



Pathway Analysis Report

This report contains the pathway analysis results for the submitted sample ". Analysis was performed against Reactome version 82 on 08/11/2022. The web link to these results is:

<https://reactome.org/PathwayBrowser/#/ANALYSIS=MjAyMjExMDYxNzUzMjVfNDc3NjQ%3D>

Please keep in mind that analysis results are temporarily stored on our server. The storage period depends on usage of the service but is at least 7 days. As a result, please note that this URL is only valid for a limited time period and it might have expired.

Table of Contents

1. Introduction
2. Properties
3. Genome-wide overview
4. Most significant pathways
5. Pathways details
6. Identifiers found
7. Identifiers not found

1. Introduction

Reactome is a curated database of pathways and reactions in human biology. Reactions can be considered as pathway 'steps'. Reactome defines a 'reaction' as any event in biology that changes the state of a biological molecule. Binding, activation, translocation, degradation and classical biochemical events involving a catalyst are all reactions. Information in the database is authored by expert biologists, entered and maintained by Reactome's team of curators and editorial staff. Reactome content frequently cross-references other resources e.g. NCBI, Ensembl, UniProt, KEGG (Gene and Compound), ChEBI, PubMed and GO. Orthologous reactions inferred from annotation for *Homo sapiens* are available for 17 non-human species including mouse, rat, chicken, puffer fish, worm, fly, yeast, rice, and *Arabidopsis*. Pathways are represented by simple diagrams following an SBGN-like format.

Reactome's annotated data describe reactions possible if all annotated proteins and small molecules were present and active simultaneously in a cell. By overlaying an experimental dataset on these annotations, a user can perform a pathway over-representation analysis. By overlaying quantitative expression data or time series, a user can visualize the extent of change in affected pathways and its progression. A binomial test is used to calculate the probability shown for each result, and the p-values are corrected for the multiple testing (Benjamini–Hochberg procedure) that arises from evaluating the submitted list of identifiers against every pathway.

To learn more about our Pathway Analysis, please have a look at our relevant publications:

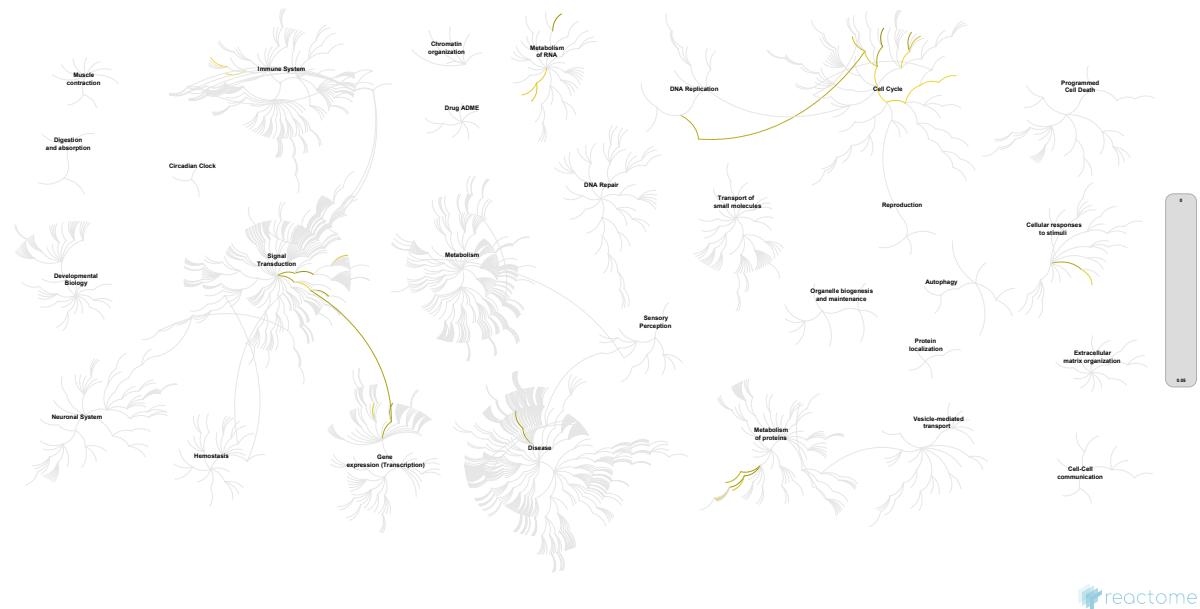
Fabregat A, Sidiropoulos K, Garapati P, Gillespie M, Hausmann K, Haw R, ... D'Eustachio P (2016). The reactome pathway knowledgebase. *Nucleic Acids Research*, 44(D1), D481–D487. <https://doi.org/10.1093/nar/gkv1351>.

Fabregat A, Sidiropoulos K, Viteri G, Forner O, Marin-Garcia P, Arnau V, ... Hermjakob H (2017). Reactome pathway analysis: a high-performance in-memory approach. *BMC Bioinformatics*, 18.

2. Properties

- This is an **overrepresentation** analysis: A statistical (hypergeometric distribution) test that determines whether certain Reactome pathways are over-represented (enriched) in the submitted data. It answers the question 'Does my list contain more proteins for pathway X than would be expected by chance?' This test produces a probability score, which is corrected for false discovery rate using the Benjamani-Hochberg method. ↗
- 5189 out of 8130 identifiers in the sample were found in Reactome, where 2342 pathways were hit by at least one of them.
- All non-human identifiers have been converted to their human equivalent. ↗
- This report is filtered to show only results for species 'Homo sapiens' and resource 'all resources'.
- The unique ID for this analysis (token) is MjAyMjExMDYxNzUzMjVfNDc3NjQ%3D. This ID is valid for at least 7 days in Reactome's server. Use it to access Reactome services with your data.

