

Supplementary Methods and Materials

RNA-seq

Before mapping, low quality ($Q < 20$) reads and adaptor sequences were removed using Trimmomatic v0.32 (<http://www.usadellab.org/cms/?page=trimmomatic>). Clean data were mapped against the *X. laevis* v7.1 reference (downloaded from Xenbase) using TopHat v2.0.9 (ccb.jhu.edu/software/tophat). Only unique mapped reads were used in the subsequent analyses. BEDtools v2.16.2 was used to calculate the gene counts, and the Bioconductor edgeR package v3.8.5 was used to normalize the gene counts using the RPKM method. Then, the normalized gene counts were used to evaluate differential expression with the Bioconductor DEGseq package v1.20.0. The differentially expressed genes between two conditional samples were determined using the MARS (MA-plot-based method with random sampling model) method, with a fold change cutoff=1.0 and a p value cutoff=0.001 (signature called by DEGseq). Gene Ontology analysis of differentially expressed genes was performed using DAVID (Huang da et al., 2009). RNA-seq data can be found in Supplementary Table 4 (output scores) and Table 5 (depth of sequencing data).

Information for antibodies (see also supplementary Table S5 for additional information)

For Co-IPs: Anti-Flag-tag mAb-Magnetic Agarose (MBL #M185-10 10 μ l/200 ug total protein), anti-HA (Roche #11867423001 0.5 μ g/200 ug total protein), anti-Myc (Santa Cruz #sc-40 0.5 μ g/200 ug/total protein).

For western blots: anti-Flag antibody (Sigma #F1804, 1:5000), anti-HA antibody (Roche #11867423001, 1:1000), anti-Myc-tag antibody (Santa Cruz #sc-40, 1:1000).

For chromatin immunoprecipitation, 1 μ g relevant antibody (anti-H3K9ac, -H3K27ac, -H3K4me3, -CTD S5P) was used for embryonic lysate prepared from 50 embryos.

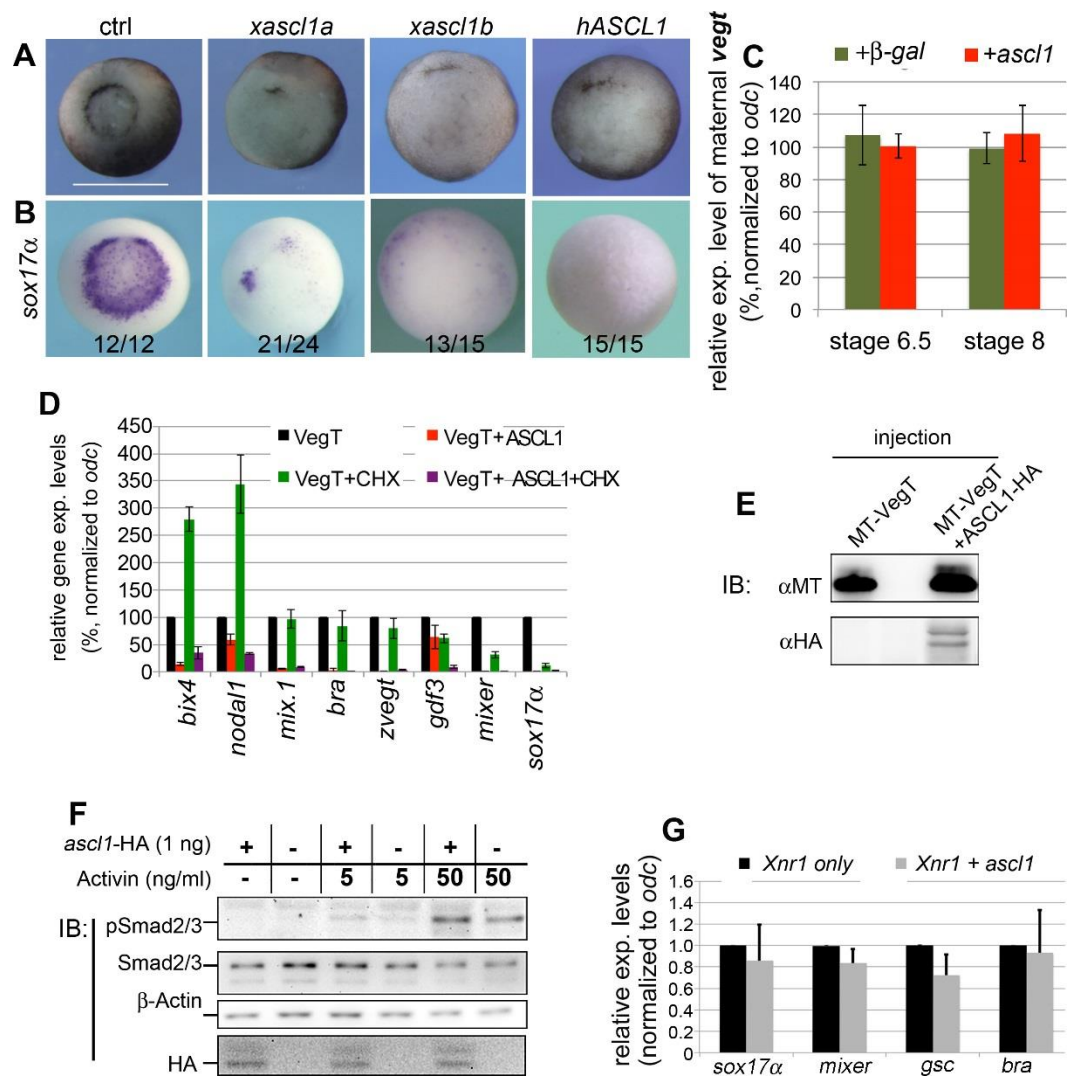


Fig. S1. (related to Fig. 1) Ectopic *Ascl1* inhibits mesendoderm induction by VegT but not by Nodal/Activin

(A) Representative control and *ascl1* mRNA (500 pg)-injected embryos at stage 11 viewed from the vegetal pole. (B) Embryos at stage 10.5 *in situ* hybridized with *sox17 α* and viewed from the vegetal pole. (C) β -gal or *ascl1* mRNA (500 pg) was injected into the vegetal pole at two-cell stage and the resultant embryos were collected at stages 6.5 and 8 for detecting maternal VegT mRNA by RT-qPCR. Values are mean \pm s.d. (D) qPCR analysis for animal cap explants injected with indicated mRNAs and cultured in the presence of CHX (100 mM) from stage 8-10.5. (E) mRNA encoding Myc-tagged VegT (MT-VegT) was injected with or without Ascl1-HA at the two-cell stage, and the resultant embryos at stage 8 were analyzed for the expression of MT-VegT protein by western blotting. (F) Western blotting using anti-phospho-Smad2/3 (pSmad2/3) antibodies. Animal caps dissected from control or *ascl1*-injected (1 ng) blastulae were treated with 5-50 ng/ml Activin protein for 2 h followed by western blotting. (G) Animal caps isolated from blastulae injected with *Xnr1* (100 pg) alone or together with *ascl1* (500 pg) were analyzed by qPCR for mesendoderm gene expression. Values are mean \pm s.d.

