

Additional Table 1: Experimentally validated NLS and NES motifs considered in this study, with their sequence and reference.

Gene name	Signal type ^a	Sequence	Reference	Database ^b supporting annotation
ACD	NES	LVCLAESCLTLE	[1]	ValidNES
ADARB2	NLS	KRRRRRRSKRKDK	[2]	
ADD1	NLS	KKKKKFRTPSFLKSKK	[3]	
ADD1	NES	LMRMLDNL	[3]	
AHR	NES	KLDKLSVLRLS	[4]	ValidNES
AHR	NLS	RKRRKPVQKTVKPIPAEGIKSNPSKRH	[4]	
AICDA	NES	LRDAFRTLGL	[5]	ValidNES
AICDA	NLS	RRKFLYQFKNVRWAKGRR	[5]	
AKT1	NES	DLKLENMLDK	[6]	ValidNES
ANKRD11	NES	LAAIVDAIKL	[7]	ValidNES
ANKRD11	NLS	RKRIKK	[7]	
ANP32B	NES	LKKLECLKSLDL	[8]	ValidNES
ANP32B	NLS	KRKRE	[8]	
ANXA2	NES	MSTVHEILCKLSLEGDHSTPPSAYGSVKA	[9]	ValidNES
APC	NES (1)	LTKRIDSLPL	[10]	ValidNES
APC	NES (2)	LLERLKEINL	[10]	ValidNES
APLNR	NLS	RKRRR	[11]	
AR	NLS	RKCYEAGMTLGARKLKK	[12]	LocSigDB
ARNT	NLS	RAIKRRPGLDFDDDGEGNSKFLR	[13]	LocSigDB, NLSdb
ARNTL	NLS	RKRKG	[14]	
ARRB1	NLS	KIHKRNSVRLVIRK	[15]	

ATF2	NLS	RRRRAANEDPDEKRRKFLERNRAAASRCRQKR	[16]	
ATF2	NES	VAQLKQLLL	[16]	ValidNES
ATF3	NLS	RKKRRRERNKIAAAKCRNKKKE	[17]	
ATXN7	NES	FDPDIHCGVIDL	[18]	ValidNES
BAG6	NLS	RKVKPQPPLSDAYLSGMPAKRRK	[19]	
BIRC5	NES (1)	VKKQFEELTL	[20]	ValidNES
BIRC5	NES (2)	NKKKEFEETAEKVRRRAIEQLAAM	[20]	ValidNES
BLM	NLS	RKRKKMPASQRSKRRK	[21]	LocSigDB, NLSdb
BOK	NES	LLRLGDELE	[22]	ValidNES
BRCA1	NES (1)	LECPICLEL	[23, 24]	ValidNES
BRCA1	NES (2)	QLVEELLKIICAFQLDTGL	[24]	ValidNES
BRCA1	NLS	PKKNRLRR	[25]	LocSigDB, NLSdb
BRCA2	NES	DLSDLTFLEVA	[26]	ValidNES
BRCA2	NLS (1)	KKRR	[27]	LocSigDB
BRCA2	NLS (2)	PIKKK	[27]	LocSigDB
BRD2	NLS	KKGVKRKADTTTP	[28]	
BRD3	NLS	KKGVKRKADTTTP	[28]	
BRD4	NLS	KKGVKRKADTTTP	[28]	
BRMS1	NLS	PPSKRKK	[29-31]	
CBY1	NES	LSNLHSLDR	[32]	ValidNES
CBY1	NLS	RKRK	[32]	
CCNB1	NES	DLCQAFSDVILA	[33]	ValidNES
CCNT1	NLS	VNMLHSLLSAQGVQPTQPTAFEFVRPY	[34]	
CDC14A	NES	ILSGLDDMSI	[35]	ValidNES
CDC14B	NES	LLSGVDDISI	[35]	ValidNES
CDC7	NES	LLDKLLDLNP	[36]	ValidNES