3. Genome-wide overview



This figure shows a genome-wide overview of the results of your pathway analysis. Reactome pathways are arranged in a hierarchy. The center of each of the circular "bursts" is the root of one top-level pathway, for example "DNA Repair". Each step away from the center represents the next level lower in the pathway hierarchy. The color code denotes over-representation of that pathway in your input dataset. Light grey signifies pathways which are not significantly over-represented.

4. Most significant pathways

The following table shows the 25 most relevant pathways sorted by p-value.

Pathway name	Entities				Reactions	
	found	ratio	p-value	FDR*	found	ratio
Endosomal/Vacuolar pathway	76 / 82	0.005	1.67e-04	0.421	4 / 4	2.84e-04
Antigen Presentation: Folding, assembly and peptide loading of class I MHC	89 / 108	0.007	0.002	0.805	15 / 16	0.001
Cell Cycle, Mitotic	409 / 596	0.039	0.002	0.805	352 / 352	0.025
Cell Cycle	495 / 734	0.048	0.002	0.805	449 / 451	0.032
Mitotic Spindle Checkpoint	89 / 111	0.007	0.004	0.805	7 / 7	4.97e-04
Amplification of signal from unattached kinetochores via a MAD2 inhibitory signal	77 / 94	0.006	0.004	0.805	4 / 4	2.84e-04
Amplification of signal from the kinetochores	77 / 94	0.006	0.004	0.805	4 / 4	2.84e-04
Mitotic Prometaphase	155 / 211	0.014	0.005	0.805	20 / 20	0.001
Signaling by TGF-beta Receptor Complex	85 / 107	0.007	0.006	0.805	98 / 100	0.007
Mitotic G1 phase and G1/S transition	130 / 174	0.011	0.006	0.805	101 / 101	0.007
Response of EIF2AK4 (GCN2) to amino acid deficiency	89 / 115	0.008	0.009	0.805	16 / 16	0.001
Cell Cycle Checkpoints	197 / 279	0.018	0.009	0.805	56 / 56	0.004
Nonsense-Mediated Decay (NMD)	95 / 124	0.008	0.009	0.805	6 / 6	4.26e-04
Nonsense Mediated Decay (NMD) enhanced by the Exon Junction Complex (EJC)	95 / 124	0.008	0.009	0.805	5 / 5	3.55e-04
Formation of a pool of free 40S subunits	82 / 106	0.007	0.012	0.805	2 / 2	1.42e-04
G1/S Transition	111 / 150	0.01	0.013	0.805	61 / 61	0.004
Nonsense Mediated Decay (NMD) independent of the Exon Junction Complex (EJC)	78 / 101	0.007	0.014	0.805	1 / 1	7.10e-05
RHO GTPases Activate Formins	110 / 149	0.01	0.014	0.805	25 / 27	0.002
TP53 Regulates Transcription of Cell Cycle Genes	53 / 65	0.004	0.016	0.805	42 / 42	0.003
EML4 and NUDC in mitotic spindle formation	91 / 121	0.008	0.016	0.805	5 / 5	3.55e-04
GTP hydrolysis and joining of the 60S ribosomal subunit	90 / 120	0.008	0.018	0.805	3 / 3	2.13e-04
L13a-mediated translational silencing of Ceruloplasmin expression	90 / 120	0.008	0.018	0.805	3 / 3	2.13e-04

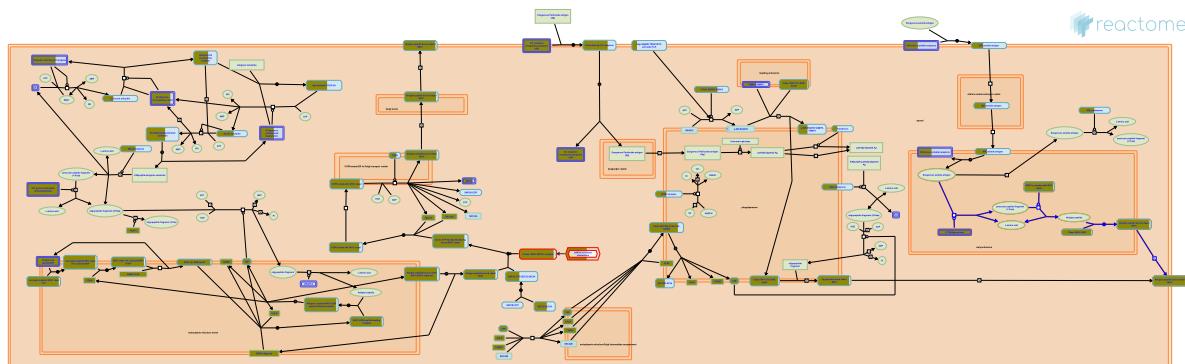
Pathway name	Entities				Reactions	
	found	ratio	p-value	FDR*	found	ratio
G1/S-Specific Transcription	37 / 43	0.003	0.019	0.805	28 / 28	0.002
Peptide chain elongation	73 / 97	0.006	0.028	0.805	4 / 5	3.55e-04
Activation of the pre-replicative complex	31 / 36	0.002	0.029	0.805	9 / 9	6.39e-04

* False Discovery Rate

5. Pathways details

For every pathway of the most significant pathways, we present its diagram, as well as a short summary, its bibliography and the list of inputs found in it.

1. Endosomal/Vacuolar pathway (R-HSA-1236977)



Cellular compartments: early endosome.