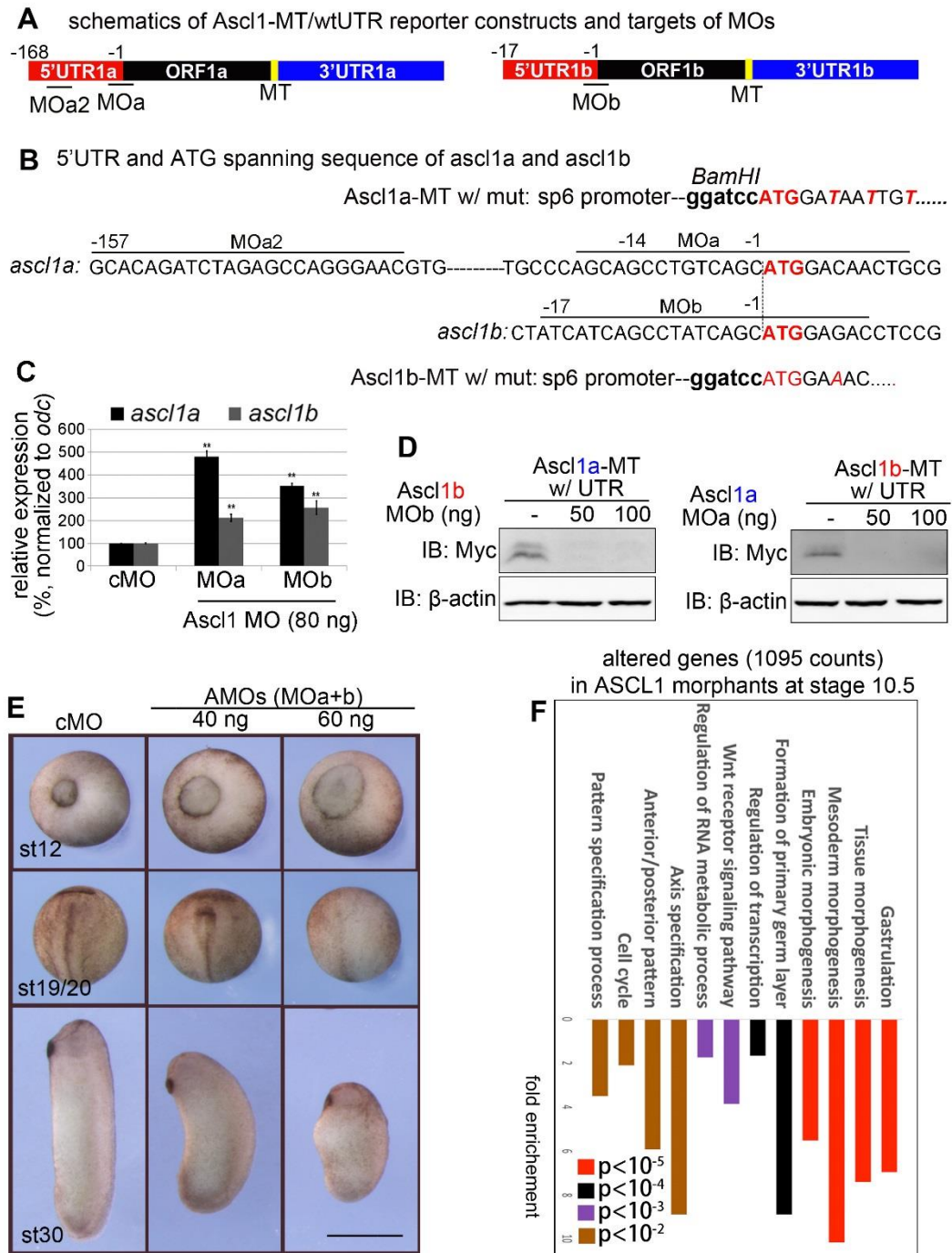


Fig. S2. (related to Fig.2) Ascl1 morpholinos and GO analysis for genes altered in Ascl1 morphants

(A) Schematic of the reporter constructs used to assess the translation blocking effects of the Ascl1 MOs: MOa, MOa2, and MOb. A Myc-tag (MT) is inserted in the C-terminus of Ascl1 polypeptide. (B) cDNA sequences flanking the start codon (red characters) of two pseudoalleles of Ascl1. The MO-

recognizing sequences are indicated. (C) qPCR analysis of *ascl1a* and *1b* expression in *Ascl1* morphants at stage 10.5. Values are mean \pm s.d. $**P < 0.01$. (D) Western blot analysis of MOa (MOb) inhibition of the translation of reporter *Ascl1b* (1a). (E) Representative control and *Ascl1* morphants at different development stages. Incidence of blastopore closure delay: 97.8% (n=184) in *Ascl1* morphants. All control morphants (cMO) closed blastopores by the end of gastrulation (n=168). The incidence body axis shortening with anteriorization of gut was near 100% (152/155) in *Ascl1* morphants. The data were combined from 4 independent experiments. (F) Results from GO analysis for the genes (1095 counts) altered by *Ascl1* depletion in embryos at stage 10.5.