CDC7	NES	LRKLCERLRG	[36]	ValidNES
CDKN1A	NES (1)	LQGTAEDHVDLSLSCTL	[37]	ValidNES
CDKN1A	NES (2)	VRGLGLPKLYL	[37]	ValidNES
CDKN1A	NLS	RKRRQTSMTDFYHSKR	[37, 38]	
CDKN1B	NES	LFGPVDHEELTRDL	[39]	ValidNES
CFL1	NES	VIKVFNDMKV	[40]	ValidNES
CFL1	NLS	RKSSTPEEVKRRKK	[40-42]	LocSigDB
CFLAR	NES	LLDLHIEL	[43]	ValidNES
CFLAR	NLS	RKRPLLDLHIELNGYMYDWSRVSAAKEKYYVWLQHTLRKKL	[43]	
CLIC4	NLS	KVVAKKYRN	[44, 45]	
CLK3	NLS	RSPSFGEDYYGPSRSRHRRRSRERGPY	[34]	
CPEB1	NES (1)	LSDLISLRI	[46]	ValidNES
CPEB1	NES (2)	LCLGLQSLSL	[46]	ValidNES
CPSF6	NLS	PPTNSGMPTSDSRGPPPTDPYGRPPPY	[34]	
CRY2	NLS	PKRKLEAAEPPGEELSKRAR	[47]	
CTNNBL1	NLS	RGTKRPRDDEEEQKMRRK	[48]	
CTNND1	NES	ESLEEELDVLVLDDEGG	[49]	ValidNES
CUL4B	NLS	KKRK	[50]	LocSigDB
DAG1	NLS	RKKRKGK	[51]	
DBR1	NLS	KRLSDEHEPEQRKKIKRR	[52]	
DCAF8	NES	IEVEASDLSLSL	[53]	
DCAF8	NLS	PRRRVQRKR	[53]	
DEAF1	NLS	KRRKK	[54]	
DEAF1	NES	WLYLEEMVNSLLNTAQQLKTLFEQ	[54]	ValidNES
DGKZ	NLS	KASKKKKRASFKRKSSKK	[55]	
DKC1	NLS	KKEKKKSKK	[56]	LocSigDB, NLSdb

DOK1	NES	LLKAKLTDPKED	[57]	ValidNES
DOK7	NES	QLEKRLSLLS	[58]	ValidNES
DR1	NES	VIQALESLGF	[59]	ValidNES
DR1	NLS	KRRK	[59]	
DST	NLS	PVKRRRM	[60]	
DUSP16	NES	LVQALSGLHL	[61]	ValidNES
DUSP16	NLS	KKIKNQTGASGPKSKLK	[61]	
DYRK4	NLS	KKPRKCDLTPFLVLKARKKQ	[62]	
ECT2	NLS	RKRRRLKETLAQLSRETDVSPFPPRKR	[63]	
EGFR	NLS	RRRHIVRKRTLRR	[64]	LocSigDB
EIF3E	NLS	RKRRQVLKDLVKVIQQESYTYKDPITEFVECLYVNFDFDGAQKKLR	[65]	
EIF3E	NES	LTTRIAHFDRHLV	[65]	ValidNES
ELAVL1	NLS	HHQAQRFSPMGVDHMSGVNVPG	[34]	
ELF3	NES	LCNCALEELRL	[66]	ValidNES
ELF3	NES	LWEIFRDILI	[66]	ValidNES
ELF3	NLS	HGKRKR	[66]	
ESR1	NES	EFVCLSKIILLNS	[67]	ValidNES
EWSR1	NLS	GGRRGGRGGPGKMDKGEHRQERRDRPY	[34]	
EXO1	NLS	KRPR	[68]	LocSigDB
FGF1	NES	ILFLPLPV	[69]	ValidNES
FGF1	NLS	NYKKPKL	[70]	LocSigDB
FGF2	NLS	RSRKYTSWYVALKR	[71]	
FGF3	NLS	RLRRDAGRGGVYEHGGAPRRR	[72]	LocSigDB
FHL1	NLS	KRTVSRVSHPVSKARK	[73]	
FHL1	NES	LPLTLFPSANL	[74]	ValidNES
FMR1	NES	EVDQLRLERLQIDEQLR	[75]	ValidNES