Some antigens are cross-presented through a vacuolar mechanism that involves generation of antigenic peptides and their loading onto MHC-I molecules within the endosomal compartment in a proteasome and TAP-independent manner. Antigens within the endosome are processed by cathepsin S and other proteases into antigenic peptides. Loading of these peptides onto MHC-I molecules occurs directly within early and late endosomal compartments. Why certain antigens are cross-presented exclusively by the cytosolic pathway while others use the vacuolar pathway is unknown. It may be because some epitopes cannot be generated by endosomal proteolysis, or are completely destroyed. Alternatively, the physical form of the antigen may influence its accessibility to the endosomal or vacuolar pathways (Shen et al. 2004).

References

Banchereau J, Montes M, Mellman I, Xue Y, Connolly JE, Clayton S, ... Di Puccio T (2008). Direct proteasome-independent cross-presentation of viral antigen by plasmacytoid dendritic cells on major histocompatibility complex class I. *Nat Immunol*, 9, 551-7. [🔗](#)

Edit history

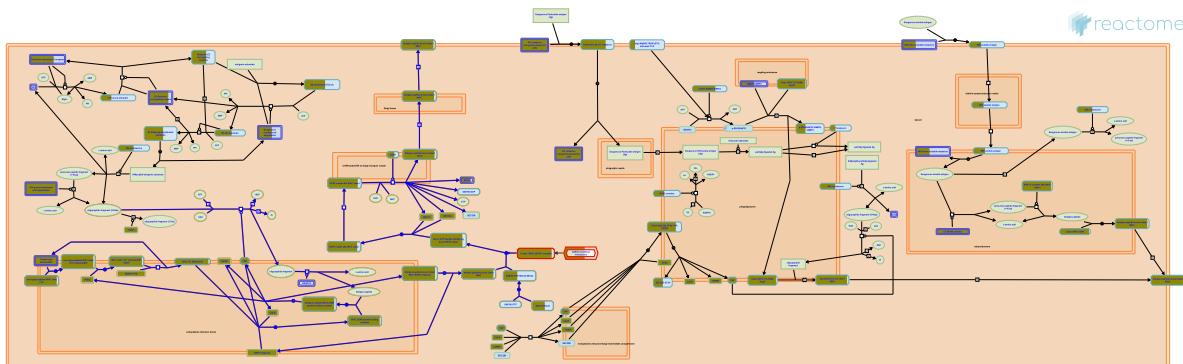
Date	Action	Author
2011-03-28	Edited	Garapati P V
2011-03-28	Authored	Garapati P V
2011-03-28	Created	Garapati P V
2011-05-13	Reviewed	Desjardins M, English L
2022-08-25	Modified	Wright A

9 submitted entities found in this pathway, mapping to 78 Reactome entities

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
B2M	P61769	CTSL	O60911, P07711	CTSS	P25774

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
CTSV	O60911, P07711	HLA-A	P01891, P01892, P04439, P05534, P10314, P10316, P13746, P16188, P16189, P16190, P18462, P30443, P30447, P30450, P30453, P30455, P30456, P30457, P30459, P30512, Q09160	HLA-B	P01889, P03989, P10319, P18463, P18464, P18465, P30460, P30461, P30462, P30464, P30466, P30475, P30479, P30480, P30481, P30483, P30484, P30485, P30486, P30487, P30488, P30490, P30491, P30492, P30493, P30495, P30498, P30685, Q04826, Q29718, Q29836, Q29940, Q31610, Q31612, Q95365
HLA-C	P04222, P10321, P30499, P30501, P30504, P30505, P30508, P30510, Q07000, Q29865, Q29960, Q29963, Q95604, Q9TNN7	HLA-E	P13747	LNPEP	Q9UIQ6

2. Antigen Presentation: Folding, assembly and peptide loading of class I MHC (R-HSA-983170)



Unlike other glycoproteins, correct folding of MHC class I molecules is not sufficient to trigger their exit from the ER, they exit only after peptide loading. Described here is the process of antigen presentation which consists of the folding, assembly, and peptide loading of MHC class I molecules. The newly synthesized MHC class I Heavy Chain (HC) is initially folded with the help of several chaperones (calnexin, BiP, ERp57) and then binds with Beta-2-microglobulin (B2M). This MHC:B2M heterodimer enters the peptide loading complex (PLC), a multiprotein complex that includes calreticulin, endoplasmic reticulum resident protein 57 (ERp57), transporter associated with antigen processing (TAP) and tapasin. Peptides generated from Ub-proteolysis are transported into the ER through TAP. These peptides are further trimmed by ER-associated aminopeptidase (ERAP) and loaded on to MHC class I molecules. Stable MHC class I trimers with high-affinity peptide are transported from the ER to the cell surface by the Golgi apparatus.

References

- Cresswell P & Wearsch PA (2008). The quality control of MHC class I peptide loading. *Curr Opin Cell Biol*, 20, 624-31. [🔗](#)
- Ploegh HL, Van der Veen AG & Vyas JM (2008). The known unknowns of antigen processing and presentation. *Nat Rev Immunol*, 8, 607-18. [🔗](#)
- Jeong E, Kim Y, Ahn K, Lee YJ, Kim I, Kang K, ... Oh C (2009). Molecular mechanisms of MHC class I-antigen processing: redox considerations. *Antioxid Redox Signal*, 11, 907-36. [🔗](#)
- Powis SJ, Elliott T & Antoniou AN (2003). Assembly and export of MHC class I peptide ligands. *Curr Opin Immunol*, 15, 75-81. [🔗](#)
- Rock KL, Goldberg AL & York IA (2004). Post-proteasomal antigen processing for major histocompatibility complex class I presentation. *Nat Immunol*, 5, 670-7. [🔗](#)