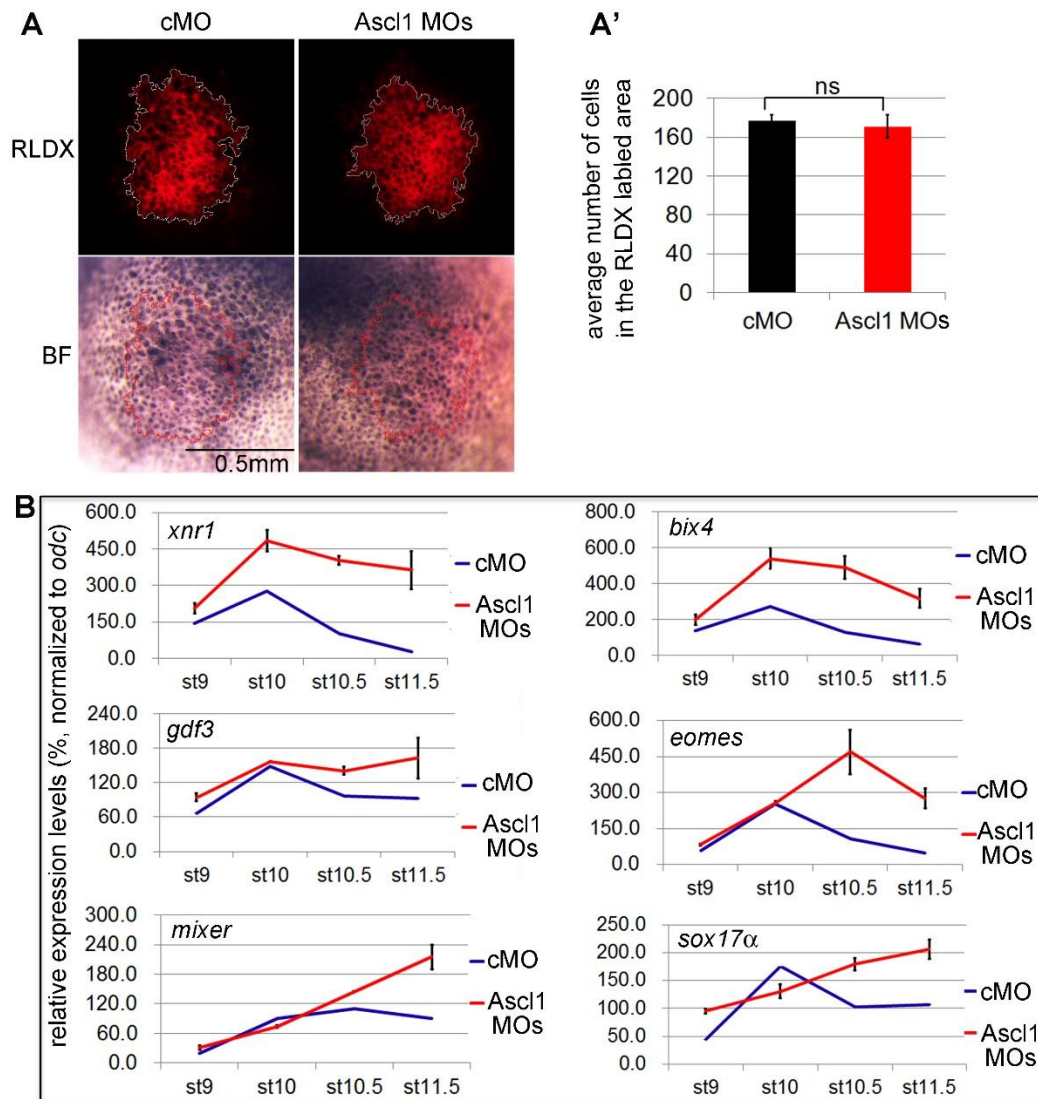


Fig. S3. (related to Fig. 2) Effects of Ascl1 depletion on cell division and gene expression

(A) 80 ng cMO or Ascl1 MOs injected at one-cell stage, RLDX injected into one animal-pole cell at 32-cs. Rhodamine channel (upper panels) or bright field (BR, lower panels) photographs taken at stage 10.5. (A') Comparison of cell numbers in the RLDX-labeled clones from 10 control or Ascl1 morphants at stage 10.5. n.s.: no significance by Student's *t*-test. (B) Gene expression in control and Ascl1 morphants during stage 9 to stage 11.3 analyzed through the semi-qPCR.

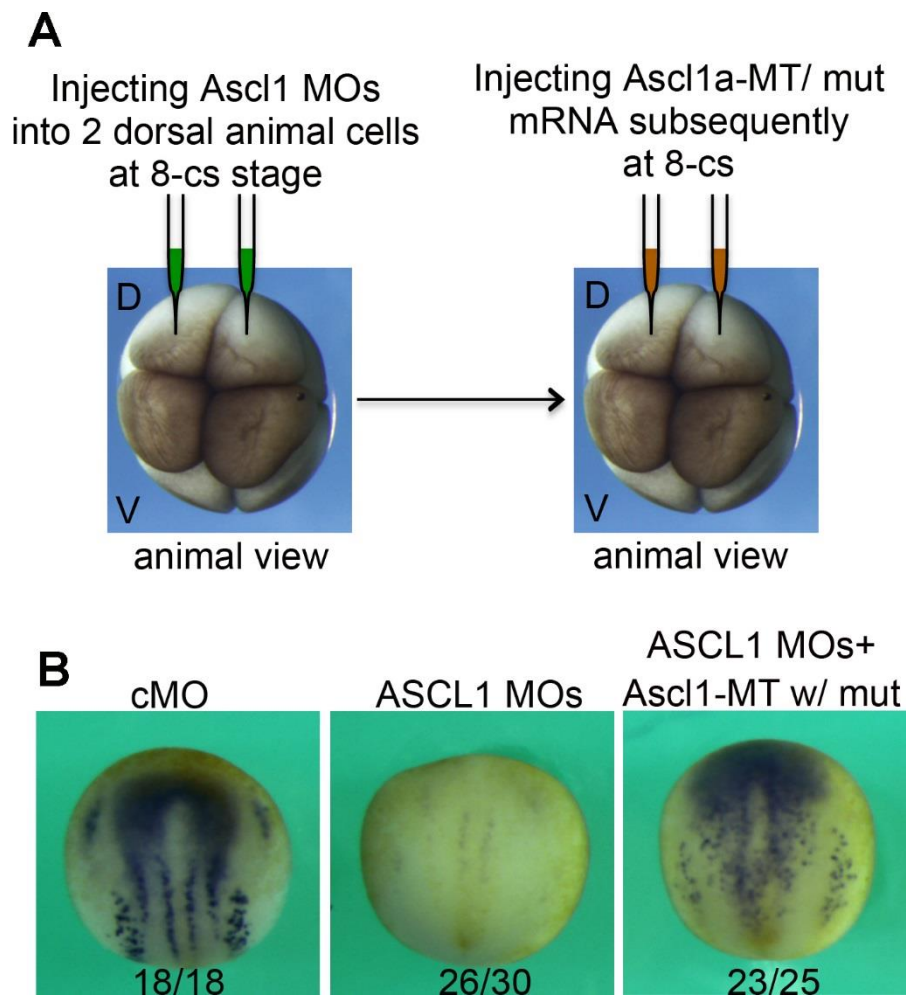


Fig. S4. (related to Fig. 4) Ascl1 is required for neuronal gene expression in early *Xenopus* embryos

