplementary Table S1: Sequences of microRNA Primers for qRT-PCR

microRNA Primer	Target sequence (5'- 3')	Accession (Exiqon)
hsa-miR-128-3p LNA™ PCR primer set, UniRT	UCACAGUGAACCGGUCUCUUU	MIMAT0000424
hsa-miR-1 LNA™ PCR primer set, UniRT	UGGAAUGUAAAGAAGUAUGUAU	MIMAT0000416
hsa-miR-133a-5p LNA™ PCR primer set, UniRT	AGCUGGUAAAAUGGAACCAAAU	MIMAT0026478
hsa-miR-20b-5p *LNA™ PCR primer set, UniRT*	CAAAGUGCUCAUAGUGCAGGUAG	MIMAT0001413
hsa-miR-30b-5p *LNA™ PCR primer set, UniRT*	UGUAAACAUCCUACACUCAGCU	MIMAT0000420
hsa-miR-30a-5p *LNA™ PCR primer set, UniRT*	UGUAAACAUCCUCGACUGGAAG	MIMAT0000087
U6 snRNA LNA™ PCR primer set, UniRT **(reference RNA)**	GUGCUCGCUUCGGCAGCACAUAU ACUAAAAUUGGAACGAUACAGAG AAGAUUAGCAUGGCCCCUGCGCA AGGAUGACACGCAAAUUCGUGAA GCGUUCCAUAUUUUU	without MIMAT #

Supplementary Table S2: Predicted target genes of miR-128a (hsa-128-3p, mmu-128-3p) by TargetScan (http://www.targetscan.org) or miRDB (http://mirdb.org).

TargetScan	**TargetScan**	**miRDB**	**miRDB**
human	*mouse*	*human*	*mouse*
1225 genes	**988 genes**	**1254 genes**	**1205 genes**
SZRD1	SZRD1	AFF4	Szrd1
PAIP2	NOVA1	SZRD1	Anks1
NOVA1	LBH	KDM7A	Plk2
PRKX	PRKD1	SEC22A	Erlec1
PRKD1	HIPK2	GPAM	Ret
CLPP	AGRN	FRMPD3	Mapk14
DUSP18	PDIA5	RPS6KA5	Dcun1d4
PDIA5	PLK2	PAIP2	Ube2e2
PLK2	PLAGL1	PHF6	Zfp26
STAB2	APEX1	DCUN1D4	Ugt8a
SEC22A	TMSB10	SMAP1	Reln
CASC3	ANK2	IGLON5	Diras1
GPATCH2L	RAB20	UBE2E2	Poglut1
UBE2E2	PPP1CC	KCNK2	Dot1l
TMSB10	MAPK14	POGLUT1	Arhgap12
YWHAB	YWHAB	ARRDC4	Nfx1
TMEM167A	MIPOL1	MOSMO	Kctd11
VWC2L	POGLUT1	KCNK10	Aff4

DCUN1D4	TRIM23	CDS1	Ece2
AK2	DCUN1D4	PLK2	Matn3
APEX1	GOLM1	TNPO1	Eef1akmt4-ece2
LBH	RET	TRPV3	Mosmo
ST6GALNAC3	SH3BGRL2	TMTC2	Zfp652
H3F3C	FAM184A	GRIA3	Ubr5
BAG2	YPEL3	SRGAP2	B3gnt7
PITHD1	GATAD2A	OTULIN	Cds1
MIPOL1	C16orf80	MSI2	Arid1b
VEGFC	GLTP	DTX4	Phf6
SFXN2	CSDC2	CSF1	Ttc9
SNX12	POGZ	BEND4	Tmem64
MEGF11	ORC5	NGFR	Kcnk10
POGLUT1	BEND4	SS18	Pogz
BAZ2B	HOXA13	POGZ	Rab11fip1
TBC1D9B	CASC10	SOCS5	Cbx5
KCNJ6	H3F3B	ECE2	Slc8a1
TTC39A	ONECUT2	CACNG2	Dnajc13
FAM184A	PHB	RGL2	Pdia5
YPEL3	MMD	UBR5	Bend4
RND3	CASC3	PRKX	Slc35f3
UBE2NL	SNX12	MPP6	Epb41l1
C16orf52	NXT2	FAM184A	Dtx4
ZBTB37	SORL1	PCNX1	Srek1
WEE1	PPIF	EEF1AKMT4-ECE2	Rcor3
ONECUT2	MOSPD3	SLC22A23	Rnf144a
TCEANC2	AGFG1	NRK	Unc13c
CDIP1	MSANTD3-TMEFF1	GAB1	Neo1
SPG21	UBE2N	TUB	Sec24a
SH3BGRL2	HLX	TEAD1	Ptpn9
H3F3B	TMEFF1	DOT1L	Nemp1
GRIN2D	GRIN2D	NFIL3	Kdm7a
PHB	KCNJ6	PDIA5	Fam184a
GMPS	PPP4C	SLC6A1	Mief1
RAB20	ADORA2B	GCC1	Nrk
ZNF385D	SEC61A1	AKIRIN1	Rgl2
LAPTM4B	CCDC71	UNC13C	Unc80
MOB1B	SP1	CCDC88A	Tgfbr1
BEND4	SLC6A1	RO60	Sdha
ORC5	GTF2A2	MED13L	Msi2
CA10	TBC1D9B	RETREG3	Ttc39a
SEC61A1	AK2	SOS1	Neurod6
NEK2	ZNF462	FAM126A	Frmpd3

ECE1	RNF38	IRS1	Ak2
SNAP25	RYBP	TTC39A	Abl2
VANGL1	UNC13C	CEP76	Iglon5
GALNT7	SAMD10	PHB	Ccdc88a
MIER2	C16orf52	RNF182	Fam126b
GTF2A2	ACVR1C	GATA6	Tril
MOSPD3	RAD51L3-RFFL	AK2	Stk32a
MINPP1	FBXO33	PTPRB	Slc22a23
CASP8	SGPP1	AK4	Sgcb
PHGDH	LIN28A	GXYLT1	Pdgfra
EML1	CDIP1	UGT8	Ptprt
NXT2	CYP39A1	NEO1	Pde3a
GLTP	CCDC92	PDE3A	Gabra6
UBE2N	NREP	GRIN2D	Ywhab
NHS	CA10	ADCY2	Gria3
CABLES2	NGFR	H3F3B	Nf1
RNF38	ARRDC4	ZNF704	Ak4
AKIRIN1	ST6GALNAC3	TGFBR1	Itsn2
CCDC71	NEK2	XPR1	Luc7l
PHF6	TTC39A	CNOT6	Kcnk2
IGLON5	DIRAS2	NF1	Eif2s2
EFR3A	NRBF2	VEGFC	Plagl2
G6PC3	VANGL1	CXADR	Grik3
BLOC1S5	RAP1B	TRIL	Ube2n
PPP1CC	CNR1	ARMC8	Fbxw7
CXADR	UBE2E2	CABLES2	Dpys
PPP4C	RFFL	SETD7	Vangl2
NREP	EML1	SPTY2D1	Ppm1e
SH2D3C	CABP1	TTC9	Acvr1c
VANGL2	MIEF1	RCOR3	Setd7
POGZ	PHF6	PTPN9	Rfxap
TMX1	FAM134C	USP42	Slc39a12
RNF182	SEC24A	EIF2S2	Phb
PLAGL1	TCEANC2	ABL2	Cts8
RYBP	IGLON5	GALNT7	Atp8a1
MDN1	JAG1	ROR1	Retreg3
ISL1	KCNK2	MIEF1	Cdip1
FNDC4	ISL1	USH2A	Ice1
CCDC92	NEUROD6	YWHAB	Ephb2
RGS17	SLC35F1	ERC2	Dclre1c
GATA6	PAIP2	ARHGEF38	Kmt2a
KCNK10	CA7	PDHX	Gigyf2
DIRAS1	FAM78A	NEK2	Met
XCR1	STK32B	ATP8A1	Mapk8ip3

CABP1	BGN	MAPK14	Car10
THAP11	BMI1	NXT2	Slc6a1
RGL2	AFF4	NABP1	Fut9
ALDH4A1	SSSCA1	VANGL2	Akirin1
SEC24A	UBR5	STOX2	Tmem170b
TFEB	ZKSCAN2	GRIK3	Pgap1
RAP1B	MOB1B	RNGTT	Nxt2
F3	RNF144A	NFX1	Ing5
SLC35F3	EN1	RYBP	Sim1
ARRDC4	VAV3	COMMD3-BMI1	Dcaf7
FAM84B	MCF2L	FBLN5	Cyp39a1
CYP39A1	SGMS1	SLC39A7	Strn4
SP1	RELN	FOXA3	Adgrg6
BMI1	SMAD9	BAG2	Sema6d
PDE7B	PAX9	FRYL	Stox2
NEUROD6	ABHD17B	STK32A	Smad9
PNRC2	SLC35F3	PPM1E	Gltp
RCAN2	ZFP36L1	STRN4	Kcnn3
SLC6A1	RP1-170O19.20	PLCH1	Rngtt
PDLIM2	TMX1	ARHGAP12	Limk1
RPS6KA5	NHS	HIC1	Fryl
SREK1	KIAA1045	SNAP25	Mmd
WNK1	WNK1	CYP39A1	Ticam1
NGFR	ARHGAP12	EPHB2	Ppfia2
BTG2	GALNT3	COL27A1	Gcc1
RP1-170O19.20	COMMD3-BMI1	KDM3A	Tmem25
MSANTD3-TMEFF1	MIER2	AMER2	Mdn1
SRPK2	KCND3	PHF24	Arhgef40
NRBF2	STK32A	FAM126B	Isl1
ABHD12B	ARHGEF11	MDN1	Galnt3
MVB12B	GPAM	RAB20	Rsbn1l
FBXO33	HIC1	EML1	Trove2
TMEFF1	NGLY1	ISL1	Kdm3a
KBTBD11	GABRA6	RNF38	Snx12
SOCS6	UGT8	USP49	Armc8
PKIA	DLGAP3	TMEM64	Mnt
ZFP36L1	ELOVL6	PPFIA2	Erich5
CASC10	VANGL2	SCAI	Ulk1
SS18	CHRM2	SFXN2	Vegfc
COMMD3-BMI1	FAM222B	SORL1	Pdhx
AFF4	FBXW7	TMEM167A	Gpr149
OSBPL10	RNF125	ZNF652	Trim12c
COL21A1	UBE2W	UGCG	Sh3bgrl2
FAM133B	FAM84B	MET	Zfp36l1

SSH1	PPAP2B	ARHGAP32	Nemp2
HOXA13	CDH24	RET	Krit1
JAG1	FAM155A	CASC3	Spty2d1
RELN	PDE1C	SLC7A11	Cables2
IGJ	SAMD12	BAZ2B	Cox11
PDHX	NAA15	PLAGL2	Samd10
AK4	TMEM25	RECK	Rapgef2
TRIM23	CATSPERG	NAA50	Colca2
LIN7C	PPARG	MED12L	Nsd2
UBE2E3	ZBTB37	SH2D3C	Ccdc92
UBR5	KIAA1199	FAM155A	Mtss1l
RNF144A	KBTBD8	GRIA4	Casc3
ABHD17B	GRIK3	C20orf194	Ppp1cc
SGMS1	DLL4	WNK1	Csf1
FBLN2	TRABD	PLCL2	Scai
HOXA5	HOXA5	MAPK8IP3	2310007B03Rik
HIC1	SH2D3C	CECR2	Tmtc2
FAM155A	COL11A2	PDPK1	Pxmp2
RASGEF1B	STIM2	ZFP36L1	Rps6ka5
CA7	YPEL2	IRF4	Kcne4
ZNF488	ALDH4A1	LTBP1	Cxadr
GREM1	TMEM132E	CLPP	Nrep
TMTC2	TRMT2A	ZFHX3	Ubr1
PAX9	MTMR12	VPS4B	Ikbip
UBE2W	ZNF385A	SNX12	Syn3
ATP8A1	MTSS1L	GREM1	Tmem240
NGFRAP1	TMEM64	NRBF2	Agfg1
NRP2	DCAF7	NUS1	Esr1
SH3RF1	NR2F6	PDE10A	Wnk1
HAND2	DCX	RASGEF1B	Ltbp1
GPAM	CTDSP2	RHOT2	Samd12
GCNT2	CRKL	CDIP1	Pom121
TNR	ARHGAP21	SH3BGRL2	Usp49
FBXW7	ZNF618	FEM1B	Klhdc8a
CCDC50	WEE1	UNC80	Ech1
APLNR	CORO1C	RELN	Snap25
MDM4	SLC39A13	ABCA12	Pira1
FAM134C	C10orf54	IGSF3	Sall4
MSL1	IGJ	DIRAS1	Ncam1
SCAMP3	MYEF2	CDH24	Sirt1
KCND3	LETMD1	ZNF800	Colgalt2
SOCS5	GALNT7	PDE7B	Arhgap21
RNGTT	SOCS6	PTPRT	Ttc30a1
CTDSP2	TLX1	SP1	Hoxa5

