

**Supplemental Figure 1. Structural changes in nephron-like structures after transplantation.**

(A): Representative confocal fluorescence images showing podocyte (NPHS1) and parietal epithelial cells (Claudin 1) populations in kidney organoids *in vitro* and the transplanted kidney organoids. Scale bars, 50 $\mu$ m. (B): Quantification of diameter of Bowman's space (kidney organoids *in vitro* (n=12) vs. transplanted kidney graft (n=3). \*, p< 0.05) (C): Representative confocal fluorescence images showing proximal tubular epithelial cells (LTL) populations in kidney organoids *in vitro* and the transplanted kidney organoids. Scale bars, 50 $\mu$ m. (D): Quantification of diameter of lumens of tubule-like structures (kidney organoids *in vitro* (n=12) vs. transplanted kidney graft (n=3). \*, p< 0.05)

**Supplemental Figure 2. Alternative differentiation protocols do not produce more mature cells.**

(A): Representative confocal immunofluorescence images from two additional batches of organoids distinct from the batch shown in Figure 5 for the Morizane and Takasato protocols, scaled identically to those images. (B): Identical images as those shown in Figure 5A, with the scaling increased to the point of being overexposed in the tissue sections. Scale bars, 50  $\mu$ m.

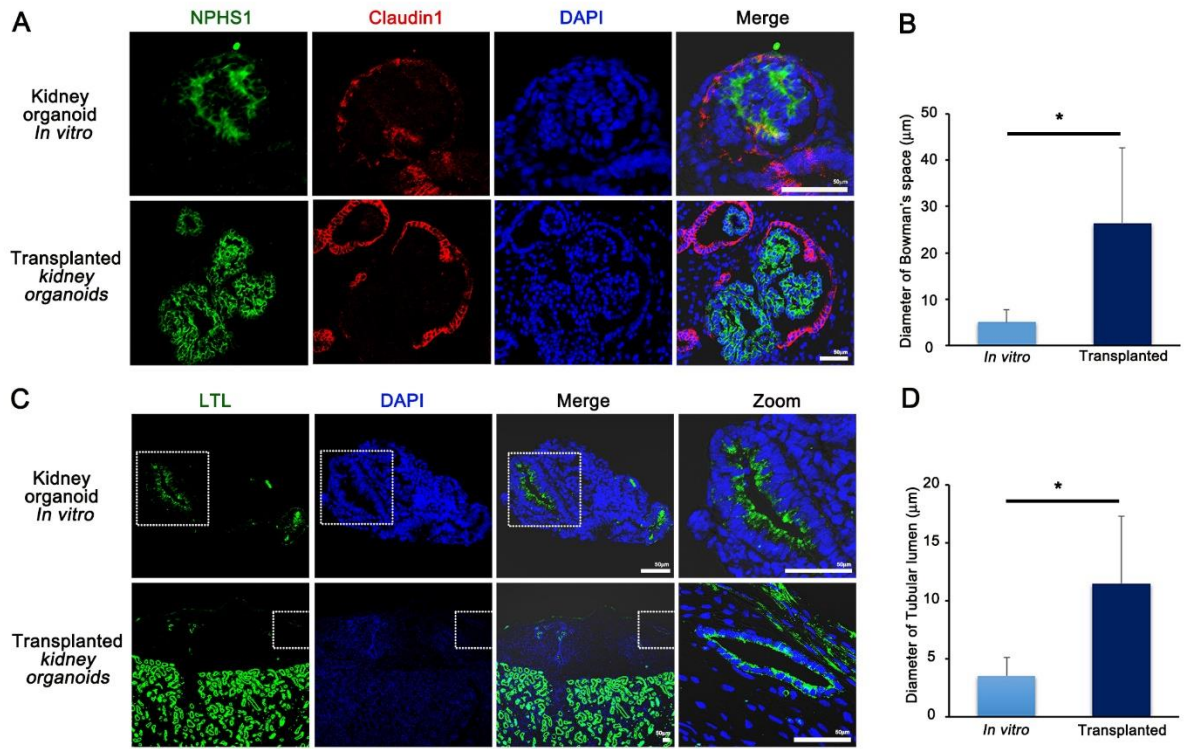
**Supplemental Figure 3.** Outgrowth of kidney organoids 7 days after implantation on glass plates coated with 3 % GelTrex. Scale bars, 600 $\mu$ m.

**Supplemental Figure 4.** Representative images of the transplanted kidney organoids graft at 2 weeks and 6weeks after renal subcapsular transplantation on NOD-SCID mouse kidney. Open arrows and black arrows indicate the kidney organoids graft at 2 weeks and 6weeks after transplantation, respectively. Scale bars, 2mm.