(A). A schematic display of how Ascl1 MOs and Ascl1-MT/mut mRNA were sequentially injected into 2 dorsal animal cells at 8-cs. D: dorsal; V: ventral. (B) Representative embryos at stage 14/15 in situ hybridized with *tubb2b*, dorsal view, anterior to the up. Ascl1 MOs (MOa and MOb, 20 ng each) was injected into two dorsal animal cells at 8-cell stage. For the rescue attempt, synthetic Ascl1-MT/mut mRNA (30 pg) was injected into the same cells after injection of Ascl1 MOs.

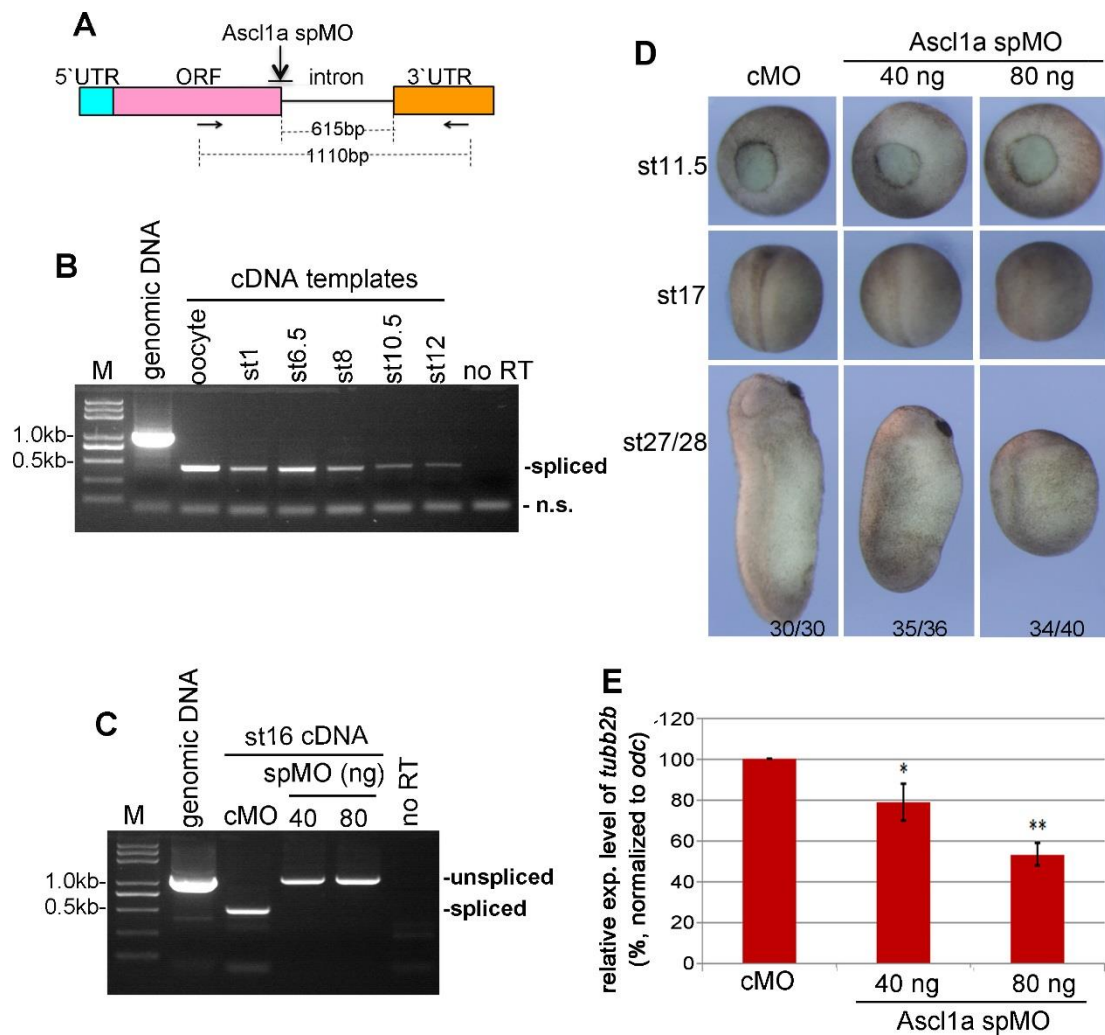


Fig. S5. (related to Fig. 4) Depleting the zygotic *Ascl1a* using a splice blocking MO (spMO)

(A). A schematic presentation of *ascl1a* gene containing a single intron of 615 bp long in the 3'UTR. The *Ascl1a* splice blocking MO (spMO) recognizes the donor sites. The unspliced mRNA is predicted to yield a PCR product of 1100 bp long. (B). PCR verification of the primers designed for assessing the effects of *Ascl1a* spMO using genomic DNA template or cDNA templates made from oocytes and embryos at different developmental stages. (C). RT-PCR results showing that injection *Ascl1a* spMO markedly increased the unspliced mRNA in stage 16 embryos and therefore the PCR products of 1100bp long. (D). cMO and *Ascl1a* spMO injected embryos at different stages of development. (E). qPCR detection of *tubb2b* expression in *Ascl1a* morphants at stage 18. Values are mean \pm s.d. * P <0.05.