ZNF385A	C19orf81	RNF144A	Dcp2
MAPK14	HOXA9	SAMD10	Pira2
UGT8	TFEB	MAPKAPK3	Nrbf2
SMURF2	FUBP3	ARHGAP21	Camta1
SAMD10	ABCB9	SMARCA2	Usp46
GPR135	BTG2	FAM155B	Sp1
CLCN6	MDFI	SEC24A	Map2k7
SLC39A11	VEGFC	CREB1	Ube2w
SP2	SALL4	NSD1	Riok2
CSRP2	WNT3A	RSBN1L	Xirp2
KITLG	XPR1	CCNC	Slc10a7
CLP1	NIPAL4	IL13RA1	Itga5
YPEL2	NDST1	ABCB9	Lrguk
NR2F2	PDHX	PGAP1	Capza1
SOX7	HMGB3	KBTBD11	Mknk2
LRAT	NGFRAP1	UBR1	Tmem167
FAM222B	FOXQ1	LITAF	Bcorl1
SAYSD1	CACNA2D3	H3F3C	Tgds
CDS1	PRICKLE1	UBE2W	Osbpl2
FAM193B	PDE8B	PIH1D3	Crkl
HAO1	FAM126B	COL21A1	Phf20
LDLR	HAO1	MEGF11	Eml1
SSSCA1	MATN3	C20orf202	Fn3krp
KPNA5	KCNK10	NREP	Plppr1
HOXA9	AK4	MSL1	Abcb9
ZNF618	MAP2K7	CA10	Nav2
SYT1	FAM155B	DCC	1700025G04Rik
MATN3	TMEM91	PPP4C	Gys1
IRS1	PALM2	MTMR4	Sec61a1
EPB41L4A	LRRC55	UBE2N	Fam78a
STK24	MEGF11	GLTP	Car7
PPARG	CSF1	PPME1	Med12l
FAM78A	EPB41L4A	SYT1	Elmo1
RAB33B	TTC9	TMEM30A	Klrb1f
FBLN5	MINPP1	WDR7	Tbc1d8
UBE2D1	CCDC28B	STK24	Jag1
SMAD9	AKIRIN1	ATXN10	Chd2
STIM2	PKIA	GCC2	Zfp664
POU2F3	RASGEF1B	FBXW7	Ngfr
FAM172A	SP2	CCNT2	Ppig
CACNA2D3	ZNF652	DCP1A	Naa15
PKIB	PELI2	FAM177A1	Ankrd40
MARCH8	PTPN5	PNKD	Dcx
THOC1	DVL2	AMD1	Zfp704

GRIK3	TRAPPC8	CTDSP2	Soga1
ELMO1	ARHGAP1	MBTD1	Peli2
SLC26A11	VWC2L	OSBPL10	Dcc
XPR1	GCC1	BCORL1	Fam120c
RAB24	FAM102A	VANGL1	Cecr2
CBX5	THRB	TXNIP	Pank1
MMD	DOT1L	SREK1	Slc7a14
ELP6	C7orf41	FNDC4	Stk40
ADORA2B	SH3RF1	SOX7	Atxn10
FOXQ1	NR2F2	C1QTNF7	Zhx1
DCAF7	DCP2	KCNN3	Fam91a1
PLEKHH2	ECE1	RPS6KB1	Usp42
NAA50	FAM49B	TRIM23	Hcn4
ATP5G3	NDUFS4	FBLN2	Nusap1
GALNT3	JHDM1D	DISC1	Col27a1
LIN28A	CITED2	SEC61A1	Tmem170
NDST1	FAM193B	SGMS1	Rps6kb1
CAPN7	CD34	MDH1B	Gab1
FBXL20	SAMD9L	SLC35F3	Palld
MIEF1	CABLES2	ANKRD40	Ankrd6
DIRAS2	ARPP21	ABHD17C	Msl1
NRIP2	ZC3H12D	SIRT1	Usf3
AMD1	SV2A	GSPT1	9130008F23Rik
CDH11	TGFBR1	NAV2	Tmem178b
CORO1C	STK24	NEMP2	Acvr2a
SAMD12	ULK1	CKAP4	Naa50
ABCB9	GRIA1	ITGA5	Mtdh
COX7B	SSH1	AKR7A2	Chtf8
GSPT1	STRN4	ADAMTS5	Car12
CDH24	TNPO1	GALNT3	Opn4
EGR3	NABP1	PROSER2	Ppp1r3d
ZNF462	NFX1	SP2	Edn3
MTSS1L	SYT1	GRM5	Bag2
RAB27A	KIAA1033	SPG21	Kcnd3
PDE3A	GREB1L	ZNF618	Lbh
GPR61	STK35	HECTD1	Glipr2
ARPP21	GPR135	SSH1	Plekhm3
UNC13C	HGF	RAP1B	Csmd2
CSDC2	RPS6KA5	SAMD12	Dlk1
ROR1	KDM3A	UBA6	Pds5b
SALL4	GPR126	HOXA5	Kmt2c
OSER1	MPPED2	JAG1	Nsd1
TMEM25	LRAT	HAPLN1	Sertad2
MTDH	C10orf137	RND3	Adamts18

TNPO1	MPP6	EFR3A	Magi3
SRSF9	GRB2	MATN3	Vps4b
MDFI	ZNF24	N4BP1	4930564D02Rik
KCNK2	CACYBP	MLLT10	Iffo2
STAT1	CDH11	SH3RF1	Gcc2
SHISA6	MTA3	ZKSCAN2	Hapln1
C20orf194	INSM1	CEMIP	Melk
ZBTB34	PDE7B	RERE	H3f3b
KCNA4	ELMO1	ERLEC1	Gpd2
RBPMS2	MME	GABBR2	Ncapg2
HMGB3	TPD52L2	ZFP82	Slc5a3
TPD52L2	E2F7	AFF3	Abhd17c
NABP1	RAPGEF2	GSK3B	Mdfi
ZNF652	SNX18	MYT1	St6galnac3
ZNF784	AGFG2	BMI1	Pikfyve
CSF1	KLF4	LYPD3	Vangl1
NUS1	PTPRB	TMC7	Paip2
TMEM229A	NUS1	TMEM25	Mmp1a
SMAP1	FLRT3	INO80D	Slc39a13
TDP1	NT5C1A	CACNA2D3	Dpy19l3
CACYBP	PAPPA	ITPKC	Tor1aip2
ARHGAP12	DCUN1D1	MMD	Slu7
GRIA1	DROSHA	ST6GALNAC3	Cep162
FAM133A	PDS5B	MAP2K7	Wbp1l
CBFB	MSL1	SLC35F1	Gnpnat1
AGFG2	ACTA2	WEE1	Kcnj3
WDR7	FBLN2	LBH	Rgs8
C19orf81	EFR3A	PAX9	Myt1
DAZAP2	NLN	FBXO30	Irs1
EN1	OTX2	PDS5B	Cpne8
DDAH1	ATP8A1	NEUROD6	Pparg
ACTA2	PDE3A	APOLD1	Pcdh20
GALNT5	IRS1	EPB41L1	Plekhh1
DLGAP3	MGAT1	COPB2	Rere
NDUFS4	TMEM229A	STX7	Wsb1
UBR1	SP4	MINPP1	Pde8b
FUBP3	MAPK8IP3	PLPPR1	Hic1
MAPK6	AXIN1	MNT	Aph1a
VPS4B	MDM4	ALDH4A1	Sgms1
CITED2	FAM104A	CA7	Prr18
PPME1	CCNG1	FAM78A	Adcy2
LRRFIP1	UGCG	HCN4	Itpkc
KIAA1033	CBX5	DCX	Rbpms2
EYA4	HSPD1	EYA4	Nab1

CRKL	HAPLN1	GNS	Dnajc3
PDE8B	ADAM10	NPTXR	Zfhx3
UNKL	LYPD3	HMBOX1	Bahd1
JHDM1D	UPF1	IFITM10	Aff3
TMEM132E	SLC39A11	GPATCH2L	Syt4
GPD2	ARID1B	MOSPD3	Cacna2d3
LDLRAD3	PCM1	LHFPL3	Ngdn
GOLM1	MKNK2	ING5	Ypel2
REPS1	SPRY2	RETREG1	Selenon
C1orf52	CDS1	MTSS1L	Slc7a11
GNS	TADA1	C1orf21	Tbc1d22b
ELOVL6	PDE10A	ST14	Rab36
DCP1A	HBEGF	ARF3	Tab3
SLC39A13	RLIM	SOCS6	Tet1
DCX	ZCCHC24	OPA1	Tub
WBP1L	MAFG	ZC3H12D	Clcn3
UAP1	PCP4L1	DPY19L3	Nipal4
LIN28B	FRMPD3	CHTF8	Grm5
FRMPD3	HOXB8	CCDC92	Enah
MLLT10	IFFO2	MIPOL1	Gng12
STRN4	DUSP5	COLGALT2	Slc35f1
TMEM64	TMCC1	CRKL	Sh3rf1
C8orf4	ERMP1	MED14	Hlx
MME	RSBN1L	WBP1L	Cpeb3
SNX18	RPGRIP1L	GIGYF2	Ugcg
PTPN5	HSP90AA1	SOGA1	Swsap1
KLF4	NPEPPS	KIRREL1	Plagl1
ZEB1	SET	KLHDC8A	Rnf139
SRGAP2	EFNA2	KAT7	Scaf11
KLHDC8A	CDH5	ARID1B	Nrp2
UBE2F	DAZAP2	CLDN18	E2f7
TRMT2A	FBRSL1	TCEA1	Mcmbp
UGCG	FAM222A	ZBTB20	Btg2
FBXO30	SMAP1	SLC39A11	Ccdc71
TAF4	APLNR	STIM2	Pik3r1
GCC2	BDP1	SCAF11	Xpr1
DNAJC3	CCDC88C	LPAR6	Mybpc2
HIPK2	UNKL	SMAD9	1700066M21Rik
TRABD	MARCKS	NDST1	Fbxo33
BCORL1	NCOA7	DHTKD1	Hip1
FLRT3	CSRP2	B3GNT7	Arrdc4
ARHGEF11	SMARCA2	SLIT2	Mtfr1
FAM155B	CBFB	TMEM87A	Med13l
NLN	NFE2L2	REPS1	Rnf38

CNR1	STK39	F3	Tmem121b
RUNX1	DDAH1	EPB41L4A	Mier2
OTX2	VWC2	HIP1	Lrat
MPPED2	GIMAP6	USP46	Rspo4
TMCC1	PIK3R1	SHTN1	Plxnc1
KCNN3	MYT1	GTF2A2	Cipc
E2F7	ITPKC	ASPH	Steap3
RRAS	PHLPP2	GPD2	Pard6b
TMEM91	SUCO	MARK4	Arhgap32
PPFIA2	NFIA	SASH1	Med14
ARL8B	ABL2	SLC26A11	Suz12
STK35	RP11-122A3.2	ITCH	Ino80d
C2CD2	GATA2	KIAA1109	Bub1b
TMEM151B	MLLT10	SLC5A3	Amer2
AMMECR1L	MSN	NKX3-1	Onecut2
SV2A	CAMK1D	DPY19L4	Sgpp1
FAM102A	COL27A1	SNX18	Phactr4
NAA15	OAF	DPP10	Stmn2
CCDC149	EDAR	RCAN2	Syt1
GOLGA6C	ITGA5	G6PC3	Adamts16
ABL2	SLC6A6	TPPP	Nptx2
RSBN1L	UBE2E3	LIMK1	Lpp
TEAD1	ING5	CBLB	Cnot6
KIAA1045	GNS	ENAH	Fbln2
NGLY1	GCC2	KMT2A	Lonrf1
POM121C	ADAMTS10	SKA3	Nabp1
AGFG1	SIRT1	COL5A1	Ildr2
ING5	SLCO3A1	ONECUT2	Ndufs4
GNG12	FAM133B	MME	Mcf2l
PPIF	BRSK1	FXR2	Fbrsl1
ULK1	ZHX1	SLC24A4	Ssbp2
TSTD2	NBEAL1	SPATA17	Itga4
C17orf85	SHOC2	FSD2	Tmem206
SMPD3	VPS4B	CSRP2	Rybp
DUSP5	TFAM	APBA2	Plpp3
TYW1	KCNJ3	CNTLN	Sfrp1
ZKSCAN2	AMMECR1L	ELMO1	Opa1
GAB1	TMEM151B	NRXN1	Trim23
GOLGA6A	RND3	MCF2L	Socs6
MCF2L	GNG12	RAB11FIP1	Elfn2
MPP6	C8orf4	UTP15	Vip
RET	DYNLL2	GAPT	Pitpnm2
TGFBR1	STOX2	RAB39B	Rhbdf2
WNK3	CCT3	STK35	Mapkapk3

PLXNC1	RUNX1	ECE1	Nus1
MAP2K7	SNAP25	MSTO1	Snx18
TMEM170A	WNK3	TNFRSF10D	Foxa3
SPRY2	DTNA	BICC1	Bmi1
MYOCD	CLVS2	NEURL4	Rap1b
SP4	SYT2	RARA	Ifih1
NPEPPS	SKOR1	WNT3A	Abhd17b
ERMP1	RRAS	MBOAT2	Cdk18
PPP4R2	EYA4	PPP1CC	Stk39
RP11-122A3.2	AMER2	NRP2	Zfp143
GCC1	FOXB1	CA12	Zfp385a
C7orf76	KSR1	TTC39B	Traf3
GATAD2A	CD2AP	SERTAD2	Bche
NAV3	CAPZA1	MIER2	Sh2d3c
BMP2K	ITSN2	SAMD9L	Ntrk3
HBEGF	BCORL1	CCNK	Cabp1
KAT7	EBF3	E2F7	Mageb4
PCM1	MSTN	MTDH	Mospd3
C10orf137	MNT	OPHN1	Apaf1
PXN	WBP1L	GLRA2	Stag1
UST	TAF4	STAG1	Stk35
COLQ	PRR3	ZDHHC17	Insm1
CCDC88C	ARHGEF37	SLC39A13	Fubp3
DVL2	NRK	UBN2	Fam69a
DTX4	PRDM12	PITPNM2	Rasgef1b
HOXB8	MYOCD	GEM	Ammecr1l
ID3	UBA2	SMAD2	Nr2f6
NR2F6	C7orf60	TSR1	Scml4
ERC2	CCDC50	PANK1	Ikzf1
SLC6A6	NPTX1	ZNF705E	Myocd
CCNG1	NETO1	KCNA1	Npbwr1
MED14	GSPT1	TET1	Lhfpl3
TLK2	STAG1	UBE2V1	Igsf6
HGF	RP11-192H23.4	YAF2	Vav3
THAP1	MEPCE	DYNLL2	Ikbke
SMARCA2	MSI2	PLD6	Pde3b
IGSF3	RNGTT	DBF4B	Shisa6
CYB561D1	MFSD2A	AARD	Adora2b
NEUROD4	RBBP6	NCOA7	Kirrel
SAMD9L	RCAN2	FAM102A	Ubn2
ARF3	PEAK1	RIC3	Ss18l1
C15orf27	MESDC1	MTA3	2410004B18Rik
RPGRIP1L	ZBTB42	PTPRQ	Ypel3
H2AFY	AFF3	PTAR1	Fam102a