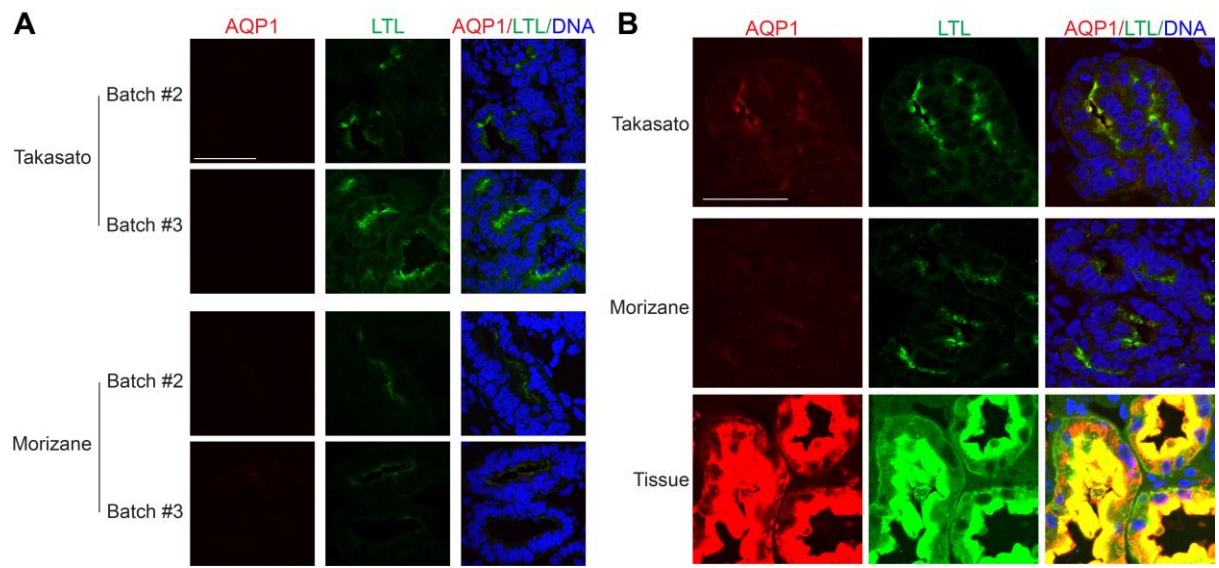
**Supplemental Figure 5.** (A): Representative images of H&E staining and immunohistochemical staining for safranin O of the kidney organoids transplanted with kidney dECM at 6 weeks after transplantation. Scale bars, 500  $\mu$ m. (B): Quantification of diameter of cartilages at 6 weeks after

transplantation. (transplanted kidney organoids (n=6) vs. transplanted kidney organoids with kidney dECM (n=6). \*,  $p < 0.05$ ).