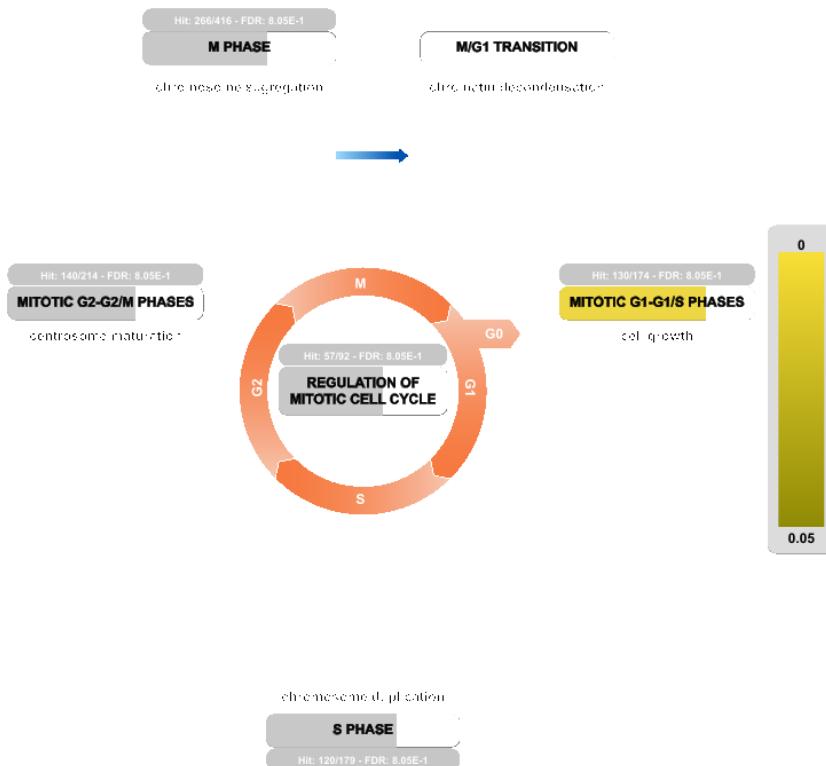
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Date	Action	Author
2010-10-29	Edited	Garapati P V
2010-10-29	Authored	Garapati P V
2010-10-29	Created	Garapati P V
2011-02-11	Reviewed	Elliott T
2022-08-26	Modified	Wright A

22 submitted entities found in this pathway, mapping to 89 Reactome entities

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
ATG14	Q6ZNE5	B2M	P61769	BCAP31	P51572
BECN1	Q14457	CALR	P27797	CANX	P27824
HLA-A	P01891, P01892, P04439, P05534, P10314, P10316, P13746, P16188, P16189, P16190, P18462, P30443, P30447, P30450, P30453, P30455, P30456, P30457, P30459, P30512, Q09160	HLA-B	P01889, P03989, P10319, P18463, P18464, P18465, P30460, P30461, P30462, P30464, P30466, P30475, P30479, P30480, P30481, P30483, P30484, P30485, P30486, P30487, P30488, P30490, P30491, P30492, P30493, P30495, P30498, P30685, Q04826, Q29718, Q29836, Q29940, Q31610, Q31612, Q95365	HLA-C	P04222, P10321, P30499, P30501, P30504, P30505, P30508, P30510, Q07000, Q29865, Q29960, Q29963, Q95604, Q9TNN7
HLA-E	P13747	HSPA5	P11021	PDIA3	P30101
PIK3C3	Q8NEB9	PIK3R4	Q99570	SEC13	P55735
SEC24B	O95487	SEC24C	P53992	SEC24D	O94855
SEC31A	O94979	TAP1	Q03518	TAP2	Q03519
TAPBP	O15533				

3. Cell Cycle, Mitotic (R-HSA-69278)



The events of replication of the genome and the subsequent segregation of chromosomes into daughter cells make up the cell cycle. DNA replication is carried out during a discrete temporal period known as the S (synthesis)-phase, and chromosome segregation occurs during a massive re-organization of cellular architecture at mitosis. Two gap-phases separate these cell cycle events: G1 between mitosis and S-phase, and G2 between S-phase and mitosis. Cells can exit the cell cycle for a period and enter a quiescent state known as G0, or terminally differentiate into cells that will not divide again, but undergo morphological development to carry out the wide variety of specialized functions of individual tissues.

A family of protein serine/threonine kinases known as the cyclin-dependent kinases (CDKs) controls progression through the cell cycle. As the name suggests, the kinase activity of the catalytic subunits is dependent on binding to cyclin partners, and control of cyclin abundance is one of several mechanisms by which CDK activity is regulated throughout the cell cycle.

A complex network of regulatory processes determines whether a quiescent cell (in G0 or early G1) will leave this state and initiate the processes to replicate its chromosomal DNA and divide. This regulation, during the **Mitotic G1-G1/S phases** of the cell cycle, centers on transcriptional regulation by the DREAM complex, with major roles for D and E type cyclin proteins.

Chromosomal DNA synthesis occurs in the **S phase**, or the synthesis phase, of the cell cycle. The cell duplicates its hereditary material, and two copies of each chromosome are formed. A key aspect of the **regulation of DNA replication** is the assembly and modification of a pre-replication complex assembled on ORC proteins.

Mitotic G2-G2/M phases encompass the interval between the completion of DNA synthesis and the beginning of mitosis. During G2, the cytoplasmic content of the cell increases. At G2/M transition, duplicated centrosomes mature and separate and CDK1:cyclin B complexes become active, setting the stage for spindle assembly and chromosome condensation at the start of mitotic **M phase**. Mitosis, or M phase, results in the generation of two daughter cells each with a complete diploid set of chromosomes. Events of the **M/G1 transition**, progression out of mitosis and division of the cell into two daughters (cytokinesis) are regulated by the Anaphase Promoting Complex.