LASP1	PELI3	GCNT2	Wnt3a
GPR125	KLHL31	DZIP1	Hbegf
NIPAL4	SOWAHA	ZNF84	Dlgap3
GRB2	PLEKHM1	DENND1B	Skap2
GNB5	CLCN6	ATP6V1C1	Ccnk
CCDC28B	ELL2	KCTD4	Pde10a
DDX6	GFPT2	CCN4	Adamts20
CCNT2	LPPR1	SBF2	Zbtb39
DDHD1	PDPK1	SETD5	Lypd3
FOXB1	ZMAT3	TMEM132E	Diras2
LMNB1	GPD2	FBRSL1	Eya1
AMER2	PSEN1	CLCN3	Ankrd10
KSR1	CNOT6	SLITRK1	Lpin1
GOLGA8A	PDE3B	ZNF737	Ppp4c
CNOT7	TUB	CIPC	Znrf2
WNT3A	CYB561D1	SRP72	Slco4a1
C19orf40	B3GNT7	TBC1D22B	Greb1l
FAM126B	ST14	YPEL3	Gosr2
RPN1	TMEM170B	MED13	Nr5a2
SHOC2	LCOR	C17orf102	Elovl6
RGPD6	GLRA2	IFFO2	Tmem132e
TGOLN2	POU2F3	ADGRG6	Creb1
MSI2	ERC2	PITHD1	Hoxa9
NCS1	DKK2	SLC6A17	Smap1
DROSHA	NEURL4	RGS6	Clpp
STOX2	C15orf27	PCM1	Sv2a
UBE2V1	IPO7	WNK3	Zc3h12c
ENAH	FAM83F	PFKL	Ntrk2
AGPAT3	COLQ	MDFI	Ppme1
HSPD1	MPP2	RBPMS2	Necab1
SASH1	CSRNP1	EBI3	Prx
ADAMTS5	INSR	NXF1	Mtx3
DCUN1D1	LIMK1	WASHC4	Tmx1
PPM1E	TMTC2	SEMA6A	Grk6
BRSK1	SRL	PHF20	Galnt7
CNN3	NEDD4	ZHX1	Cdh11
RLIM	TNRC18	PLXNC1	Hectd1
ITSN2	MFHAS1	ABHD17B	Clcn1
NETO1	LPPR5	VAV3	Tmem266
BRWD3	AGPAT3	EDRF1	Ctu1
RSPO3	NEURL1B	TCEANC2	Stim2
ZHX1	ZNF800	ZCCHC24	Tnrc18
MTA3	CEP128	STARD4	Mphosph9
PLCL2	PPME1	EYA1	Sash1

EIF5	TLK2	PDE12	1110004F10Rik
CNOT6	NR5A2	NR2F6	Eml5
ZNF608	UBE2V1	SEMA6D	Cited2
KCNA1	HOXC6	ARHGAP28	Neurl4
SLC10A7	TMEM110	MPL	Ctdsp2
BCL3	CBFA2T3	CDCP1	Srgap2
NFX1	FAM65B	PIK3R1	Csdc2
PELI3	RPS6KB1	TMEM266	Pdxk
PTGER3	RORA	FOXO1	Psmb1
C11orf87	DCP1A	LRAT	Zic4
PTPRB	HECTD1	OGFRL1	Prkag1
SYNDIG1	ARX	LMTK2	Ebf4
INSM1	BRPF3	FAM172A	Cfap300
NT5C1A	RAB11FIP1	NCBP3	Ppif
GLRA2	FOXP2	ANK1	Msh4
TUB	CCM2	CPEB3	Zfp827
SYT2	RCOR3	TMBIM6	Syndig1
HECTD1	DTX4	RASL12	Hoxa10
EFNA2	E2F3	CYLD	Xrcc2
RNPEPL1	POM121C	MOB1B	Prom2
LHX1	KCNAB1	SYNDIG1	Stk24
KDM3A	DDX6	RGS8	Traf6
SLC16A10	GMPS	AMMECR1L	Hdgfl3
CHRM2	CREB1	ATL3	Sep 02
ADAM10	ZBTB34	CCR9	Dcp1a
GXYLT1	GLIPR2	EHF	Ptprb
NPTXR	MED13	LSM1	1600012H06Rik
NPAT	HOXA10	NPTX1	Plxnb1
MBLAC2	LRRC10B	YPEL2	Rgs6
PDK1	NCAN	IBSP	Grm1
SPTBN1	LONRF1	NTRK3	Notch2
BCL2L13	ARHGAP19-SLIT1	TNRC18	Nrl
TLX1	PPM1E	CAPZA1	Cntln
HAPLN1	STEAP3	CBFB	Gfpt2
SMIM14	ARID2	DLGAP3	Psmd6
FOXO4	SHISA6	AGO3	Spindoc
DLL4	BAHD1	UBE2E3	Agrn
CAPZA1	SRP72	PLEKHJ1	Cbwd1
GREB1L	FOXP4	DUSP18	B4galt1
SET	TBC1D22B	CCT3	Prex2
MARCKS	CDK18	PFKFB4	Rnd3
SMAD5	MAP4K5	SMURF2	Mme
RAPGEF2	HIP1	DCAF7	Nhsl2
NCAN	DNAJC13	SPTBN1	Washc4

GOLGA6D	LMBR1L	ACVR2A	Nin
ATXN10	SREK1	LIX1	Zfp740
CECR2	APPBP2	GNG12	Itch
PANK1	LHX1	LY6G5B	Cdca7l
STAC	ACOT11	IKZF2	Rnft1
EEPD1	ELFN2	SLU7	Plcl2
MET	SEMA6D	CNR1	Utp15
SERTAD2	USP46	CPD	Tia1
NEURL1B	C17orf85	PDGFRA	Gns
KBTBD8	DPY19L3	TAB3	Slc26a2
MIER3	SYDE1	TRAF3	Stk32b
PALM2	KIAA1109	TFEB	Edrf1
IFFO2	DTX1	HEG1	Fam155a
VAV3	RAI14	ADCY3	Sos1
GABBR2	ZADH2	GATAD2A	Slc6a6
USP46	SFMBT2	RBM4	Dnajb1
FGD6	EIF5	ELOVL6	2010111I01Rik
FAM105B	CPEB3	FUBP3	Mpped2
KIRREL	HEG1	MIER3	Cemip
SHE	CTDSPL	PCTP	Gatad2a
LIMK1	SRSF1	MAGI3	Tlk2
LPPR1	MAPKAPK3	PTPN5	Ttc28
STAG1	SIPA1L3	GOT2	Nxf1
FOXN4	SERTAD2	HIPK2	Pax9
DEPDC1B	MED14	UNC45B	Arid2
MAPK8IP3	PPFIA2	TMEM91	Cacng2
NFE2L2	CCAR2	INSR	Ccdc28b
TRPV3	PCDH9	SFRP1	Kpna3
NEDD4	CTDSPL2	ZNF510	Plekhg1
PRMT8	RNF141	HOXA9	Srp72
AGO3	TSTD2	DCP2	Prmt2
EDEM3	ELOVL4	SCAMP3	Lpar6
PDPN	RASA2	C11orf87	Slk
CCM2	CLSTN2	PLPP3	Nptx1
ARID2	FOXO4	IPMK	Akap10
METTL21A	SYNDIG1	TM9SF2	Ddx6
SLC16A1	GAD1	LGALS3	Aldh5a1
ELL2	CCNJ	BAHD1	Ncoa7
CKAP4	TBC1D4	RIPOR2	Dcdc2a
EBF4	TRPV3	NPAS3	Fbxw11
GFPT2	IRF4	HOXA10	Fam126a
ADCY2	BCL3	TCAIM	Fut2
NCOA7	ADCY2	PTPRJ	Ncoa5
TNRC18	FOSB	BEX3	Coq7

SYDE1	C11orf87	KMT2C	Ccn4
TGIF2	IKZF2	TLK2	Chrnb3
SUCO	NAV2	RESF1	Chst12
PDPK1	PLEKHH2	SEMA7A	Sox7
RNF141	MBTD1	H2AFY	Arhgef26
AFAP1	FGF14	UNC5D	Cacnb2
ADAMTS10	EYA1	ZBTB39	Igsf3
FGF14	PLXNC1	GRIP1	Olfm3
FOSB	NRP2	ZNF696	Lsm12
VASH2	FAM13A	NUDT6	Acad12
HOXA10	TSC1	GFPT2	Slc39a11
MED13	MDGA1	CCDC50	Dnajc27
TSC1	ZNF608	PPIL4	Erc2
PDGFRA	PTPRT	PTPN4	Cep70
ZBTB39	ZC3H12B	COL3A1	Fgf1
ARX	GRM5	DCK	Lasp1
SETD7	EDEM3	DDX6	Cmtm3
LPCAT1	LDLR	BMPR2	Cfap97
UPF1	ERG	CCDC71	Pgm2
RERE	ADCY3	UNKL	Arhgef11
EHD3	GDF11	CASC10	Abca1
ZNF800	PDLIM4	FBXO33	Iqsec1
E2F6	BRWD3	PRKAG2	Nfe2l2
FOXP2	PURA	COX6C	AI593442
GAD1	ADAM19	ULK1	Heg1
SERBP1	EPB41	ABCB10	Ptpn4
PLEKHM1	GABBR2	TRIM32	Cbfa2t3
FAM222A	ADAMTSL1	TPH2	Mob3a
SKOR1	HCN4	MAGEA10	Fads1
CALN1	TMEM189-UBE2V1	USP15	Oxgr1
C6orf211	TMEM189	CDKN2A	L2hgdh
ELOVL4	SOX11	PTGER3	Mcm6
ITGA5	RBM12B	MEGF6	Lsm1
TMEM189-UBE2V1	STK38L	ADGRA3	Sfmbt2
TMEM189	TET1	ACTA2	Traf1
CCT3	MAN2A1	SLC25A25	Trim66
CAND1	DAB2IP	ID2	Kcna1
TMEM123	CLCN5	DEF8	Zfp677
PPAP2B	KAT7	FGD6	Hsf2
MESDC1	SIK1	LRRN4CL	Ythdf1
RPS6KB1	LSM12	ACTR8	Csrp2
NEURL4	PDGFRA	ARHGAP19	Vsx1
LONRF1	TCF4	RAB3B	Abl1

PDE10A	SATB2	NAA15	Foxo1
LMBR1L	ZEB1	RAP2A	Brsk2
PEAK1	TIAL1	STK40	4932438A13Rik
DYNLL2	AFAP1	TMCC1	Zdhhc17
PNISR	VGLL3	RALGAPA2	Clec14a
LCOR	KLHL18	ST13	Dkk2
RREB1	ZBTB39	ZBTB34	Dll4
PDE3B	MAPK10	NHS	Ehf
TRAPPC8	USP42	NETO2	Arl4c
SPOPL	RAD54L2	TRMT2A	Zfp800
C17orf70	STK40	PELI2	Baz2b
MAPKAPK3	SS18L1	UBE2K	Gpr156
HOXC6	FIGN	CDYL2	Nyap2
KCNAB1	KCNN3	VSIG10	Gata2
MAP4K5	C1orf21	FAM122B	Sfxn2
CTDSPL2	DFFA	PARK7	Paqr9
PARD6B	RUFY3	KPNA3	Dcun1d1
APPBP2	FXR2	CPA4	Dennd1b
ABCA1	ABCA1	SBNO1	Adam22
SORL1	NXF1	SDF2	Fga
DMBX1	MTMR4	NOVA1	Nrf1
ZMYM4	JMJD1C	NIPAL4	Rxra
PAIP2B	SLC38A4	CAB39	Arhgef37
TRIM67	NPTX2	CHKA	Twistnb
GDF6	COLGALT2	PLAGL1	Fuca2
PRPF19	KPNA6	PSPC1	Smarca2
TXNIP	FZD3	PROZ	Ank1
MAP3K4	MAN1A1	GOLGA6C	Zfp275
ARHGAP21	SH3PXD2A	RUNDC3A	Ngp
LANCL3	NKX3-2	MDM4	Brpf3
RUFY3	AMD1	NRARP	Appbp2
PCDH9	PTPN4	ORMDL3	Depdc1b
CSRNP1	TBC1D25	TM4SF20	Kif21a
EYA1	TGFBR3	ANKS1A	Rara
GRAMD2	NTN1	TMX1	Med13
PIK3R1	NRXN1	TYW1	Ccdc50
CCNY	FURIN	USP25	Sowaha
PAPSS2	MYH15	TMEM170A	Cd34
TNIK	CCNY	IKZF1	Ccdc141
GSPT2	ZC3H12C	DOCK11	Kcnk1
FBXO21	GRIN2B	DNAJC13	Pkia
CPEB3	KIRREL	LPGAT1	Lancl3
SATB2	UBE2F	ZEB1	Ppil4
TMEM110	RERE	ZNF569	Msrb3