FOXO3	NES	LTDMAGTMNLDGLTENLMDDLLDNITL	[76]	ValidNES
FOXO3	NLS	RRRA	[76]	
FUS	NLS	GGDRGGFGPGKMDSRGEHRQDRRERPY	[34]	
GABPB1	NLS	EEPPAKRQCIEI	[77]	
GAPDH	NES	KKVVKQASEGPLK	[78]	ValidNES
GPR158	NLS	LKKLYAQLEIYKRKK	[79]	
GRK4	NLS	QKKRIKKRK	[80]	
GRK5	NLS	RKEKVKRE	[80]	
GRK6	NLS	RKKKIKRE	[80]	
HDAC4	NLS	KLRSRLKQKVAERRSSPLLRRK	[81]	
HDAC4	NES	VTAMASLSVGVKPA	[81, 82]	ValidNES
HDAC5	NES	VSAMALLSVGAEQAQAAAAREHSPRAEEPMEQEPAL	[82]	ValidNES
HDAC5	NLS	EPNLKVRSLKQKVAERRSSPLLRRKDGTVISTFKKRAVEITGAG	[82, 83]	
HEXIM1	NLS	WGQQQRQLGKKKHRRRPSKKKRHWKPY	[34]	
HEY1	NLS	ARKRRR	[84]	
HIF1A	NES	MEDIKILI	[85]	ValidNES
HNRNPA0	NLS	SYGPMKSGGGGGGGSSWGGRSNSGPY	[34]	
HNRNPA1	NLS	FGNYNNQSSNFGPMKGGNFGGRSSGPY	[34, 86]	LocSigDB
HNRNPA2B1	NLS	NYNQQPSNYGPMKSGNFGGSRNMGGPY	[34]	
HNRNPA3	NLS	NYSGQQSNGYGPMMKGGSFGRSSGPY	[34]	
HNRNPD	NLS	YGDYSNQQSGYGKVSRRGGHQNSYKPY	[34]	LocSigDB
HNRNPF	NLS	FKSSQEEVRSYSDPPLKFMSVQRPGPY	[34]	LocSigDB
HNRNPM	NLS	GGERPAQNEKRKEKNIKRGGNRFEPY	[34]	LocSigDB
HSPA8	NLS	KRKHKKDISENKRAVRR	[87, 88]	LocSigDB
HSPA8	NES	LDVTPLSL	[87]	ValidNES
HSH2D	NES	LWRSLKML	[89]	ValidNES

HTT	NES	IIISLARLPL	[90]	ValidNES
IFI16	NLS	QKRKKSTKEKAGPKGSKVS	[91]	
IGFBP2	NLS	PKKLRPPP	[92]	LocSigDB
IL5	NLS	KKYIDGQKKKCGEERRRV	[93]	LocSigDB
ILKAP	NLS	KTEGKGAKRKTSEEEK	[94]	
INHBA	NLS	KKKKKEEEGEGKKK	[95]	LocSigDB
IPMK	NLS	RHRKIYTKKHH	[96, 97]	
IPMK	NES	LMEEIGFLVL	[97]	ValidNES
IRF2BP2	NLS	ARKRKPSP	[98]	LocSigDB
IRF3	NES	ILDELLGNMVL	[99]	ValidNES
ITPKB	NES	LQRELQNVQV	[100]	ValidNES
ITPKB	NLS	KRKLRL	[100]	
JUN	NLS	RKRKL	[101]	LocSigDB
KANK1	NLS (1)	KRRK	[102]	
KANK1	NLS (2)	KKKDGNGKDSNGAKK	[102]	
KANK1	NES	LTLKTNLNL	[102]	ValidNES
KDM8	NLS	KRPARGSLPEQPCTKKARA	[103]	
KDM8	NES	EDLKLDL	[103]	
KEAP1	NES	LVKIFEELTL	[104]	ValidNES
KHDRBS1	NLS	DDWNGTRPSLKAPPARPVKGAYREHPY	[34]	
KIF4A	NLS	PKLRRR	[105]	
KLF6	NLS	CHFNGCRKVYTKSSHLKAHQRTHT	[106]	
KLF6	NES	MDVLPMCSIFQELQIV	[106]	ValidNES
LPIN1	NLS	KKRRKRRRK	[107]	
LZTS2	NES	LEQELQQLSLEL	[97]	ValidNES
MALT1	NES (1)	LTNLLRQL	[108]	ValidNES