The Anaphase Promoting Complex or Cyclosome (APC/C) plays additional roles in **regulation of the mitotic cell cycle**, insuring the appropriate length of the G1 phase. The APC/C itself is regulated by phosphorylation and interactions with checkpoint proteins.

References

Edit history

Date	Action	Author
2005-01-01	Authored	Walworth N, Bosco G, O'Donnell M
2005-01-01	Created	Walworth N, Bosco G, O'Donnell M
2010-01-19	Revised	Matthews L
2011-06-15	Reviewed	Grana X
2011-08-25	Reviewed	MacPherson D
2011-08-27	Revised	Orlic-Milacic M
2013-11-25	Edited	Matthews L, Gopinathrao G
2018-07-10	Reviewed	Manfredi JJ
2022-08-26	Modified	Wright A

400 submitted entities found in this pathway, mapping to 449 Reactome entities

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
AAAS	Q9NRG9	ABL1	P00519	AJUBA	Q96IF1
AKAP9	Q99996	AKT2	P31751	AKT3	Q9Y243
ANAPC1	Q9H1A4	ANAPC10	Q9UM13	ANAPC16	Q96DE5
ANAPC2	Q9UJX6	ANAPC7	Q9UJX3	ARPP19	P56211
AURKA	O14965	AURKB	Q96GD4	B9D2	Q9BPU9
BANF1	O75531	BIRC5	O15392	BLZF1	Q9H2G9
BORA	Q6PGQ7	BTRC	Q9Y297	BUB1	O43683, O60566
BUB1B	O60566	BUB3	O43684	CABLES1	Q8TDN4
CAPG	Q9BPX3	CC2D1A	Q5T0F9	CC2D1B	Q5T0F9
CCN1	P20248	CCNA2	P20248	CCNB1	P14635
CCNB2	O95067	CCND1	P24385	CCNE2	O96020
CCNL1	P49736	CDC14A	Q9UNH5	CDC16	Q13042
CDC20	Q12834	CDC23	Q9UJX2	CDC25A	P30304
CDC25B	P30305	CDC25C	P30307	CDC27	P30260, Q15054
CDC45	O75419	CDC6	Q99741	CDC7	O00311
CDCA5	Q96FF9	CDCA8	Q53HL2	CDK1	P06493
CDK2	P24941	CDK4	P11802	CDK5RAP2	Q96SN8

