Table A4.2: Marker genes used in transcriptome panels to monitor undifferentiated hPSCs and their multi-lineage differentiation

This table lists genes the expression of which has been used in published studies to provide evidence of undifferentiated cells or differentiation into the different germ layers. It is important to note that no single gene is expressed uniquely by a single cell type or lineage. Thus, conclusions should be based upon the patterns of gene expression observed compared with proper controls. Minimally, conclusions can be based on the expression of two or three genes indicative of each germ layer, but the strength of any conclusions is enhanced further as additional markers are included in the panel.

Gene	Undiff	Ectoderm	Mesoderm	Endoderm	Trophoblast
ABCB1		3	3		
ABCG2	3	2, 3	2, 3		
ACTA2			3		
ACTB			3		
ACTC			1		
ACTN1			3		
ADIPOQ			2, 3		
AFP				1, (3?)	
ALB				3	
ALPL	3				
ANPEP			2, 3		
APOE		2, 3		2, 3	
BMP2			3		
BRIX	1				
CAMK2A	3				
CAPN1			3		
CD14			3		
CD151			3		
CD19			3		
CD24	3	3	3		

CD34			2, 3	1	
CD36			2, 3		
CD4			2, 3		
CD44		2, 3	2, 3	2, 3	
CD59			3		
CD9	1, 3		3		
CDCP1			3	3	
CDH1	3		2, 3		
CDH15			3		
CDH2		2, 3	2, 3	2, 3	
CDH5			2, 3	1	
CDKN2A	3				
CDX2	3			2, 3	
CEACAM1			2, 3		
CGB					1
COL1A1			1		
COL2A1			1		
COMMD3	1				
CRABP2	1	2, 3			
CREBBP	3				
CSF1R			3		
CTNNB1	3			2, 3	
CXCR4		3	3	3	
DDX3X	3				
DES			1, 3		
DIAPH2	1				
DLL1	3		2, 3		
DLX5				3	
DNMT3B	1				
DPPA3	3				
E2F1	3				
EBAF	1				
EDNRB	1				
EN1		2, 3			
ENG			3		
ENO3			3		
EOMES					1
EP300	3				
EPCAM	3				

EPHB2	3				
ERAS	3				
FABP1				3	
FABP2				3	
FABP4			3		
FAS		2, 3			
FCGR3A			3		
FCGR3B			3		
FGF10	3				
FGF2	3				
FGF4	1				
FGF5	1				
FGFR2		2, 3			
FLT1				1	
FN1		3	3	1	
FOXA1				3	
FOXA2			3	1, 2, 3	
FOXD3	1, 3				
FUT4	3	2, 3	2, 3		
GABRB3	1				
GAL	1				
GATA2		2, 3			
GATA3		2, 3	2, 3	3	
GATA4			2, 3	1, 2, 3	
GATA6	1			2, 3	
GBX2	1				
GCG				1, 2, 3	
GCM1					1
GDF3	1				
GFAP		1, 3			
GNL3	3				2, 3
GRB7	1				
GREM1	3				
GSC			3		
GSK3B	3				
HAND1		2, 3	3		
HBB			1		
HBZ			1		
HHEX			2, 3		

HLA-DRA			3		
HLXB9		1			
HNF1A				2, 3	
HNF1B				2, 3	
HTATSF1				3	
IAPP				1	
ICAM1		2, 3	2		
IFITM1	1				
IFITM2	1				
IFNGR1	3				
IGFBP3			3		
IL6ST	1				
IMP2	1				
INHBA			2, 3		
INS				1	
IPF1				1	
IRF6	3				
ISL1		1		2, 3	
ITGA2B			3		
ITGA4		2, 3	2, 3		
ITGA6	3	2, 3	2, 3	2, 3	
ITGAL			2, 3		
ITGAM			2, 3		
ITGAV			2, 3		
ITGAX			2, 3		
ITGB1	3	2, 3	2, 3	2, 3	
ITGB2			3		
ITGB3			2, 3		
JAG1	3	3			
JMJD6	3				
KDR			2, 3		
KIT	1, 3		2, 3		
KLF4	3				
KRT1					1
LAMA1				1	
LAMB1				1	
LAMC1				1	
LEF1			2, 3		
LEFTB	1				

LIFR	1				
LIN28	1, 3				
LRP2				3	
MAP2		2, 3			
MAP2K1	3				
MAPK1	3				
MAPK3	3				
MAPT		2, 3			
MCAM		2, 3	2, 3		
MIXL1			3	3	
MME			2, 3		
MNX1		2, 3			
MYC	3				
MYF5			1		
MYH3			3		
MYOD1			1, 2, 3		
MYOG			2, 3		
NANOG	1, 3				
NCAM1		2, 3	2, 3		
NEFL		2, 3			
NES		1, 2, 3	2, 3		
NEUROD		1			
NEUROG3	3	2, 3		2, 3	
NGFR		2, 3	2, 3		
NKX2-5				2, 3	
NODAL	1, 3		3		
NOG	1				
NOG		2, 3			
NOTCH1	3	2, 3	2, 3		
NPPA			1		
NR5A2	1, 3				
NR6A1	1				
NUMB	1				
OLIG2		1			
OTX2		2, 3			
PAX3		2, 3			
PAX4				1	
PAX5		3			
PAX6		1, 2, 3		2, 3	

PAX7		2, 3			
PDGFRA		2, 3			
PDX1				3	
PDX1				2	
PECAM1			2, 3	1	
PODXL	1, 3				
POU5F1	1, 3				
PROM1	3				
PTEN	1				
PTF1A				1	
PTPRC			3		
RAF1	3				
REST	1				
ROCK1	3				
RUNX2			1		
S100B		3			
SDC1			2, 3		
SEMA3A	1				
SERPIN				1	
SFRP2	1				
SHH	3				
SLC2A2				2, 3	
SNAI2		2, 3			
SOX10		2, 3			
SOX17	3			3	
SOX17				1	
SOX2	1, 3	2, 3			
SOX7				3	
SOX9		2, 3			
SP1	3				
SPARC				3	
SPI1			2, 3		
SRF			2, 3		
SST				1, 2, 3	
STAT1	3				
STAT3	3		2, 3		
STAT5A	3				
SYP		1, 2, 3		2, 3	
SYT1		3			

TBXT			1, 2, 3		
TAT				1	
TAZ			3		
TDGF1	1, 3	2, 3			
TERT	1, 3				
TFCP2L	1				
TFRC			3		
TGFB1			3		
TGIF1	3				
TH		2, 3			
TH0		1			
THBD			3		
THY1		2, 3	2, 3	2,3	
TNFRSF1A			2, 3		
TNFRSF1B			3		
TNFRSF8	3				
TNNI3			3		
TP63		3			
TWIST1			2, 3		
UTF1	1, 3				
VCAM1			3		
VIM		3	3	3	
WT1			1		
XIST	1				
ZFP42	1, 3				
ZFX	3				

1) Characterization of human embryonic stem cell lines by the International Stem Cell Initiative (The International Stem Cell Initiative, 2007).
2) Reference maps of hESC and hiPSC variation enable high-throughput characterization of pluripotent cell lines (Bock et al., 2011).
3) Assessment of established techniques to determine developmental and malignant potential of human pluripotent stem cells by the International Stem Cell Initiative (Allison et al., 2018).