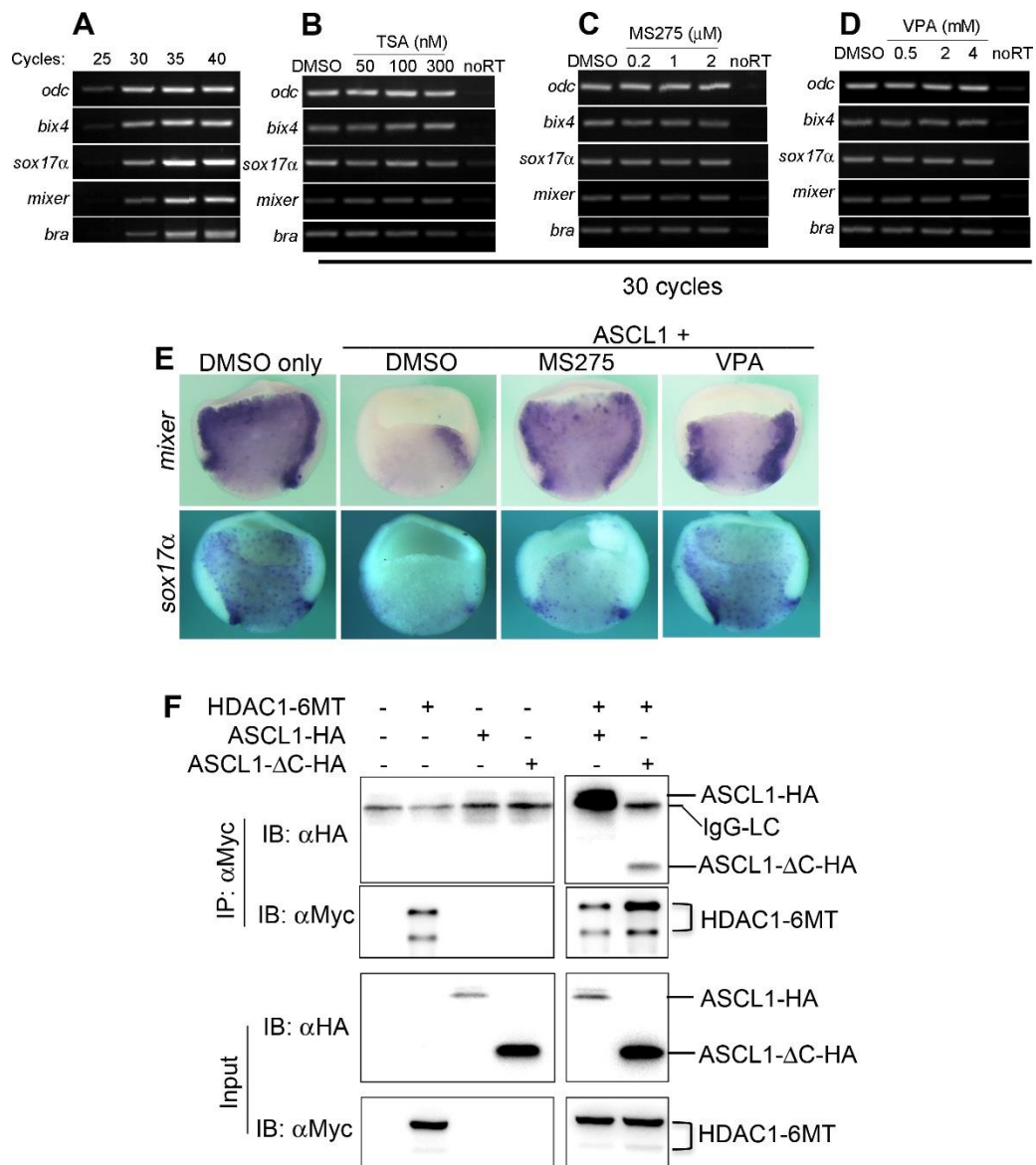


Fig. S6. (related to Fig. 6) Ascl1 interacts with HDAC1

(A). Optimization of the PCR cycle number for mesendoderm genes. (B-D) RT-PCR results showing the effects of HDACis at the indicated doses on mesendoderm gene expression. (E) Bisection view of embryos showing that the expression of *mixer* and *sox17α* was inhibited by Ascl1 overexpression and rescued by the application of MS-275 (1 μM) or VP (2 mM). (F) HDAC1-6MT and HA-ASCL1 mutants were used to confirm the association between Ascl1 and HDAC1 as detected under experimental conditions and shown in Fig. 6D.