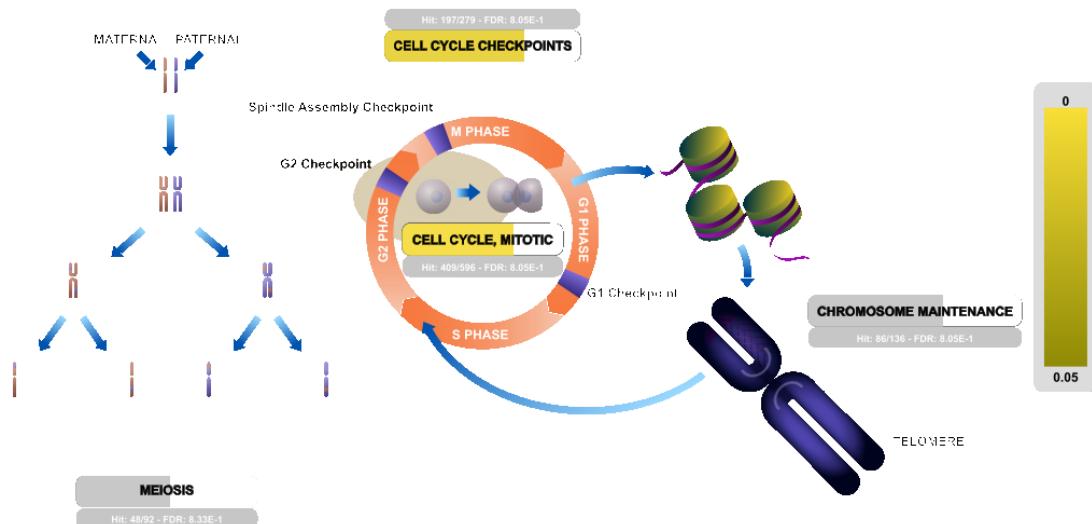
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CDK6	Q00534	CDKN1A	P38936	CDKN1B	P46527
CDKN1C	P49918	CDKN2B	P42771, P42772	CDKN2C	P42773
CDT1	Q9H211	CENPA	P49450	CENPE	Q02224
CENPF	P49454	CENPH	Q9H3R5	CENPI	Q92674
CENPK	Q9BS16	CENPL	Q8N0S6	CENPM	Q9NSP4
CENPN	Q96H22	CENPO	Q9BU64	CENPP	Q6IPU0
CENPQ	Q7L2Z9	CENPT	Q96BT3	CENPU	Q71F23
CEP131	Q9UPN4	CEP135	Q66GS9	CEP152	O94986
CEP164	Q9UPV0	CEP192	Q8TEP8	CEP41	Q9BYV8
CEP70	Q8NHQ1	CEP76	Q8TAP6	CEP78	Q5JTW2
CHMP2A	O43633	CHMP2B	Q9UQN3	CHMP4B	Q9H444
CHMP7	Q8WUX9	CKAP5	Q14008	CKS1B	P61024
CLASP1	Q7Z460	CLASP2	O75122	CLIP1	P30622
CLN3	P24864	CNTRL	Q7Z7A1	CSNK1D	P48730
CSNK1E	P49674	CSNK2A2	P19784	CSNK2B	P67870
CUL1	Q13616	CYB561D1	P51948	DBF4	Q9UBU7
DBT	P49674	DCTN1	Q14203-2	DCTN2	Q13561
DCTN3	O75935	DHFR	P00374	DLC1	P63167
DSN1	Q9H410	DYNC1H1	Q14204	DYNC1I1	O14576
DYNC1I2	Q13409	DYNC1LI1	Q9Y6G9	DYNLL1	P63167
DYNLL2	P63167, Q96FJ2	DYRK1A	Q13627	E2F1	O00716, Q01094
E2F2	Q14209, Q16254	E2F4	Q16254	E2F6	O75461
EMB	O14980	EML4	Q9HC35	EP300	Q09472
ERCC6L	Q2NKKX8	ESCO1	Q5FWF5	ESCO2	Q56NI9
ESPL1	Q14674	FBXO5	Q9UKT4	FBXW11	Q9UKB1
FEN1	P39748	FOSB	O75419	FOXM1	Q08050
FZR1	Q9UM11	GAA	P27694	GINS1	Q14691
GINS2	Q9Y248	GINS3	Q9BRX5	GINS4	Q9BRT9
GMNN	O75496	GORASP1	Q9BQQ3	GORASP2	Q9H8Y8
GSK3B	P49841	GTSE1	Q9NYZ3	H2AC6	Q93077
H2AJ	Q9BTM1	H2AX	P16104	H2AZ1	P0C0S5
H2AZ2	Q71UI9	H2BC11	P06899	H2BC21	P06899, Q16778
H2BC5	P58876	H2BC8	P62807, Q93079	H2BC9	P58876, Q93079
H3-3A	P84243	H3-3B	P84243	H4C8	P62805
HAUS2	Q9NVX0	HAUS5	O94927	HAUS6	Q7Z4H7
HAUS8	Q9BT25	HDAC1	Q13547	HMMR	O75330
HSP90AA1	P07900	HSP90AB1	P08238	IDE	P20700
INCENP	Q9NQS7	ITGB3BP	Q13352	JAK2	O60674
KIF18A	Q8NI77	KIF20A	O95235	KIF23	Q02241
KIF2A	O00139	KIF2C	Q99661	KMT5A	Q9NQR1
KNL1	Q8NG31	KNTC1	P50748	KPNB1	Q14974
LBR	Q14739	LEMD2	Q8NC56	LEMD3	Q9Y2U8
LIG1	P18858	LIN52	Q52LA3	LIN9	Q5TKA1
LMNA	P02545-1, P02545-2	LMNB1	P20700	LPIN2	Q92539
MAD2L1	Q13257	MAPK1	P28482	MAPK3	P27361-3, P28482
MAPRE1	Q15691	MASTL	Q96GX5	MAU2	Q9Y6X3
MAX	P61244	MCM10	Q7L590	MCM2	P33993, P49736
MCM3	P25205	MCM4	P33991	MCM5	P33992
MCM6	Q14566	MCM7	P33993	MCM8	Q9UJA3

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MIS12	Q9H081	MPP2	Q08050	MYBL2	P10244
MYC	P01106	MZT1	Q08AG7	MZT2A	Q6P582
MZT2B	Q6NZ67	NCAPD2	Q15021	NCAPD3	P42695
NCAPG	Q9BPX3	NCAPG2	Q86XI2	NCAPH	Q15003
NCAPH2	Q6IBW4	NDC1	Q9BTX1	NDC80	O14777
NDE1	Q9NXR1	NDEL1	Q9GZM8	NEDD1	Q8NHV4
NEK2	P51955	NEK6	Q9HC98	NEK7	Q8TDX7
NEK8	Q8TD19	NINL	Q9Y2I6	NIPBL	Q6KC79
NSL1	Q96IY1	NUDC	Q9Y266	NUF2	Q9BZD4
NUMA1	Q14980	NUP107	P57740	NUP155	O75694
NUP188	Q5SRE5	NUP205	Q92621	NUP214	P35658, Q96HA1
NUP35	Q8NFH5	NUP37	Q8NFH4	NUP43	Q8NFH3
NUP50	Q9UKX7	NUP54	Q7Z3B4	NUP62	P37198
NUP85	Q9BW27	NUP88	Q99567	NUP93	Q8N1F7
ODF2	Q5BJF6	OPTN	Q96CV9	ORC1	Q13415
ORC3	Q9UBD5	ORC4	O43929	ORC5	O43913
ORC6	Q9Y5N6	PCM1	Q15154	PCNA	P12004
PCNT	O95613	PDS5B	Q9NTI5	PHLDA1	Q8WV24
PIM1	P18754	PKMYT1	Q99640	PLK1	P53350
PLK4	O00444	POLA1	P09884	POLA2	Q14181
POLD1	P28340	POLD2	P49005	POLD3	Q15054
POLD4	Q9HCU8	POLE	Q07864	POLE2	P56282
POLE3	Q9NRF9	POM121	Q96HA1	POM121C	A8CG34, Q96HA1
PPP1CB	P62140	PPP1CC	P36873	PPP1R12A	O14974
PPP1R12B	O60237-4	PPP2CA	P67775	PPP2CB	P62714
PPP2R1A	P30153, P30154	PPP2R1B	P30154	PPP2R2A	P63151
PPP2R5D	Q14738	PRDM5	Q08AG7	PRIM1	P49642
PRIM2	P49643	PRKACA	P17252, P17612	PRKAR2B	P31323
PRKCA	P17252	PSMA4	P25789	PSMB10	P40306
PSMB6	P28072	PSMB7	P40306, Q99436	PSMB8	P28062
PSMC1	P62191	PSMC2	P35998	PSMC3	P17980
PSMD1	Q99460	PSMD10	Q75832	PSMD11	O00231
PSMD13	Q9UNM6	PSMD14	O00487	PSMD2	Q13200
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4. Cell Cycle (R-HSA-1640170)