MGAT4B	NAV3	NKX3-2	Sep 12
PRICKLE1	CCDC85C	DVL2	Hadha
WSB1	MYBL1	NDUFS4	Aldh1l2
LYSMD3	ZZZ3	KCNA4	Mroh2a
SRL	ACER2	CBFA2T3	Litaf
CCNJ	SMG1	NTNG1	Hif3a
HLX	TRERF1	TTC28	Optn
SLC35F1	MET	GATA2	Rnf145
ZNF24	FGD6	BRSK2	Ston2
CHST1	WDTC1	DMTF1	Frem1
MPP2	NEO1	FN1	Epb41l4a
ARHGAP19-SLIT1	SLC10A7	CLP1	Vcan
ELFN2	NAIF1	KMT5A	Taf4
NF1	SOS1	EIF5	Gm5615
ARHGEF37	MGAT4B	INPP5J	Cd8a
LPPR5	SLK	PIAS2	Scn3a
MNT	ARFGAP2	INPP1	Cptp
GPR75	BBX	POU2F1	Calm1
PHF20	EN2	NEK6	N4bp1
PRELID2	LMTK2	TBC1D9B	Plscr1
PURA	SCYL3	JCHAIN	P2ry4
SURF4	EIF2S2	ARFGEF1	Mob1b
EPB41L2	KIF5B	FAM102B	Orc5
B3GNT7	ADCY6	CDH6	Fam120b
NPTX1	TMEM178B	SUZ12	Pde7b
GHR	TOM1L2	KCNJ3	Thsd4
TCF4	TXNIP	SHISA6	Pdpk1
MGAT1	WSB1	ALG9	Egln1
SRSF1	HIVEP3	TENT4A	Mlycd
PLAG1	INO80D	PRDM16	Lynx1
RALGAPA2	CLCN3	ETV3L	Itga9
FBRSL1	ZFP36L2	HAND2	Foxq1
KIAA1109	FRYL	LRRFIP1	Crocc2
MBTD1	WIPF2	UNC5C	Txnip
CHIC1	SEMA6A	DMKN	Utp14b
REEP2	NRARP	ADH7	Fry
TAF5L	PGAP1	SPATA2	E330034G19Rik
IPO7	ITCH	ATOH8	Gxylt1
CCNK	ELAVL2	ARL8B	Zadh2
PRR12	DNAJB1	SHE	Arnt
VAT1L	PHF20	YTHDC1	Atoh8
TBC1D22B	RNF146	OGA	Nup50
MFHAS1	MBOAT2	ORC5	Timm21
NRK	CDYL2	ELFN2	Il17b

ITGA2	USP49	PKIA	Inka2
NFIA	SLIT1	LIN7C	Ano6
HIVEP3	MDN1	KIAA1549L	E2f3
RSBN1	SLC5A3	ILDR2	Styk1
NETO2	QKI	SESN2	Ccnb1
KCNJ3	ZFHX4	TDRP	Fam84b
PDS5B	FAM129A	NECTIN3	Zfp462
PMF1-BGLAP	RREB1	S100A7A	Zc3h12d
CDYL2	ACVR2A	TCIM	Dnajb11
DOCK11	CREBRF	DCAF17	Gtf2a2
SIRT1	UNC80	UHRF2	Dvl2
CDK18	UBR1	FOXN3	Focad
CLCN3	SRGAP2	TAF4	Slc12a2
CREBRF	BICC1	SSX2B	Lhpp
LYPD3	KMT2A	NEMP1	Trio
FKBP14	CEP135	DDHD1	Fbxo30
EN2	TNIK	PDE3B	Ptgfr
NPTX2	ZNF516	RMND5A	Homez
ZCCHC24	NOL4	CRB2	1700015F17Rik
BICC1	DGKI	TMEM229A	Tspyl3
ABCA12	KCNA6	TRIM6-TRIM34	Gm14440
SOX11	TNR	PNISR	Unkl
SEMA6A	IKZF5	MAST4	Smim20
ZZZ3	GAB1	TRIM34	Tmcc1
PPIG	FAM126A	SREBF2	Ccnj
TOX4	LOX	NLRP2B	Plcxd2
GORASP1	IKZF1	RXRA	Inpp5j
ARID3A	LSAMP	LIN28B	Pdia6
FRYL	SHANK3	TPM1	Zfp618
PLEKHH1	MARCH8	ERG	Luc7l2
NKX3-2	ZNF827	CPLX3	Rab35
CLCN5	POU2F1	DKK2	Tmem91
C6orf223	SLC7A11	SSX2	Bcas1
MEPCE	KMT2C	FAM206A	Rffl
DNAJC13	GREM1	ZNF792	Eepd1
GPR133	NF1	PLAG1	Kif5b
TFDP2	ALDH1L2	C1orf52	Unc5d
FIGN	MSI1	TBC1D1	Orc3
PELI2	DOCK11	KIAA1211L	Atg2a
E2F3	C11orf84	ADAMTS10	Smg1
OAF	ZNF638	TMUB1	Pde1c
SGPP1	IGSF3	ARHGEF26	Zeb1
CREB1	ARL8B	HBEGF	Myef2
RAD54L2	LARP4	RASAL2	Jmjd1c

EPB41	ATL3	IL12RB2	Tsc1
SNAI1	COL3A1	CRTC1	Ripor2
DTNA	ATP2B1	RFX3	Tbc1d9b
PEG10	APBA2	ELAVL2	Cdc42
C7orf60	RSBN1	AIF1L	Ptpre
MAPK1	XIRP2	BET1L	Arl8b
GNA13	E2F6	ALDH5A1	Herc3
STK32B	ITGA2	WDFY1	Lin7c
FOXP4	EFNB2	SAR1A	Dixdc1
CPEB4	LPCAT1	TRIO	Dym
HNRNPF	SASH1	TBX3	Mybl1
IKZF2	BMP2K	WIPF2	E130308A19Rik
MAN2A2	EHF	MS4A2	Cxcl13
RAB39B	CCDC120	CCDC85C	6430571L13Rik
BHLHE41	NFASC	RBM33	Larp4
LMTK2	CRTC1	MTMR10	Mbtd1
CCDC120	ENAH	POM121	Wdr60
NPAS3	TSPAN9	PDK1	Letmd1
RASD2	ZNF275	GALNT13	Cyp2b23
FXR2	ZNF664	ZFP36L2	Pigk
IKZF5	CNNM2	KIAA1210	Rfpl4
TRAF3	MANEAL	RREB1	Rad51c
PGM2L1	PLAG1	ELL2	Mal2
GRM5	UBXN7	TMCC3	Atad3a
MYT1	NFIB	ZNF385A	Ccnc
LZTS3	NPAS3	YY1AP1	Actl6b
ANK2	RIMS3	KCNAB2	Nyx
RAB11FIP1	RORB	FAM13B	Arfgef1
FEM1B	ST8SIA4	GNG2	Ints6
INSR	CTH	PBXIP1	Cab39
DTX1	JOSD1	SPOUT1	Zbtb33
ADD2	LZTS3	NR5A2	Furin
MAPK10	SETD7	TBC1D8B	Fen1
MTMR4	PGM2L1	PLXND1	Synpr
FUT9	PDE1B	RAB3IP	Timm29
BAK1	MED1	PPIF	Reps1
CD2AP	NPR1	CITED2	Aff1
PLA2G15	KIF5C	JMJD1C	Dnase2b
LSAMP	MIER3	E2F6	Tmprss11f
FAM65B	N4BP1	PDE8B	Fhod3
SOWAHA	FRMD4A	FRS3	Zfp516
TBC1D4	NCOA1	GRK6	Gm14295
MYBL1	MEIS2	COL11A2	Ell2
CEP135	TANC2	CLCN5	Asap1

PAPPA	GUCY1A2	TMED5	Mier3
TIAL1	BRSK2	MYBL1	Tmem9b
DAB2IP	RPL36A-HNRNPH2	KPNB1	Serpinb6b
KIAA1551	PTPN9	FANCA	Ncbp3
ATL3	BMP3	LRRC57	Fam19a3
DCP2	NR1D2	DPH6	Nipsnap3b
HCN4	PAK2	USP51	Rreb1
RAB15	ZFHX3	LDLRAD3	Coro1c
BMPR2	KCNK12	NOD1	Ppp2r2d
CLSTN2	KCNA1	CRB1	Tial1
PPP4R1L	DST	SS18L1	Mrpl35
ZBTB42	NEK6	GOLGA8A	Lifr
DGKE	ASAP1	FURIN	Megf11
SYNRG	SPTY2D1	ZNF140	Map3k20
CBFA2T3	NETO2	ZNF329	Slitrk1
MKNK2	RARA	STK39	Naa11
WIPF2	DLG2	NOL4	Usp25
LSM12	ANO6	ZNF577	C2cd2
GJA3	NCAM1	ZNF426	Ttc39b
CTDSPL	ARSG	POM121C	Rundc3a
TBC1D25	FAM177A1	TMEM87B	Nek4
CDR2L	RXRA	STAB2	Gsk3b
AGRN	ATP9A	MCTS1	Man2a1
RNF146	KIAA1549	KITLG	Mpzl2
SLC29A4	OPA1	EBF4	Pnisr
DPY19L3	PRDM16	MVB12B	Sh3d19
EBF3	LIFR	DLL4	Tm9sf3
ERG	EEPD1	SLC5A9	Ndst3
ABHD5	CCDC88A	EPB41	Dsc2
WDTC1	RAB14	FAM222B	Jchain
TAL1	EPHB2	ADCY6	Stx16
NR5A2	KPNA3	USF3	Mrps36
MUC19	PPP1R9A	CDK18	Crebrf
BRPF3	NFAT5	CREBRF	Flrt2
KIAA1147	HIPK3	BLOC1S5	Golt1a
GPR126	ADCYAP1R1	TIAL1	AB124611
RFX3	MAPK1	FOXO4	Neto2
RORB	TPPP	IGF2BP3	Sp2
AFF3	PLAGL2	PRKCB	Cyp2j5
SLC7A11	PTBP2	PGM2L1	Efnb3
GSK3B	MED12L	TSC1	Nap1l2
CCDC85C	LIN7A	ZNF286A	Rhoj
PTPRT	C16orf70	ITSN2	Thrb
LMX1B	PITPNM2	FOXP4	Mtmr10

OTUD7A	NFATC1	PSMA1	4930519G04Rik
FAM129A	SUZ12	GOLGA6A	Fbxo32
KLHL31	KLF3	CADM1	Lair1
PIK3C2A	PCNX	COX18	Pnkd
HNF4G	SLC9A7	ZNF500	Rsad2
FAM13A	OTUD7A	COX8A	Rgs1
CRTC1	CXADR	GOLGA6B	Fam124a
TTC9	BEND3	ZNF860	Lmtk2
NXF1	ZNF704	GOLGA6D	Elavl2
LEP	UBN2	BAX	Sec22a
TAOK1	PLEKHH1	NUP210	Col18a1
HIP1	RBP2	PROCR	Siglech
NOL4	PCDH1	CISD2	Efemp1
ATP10B	PIK3C2A	NAB1	Lmln
AXIN1	FOXN3	ANKDD1A	Kcna6
QKI	SCAI	LSM12	Rsl24d1
SRP72	TTC28	GPATCH11	Wnt1
PCNX	SIX1	ADGRF2	Efr3a
KIAA1199	CDH6	GRAMD1B	1700071K01Rik
DKK2	BAZ2B	INSM1	Tfeb
ITPKC	EPB41L1	SGPP1	Trappc8
EDAR	C1orf52	GOLM1	Krtap26-1
KMT2C	SLC8A1	SHANK3	Xrn1
SLC38A4	PPP2R1B	ZBED6CL	Syt3
GATA2	LGI2	NCOA1	Trim29
FAM126A	TXLNG	ARMC3	B3gntl1
NEO1	SFPQ	IGFBPL1	Alg11
ATP2B1	NAA50	SATB2	Adamts19
SIK1	TMEM248	PLEKHM1	Otx2
KPNB1	AGO3	E2F3	Wnk2
FZD3	NSD1	RAB3C	Myl12b
SLC25A25	CHKA	CABP1	Golm1
ALDH1L2	GFPT1	HYOU1	Dicer1
MBOAT2	SLC25A29	BMP3	Upk1b
HEG1	AGO2	FUT9	Tmem229a
NRARP	MED13L	FAM120C	Mthfd1l
SLC39A10	SFRP1	RUVBL2	Ipo11
EIF2S2	BAG2	EN1	Gtf2a1
SCN3B	SEMA7A	DNAJC3	Zfr
MICU3	ATXN10	PLPPR5	Ipo5
GRIN2B	FAM105B	SLC49A4	Cntrl
EFNB2	ILDR2	ZNF37A	Pcm1
NFIB	MAPK6	OSER1	Stxbp3
COLGALT2	EHD3	FBLN1	Wnk3