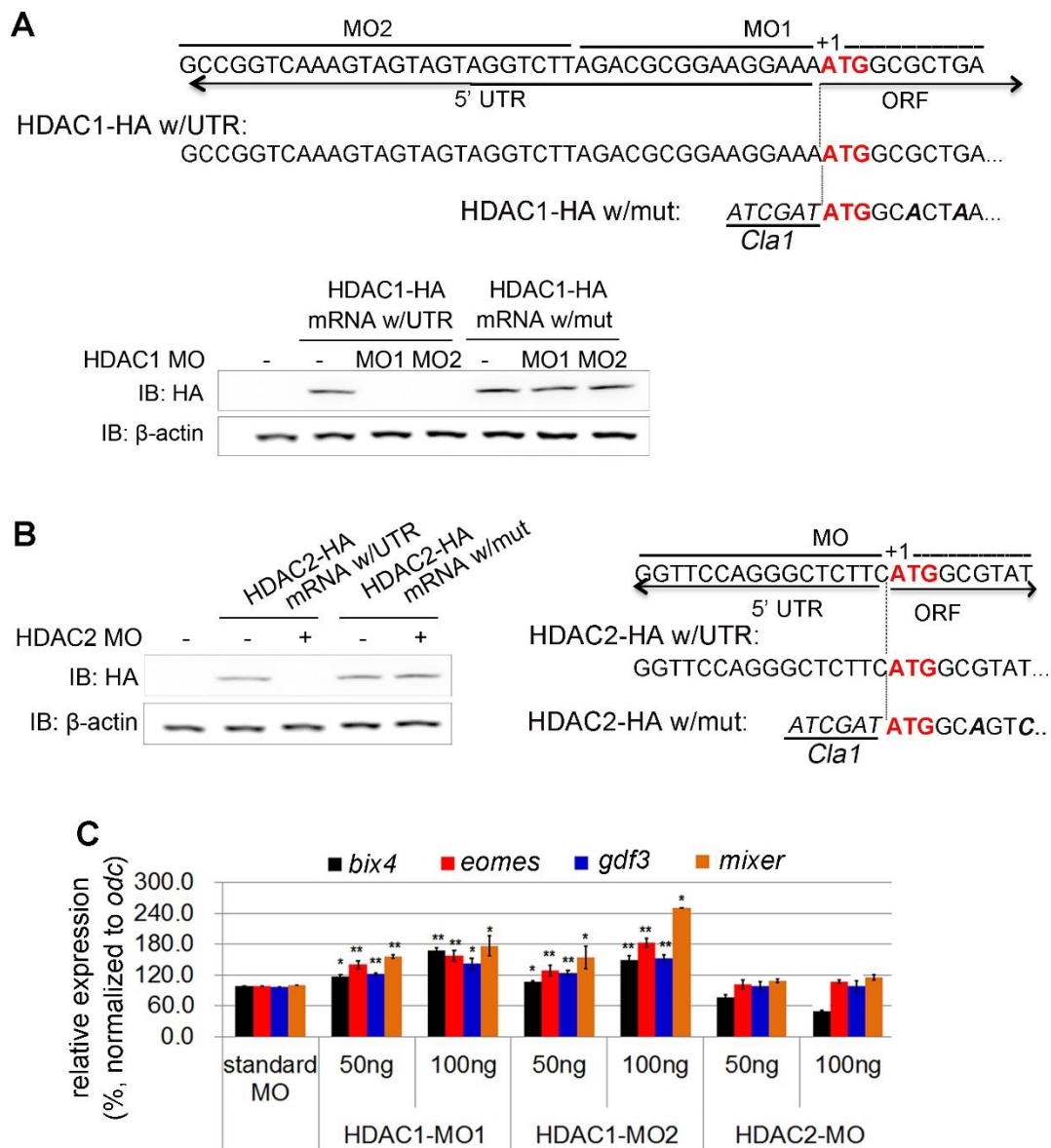


Fig. S7. (related to Fig. 6) Depleting HDAC1 using two non-overlapping MOs

(A). Sequence information for the 5'UTR proximal to the ATG and the sequences recognized by two non-overlapping HDAC1 MOs (HDAC1 MO1 and MO2), and the western blots showing HDAC1 MO1 and MO2 blocked the translation of the reporter mRNA with wild type 5'UTR, but not the reporter with a mutated 5'UTR. (B) Information related to HDAC2 MO and its translation-blocking efficacy assessed through a reporter assay. (C) qPCR detection of gene expression of HDAC1 or HDAC2 morphants at stage 10.5. Values are mean \pm s.d. * indicates $p < 0.05$; ** indicates $p < 0.01$ by Student's *t*-test.

Supplementary Table S1: Asc1a gene sequence

Gene	NCBI ID
Asc1a (Xenopus laevis achaete-scute family bHLH transcription factor 1)	NM_001085778.1
<p>CAGCATTGAGCGCACAGAGCTAGAGCCAGGGAACGTGCGGGGCCGCTCCTGT CACTTTGCAACAGCAGCATCATCCTCCTCCTCACCCGCACAGCCAGAGCAACA CGCGAACGGCAGCAGCCCCACTGCCTCCTCAGCTCACCTCCTCCTGCCAGCA GCCTGTCAGCATGGACAACCTGCGTCGCTGCCAAGATCATGGACAGCAACTTAT CCAGCCAGCAGCAGCATTTCCTACAGCCCCATTGCTTCTTCCCGCAGAACGTG CAGCAGCTGAGCCCGGCGGAGGAGCAACAAGCGTCCAAAGCCAAGCCCATCA AGAGGCAACGCTCGGCCTCCCCGGAGCTGATGAGGTGCAAGAGGCGGCTGAA CTTCAATGGCTTCGGCTACAGCCTCCCGCAGCAGCAACCGGGCCGCGTGGCC CGGAGGAACGAGAGGGAAAGGAACCGGGTCAAGCTGGTCAATCTCGGCTTTG CCACCCTCAGGGAGCACGTCCCCAACGGTGCGGCCAACAAGAAGATGAGCAA AGTGGAGACGCTGCGATCGGCAGTCGAGTACATCAGGGCGCTGCAACAGCTG CTGGACGAACATGACGCTGTCAGCGCCGCTTTCCAGTCCGGGGTTCTTTCCC CACCATCTCCCCCAACTATTCACGATATGAACTCTATGGCGGGCTCCCCCGT CTCCTCGTACTCCTCAGATGAAGGCTCCTATGATCCGCTGAGCCCGGAGGAGC AAGAACTTCTCGACTTCACCACTTGTTCTGAGATGCGGAGTAGCAGGTGAGTT GCCTCCATCCCTGCTTCTTGTCATCCTCCGGACCTGCTGCTGGACCACTCTGG GAACCTCCCCCCCCCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT CTCTCTCCTACTTTCTAAGCACTAGGTGCCCTTCTGTCATTGCTTTCATTCCA GAGACCTGTCAGCCTCCACTTGCCAGGCATAGTGGCAGTTGTAGCAAGTGGCA GTTGTAGTAACAACAACAGTAGGAGGGCTTGAAGGGTGGCTGTCCCTGAATTA GAATGGATCTGTTGCTTATGGGACTTTTACAACCTCCTTAGCAGTTGAGTTCATT CTCCAAGCTTTAAAATGGGACACATTTGGGATTTGAAGACCATTCTGAGTAGTTC TGTAGCCATCTCTAGTTCTTGATAGCCTTTTGACAATCATACTATTCCTTTGCT GTTCAGAAGTTGTGAGGCATTTACGGACAGTGTGGGTGAATTGCAATCACTTG AATTTCTGCAGATGGTAATACAGGGAAAATAGTGTCTGTGGTGGGGATTGCCTAA AACATATGTGATGTCAACAAGTCCCTTCTGTATACTGATTGTTTGTATTGTTCTTC AGGCTGTTTGCCTCCCTGCTTGGATAACAAAGTGAAGCACACAGGAGCAGTTG GTCCCTCCAAGAACAACCTGAAGCACTACATTTGCACTCCAGTACGATTCACTGGA TGGATAGAGACATAATGCCGTGGGGCTCGTGGGTGGTGAAGCACACAGACACC ATCCCCTCACGCATGGAAGAGACGTGGTCCGTATGAACAACCCGGGGCTACC CCATATAAAACCAAGCCCTTATTGACTATAACCCTCCTTCTTTTATCGATGGAGGC CGTTCCCGGATCAGAATTTGTGGCGTGTTTATCCAACTATGCTGTTATTCAAAG AAACCCCTCCCTTCAGACTCTACCCCTTTTTTTTTTTGTACCACTTTCATC CTTAAATGCTTCCAATCTTTTGTGAAATTTTTTTTTTATTATAAGAAATATTTCTATC TATCCCAACTGTTTTGGGATATATTAAGCTATTTTTGTACATAAGAGAGAAATTA TAGAAGTTTTGTACAAATGGTATGAAATATGTATATCTTGATACATTATTATGTAA TGCTTATTACCTCTGCATATTTAGACTTGTAGTCTATAACCTTGCAACTGCAATTT TGTATGTGGTTTTGTAAAGGACACTCCTTTAAGGTGGGGTTGGAATTCCTACA GATGTACTTTAGCACCAACGTGTCTTACTTTATAGAACTTTGTTAATGCATTAAT TGTGTTATTAACAATGTTTCACAGTGAACAAAGTTTATGCAGCTATTGTCCAAC</p>	