The replication of the genome and the subsequent segregation of chromosomes into daughter cells are controlled by a series of events collectively known as the **cell cycle**. DNA replication is carried out during a discrete temporal period known as the S (synthesis)-phase, and chromosome segregation occurs during a massive reorganization to cellular architecture at mitosis. Two gap-phases separate these major cell cycle events: G1 between mitosis and S-phase, and G2 between S-phase and mitosis. In the development of the human body, cells can exit the cell cycle for a period and enter a quiescent state known as G0, or terminally differentiate into cells that will not divide again, but undergo morphological development to carry out the wide variety of specialized functions of individual tissues.

A family of protein serine/threonine kinases known as the cyclin-dependent kinases (CDKs) controls progression through the cell cycle. As the name suggests, the activity of the catalytic subunit is dependent on binding to a cyclin partner. The human genome encodes several cyclins and several CDKs, with their names largely derived from the order in which they were identified. The oscillation of cyclin abundance is one important mechanism by which these enzymes phosphorylate key substrates to promote events at the relevant time and place. Additional post-translational modifications and interactions with regulatory proteins ensure that CDK activity is precisely regulated, frequently confined to a narrow window of activity.

In addition, genome integrity in the cell cycle is maintained by the action of a number of signal transduction pathways, known as **cell cycle checkpoints**, which monitor the accuracy and completeness of DNA replication during S phase and the orderly chromosomal condensation, pairing and partition into daughter cells during mitosis.

Replication of telomeric DNA at the ends of human chromosomes and packaging of their centromeres into chromatin are two aspects of **chromosome maintenance** that are integral parts of the cell cycle.

Meiosis is the specialized form of cell division that generates haploid gametes from diploid germ cells, associated with recombination (exchange of genetic material between chromosomal homologs).

References

Edit history

Date	Action	Author
2011-10-10	Edited	Matthews L
2011-10-10	Created	Matthews L
2022-08-26	Modified	Wright A

487 submitted entities found in this pathway, mapping to 540 Reactome entities

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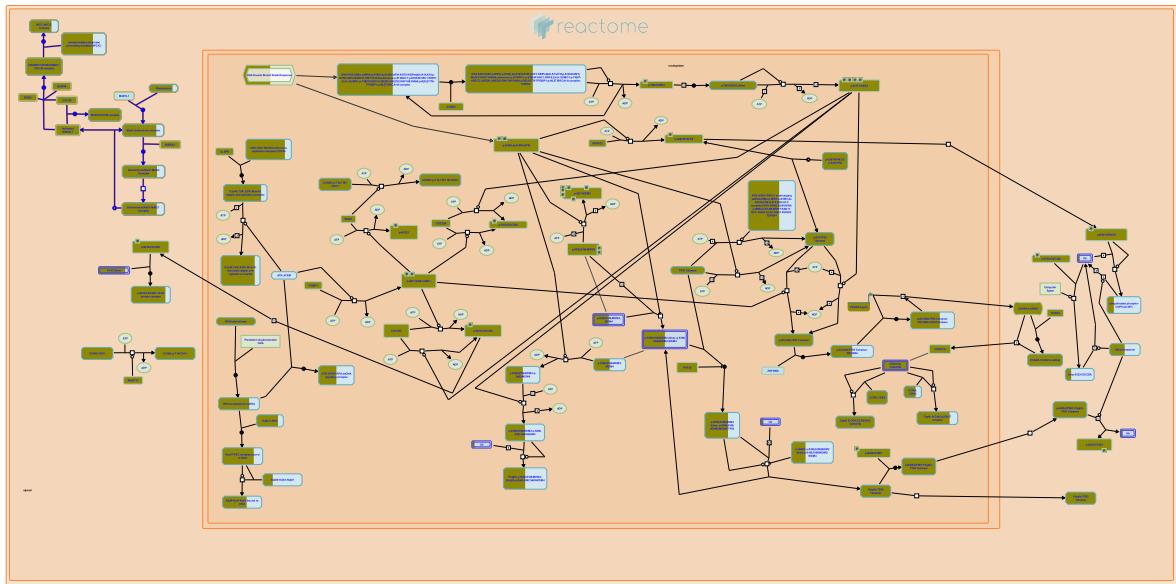
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5. Mitotic Spindle Checkpoint (R-HSA-69618)



Cellular compartments: cytosol.

The mitotic checkpoint or spindle assembly checkpoint is an evolutionarily conserved mechanism that ensures that cells with misaligned chromosomes do not exit mitosis and divide to form aneuploid cells. As chromosome attachment to the spindle microtubules is a stochastic process, not all chromosomes achieve alignment at the spindle equator at the same time. It is therefore essential that even a single unaligned chromosome can prevent the onset of anaphase. The ability of the checkpoint to monitor the status of chromosome alignment is achieved by assigning checkpoint proteins to the kinetochore, a macromolecular complex that resides at centromeres of chromosomes that establishes connections with spindle microtubules.

The checkpoint proteins monitor, in an unknown way, the mechanical activities between kinetochore-associated proteins and microtubules. Defects in mechanical activities at kinetochores activate the resident checkpoint proteins to initiate a signal that is amplified throughout the cell that ultimately prevents the activation of the proteolytic process that is required for sister chromatid separation and the onset of anaphase.