MALT1	NES (2)	IPILDAL	[108]	ValidNES
MAX	NLS	PQSRKKLR	[109]	LocSigDB, NLSdb
MCM3	NLS	KKVLEKEKKRKKRSEDESETEDEEEKSQEDQEQRKRKRKTR	[110]	
MDM2	NES	SISLSFDESLALCVI	[111, 112]	ValidNES
MIER1	NES	FTDCLWTLFL	[113]	ValidNES
MIER1	NLS	RPAKRRR	[113]	
MSH5	NES	LVDKFMKLDL	[114]	ValidNES
MSH5	NLS	KKRR	[114]	
MTF1	NLS	KRKEVKR	[115]	
MTF1	NES	LCLSDLPLL	[115]	ValidNES
MTOR	NES (1)	LEWLRRSL	[116]	ValidNES
MTOR	NES (2)	IQDGLLKMLSLVL	[116]	ValidNES
MTOR	NES (3)	ITFIFKSLGL	[116]	ValidNES
MYB	NLS	PPLLKKIKQ	[117]	LocSigDB, NLSdb
MYC	NLS	PAAKRVKLD	[118]	LocSigDB
MYO1C	NLS	GRRKAAKRKWWAAQ	[119]	LocSigDB
NACC1	NLS	KRLWDSGQKEAGGGGNGSRKMAK	[120]	
NANOG	NES	MQELSNILNL	[121]	ValidNES
NANOG	NLS (1)	RMKSKRWQ	[121, 122]	
NANOG	NLS (2)	KKQKTR	[121, 122]	
NEDD4	NES	LAEELNARLTI	[123]	ValidNES
NFAT5	NLS	RKSRKR	[124]	
NFAT5	NES	MPSDFISLLSADLDLESP	[124]	ValidNES
NFE2	NLS	RRRGKNKVAQNCRKRK	[125]	
NFE2L1	NES	LSLEECLRL	[126]	ValidNES
NFE2L2	NES (1)	LLSIPELQCLNI	[127, 128]	ValidNES

NFE2L2	NES (2)	LKKQLSTLYL	[127, 128]	ValidNES
NFKB1	NLS	RKRQK	[129]	LocSigDB, NLSdb
NFKBIA	NES	MVKELQEIRL	[130]	ValidNES
NFKBIE	NES	VLLPFDDLKI	[131]	ValidNES
NKX2-5	NLS	RRRRKPR	[132]	
NMRAL1	NES	IELTLRL	[133]	ValidNES
NOTCH1	NLS (1)	KKFRFE	[134]	
NOTCH1	NLS (2)	RKRRR	[134]	
NPM1	NLS	KRSAPGGGSKVPQKKVK	[135]	
NPM1	NES (1)	LSLRTVSL	[135-137]	ValidNES
NPM1	NES (2)	ITPPVVLRL	[135-137]	ValidNES
NR3C1	NLS	RKCLQAGMNLEARKTKK	[21, 138]	LocSigDB, NLSdb
NUCKS1	NLS	KKIR	[139]	LocSigDB
NXF1	NLS	SSRLEEDGDVAMSDAQDGPRVRYNPY	[34]	
PABPN1	NLS	FYSGFNRPGRVYRGRARATSWYSPY	[34]	
PAK1	NLS (1)	KKKPKMSDEEILEKLSIVSVDGPKKK	[140]	
PAK1	NLS (2)	EKKKKDRFYRSILPGDKTNKKKE	[140]	
PATL1	NES	LAERLSKMVI	[141]	ValidNES
PARP1	NLS	KRKGDEVDGVDEVAKKSKK	[142]	LocSigDB
PCNT	NES (1)	LQDALRLLGL	[143]	ValidNES
PCNT	NES (2)	FGETLRAAVTL	[143]	ValidNES
PCNT	NES (3)	LDEFNELAI	[143]	ValidNES
PCNT	NES (4)	VIEKLQHELSE	[143]	ValidNES
PCNT	NES (5)	LELEALRLSL	[143]	ValidNES
PCNT	NLS	RRRKVEAGRTKLAHFRQRKTKGDSSHSEKKTAKRK	[143]	LocSigDB
PDGFB	NLS	RVTIRTVRVRPPKGGKHRK	[144]	LocSigDB