GCAAAATAGTGGTCCACTGTATCTATGCTGCTTTCGGAACTCTATATACCACTG
 CCTTTTCTTACTGTTTTTAATACAAACTTACAAATGTCCTGCATAACTATGTTTTT
 TACACAATAGTTTCATAATAAAACATTTTTATATAG (The intronic sequence
 highlighted with backgreen)

Supplementary Table S2: Asc1b gene sequence

Gene	NCBI ID
Asc1b (Xenopus laevis MGC83023 protein)	NM_001092525.1
GTGCGGGGCCGCTCCTGTCACCTTGGCAACAGCAGCAACTCCCCGTCACCCGCA CAGTCAGAGCAACACGCGAACGGCAGCAGCCCCACTGGCACCCCAGCAGCAG CCGCCTATCATCAGCCTATCAGCATGGAGACCTCCGCTGCCAACCTGTCCAGCC AACAGCATTTCCTGCAGCCTCCTTGTTCCTCCCGCACAAACGTGCGGGCTGAGCC CGGCGGAGGAGCAAGAAGCGGTCAAGCCGAAGCCCATCAAGAGGCAGCGCTC GAGTCCCCGGAGCTGATGAGGTGCAAGAGGCGACTGAACTTCAATGGCTTCG GCTACAGCCTCCCGCAGCAGCAACCGGCCGCGCTGGCCCGGAGGAACGAGAG GGAGAGGAACCGAGTGAAGCTGGTCAATCTCGGCTTTGCCACCCTGAGAGAGC ACGTCCCCAACGGTGCGGCCAACAAGAAGATGAGCAAAGTGGAGACGCTGCGA TCGGCCGTCGAGTACATCAGGGCGCTGCAACAGCTGCTGGACGAACATGACGC GGTACGCGCCGCTTCCAGTCCGGCGTCTTTCCCCCAACATCTCCCCTAACTA TTCTCATGGTATGAACTCTATGGCGGGGTCTCCCGTCTCCTCGTACTCCTCAGAT GAAGGCTCCTATGATCCGCTCAGCCCTGAGGAGCAAGAGCTGCTCGACTTCAC CACTTGGTTCTGAGACACTGAGAAGCAGGCTGTTTGCCTCCCTGCTTGGATAAC AAAGTGAAGCGCACAGGAGCAGTCCGTCCCTCCAAGAACACTGAAGCACTACA TTTGCACTCCAGTAGGATTCACTGGACGGATAGAGACATAATGCAGTGGGGGTC GTGGGTGGTGCAGCACACATACACCATCCCAGCTCACACGCGGAAGAGACGTG GTCCATATGAACAACCCGGGGCTACCCCGAATAAAACGCAAGCCCTTATTGACT GTATGCTCCTTTTTTATCTATGGAGACGGTCCCGGATCAGAATTTGTCTATCCA AACAATGCTGATATCAAAGAAACCCCTCCCTTCAAGACTTACCCCTATTTT TTTGTACCACTTTCACCTTCAAATGCTTCCAAGCTTTTGTGAATTTTTTATTATAA GAATATATTTCTATCTATCCCAACTGTTTTGGGATATATTAAGCTATTTTTGTACATA AGAGAGAGAGATTTATAGAAGTTTTGTACAAATGGTATAAAATGTGTATATCTTGAT ACATTATTATGTAATGCTTATTACCTCTGCATATTTAGACTTGTAGTCTATAACCTTG CAACTGCCATTTTGTATGTGGTTTTGTAAAGGACACTCCTTTTAAGGTGGGGTTG GAATCCCACAGATGTACTTTAGCACCAACGTGTCTTACTTTATAGAACTTTGTT AATGTATTAATTGTGTTATTAACAATTGTTACAGTGAACAAAGTTTATGCAGCTA TTGTCCAAACCTAAAATAGTGGTCCACTGTATCTATGCTGCCTTTCAGAACACTAT ATACCACTGCCTTTTCTTACTGTTTTTAATACAAACTTACAAATGTCCTGCATAACT GTTTTTTTACACAATAGTTTCATAATAAAACATTTTTTATAGAAAAAACAAAAAAA AAAAAA	

Tables S3 and S4: RNA-seq data (S3: output scores; S4: the depth of RNA-seq data).

[Click here to Download Table S3 and S4](#)

Supplementary Table S5: antibodies used in this study

Antibody	Supplier	Cat.#
Anti-HA	Roche	11867423001
Anti-Myc	Santa Cruz	sc-40
Anti-Flag	MBL	M185-3L
	MBL	M185-10
Anti-H3K9ac	millipore	06-942
Anti-H3K27ac	millipore	07-360
Anti-H3K4me3	millipore	07-473
Anti-pol II S5P	Active motif	39233
Anti-phospho-smad2 (Ser465/467)	Cell signaling	3101
Anti-smad2	BD Transduction Laboratories	610843
Anti-phospho-smad1 (ser463/465)	Cell signaling	9511
Anti-smad1	Cell signaling	9743
Anti-phospho-Erk1/2 (Thr- 202/Tyr204)	Cell signaling	9101
Anti-Erk1/2 (p44/42 MAPK)	Cell signaling	9102