JMJD1C	HNRNPF	MAP3K19	Zfp606
GGA2	IL6ST	RNF139	Zbtb42
CAMK1D	SLITRK3	IQSEC1	Arpp21
SAR1A	KIAA1549L	MYOCD	Rmnd5a
ELAVL2	GSK3B	DAP3	Lin28a
PAPD7	BMPR2	PPP1R3B	Hook3
ZC3H12B	ARID4B	BEAN1	Rpgr
ZNF280C	LMX1B	PDXK	Gria4
GDF11	DRP2	ZNF34	Slc1a2
KIAA0232	SPRY3	ALDH1L2	Ndst1
ZNF704	SMCR8	LPCAT1	Tor1b
KLF3	C17orf70	KIAA1191	Mta3
USP42	PAPD7	NKAIN1	Mpp2
PCGF3	ARFGEF1	SYT4	Erv3
COL11A2	FUBP1	TTC3	Eif1ad
RORA	TMED5	MICAL3	Ccl11
C1orf21	SLC22A23	C14orf93	Gm13889
SIPA1L3	VCAN	GNA13	Pabpc1l
GPRIN2	COL26A1	C1orf229	Klhl4
LARP4	RAD51D	OTX2	Clec2h
ZC3H12D	PLXND1	SMAD5	Agtrap
NTN1	SPATA2	LAPTM4B	Tmem159
DPYSL5	SYT7	GPATCH2	Mylk4
RAB4A	MTDH	G6PC2	Cep72
ZFP36L2	PNISR	FAM84B	Nova1
IKZF1	SS18	G0S2	Ncoa4
TET1	GAREM	CCNJ	Adam19
SCN1A	REPS2	JADE2	Rora
CDH5	CA12	NOL9	Chst11
MSI1	NEBL	ZIC5	Appl2
VCL	RGL2	GATC	Gspt1
MYH10	WDFY2	NEURL1B	Dglucy
SS18L1	PTCHD1	TMEM9B	Tgm3
STK39	KIAA0232	CREB3L2	Ctnnd2
BEND3	PLEKHA3	HMGB3	Hs1bp3
ITGA8	TMBIM6	LONRF1	Tox4
NFASC	POU3F3	GPR161	Clock
PVRL4	PPARGC1A	BTBD3	Map4k5
PLAA	SMAD2	RELT	Cul4b
THRB	ZNF236	SNIP1	Camk1d
ACVR2A	HSD17B8	NMB	Mrps12
FURIN	TACC1	ASAH1	Syne3
ZADH2	MBD5	PRICKLE2	Hspd1
CABLES1	CNOT1	FAM133B	Inpp5e

KMT2A	SOX6	APPBP2	Rbm33
SLIT2	ALG9	ZNF470	Wdtc1
MAN2A1	IRS4	TM2D3	Zfp764
ADAM19	MXI1	UBE2F	Rad54l2
GOLGA6L10	PIK3CA	SLFN13	Igsf9b
RP11-192H23.4	CPD	RGPD6	Jcad
PTPN4	DLK1	RNASEH2C	Pde1a
FAM53C	PRR12	GOLGA6L4	Tmcc3
COL3A1	FADS1	ARID2	Tbck
PTGFRN	KCNMB4	FADD	Rbm43
STK40	MAPRE2	GOLGA6L10	Zfp24
DGKI	CKAP4	SUSD1	Xrcc6
VGLL3	ERP44	TRAPPC8	Oprl1
UBN2	URGCP	FOXQ1	Adamts5
ADCY6	RPN1	ZKSCAN4	Ostf1
ZMAT3	NIPBL	RGPD5	Cmtm6
PDP2	DGCR14	LDLRAP1	Rab27a
ZC3H12C	CDON	MAP4K5	Slc34a1
TMEM170B	CCNK	ELOVL4	Bloc1s3
TMEM194B	TSPAN14	SLC7A1	Nepro
INO80D	PPIG	FAM13A	Zfp52
SCYL3	FCHSD1	RCOR1	Zfp324
SLC7A14	CADM1	CDR2L	Deptor
NRXN1	SLC24A4	FAAP100	Mtmr12
DENND5B	ZBTB20	PPP2R2D	Trp53bp1
TBC1D13	ATXN3	NME4	Ralbp1
SLCO3A1	ROBO1	SPOPL	Chst7
HUNK	KCMF1	CAPN7	Vsig10
DIDO1	CPEB4	ID4	Lrrc75b
KPNA6	MAP3K2	LRP2BP	Ptpn14
USP49	CSE1L	SLC10A7	Klhl12
SMG1	CACNG2	CTPS2	Vezt
PDE1B	CLPP	SLC6A6	Krtap4-7
STEAP3	WISP1	IKZF5	Tmeff1
MANEAL	PFKM	TMOD2	Chd6
RARA	CDC6	CASP1	Slco5a1
ACVR1C	DDI2	NEBL	Slc36a4
CNNM2	PAX6	INAVA	Chek1
DCBLD2	CCDC6	EFR3B	Dynlt1a
SOS1	GPR174	VIP	D430041D05Rik
PSEN1	DCC	GYS1	Atl3
BBX	KLHDC8A	PPP2R3A	Fam222a
KCNA6	CHST1	SLC9A4	Msn
RIMS3	CACNA1A	TRABD2B	Npas3

RASA2	TRIP4	CTU1	Ehd3
RP13-996F3.5	SOCS5	SMPD4	Ckap4
KPNA3	LRRFIP1	ZNF783	Fbxl18
GAREM	CNOT7	SNRPE	Pnrc1
NBEAL1		FCHSD2	Tmem268
ZFHX4		KCNMB4	Gldc
SPTY2D1		OR11A1	Jakmip3
SFMBT2		CFC1	Azi2
MED1		APOF	Arhgap19
BRSK2		AGAP1	Vmn2r89
VWDE		ARL15	Oaf
DNAJB1		MBNL2	Fbxl14
DOT1L		FAM71F2	Pfkfb2
FAM177A1		BTG2	Tceanc2
ZNF638		KCNK6	Ulbp1
PGAP1		EDNRA	Ifng
KIAA1549		CCNG1	Glra2
POU2F1		TWISTNB	Slc26a1
MN1		SIX1	Ptpn5
N4BP1		LINGO4	Zfp36l2
PDK3		CCDC28B	Lox
MICALCL		FAM222A	Ss18
NAIF1		BRAP	Fxr2
NMRK1		DTNA	Rlim
SLK		SLC39A10	Impg1
SCAI		HOXA13	Sptbn4
APBA2		SH3GL3	Itsn1
SLC5A3		ZBTB14	Cnr1
TMEM178B		SLC9A7	Tcim
MAFG		MECP2	Kif5c
BMP3		DUSP5	Agap1
NACC2		CREG2	Prickle1
SLC25A16		CSDC2	Tgfbr3
MEIS2		NTRK2	Wee1
C7orf41		TRAF1	Rnasel
TACC1		PRLR	Amot
CSE1L		RIMS3	Pfkfb4
PTBP2		SDK2	Txnl4a
NSD1		ACOT13	Mcph1
KIF3A		WTAP	Rab34
SRCIN1		WDTC1	Ero1lb
PHC2		APCDD1L	Epha5
SCD		BHLHB9	En1
SEMA6D		CDH11	Peak1

EPHB2	C17orf51	Gtf2ird2
PHLPP2	PWWP3A	Zcchc24
ADCY3	CCM2	Sema6a
MED13L	DHCR24	Cyp2d22
PRDM16	PIGZ	R3hcc1l
TNRC6B	MBD3	Nadk2
SLIT1	PALM2	Mtmr4
ATXN3	PLEKHH1	Sox11
THAP2	MGAT1	Mrgprb2
C16orf70	ADRA1A	Slc12a7
ARFGEF1	MR1	Slc35e1
NFAT5	TRAPPC4	Efna4
HIPK3	NECAB1	Nek6
CCDC88A	IBA57	Hsp90aa1
ZNF395	XIRP1	Fndc4
DLG2	STOX1	Mbnl3
PER2	TMEM121B	Aak1
LOX	KLHL7	Nr1d2
NEK6	TSEN34	Zfp280b
ARMC8	ZNF546	Rdx
BAHD1	C2CD2	Fgf12
PRCP	TACR1	Isg20l2
MARCH5	HTT	Trappc10
MED12L	SLX4IP	Lpar2
RPL36A-HNRNPH2	ZNF627	Gpr17
PHF15	EGFR	Gmps
NCOA1	HERC3	Zdbf2
SPTLC2	PON2	Ces2e
DRP2	THAP11	Reps2
FRMD4A	DAD1	Zfp488
CTH	ATG2A	Crxos
OPA1	AGFG1	Tmem140
NAV2	AEN	Ercc4
KIAA1549L	PNRC2	Kbtbd8
PTPN9	POU2F3	Fam169a
URGCP	PHLDA2	Sema7a
FAM73B	KSR2	Ahi1
C11orf84	PEAK1	Actbl2
TEX2	SEMA4D	Hyou1
GPRIN3	CHST11	Ctc1
SUZ12	RGPD4	Steap2
CRP	ARID5B	Tubgcp3
SIX1	NAP1L2	Gm5592
TANC2	PPARG	Cpne3

BACE1	PAPPA	Ppara
COL27A1	PIK3CA	Hnrnpr
POTEG	TMEM170B	Cd2ap
RAI14	BCL3	Mllt10
ZBTB14	OIT3	Kndc1
MXI1	ERO1B	Fem1a
PDLIM4	ABCB5	Pou2f1
NR1D2	MFSD6	Stk4
UNC80	CAMTA1	Shc4
POTEM	TYRP1	Frs3
STK38L	EARS2	Map3k14
PPP1R9A	TTC17	Bhlhe22
LRP6	FCRL2	Spry2
ZFHX3	IL17RA	Map2k4
SLC8A1	NR2F2	Efhd2
PITPNM2	FOSB	Rabggta
SFRP1	ZNF20	Gabrg2
SEMA7A	PTCH1	Nrarp
SFPQ	PRMT8	Arxes1
GOLGA6L4	COG7	Adcyap1r1
NUP210	MKNK2	Man1a
KCNK12	EDEM3	Zfp442
ST8SIA4	LDLR	Il1r1
ZNF827	NRIP2	Chrdl1
PLCE1	MAVS	Vps13a
ACOT11	GJD3	En2
DST	WDR36	Med28
GFPT1	TMEM237	Arhgef6
PTCHD1	SPRY2	Foxred2
KCTD16	CD276	Adam10
FAM192A	KCTD8	Mtf2
MBD5	LRRTM2	Ptger4
FAXC	CAMK1D	Gm5114
SPATA2	AGRN	Gja3
ASAP1	RHOT1	Smad2
NCAM1	CAND1	Fndc8
TAS2R5	SOWAHA	Nol4
DDI2	ENPP1	Marveld3
PLXND1	ADAMTS16	Lrrc18
TERF2	PSEN1	Tmem45a
TMED5	NPTX2	Man2b1
AGO2	ERP27	Mpv17l
TXLNG	FSTL3	Casd1
RCOR3	CLOCK	Eya4

FUBP1	ANHX	Nr2c2ap
ATP11B	MOCS3	Map1s
CPD	E4F1	Gal3st2
TGFBR3	ARHGAP23	Ppip5k2
TRERF1	POLM	Tmem150b
UBXN7	RAD54L2	Zmym5
MAGI3	FKBP3	Rpgrip1l
KLHL18	CLDN22	Adra1d
PLAGL2	NR1D2	Amd1
EPB41L1	PDE6A	Il2ra
WDFY2	STAC	Mfsd9
CDS2	LMBR1L	Cib1
PTCHD4	ARID3B	Atp11c
SLC22A23	ZC3H12C	Kcnj8
SHH	EPHA10	Gpr174
LIFR	DDX3Y	Wipf1
CNTN2	MYH10	Wdr92
ARID4B	VASH2	Mgat1
SH3PXD2A	TGIF2	Elovl4
SPRY3	CACNA1C	Cct3
ONECUT3	ANKRD24	BC035044
ZNF185	ADH5	Fnbp1
DUSP13	SLC36A1	0610040J01Rik
ATP9A	ABCA1	Rassf5
RXRA	HMOX1	Rxfp3
CDON	RAPGEF2	Cdh5
SLC9A7	HOXC6	Tmem178
FOSL2	PVR	Gucy2c
ZBTB3	MLPH	Polr2l
FOXN3	MAGEB16	Ccng1
TMEM248	CHD2	Klhl31
SLITRK3	SPTLC2	Fem1b
ALG9	C18orf65	Nedd4l
PCDH1	ARX	Dmac2
P2RY2	TSPAN13	Igsf10
CA12	STYK1	Eif4e1b
ZBTB20	KCNA6	Cd244a
ILDR2	RSPO3	Mfsd4b2
PGP	KDM4C	Aqp11
TMBIM6	WSB1	Adcy6
NAPEPLD	SPX	Arhgap1
BZW1	RGS1	Srsf12
NEBL	CBX5	Swt1
IGF1	MAN2A1	Pappa

SMAD2	RARB	Zkscan8
RBP2	TSTD2	Trabd2b
HTT	HSPD1	Gk5
RAD51D	TNRC6B	Tbp
AP5M1	ZNF124	Cspp1
KAT6A	DEPDC4	Rab11b
PPARGC1A	SCN2B	Gprin3
SLC30A7	SLCO1A2	Frmd3
KCNMB4	KIAA1211	Zfp811
POU3F3	DLG2	Igfn1
POFUT1	NKTR	Terf2
VCAN	TET2	Tnpo3
ANKFY1	LOC101928841	Pgm2l1
MDGA1	DEPDC1B	Arhgef28
DCAF17	CEP135	Tpm3
TTC28	FAM118A	Ogfrl1
HSD17B8	LMNB1	Mycbp
FADS1	NCAN	Slc7a2
KCMF1	KAT2A	Tmem45a2
HDAC4	PPP4R2	Insr
IPMK	SUCO	Rinl
SFMBT1	RAB33B	Ldlrad3
IRS4	PAQR9	Pkn2
ARID1B	TNFSF8	Cth
PACS1	RLIM	Prkag2
CNOT1	SLFN11	Acta2
TMEM120B	ZC3H13	Atrnl1
ERP44	PTGDR	Plxnd1
PIK3CA	EXD1	Tbx22
MAPRE2	ZNF385C	Lrit2
SBNO1	GLRX	Dnajb4
NIPBL	METTL8	Edem3
CADM1	ARFGEF3	Canx
DLK1	TOPBP1	Utp14a
TSPAN14	SMCR8	Gnpat
TAF3	TMEM39A	Zfhx4
CPNE2	MSRB3	Slc6a17
RBM15B	LHX1	Spata2
UBE2K	ERI1	9530068E07Rik
CCDC6	KBTBD8	Pcnx
PFKM	CYP4F2	Tnrc6a
ROBO1	CEBPE	Pxdc1
CACNG2	IL16	Bambi
SLC24A4	RCAN3	Gfod1