PDX1	NLS	RRMKWKK	[145]	LocSigDB, NLSdb
PHB	NES	ITYLPAGQSVLLQL	[146]	ValidNES
PKIA	NES	LALKLAGLDI	[147, 148]	ValidNES
PLK1	NLS	RQEEAEDPACIPIFWVSKWVDYSDKYGLGYQLCDNSVG	[149]	
PLSCR1	NLS	GKISKHWTGI	[150]	LocSigDB
PLSCR4	NLS	GSIIKWN	[151]	LocSigDB
POU3F1	NLS	GRKRKRT	[152]	LocSigDB
POU5F1	NLS	RKRKR	[153]	
PPP2CA	NES	LFDYLPLTAL	[154]	ValidNES
PPP2R5A	NES	LWKKLEELKL	[155]	ValidNES
PQBP1	NLS	RDRGYDKADREEGKERRHHRREELAPY	[34]	LocSigDB
PRKD2	NLS	RKRR	[156]	
PRKD2	NES	GEMLFGLVRQGL	[156]	ValidNES
PRKG1	NLS	KILKKRHI	[157]	LocSigDB
PTHLH	NLS	RYLTQETNKVETYKEQPLKTPGKKKKGK	[158]	LocSigDB, NLSdb
PTHLH	NES	LSDTSTTSLEL	[159]	ValidNES
PTK2	NES	LDLASLIL	[160]	
PTMA	NLS	TKKQKT	[161]	LocSigDB
PTPN2	NLS	RKRKR	[162]	LocSigDB
RANBP1	NES	EKVAEKLEALSVEETKE	[163, 164]	ValidNES
RANBP3	NLS	PPVKRERTS	[118]	LocSigDB, NLSdb
RB1	NLS	KRSAEGSNPPKPLKCLR	[165-167]	LocSigDB, NLSdb
RBM15B	NLS	GLPKPWEERRKRRSLSSDRGRTTHSPY	[34]	
RBM39	NLS	RSRSKERRRSRSDRRFRGRYRSPY	[34]	
RCC1	NLS	KRIAKRRSPADAIPKSKVK	[168]	
RELA	NLS	EKRKR	[129]	LocSigDB, NLSdb

RELA	NES	LSEALLQLQF	[169]	ValidNES
RIPK3	NES	LEGLKELMQL	[170]	ValidNES
RIPK3	NES	MVSEWLNKLNL	[170]	ValidNES
RIPK3	NLS	NPVTGRPLVNIYNCSGVQVGDNNYLTMQQT	[170]	
RNMT	NLS	KKRKLDP EIVPEEKDCGDAEGNSKKRKR	[171]	
RPS25	NLS	DPVNKSGGKAKKKKWSKGKVRD	[172]	
SAMHD1	NLS	KRPR	[173, 174]	
SECISBP2	NLS	KKKK	[175]	
SECISBP2	NES	QMLSKEVDACVTDLLKELVRFQD	[175]	ValidNES
SENP2	NES	LEPDLSEEVSARLRL	[176]	ValidNES
SENP2	NLS	KRRRSDSTLFSTVDTDEIPAKRPR	[176]	
SERTAD2	NES	LTDLTL	[177]	ValidNES
SH2B1	NLS	KPKLKKR	[178]	
SIRT2	NES	LRNFLSQTLSL	[179]	ValidNES
SIRT7	NLS	LQGRSRRREGLKRRQE	[180]	
SMAD1	NES	LTKMCTIRM	[181]	ValidNES
SMAD1	NLS	KKLK KKK	[181]	LocSigDB
SMAD3	NLS	KKLKKT	[182]	LocSigDB
SMAD4	NES	GIDLSGLTL	[183]	ValidNES
SMARCB1	NES	IIKLNIHVGNISLV	[184]	ValidNES
SOCS1	NLS	RRMLGAPLRQRRVR	[185]	LocSigDB
SOX14	NLS	HPDYKYRPRRKPKNLLKKDRYVFPLPY	[34]	
SOX9	NLS (1)	KRPMNAFMVWAQAARRK	[186]	LocSigDB, NLSdb
SOX9	NLS (2)	PRRRK	[186]	LocSigDB, NLSdb