# Supplemental Figure 1

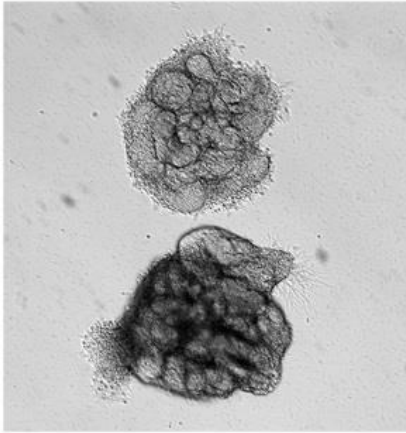


## Supplemental Figure 2

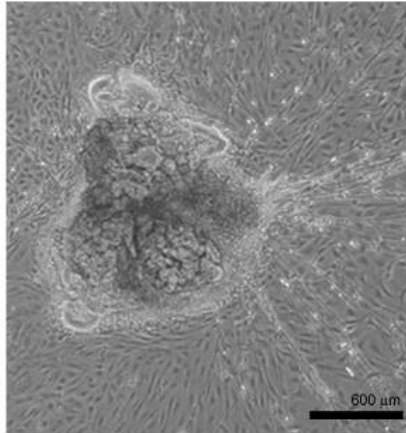


Supplemental Figure 3

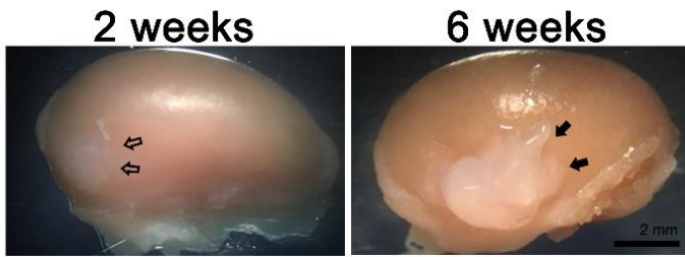
**Day 0**



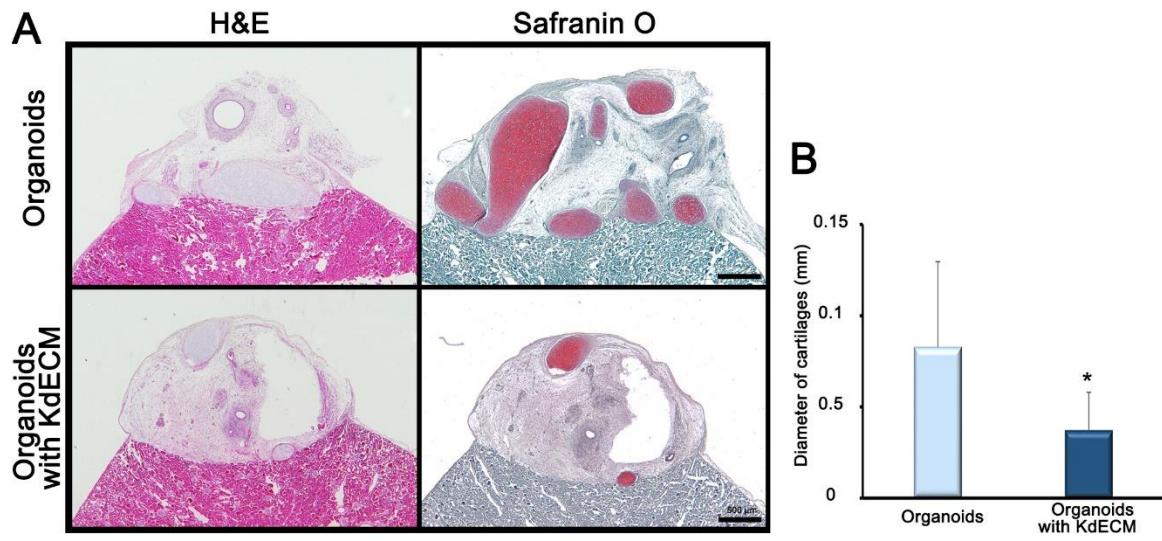
**Day 7**



Supplemental Figure 4



Supplemental Figure 5



**Supplemental Table 1.** Top 20 down-regulated leading-edge genes in subset of cell cycles

Gene Symbol	Gene Name
HIST1H2AJ	histone cluster 1 H2A family member j
DBF4	DBF4 zinc finger
CDK1	cyclin dependent kinase 1
HIST1H2BH	histone cluster 1 H2B family member h
ZWILCH	zwilch kinetochore protein
DNA2	DNA replication helicase/nuclease 2
PLK4	polo like kinase 4
CCNB2	cyclin B2
KIF18A	kinesin family member 18A
MCM10	minichromosome maintenance 10 replication initiation factor
CDC6	cell division cycle 6
ORC6	origin recognition complex subunit 6
CCNB1	cyclin B1
NEK2	NIMA related kinase 2
E2F3	E2F transcription factor 3
NPM1	nucleophosmin 1
CENPN	centromere protein N
CENPH	centromere protein H
NDC80	NDC80, kinetochore complex component
CDC7	cell division cycle 7



**Supplemental Table 2.** Top 20 up-regulated leading-edge genes in subset of extracellular matrix organization

Gene Symbol	Gene Name
COL12A1	collagen type XII alpha 1 chain
MMP7	matrix metalloproteinase 7
COL14A1	collagen type XIV alpha 1 chain
COL15A1	collagen type XV alpha 1 chain
COL8A1	collagen type VIII alpha 1 chain
MMP13	matrix metalloproteinase 13
COL3A1	collagen type III alpha 1 chain
COL5A1	collagen type V alpha 1 chain
COL21A1	collagen type XXI alpha 1 chain
COL6A2	collagen type VI alpha 2 chain
MMP8	matrix metalloproteinase 8
MMP3	matrix metalloproteinase 3
COL1A1	collagen type I alpha 1 chain
COL16A1	collagen type XVI alpha 1 chain
COL19A1	collagen type XIX alpha 1 chain
CTRB1	chymotrypsinogen B1
TPSAB1	tryptase alpha/beta 1
TLL1	tolloid like 1
ADAMTS2	ADAM metalloproteinase with thrombospondin type 1 motif 2
COL4A4	collagen type IV alpha 4 chain