PAX6	PTCD2	Lrrc31
TRIP4	DIRAS2	
CDC6	SLC26A2	
FCHSD1	RIMS1	
WISP1	C16orf54	
SMIM17	CIART	
GABRB1	HDHD2	
DCC	PTGER4	
EHF	NEK1	
EIF2B3	APAF1	
GOLGA6B	STK3	
GPR174	EIF4EBP2	
PTGDR	ZNF587B	
RGPD4	CDS2	
CISD2	ADAM19	
RP13-996F3.4	GPR35	
MAP3K2	THRB	
TGFBR2	MPP2	
CACNA1A	MLYCD	
COL26A1	TNPO3	
DDB1	MARK1	
	EPB41L2	
	UMAD1	
	PTAFR	
	IFNA1	
	TBP	
	TRIM50	
	LETMD1	
	PIGT	
	ZSCAN20	
	CD93	
	SP100	
	XKRY2	
	GVQW2	
	CYB561D1	
	TBCC	
	EFNB2	
	HIVEP3	
	RPGRIP1L	
	TTC39C	
	NCOA5	
	HSPA1L	
	ARHGEF11	
	XKRY	

VEGFB
STAM
TNFAIP3
DPYS
PAXBP1
NRIP1

Supplementary Table S3: qRT-PCR and endpoint PCR Primer

Gene	Direction	NCBI Reference Sequence*	Sequence (5'- 3')
β-Actin	for rev	NM_007393.5	**CCAACCGTGAAAAGATGACC** **ACCAGAGGCATACAGGGACA**
Isl1	for rev	NM_021459.4	**CCACGATGTGGTGGAGAGA** **CTAGCCGAGATGGGTTCG**
Nkx2.5	for rev	NM_008700.2	**GAGCCTACGGTGACCCTGA** **GTGGTCTCTCGGCGCCAT**
Mef2c	for rev	NM_025282.3	**ATGGGCGGAGATCTGACA** **TTCTTGTTCAGGTTACCAGGTG**
Acta2	for rev	NM_007392.3	**CCAACCCGGGAGAAAATGAC** **CAGTTGTACGTCCAGAGGCATA**
Tbx5	for rev	NM_011537.3	**GGATGTCTCGGATGCAAAGT** **GGTTGGAGGTGACTTTGTGC**
Tnnt2	for rev	NM_011619.3	**TTCGACCTGCAGGAAAAAGTT** **CTTCCCAGGAGTTTTGGAGA**
Pecam1	for rev	NM_008816.3	**GTTGCAGCCAAATGCTACTT** **GAAATCTTCTCGCTGTTGGA**
Myh6	for rev	NM_010856.4	**CCTATGCTTCTGCTGATACCG** **TCATCAGCTTGTTCAGATTTTCC**
Cited2	for rev	NM_010828.3	**GTTTAACAACTCCCAGTTCATGG** **AATACTGGTTGTTGAGCTTCTGC**
Hcn4	for rev	NM_001081192.2	**CGCATTGTCCGTTTCACTAA** **CAGGTCATAGGTCATGTGGAAG**
Myl2	for rev	NM_010861.4	**GACTGAGCCCTGAACCACAG** **ACATCATCAACTTGCGGTCA**
Shox2	for rev	NM_013665.1	**CCCACTATCCAGACGCTTTC** **TCGATTTTGAAACCAAACCTG**
Myl7	for rev	NM_022879.2	**CCCATCAACTTCACCGTCTT** **AGGCACTCAGGATGGCTTC**
Sfrp5	for rev	NM_018780.3	**GATCTGTGCCCAGTGTGAGA** **TTAATGCGCATCTTGACCAC**
Ki67	for rev	NM_001081117.2	**CCAGGAAAGTCCCTTGGAA** **CATTTTTGAAGCTTTGGTATCTTG**
Irx4	for rev	NM_018885.2	**GATGAGAAGCGCCCCTATG** **GTCTTTGCCAGCATGACCTT**

Neurod1	for rev	NM_010894.2	**CGCAGAAGGCAAGGTGTC** **TTTGGTCATGTTTCCACTTCC**
Nanog	for rev	NM_028016.3	**TTCTTGCTTACAAGGGTCTGC** **AGAGGAAGGGCGAGGAGA**
Gata4	for rev	NM_008092.3	**GGAAGACACCCCAATCTCG** **CATGGCCCCACAATTGAC**
Hand1	for rev	NM_008213.2	**CAAGCGGAAAAGGGAGTTG** **GTGCGCCCTTTAATCCTCTT**
Nestin	for rev	NM_016701.3	**TGCAGGCCACTGAAAAGTT** **TTCCAGGATCTGAGCGATCT**
Ncam1	for rev	NM_001081445.1	**ACCTGAAACCTGAGACGAGGT** **CTTGGGTGCACTGGGTTC**
Afp	for rev	NM_007423.4	**GCTTATCTCTAAATCCAAGCCAGT** **AGGAAGGTTGGGGTGAGTTC**
Sox17	for rev	NM_011441.5	**CAACGCAGAGCTAAGCAAGA** **TTGTAGTTGGGGTGGTCCTG**
Sox2 (endogene)	for rev	NM_011443	**TCTGTGGTCAAGTCCGAGGC** **TTCTCCAGTTCGCAGTCCAG**
cMyc (endogene)	for rev	NM_001177352	**TCAAGCAGACGAGCACAAGC** **TACAGTCCCAAAGCCCCAGC**
Oct3/4 (endogene)	for rev	NM_013633	**CCAACGAGAAGAGTATGAGGC** **CAAAATGATGAGTGACAGACAGG**
Klf4 (endogene)	for rev	NM_010637	**GGCGAGAACCTTACCACTGT** **TACTGAACTCTCTCTCCTGGCA**
cMyc/Sox2 (exogene)	for rev	NM_011443 NM_001177352	**AGGGCGCCCTGCCAGGC** **GGGAAGCAGCTCGAATTTCTT**

*Data adopted from https://www.ncbi.nlm.nih.gov/nuccore/ (NCBI Nucleotide)

Supplementary Table S4: Antibodies

Primary Antibody	Dilution	Secondary Antibody	Dilution
Anti-SOX2 (rabbit polyclonal IgG)*****	1:250	Goat anti rabbit IgG H&L (Alexa Fluor 488)*	1:500
Anti-NANOG (rabbit polyclonal IgG)*****	1:100		
Anti-sarcomeric α-Actinin (mouse monoclonal IgG1**)***	1:200		1:500
Anti-αMHC mouse (Myh6) (monoclonal IgG2b)[#]	1:100		

		Goat anti mouse IgG H&L (Alexa Fluor 555)*	
Anti-αSMA (Acta2) (mouse monoclonal IgG)†	1:20		
Anti-CD31 (CD31) (rabbit polyclonal IgG)*	1:50	Goat anti rabbit IgG H&L (Alexa Fluor 488)*	1:500

Antibodies are purchased from *Abcam (Cambridge, UK), #R&D Systems (Minneapolis, MN, USA) or †Santa Cruz Biotechnology (Santa Cruz, CA, USA).

4. Supplementary Methods

Isolation of cells for microRNA array analysis

GFP-positive CPCs were isolated from embryonic hearts at E9.5 of NkxCE-GFP mice from timed matings (a positive mating plug indicated E0.5). After animals were euthanized (as described above), embryos were collected and directly placed in ice-cold 1x PBS. Embryos were mechanically dissociated and digested with a Collagenase II (10.000 U/mL, Thermo Fisher Scientific, Waltham, ME, USA)/ DNase I (10.000 U/µL, Sigma Aldrich, St. Louis, MO, USA) solution for 1 h at 37°C. After washing with 1x PBS, cells were resuspended in FACS buffer (1x PBS / 0.5% BSA / 2 mM EDTA). GFP-positive cells and their negative counterparts were then sorted by flow cytometry and collected as described in the "flow cytometry" section (Suppl Fig S1A). In addition, *in vitro* differentiated GFP-positive CPCs were isolated by flow cytometry on day seven of the differentiation of NkxCE-GFP ES cells (ESCs) (Suppl Fig S1B). ESCs were differentiated by the "hanging drop" method, building embryoid bodies (EBs) as described in the respective "Differentiation of murine pluripotent stem cell lines" section. EBs were collected mechanically with a cell scraper on day seven and further digested as described for mouse embryos.

For isolation of tail tip (TTFs) and cardiac fibroblasts (CFs) (Suppl Fig S1C-D), NkxCE-GFP mice (age between six and eight weeks) were euthanized, the tailtip and the heart were removed and digested with the same Collagenase Typ II / DNaseI solution as mentioned above. Then, erythrocyte lysis was performed with red blood cell lysis solution (Miltenyi Biotec, Bergisch-Gladbach, Germany). Digested cells were centrifuged for 5 min at 300 xg and finally plated on gelatine-coated 6-well plates with fibroblast medium consistent of Dulbecco's MEM high glucose and stable glutamine (Biochrom, AG, Billierica, MA, USA), 10% FCS (Thermo Fisher Scientific, Waltham, MA, USA), 1% Penicillin/Streptomycin (Thermo Fisher Scientific, Waltham, MA, USA), 1% Sodium Pyruvate (Thermo Fisher Scientific, Waltham, MA, USA). After 24 hours, the cells were washed twice with 1x PBS and supplied with fresh medium. TTFs and CFs were further cultivated and directly harvested in RLTplus Buffer (Qiagen, Hilden, Germany) containing 10 µL/mL β-mercaptoethanol (Sigma-Aldrich, St. Louis, MO, USA) at low passage for RNA/miR isolation.

Cell culture of murine pluripotent stem cells

Several murine pluripotent stem cell lines were utilized for this study such as non-transgenic V6.5 ESCs (Novus Biologicals, Centennial, CO, USA), transgenic NkxCE-GFP ESCs as well as self-generated ESCs/iPSCs including miR-128a-overexpressing NkxCE-

GFP ESCs (OE-128), the miR-Ctr-overexpressing NkxCE-GFP ESCs (OE-Ctr) (see below in "Generation of miR-overexpressing NkxCE-GFP ESC lines") and Isl1-Cre/ROSA^{mTmG} iPSCs (iITG-iPSCs) as described in the "Generation of Isl1-Cre/ROSA^{mTmG} iPS line" section. All above-mentioned murine ESCs/iPSCs were cultured on gelatinized 6-well plates coated with mitomycine-inactivated murine embryonic fibroblasts (MEFs) as feeder layer in ESC medium (Dulbecco's MEM high glucose, stable glutamine (Biochrom, AG, Billierica, MA, USA), 20% FCS (Thermo Fisher Scientific, Waltham, MA, USA), 1% Penicillin/Streptomycin (Thermo Fisher Scientific, Waltham, MA, USA), 1% non-essential amino acid solution (NEAA) (Thermo Fisher Scientific, Waltham, MA, USA), 0.1 mM β-mercaptoethanol (Sigma-Aldrich, St. Louis, MO, USA), and 10^3 U/ml leukemia inhibitory factor (LIF) (Millipore, Billerica, MA, USA)). Cells were cultivated in a CO_2 incubator (5% CO_2) at 37°C. The ESC medium was changed every day and cells were passaged every second or third day at a ratio of 1:3 to 1:6. For the cell culture of miR-overexpressing NkxCE-GFP ESCs (OE-Ctr, OE-128), the ESC medium was supplied with tetracycline-free FCS (Biochrom, AG, Billierica, MA, USA) and 1µg/ml puromycin (GE Healthcare, Chicago, IL, USA) for a permanent selection pressure to keep established ESC clones. To test miR-induction, 2µg/ml doxycycline (Sigma-Aldrich, St. Louis, MO, USA) was added.

Differentiation of murine pluripotent stem cells

Murine ESCs and iPSCs were differentiated according to a standard "hanging drop" protocol as described previously[1-4]. In short, ESCs/iPSCs were grown on feeder free gelatin-coated 6-well plates for two days in IMDM-ES medium (Iscove's Modified Dulbecco's Medium (IMDM) with stable glutamine (Biochrom, AG, Billierica, MA, USA), 20% FCS (Thermo Fisher Scientific, Waltham, MA, USA), 1% Penicillin/Streptomycin (Thermo Fisher Scientific, Waltham, MA, USA), 0.1 mM 1-Thioglycerol (Sigma-Aldrich, St. Louis, MO, USA), and 10^3 U/ml LIF (Millipore, Billerica, MA, USA)). IMDM-ES medium was supplied with tetracycline-free FCS (Biochrom, AG, Billierica, MA, USA) for iITG-iPSCs and miR-OE-ESCs.

To start differentiation, hanging drops (11 µl per droplet) were prepared on 15 cm cell culture dishes (V6.5 ESCs, NkxCE-GFP ESC and both OE-ESC lines 1,000 cells/droplet (~$0.9*10^5$/ml); iITG-iPS 2000 cells/droplet (~$1.8*10^5$/ml)) with differentiation medium (Iscove's Modified Dulbecco's Medium (IMDM) with stable glutamine (Biochrom, AG, Billierica, MA, USA), 20% heat-inactivated (30 min at 56°C) FCS (Thermo Fisher Scientific, Waltham, MA, USA), 1% Penicillin/Streptomycin (Thermo Fisher Scientific, Waltham, MA, USA), 0.1 mM 1-Thioglycerol (Sigma-Aldrich, St. Louis, MO, USA), 0.05mg/ml L-ascorbic acid (Sigma-Aldrich, St. Louis, MO, USA). The medium was supplied with tetracycline-free FCS (Biochrom, AG, Billierica, MA, USA) for experiments with iITG-iPSCs and miR-OE-ESCs.

The cell culture dishes were stored upside-down at 37°C (5% CO_2) for two days until embryoid bodies (EBs) had formed. The EBs were subsequently flooded with differentiation medium and either replated (see below) or differentiated further on 15 cm plates. Flooding of some miR-OE EBs was conducted with differentiation medium supplied with 2 µg/ml doxycycline (Sigma-Aldrich, St. Louis, MO, USA) for miR induction (Suppl Fig.10A).