SPAST	NLS	RKKK	[187, 188]	
SPAST	NLS	RGKKK	[187]	
SRF	NLS	RRGLKR	[189]	LocSigDB
SRY	NLS (1)	RPRRK	[190]	LocSigDB, NLSdb
SRY	NLS (2)	KRPMNAFIVWSRDQRRK	[190]	LocSigDB, NLSdb
STAG2	NLS	KNQKQGKGKTCKKGKK	[191]	LocSigDB
STAT1	NES	LLLKKMYL	[43]	ValidNES
STK4	NES (1)	LPSQLGTMVI	[192]	ValidNES
STK4	NES (2)	LKSWTVEDLQKRL	[192]	ValidNES
STK4	NLS	KRQPILDAIEAKRRR	[192]	
TAF15	NLS	YGGDRGGYGGKMGGRNDYRNDQRNRPY	[34]	
TFEB	NLS	IERRRR	[193]	
TFIP11	NLS	VKDKFN	[194]	
THRB	NLS	KRLAKRKLIEENREKRRR	[195]	LocSigDB

TMOD1	NES	ELCDIAAIL	[196]	ValidNES
TMOD1	NLS	RKRR	[196]	
TOB1	NES	QLEIQVALNFIIS	[197]	ValidNES
TOB1	NLS	NKLPRRRVNIFGEELERLLKKKY	[197]	
TOP1	NLS	NKKKKPKKEEQKWKWWEERYPEGIKW	[198]	
TOP2A	NLS	KPDPAKTKNRRRKRKPSTSDSDSNFEKIVSKAVTSKSKSGESD	[199]	
TOP2A	NES	ILRDFELRLK	[200]	ValidNES
TOP2B	NES	ILKEFFDLRLS	[200]	ValidNES
TP53	NLS	TKRALPNNTSSSPQPKKK	[201]	LocSigDB, NLSdb
TP53	NES	MFRELNEALEL	[111, 202, 203]	ValidNES
TP73	NES	ILMCLKESLEL	[203]	ValidNES
TP73	NLS	KRAFKQSPPAVPALGAGVKRRR	[203]	
TRIM27	NES	LEELD	[204]	ValidNES
USP21	NES	ELGAALSRLALRPEPTLR	[205]	ValidNES

USP22	NLS	KRELELLKHNPKRKIT	[206]	LocSigDB
VDR	NLS	RRSMKRK	[207]	LocSigDB, NLSdb
WASL	NES	LNNLDPELKNL	[208]	ValidNES
WASL	NLS	KKFRKAVTDLLGRRQRKSEK	[208]	
WBP11	NLS	KKNKK	[209]	
WBP11	NLS	KRKKL	[209]	
WBP11	NES	DDVYEAFMKEMEGLL	[209]	ValidNES
WBSCR16	NLS	PSFVVPSSGPGPRAGARPRRRIQVPY	[34]	
WEE1	NES	PHKTRKRLR	[54]	ValidNES
XPA	NLS	RKRQR	[210]	
YBX1	NLS	SAPEGQAQRRPYRRRRFPPY	[34]	
ZNF131	NLS (1)	KKQRTGKKIH	[211]	
ZNF131	NLS (2)	GKNEAKKRKIA	[211]	
ZNF655	NES	LERLQEILRKFLYL	[212]	ValidNES

^a When more than one motif of the same type are validated in one gene, their motif type is followed by a number to uniquely identify the individual motifs. The same number is used in the heatmaps (Figures 6, 7, S2 and S3).

^b NLS and NES databases considered: for NESs, ValidNES [213]; for NLSs, NLSdb [214] and LocSigDB [215].

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