Supplementary Table S6: oligos and primers used in this study

Antisense morpholino oligonucleotides		
Items	Sequences	Notes/Reference
Ascl1a MOa	5' CAGTTGTCCATGCTGACAGGCTGCT 3'	Gene Tools/ New
Ascl1a Moa2	5' GTTCCCTGGCTCTAGCTCTGTGC3'	Gene Tools/ New
Ascl1a 5mm cMO	5' CACTTCTCCATCCTCACACGCT 3'	Gene Tools/ New
Ascl1a spMO	5' GATGGAGGCAACTCACCTGCTACTC 3'	Gene Tools/ New
Ascl1b MOb	5' GTCTCCATGCTGATAGGCTGATGAT 3'	Gene Tools/ New
Ascl1b 5mm cMO	5' GTATCCATACTAATAGGCTAATAAT 3'	Gene Tools/ New
HDAC1 MO1	5' TCAGCGCCATTTTCCTTCCGCGTCT 3'	Gene Tools/ New
HDAC1 MO2	5' AAGACCTACTACTACTTTGACCGGC 3'	Gene Tools/ New
HDAC2 MO	5' ATACGCCATGAAGAGCCCTGGAACC 3'	Gene Tools/ New
VegT MO	5' CCCGACAGCAGTTTCTCATTCCAGC 3'	Gene Tools /Heasman et al., 2002
RT-PCR primers		
Items	Sequences	Notes/Reference
ascl1-f	5' GAGCTGATGAGGTGCAAGAG3'	New
ascl1-r	5' TTTGCTCATCTTCTTGTTGG 3'	
bix4-f	5' CTGCGCCTGAACAATAGAAA 3'	New
bix4-r	5' CAGGTAGCTAAAATCTTCAC 3'	
bra-f	5' TTCTGAAGGTGAGCATGTCTG 3'	Sun et al., 1999
bra-r	5' GTTTGACTTTGCTAAAAGAGACAGG 3'	
chrd-f	5' AACTGCCAGGACTGGATGGT 3'	XMMR
chrd-r	5' GGCAGGATTTAGAGTTGCTTC 3'	
eomes-f	5' CCTCCACAGAGGTGGTTTGT 3'	New
eomes-r	5' GCTGCATCTGGGTAGTAGGC 3'	
gata4-f	5' AGTGCTACTGCTGCTACCTC 3'	Xathos and Janet, 2001
gata4-r	5' ACTGTAGGAGACCTCTCTGC 3'	
gata5-f	5' ACCTTCAGAGCTGCGACACT 3'	Xathos and Janet, 2001
gata5-r	5' CAGTGTATTGCCATACTGGTC 3'	
gdf3-f	5' TGGCAGAGTTGTGGCTATCA 3'	Xathos and Janet, 2001
gdf3-r	5' CTATGGCTGCTATGGTTCCTT 3'	
gsc-f	5' TTCACCGATGAACAACCTGGA 3'	New
gsc-r	5' TTCCACTTTTGGGCATTTTC 3'	
mix. 1-f	5' GCAGATGCCAGTTCAGCCAATG 3'	Xathos and

mix.1-r	5' TTTGTCCATAGGTTCCGCCCTG 3'	Janet,2001
mixer-f	5' CACCAGCCCAGCACTTAACC 3'	Henry and Melton,1998
mixer-r	5' CAATGTCACATCAACTGAAG 3'	
nodal 1-f	5' AGAGGAATGTGGGTGCAGTT 3'	New
nodal 1-r	5' CAACAAAGCCAAGGCATAAC 3'	
nodal 2-f	5' TTACTGTATGAAGACGGAGAAGTTG 3'	New
nodal 2-r	5' ATGCGACATGCCACAAAAC 3'	
odc-f	5' GCCATTGTGAAGACTCTCTCCATTC 3'	Heasman et al., 2000
odc-r	5' TTC GGG TGA TTC CTT GCC AC 3'	
pou5f3.3-f	5' TGACGGAAATTGCCAAAGAAC 3'	New
pou5f3.3-r	5' CCTTGGACATTCTGAATTTGCTC 3'	
sox17a-f	5' GCAAGATGCTTGGCAAGTCG 3'	Xathos and Janet,2001
sox17a-r	5' GCTGAAGTTCTCTAGACACA 3'	
vegt-f	5' CAAGTAAATGTGAGAAACCGTG 3'	Zhang et al., 1998
vegt-r	5' CAAATACACACACATTTCCCGA 3'	
ChIP-qPCR primers		
Items	Sequences	Notes/Reference
For VegT and Ascl1		
bix4-f	5' GCCTCCAGCCTACTTCTACT 3'	New -148~-14 from TSS
bix4-r	5' CCCTCCTTCTGGGGCTTTAT 3'	
sox17a-f	5' GCCAATAGACACCTTTCTAG 3'	New -9801~-9538 from TSS
sox17a-r	5' GAGAATGGGACTGTGTTAAC 3'	
mixer-f	5' TGGTTCATCCATGCGTTTC 3'	New -112 ~ +38 from TSS
mixer-r	5' TCCCAAATCTTGTGGCTCCC 3'	
gsc-f	5' CAGAGGACAATGGCATTAAATCA 3'	New -239 ~ -55 from TSS
gsc-r	5' AAGCACAGCAGCTCCACTCT 3'	
ef1 α -f	5' GTCTCGGCCCTAAATATGA 3'	Blythe,2009
ef1 α -r	5' CAGCTCCCAGCTCTTTTGTC 3'	
For histone marks and Pol II S5P		
bix4-f	5' TGGGAAGAGGCAGATTTGGA 3'	New +29 ~ +133 from TSS
bix4-r	5' AGATGGTCACTGGAGGAGAA 3'	
mixer-f	5' TGGTATAAGTAGGGACTCAGGT 3'	New -46 ~ +113 from TSS
mixer-r	5' GAGAAGCAAGATGGGTAGAA 3'	
gsc-f	5' CCCACCAAACCCTGTCCAAG 3'	New +102 ~ +190 from TSS
gsc-r	5' ATGCTGAACATGCCAGAAGG 3'	
gdf3-f	5' CAGAAGTTGCTGTAGGGAGA 3'	New -531 ~ -370 from TSS
gdf3-r	5' GTAATAGTGCCAAGAGTGTC 3'	
bmp4-f	5' CTGGGCAAGGGTGATTGTAT 3'	New

bmp5-r	5' GGCGCTCAATAAATGAAGGT 3'	-605 ~ -432 from TSS
ef1 α -f	5' GTCTCGGCCCTAAATATGA 3'	Blythe,2009
ef1 α -r	5' CAGCTCCCAGCTCTTTTGTC 3'	

Table S7: cDNA constructs used in this study.

cDNA cloning information, restriction enzymes for linearization and/or RNA polymerase for RNA probe labeling/in vitro transcription used in this study.

[Click here to Download Table S7](#)