For all miR knockdown and overexpression experiments, EBs of three to four 15 cm plates were pooled and replated on one gelatin-coated 12-well plate. For ICC stainings during differentiation, one EB was transferred into one well of a gelantin-coated 96 well plate. In general, differentiation medium was changed if necessary, either due to experimental set-up or when the medium was substantially consumed.

Differentiation of hiPSCs

HuiPSCs were differentiated according to the protocol of Burridge et al.[5] by modulating the Wnt-signaling pathway with several small molecules. Therefore, huiPSCs were grown as "monolayer" (single cells) until confluent in mTeSR E8 medium (Stem Cell Technologies, Cologne, Germany). The medium was changed at the beginning of differentiation to CDM3 medium (day 0), consisting of RPMI1640 medium (Sigma-Aldrich, St. Louis, MO, USA) supplemented with 500 µg/ml *O. sativa*–derived recombinant human albumin (Sigma-Aldrich, St. Louis, MO, USA) and 213 µg/ml L-ascorbic acid 2-phosphate (Sigma-Aldrich, St. Louis, MO, USA) which had to be freshly added each time the medium was replaced. Additionally, CDM3 was supplemented with 3 µM CHIR99021 (LC Laboratories, Woburn, MA) from day 0 to day 2. From day 2 to day 4, the cells received CDM3 supplemented with 2 µM WNT-C59 (Selleckchem, Munich Germany) (Suppl.Fig.S2B). Thereafter, the CDM3 medium without small molecules was replaced every other day. RNA was isolated every other day for analysis of microRNA kinetics during differentiation.

RNA and miR isolation

Isolation of miRs for microRNA array analysis from generated TTFs and CFs as well as FACS-isolated NkxCE-GFP+ CPCs and correspondent GFP-negative fractions was conducted with the miRVana microRNA isolation kit (Thermo Fisher Scientific, Waltham, MA, USA) according to the manufacturer's instructions (Fig. 1C&1E, Suppl.Fig S1A-D).

Total RNA, including small RNAs and microRNA of cultured murine ESCs/iPSCs as well as differentiated murine and human ESCs/iPSCs was isolated using the peqGold total RNA Kit according to manufacturer's instructions (Peqlab, Erlangen, Germany) (Fig. 1G, 3A, 4A, 5A , Suppl.Fig S2B, S7F, S8A, S9F,S10A).

Prior to RNA isolation of zebrafish embryos, embyos were collected at respective timepoints

(Fig. 2A&2C), covered with 400µl peqGold TriFast^{TM} reagent and homogenized with syringes. RNA isolation was then conducted with the peqGold TriFast^{TM} reagent (VWR International, Radnor, PA, USA) in compliance with the manufacturer's protocol.

If required for further experiments (e.g. miR or mRNA qRT-PCR), total RNA concentrations were determined by a Nanodrop 2,000 (VWR International, Radnor, PA, USA) and RNA was then stored at -20°C (short term) or -80°C (long term).

MicroRNA array analysis

MicroRNA array analysis was conducted with the above described islolated cells ("Isolation of Cells for MicroRNA Array Analysis") using a TaqmanTM Array Rodent MicroRNA A+B Card Set (Thermo Fisher Scientific, Waltham, MA, USA). Hereby, the expression of about 750 known miRs was evaluated and quantified by a Taqman 7500HT Fast Real-Time PCR System (Applied Biosystems, Foster City, CA, USA). For comparative analysis of miR expression profiles, U6 and sno202 were used as internal controls (ΔCt = Ct (Target) - Ct (Reference) and fold change (FC) was calculated by the $2^{-\Delta\Delta Ct}$ method[6]. miRs were considered differentially-expressed using a threshold of a |1.5| FC and two-sided Student's t-test p-value $\leq$ 0.05 between cell populations of interest (NkxCE-GFP CPCs *in vitro* and *in vivo* vs. respective GFP-negative fractions and NkxCE-GFP CPCs *in vitro* and *in vivo* CPCs vs. fibroblast populations).

cDNA synthesis

A total of 100 ng of extracted total RNA from all *in vitro* experiments (cells) was reverse transcribed into cDNA using M-MLV reverse transcriptase (Invitrogen, Darmstadt, Germany) and random hexamer primers (Thermo Fisher Scientific, Waltham, MA, USA) according to the manufacturer's recommendations in a Thermocycler C1000 (BioRad, Hercules, CA, USA). The following conditions were used: 5 min at 65°C, 2 min 37°C, 10 min 25°C, 50 min 37°C and 15 min 75°C.

For miR cDNA synthesis of all murine and human differentiated ESCs and iPSCs, 100 ng of total RNA were reverse transcribed using the Universal cDNA synthesis kit II (Exiqon, Vedbaek, Denmark) according to the manufacturer's recommendations in a Thermocycler C1000. The following conditions were used: 1h at 42°C, 5 min 95°C.

For reverse transcription of miRs isolated from zebrafish, the miScript II RT Kit (Qiagen, Hilden, Germany) was used under the following conditions: 1h at 37°C, 5 min 95°C.

qPCR analysis

Semiquantitative real time PCR (qRT-PCR) for evaluation of gene expression was performed with gene-specific primer sets (ELLA Biotech, Munich, Germany, Suppl Tab S3) using the Power SYBR Green PCR master mix (Applied Biosystems, Foster City, CA, USA) under the following conditions: Activation of *Taq* DNA polymerase (2 min at 50°C, 10 min at 95°C) followed by 40 cycles with 15 s at 95°C and 60 s at 60°C. Gene expression was calculated using arbitrary units (AU) and each sample was normalized to *β-actin.*

A real time PCR of miRs of *in vitro* generated cell samples was performed with miR specific primer sets (Exiqon, Vedbaek, Denmark; Suppl Tab S1) and ExiLENT SYBR Green Master mix (Exiqon, Vedbaek, Denmark) according to the miRCURY LNA™ Universal RT protocol under the following conditions: 10 min, 95°C, 10 min, 95°C (40 cycles), 60 min, 60°C. Amplification of miR from zebrafish samples was performed using the miScript Primer Assay (Qiagen, Hilden, Germany) and the miScript Green PCR Kit (Qiagen, Hilden, Germany) according to the manufacturer's protocol. Each sample was normalized to U6 and internal control and quantification of miRs was calculated by the $2^{-\Delta\Delta C_T}$ method.

All real time PCRs were performed in MicroAmp Optical 96-well plates (Thermo Fisher Scientific, Waltham, MA, USA) on a QuantStudio™ 3 Real-Time PCR System (Thermo Fisher Scientific, Waltham, MA, USA) using the QuantStudio™ Design and Analysis Software v1.4.

Morpholino microinjection

Morpholinos (MOs) were synthesized by Gene Tool LLC, OR, USA (MO-miR-20b: TTGCAGTAGATCCACTGGCACTACC; MO-miR-30a: AGCTGAGATTTTCTGCATTACAACT; MO-miR-30b: AACACCCTCCGCCCAGCCTCGTC; MO-miR-128-1: ACTGTGAGAAAGCCTACATGAATCT). MOs were dissolved to a stock solution of 1 mM with Braun water and subsequently diluted with 200 mM KCl (Carl Roth, Karlsruhe, Germany) to the correspondent final concentrations. MOs were loaded into a fine-tipped needle and further injected into the yolk center of zebrafish embryos at the 1 or 2-cell stage (Fig 2C) by a microinjector. We injected 2-3 ng per embryo of MO-miR-20b; 1-2 ng per embryo of MO-miR-30a; 1-2 ng per embryo of MO-miR-30b, and 1-2 ng per embryo of MO-miR-128a. After MO microinjection, embryos were kept and grown in E3 medium as described in the "Transgenic Animals" section. After 24 hpf, the medium was replaced with E3 medium containing 0.003% PTU (1-phenyl-2-thiourea (Sigma-Aldrich, St. Louis, MO, USA) to reduce zebrafish skin pigmentation. Uninjected sibling embryos were processed as controls.

Heart Rate and Fractional Shortening of Zebrafish Larvae

Cardiac contraction videos at 72 hpf of MO knockdown and control larvae were recorded by a Leica DM IRB high-resolution video microscope (Leica, Wetzlar, Germany) with an optical

magnification of 20 and visually counted by at least two independent observers. To determine the diameter of ventricles during systole and diastole the Meazure^{TM} v2.0 tool (C Thing Software, Mountain View, CA, USA) was used. The percentage of ventricular fractional shortening (VFS) was finally calculated by ((Diastole-Systole)/Diastole).

Knockdown of miR-128a during *in vitro* differentiation by LNA probes

Knockdown of miR-128 during *in vitro* differentiation of NkxCE-GFP ESCs and iITG-iPSCs was conducted using the miRCURY LNA™ Power microRNA inhibitor System (Exiqon, Vedbaek, Denmark). ESCs/iPSCs were either transfected with mmu-miR-128-3p probes (LNA-128; UCACAGUGAACCGGUCUCUUU, MIMAT0000140) or a control LNA probe (LNA-Ctr) as corresponding negative control (Exiqon, Vedbaek, Denmark) without any homology (>70%) to any sequence in any organism.

For transfection, ESCs/iPSCs were differentiated in 12-well plates using the hanging drop method as described above ("Differentiation of murine Pluripotent Stem Cell lines"). At specific time points during differentiation (Fig.3A& 4A), ESCs/iPSCs were transfected with LNA probes at a final concentration of 50 nM. In detail, medium was replaced by 500µl fresh differentiation medium without Pen/Strep. For transfection, 25 pmol of LNA probes were resuspended in pure IMDM (Biochrom, AG, Billierica, MA, USA) and supplied with 5µl of Fugene (Madison, WI, USA). After 15 min of incubation, the transfection mixture was added dropwise to the cells. After two days, the medium was changed to fresh differentiation medium with Pen/Strep and further analysis was performed (Fig.3A & 4A).

Cell proliferation - MTT assay

To evaluate influences of LNA probes, doxycycline addition or miR-128 overexpression on proliferation capacity of NkxCE-GFP ESCs or miR-OE ESCs MTT assay was used as previously described[2, 4].

NkxCE-GFP ESCs were cultured and differentiated as described above ("Differentiation of murine Pluripotent Stem Cell lines") and transfected with LNA-probes (LNA-Ctr) according to the respective protocol (Suppl.Fig4A). Differentiating cells were replated on gelatinized 48 well plates two days before the MTT assay was performed one week after LNA-transfection.

miR-OE ESCs were cultured as described above ("Cell Culture of murine Pluripotent Stem Cell lines**"**) either with or without doxycyxline for three days on a gelatine-coated 96-well plate.

For MTT assays, ESCs were incubated with 10 µl of 3-[4.5-Dimethylthiazol-2-yl]-2.5-di phenyltetrazolium bromide (MTT) solution (conc. 5 mg/ml) (Sigma-Aldrich, St. Louis, MO,

USA) diluted in 90 µl DMEM basal medium (final conc. 0.5 mg/ml) for 1h at 37°C, 5% CO_2. For differentiating ESCs, MTT solution was diluted in IMDM basal medium. The MTT solution was then aspirated carefully and 100 µl of dimethyl sulfoxide (DMSO, Sigma-Aldrich, St. Louis, MO, USA) were added to each well to dissolve formazan. DMSO was thoroughly mixed in each well and then transferred to a fresh 96-well plate. The absorbance was measured at 570 nm on a Tecan Safire 2 Multimode Microplate Reader with the software XFLUOR4 version 4.51. The reference wavelength was set at 690 nm.

Immunocytochemistry (ICC)

Pluripotency of newly generated iITG-iPSCs and miR overexpressing ESCs (OE-Ctr, OE-128) was verified by immunostainings with anti-Sox2 and anti-Nanog antibodies (Suppl.Fig.S7G, Suppl.Fig. S9D, Suppl.Tabl.S3) as described previously[4]. ESCs and iPSCs were seeded on gelatine-coated 8-well chamber slides (BD, Franklin Lakes, NJ, USA) on a mitomycin-inactivated MEF feeder layer in ESC medium. Cells were fixed with ice-cold acetone (Sigma-Aldrich, St. Louis, MO, USA) for 10 min at -20°C and subsequently washed 3 times with 1x PBS. Permeabilization was conducted by incubation with 0.25% v/v Triton-X-100 (Carl Roth, Karlsruhe, Germany) diluted in 1x PBS (PBS-T) for 10 min. After another washing step with 0.1% v/v PBS-T, blocking was performed by incubation with 5% v/v normal goat serum (Santa Cruz, Dallas, TX, USA) in 1% v/v PBS-T (1x PBS-T) for 30 min at room temperature. In a first step, anti-Sox2 and anti-Nanog antibodies (both Abcam, Cambridge, UK) were diluted in 1.5% v/v goat serum in 1x PBS-T and incubated with the cells for 1 h at 37°C. After washing with 0.1% v/v PBS-T, an appropriate diluted Alexa-Fluor labeled secondary antibody (in 1.5% v/v goat serum in 1x PBS-T) (Suppl.Tabl.S3) was added to the cells at room temperature for 1 h in the dark. As a negative control, ESCs or iPSCs were stained with correspondent secondary antibodies only. Nuclear staining was conducted by covering the dried chamber slides in mounting medium containing 4′,6-Diamidin-2-phenylindol (DAPI) (Abcam, Cambridge, UK).

Cardiac linages including cardiomyocytes (CMs), smooth muscle cells (SMCs) and endothelial cells (ECs) were stained according to the above-mentioned protocol with antibodies for sarcomeric α-actinin, α-myosin heavy chain (α-MHC, MYH6), α-smooth muscle actin (α-SMA, ACTA2) and for platelet endothelial cell adhesion molecule (PECAM1, CD31). Cells were however fixed with 4% v/v paraformaldehyde in 1x PBS at room temperature, for these stainings. Correspondent antibodies as well as dilutions are listed in Suppl Tab S4.

Flow cytometry

For isolation of NkxCE-GFP-positive CPCs and their correspondent GFP-negative fractions for MicroRNA Array analysis (from E9.5 NkxCE-GFP embryos and day 7 differentiated

NkxCE-GFP ESCs), single cell suspensions were prepared as described in the respective "Isolation of Cells for MicroRNA Array Analysis" section (Fig. 1C, Suppl.Fig.1-A-B). Additionally, day seven differentiated NkxCE-GFP ESCs (independent samples for verification of MicroArray results) were harvested and single cell suspensions were prepared as described above (Fig. 1E).

Before this, flow cytometry cells were resuspended in FACS buffer (1x PBS / 0.5% w/v Bovine Serum Albumin (BSA, Thermo Fisher, Scientific, Waltham, MA, USA), 2 mM EDTA (Carl Roth, Karlsruhe, Germany)) and subsequently filtered through a 30 µm filter to prevent cell clumping. Dead cells were stained with propidium iodide (PI, final conc. 2 µg/ml) (Sigma-Aldrich, St. Louis, MO, USA) or DAPI (final conc. 1 µg/ml) (BioLegend, San Diego, CA, USA). Cell fractions were sorted directly into RLTplus Buffer (Qiagen, Hilden, Germany) containing 10 µl/ml β-mercaptoethanol (Sigma-Aldrich, St. Louis, MO, USA) for further RNA/miR isolation as described in the "RNA and miR isolation" section by a BD FACS ARIA III (BD Biosciences, San Jose, CA, USA) using the BD FACS Diva software version 6.1.2 (BD Biosciences).

For quantitative analysis of GFP-positive CPCs during *in vitro* differentiations (Fig.3D, Fig.4D, Suppl.Fig.S4D, Fig.5D, Suppl.Fig.S10C) or RFP-positive miR-OE-ESCs (Suppl.Fig.9E), flow cytometry was performed on a BD LSR Fortessa™ using the BD FACS Diva software version 6.2.

For quantification of GFP-positive CPCs during ESC/iPSC *in vitro* differentiations, EBs were scraped mechanically from cell culture dishes and enzymatically digested as described in the "Isolation of Cells for MicroArray Analysis" section, followed by resuspension in FACS buffer. For quantification of RFP-positive miR-OE-ESCs (cultured with 2µg/ml or without doxycycline), ESCs were detached with 0.25% Gibco™Trypsin-EDTA solution (Thermo Fisher Scientific, Waltham, MA, USA), and subsequently resuspended in FACS buffer. All samples were filtered through a 30 µm filter before flow cytometry and dead cells were stained with DAPI (final conc. 1 µg/ml).

The final analysis of results was conducted with the FlowJo 7.6.5 software (FlowJo, LLC, Ashland, OR).

Analysis of beating frequency of cell clusters during *in vitro* differentiation

Beating frequency (or beating rate) of differentiating miR-128 knockdown and overexpression ESCs/iPSCs and corresponding controls were evaluated using the Nikon Eclipse Ts2 inverted microscope (Software TiControl Ver. 4.4.2.) video feature at respective timepoints (Fig 3J& 4F& 5G). Nine videos of different beating foci per condition per time point with a

length of 20 sec were recorded and beats of the beating areas were subsequently counted visually by at least two independent observers. Beating rates were calculated by dividing the number of counts by time (beats/min, bpm).

RNA sequencing (RNAseq) analysis

RNAseq data from a previous study were reanalyzed[7]. Original sequencing data were deposited at the Sequencing Read Archive (SRA, PRJNA229481). For this study, NkxCE-GFP-positive CPCs from embryonic hearts at E9 and E11 of NkxCE-GFP mice were obtained by enzymatic digestion as described in detail in the "Cell isolation for MicroRNA Array analysis" section. For embryonic stages > E10, erythrocyte lysis (red blood cell lysis solution, Miltenyi Biotec, Bergisch-Gladbach, Germany) was additionally performed. Single cell suspensions were resuspended in FACS buffer, filtered (30 µm) and dead cells were stained with PI (final conc. 2 µg/ml) before GFP-positive CPCs were subsequently sorted directly into RLTplus buffer (Qiagen) containing 10 µl/ml β-mercaptoethanol (Sigma-Aldrich, St. Louis, MO, USA) by a BD FACS ARIA III (BD Biosciences, San Jose,CA, USA) as described in the "Flow Cytometry" section. DNA and total RNA were then extracted using the AllPrep Kit (Qiagen, Hilden, Germany) in accordance with the manufacturer´s instructions. In addition, cardiomyocytes (CMs) were isolated from C57/Bl6 mice on postnatal day 21 (P21). In brief, hearts were retrogradially perfused with digestion buffer for 12 min until the enzymatic digestion was stopped by the addition of 5% FCS followed by a filtration step (100µm filter). CMs were identified by a high FSC signal and viable cells were discriminated by Draq5 (Cell Signaling Technology, Frankfurt, Germany).

For RNAseq, polyadenylated RNA was isolated from total RNA using magnetic beads (NEBNext Poly(A) mRNA Magnetic Isolation Module, NEB, Frankfurt, Germany). Libraries were constructed using the NEBNext Ultra RNA Library Prep Kit for Illumina (NEB) according to the manufacturer´s instructions and corresponding relative mRNA levels were calculated.

Lentiviral production

Lentivirus production was previously described by Doppler et al.[2]. In short, muSTEMCCA and rtTA lentiviruses were produced by 293FT cells (Thermo Fisher Scientific, Waltham, MA, USA). $7x10^6$ 293FT cells on gelatine coated 10 cm dishes were transfected after 24h either with the pHAGE-STEMCCA (muSTEMCCA) expression vector[8] or the FUdeltaGW-rtTA plasmid (referred to as rtTA)[9], each combined with the CMV-VSV-G plasmid[10] for viral envelope protein expression as well as the pCMV-dR8.2 dvpr for viral packaging[10]. Transfections were performed in 10 ml of Pen/Strep-free fibroblast medium with the FuGENE^{TM} transfection reagent (Promega, Madison, WI, USA). FuGENE-DNA complexes were prepared containing 11 µg of the respective lentiviral plasmid DNA (either pHAGE-

STEMCCA or FUdeltaGW-rtTA), 5.5 µg of pCMV-VSV-G as well as 8.25 µg of pCMV-R8.2 diluted in 600 µl basal DMEM (Biochrom, AG, Billierica, MA, USA) supplied with 50 µl (ratio 4:2, 50 µl to 25 µg total DNA) of the transfection reagent. After 15 min of incubation at room temperature, FuGENE-DNA complexes were added drop-wise to the 293FT cells.

Virus-containing supernatants of 293FT cells were collected after 72 h, centrifuged for 10 min at 300 x g, filtered (0.45 µm) and then directly applied to ITG fibroblasts for reprogramming as described in detail in the "Generation if Isl1-Cre/ROSA^{mTmG} iPS line' section below.

Generation of Isl1-Cre/ROSA$^{mT/mG}$ iPSCs (iITG-iPSCs)

Isl1-Cre/ROSA26$^{mT/mG}$ is a double-fluorescent Cre reporter mouse line, which contains membrane-tagged tandem dimer Tomato (mT) and membrane-tagged green fluorescent protein (mG) (Suppl.Fig.S7A), which was kindly provided by Prof. Sylvia Evans (University of California, San Diego). Upon Cre-mediated excision of mT, *Isl1*-positive CPCs will be marked by GFP from E8.5 of embryonic development[11, 12]. Once Isl1-positive CPCs are marked, their progeny stays GFP-positive. For reprogramming into iPSCs (further referred to as iITG-iPSCs), primary tailtip fibroblasts (TTFs) were used at a low passage (p 3) from an Isl1-Cre/ROSA26$^{mT/mG}$ mouse. Reprogramming was achieved by co-transducing fibroblasts with doxycycline inducible muSTEMCCA expressing mOct-4, mKlf4, mSox-2, and mc-Myc[8] ((Suppl.Fig.S7B) and rtTA[9] lentiviral particles, which were generated as described above in the "lentiviral production" section. For transduction, 2*10^5 TTFs were resuspended in 500 µl fibroblast medium without Pen/Strep, supplied with polybrene (Sigma-Aldrich, St. Louis, MO, USA) at a final concentration of 8 µg/ml and mixed with 1,000 µl of each lentiviral supernatant from 293FT cells (muSTEMCCA and rtTA) ("lentiviral production"). Transduced fibroblasts were then seeded on gelatin-coated 6-well plates. After 24 h, the cells were washed twice and supplied with fresh fibroblast medium (with Pen/Strep) containing 2 µg/ml doxycycline for viral induction. After reaching 80-90% confluency, the cells were split at a 1:3 ratio to a mitomycin-inactivated MEF feederlayer with ESC medium supplied with 2 µg/ml doxycycline and the double amount of LIF (10^6 U/ml). The medium was changed every other day until iPSC clones first started evolving (Suppl. Fig. S7C, D (left pane)). After two to three weeks, selected clones were picked using a 20 µl pipette tip and transferred into 50 µl 0.25% Gibco™Trypsin-EDTA solution (Thermo Fisher Scientific, Waltham, MA, USA) for dissociation (5 min at 37°C). After centrifugation (5 min at 300 x g), each clone was resuspended in 500 µl ESC medium supplied with 1 µg/ml doxycycline and the double amount of LIF (10^6 U/ml) and seeded into one well of a 24 well plate on an inactivated MEF feeder layer. The ESC medium was changed every day and iPSC clones were further cultivated as described in the "Cell culture of murine pluripotent stem cell lines" section. Before being used for knockdown experiments (Fig. 4A), generated iITG-iPSC clones were

verified regarding their pluripotency (Suppl.Fig.S7E-G) as well as for suitable differentiation capacity into all three germ layers (Suppl.Fig.S8).

Generation of miR-overexpressing NkxCE-GFP ESC lines

The NkxCE-GFP miR-128a-overexpressing ESCs (OE-128) as well as the miR-Ctr-overexpressing (OE-Ctr) ESCs were generated by transduction with either shMIMIC mouse doxycycline-inducible microRNA mmu-miR-128-3p mCMV-TurboRFP (shMIM-128) or SMARTvector non-targeting Control mCMV/TurboRFP lentiviruses (shMIM-Ctr) (Dharmacon, Lafayette, CO, USA) (Suppl.Fig.S9A).

Initially, transgenic NkxCE-GFP ESCs were cultured as described in the respective "Cell Culture of murine Pluripotent Stem Cell lines" section. For transduction, $2*10^5$ ESCs (p16) were resuspended in 50 µl transduction medium (ESC medium without FCS and Pen/Strep) and finally mixed with $3.32*10^7$ transfection units (TU) of shMIM-128 or $2.9*10^6$ TU of shMIM-Ctr lentiviruses. Polybrene (Sigma-Aldrich, St. Louis, MO, USA) was added at a final concentration of 8 µg/ml and transduced NkxCE-GFP ESCs were seeded on one well of a 48-well plate on an inactivated MEF feeder layer and incubated for 24h. The transduction medium was subsequently aspirated and changed into ESC medium containing teteracycline-free FCS (Biochrom, AG, Billierica, MA, USA) and 2 µg/ml doxycycline to induce lentiviral constructs. Efficiently transduced ESCs, also indicated by RFP-fluorescence, were additionally selected by adding 1 µg/ml puromycin to the above-mentioned medium after three days of culture. The medium was changed every day until day seven when each well of the 48-well plate was transferred to one well of a 6-well plate on inactivated MEF feeder layers. After two weeks, RFP-positive clones from generated miR overexpression ESCs (OE-Ctr, OE-128) were picked (Suppl.FigS9B-C) as described in detail above in the "Generation if Isl1-Cre/ROSA^{mTmG} iPS line' section. All picked miR-OE-ESC clones were further cultivated/expanded in tetracycline-free ESC medium supplied with 1µg/ml puromycin (in addition to doxycycline, if required for induction). After verification of pluripotency (Suppl.FigS9D), RFP- and miR-128a expression (Suppl.Fig.S9E-F), proliferation capacity (Suppl.FigS9G) as well as differentiation behavior (Suppl.Fig.S10) selected miR-OE-ESC clones were used for further *in vitro* differentiation experiments as described in (Fig.5A).

Microscopic Imaging

All phase contrast and fluorescent images of fibroblasts, ESCs/iPSCs and immunostainings were taken with an AxioCam MR camera on an Axiovert 200M microscope (Zeiss, Oberkochen, Germany) equipped with 10x and 40x objectives, combined with a 10x ocular resulting in 100x to 400x magnification, supported by the AxioVison Rel 4.8 software (Zeiss).

Images of zebrafish embryos (24 hpf 6.3x magnification; 48 hpf or 72 hpf 2.5 or 3.2x magnifications) were taken by using the microscope Olympus SZX16 and Olympus XC30 camera (Olympus, Hamburg, Germany) supported by the CeliSens Entry software (Olymous).

Data Analysis and Statistical Analysis

All graphs were processed using GraphPad Prism Software Version 7.0d. Descriptive data analysis was performed using IBM SPSS Statistics (Version 22, SPSS Inc, Chicago, USA). Comparisons between two groups were made with the two-tailed t-test or Mann-Whitney Rank Sum test. Data are shown as mean values ± standard error of the mean (S.E.M). Values of $p \leq 0.05$ were considered to be statistically significant. The statistic in all figures is indicated by * $p \leq 0.05$, ** $p \leq 0.01$ and *** $p \leq 0.001$.

Data Availability

The authors confirm that all data underlying the presented findings are fully available without restriction upon reasonable request to the authors. Original RNA sequencing data[7] were deposited at the Sequencing Read Archive (SRA, PRJNA229481). All relevant data are in the paper and its supporting information files.

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