Kinetochores of unaligned chromosomes differ from those of aligned chromosomes in two ways. Kinetochores of aligned chromosomes are saturated with between 20 to 30 microtubules. In addition, poleward directed forces exerted at each sister kinetochore generates tension between them. Unaligned kinetochores on the other hand, are not saturated with microtubules and are not under tension. The mitotic checkpoint detects the presence of unattached kinetochores rather than monitoring for the presence of attached kinetochores. Consequently, unattached kinetochores emit an inhibitory signal that inhibits the biochemical events that are required to initiate the onset of anaphase. The mechanism by which this inhibitory signal is generated at unattached kinetochores has not precisely been determined but the signal is generated as a result of the lack of microtubule occupancy and kinetochore tension.

A single unattached kinetochore is capable of preventing cells from exiting mitosis. The mitotic checkpoint provides a way for a localized defect to affect the global biochemical status of the cell. In principle, the signal that is generated at an unattached kinetochore diffuses throughout the cell to affect its target. There are currently two models for how this is achieved. One model is based on the observation that the Mad2 checkpoint protein binds and is rapidly released from unattached kinetochores. The kinetochore is believed to act as a catalyst that converts Mad2 into an inhibitory state that diffuses throughout the cell upon its release from the kinetochore. A second model proposes that the signal is amplified by a kinase cascade much like a conventional signal transduction pathway. This kinase cascade is believed to be comprised of the checkpoint kinases, hBUBR1, hBUB1, hMPS1.

References

- Yen TJ & Chan GK (2003). The mitotic checkpoint: a signaling pathway that allows a single unattached kinetochore to inhibit mitotic exit. *Prog Cell Cycle Res*, 5, 431-9. [🔗](#)
- Hardwick KG & Musacchio A (2002). The spindle checkpoint: structural insights into dynamic signalling. *Nat Rev Mol Cell Biol*, 3, 731-41. [🔗](#)

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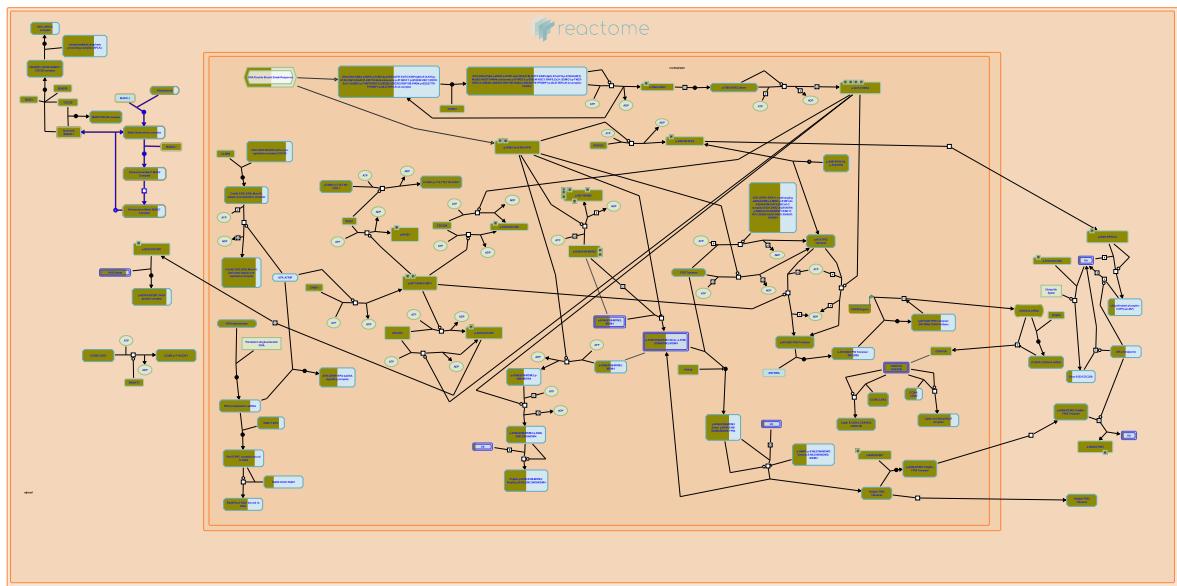
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2022-08-26	Modified	Wright A

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DYNC1H1	Q14204	DYNC1I1	O14576	DYNC1I2	Q13409
DYNC1LI1	Q9Y6G9	DYNLL1	P63167	DYNLL2	P63167, Q96FJ2
EMB	O14980	ERCC6L	Q2NKX8	INCENP	Q9NQS7
ITGB3BP	Q13352	KIF18A	Q8NI77	KIF2A	O00139
KIF2C	Q99661	KNL1	Q8NG31	KNTC1	P50748
MAD2L1	Q13257	MAPRE1	Q15691	MIS12	Q9H081
NDC80	O14777	NDE1	Q9NXR1	NDEL1	Q9GZM8
NSL1	Q96IY1	NUDC	Q9Y266	NUF2	Q9BZD4
NUP107	P57740	NUP37	Q8NFH4	NUP43	Q8NFH3
NUP85	Q9BW27	PLK1	P53350	PPP1CC	P36873
PPP2CA	P67775	PPP2CB	P62714	PPP2R1A	P30153, P30154
PPP2R1B	P30154	PPP2R5D	Q14738	RANBP2	P49792
RANGAP1	P46060	RCC2	Q9P258	SEC13	P55735
SEH1L	Q96EE3-1	SGO1	Q5FBB7	SGO2	Q562F6
SKA1	Q96BD8	SKA2	Q8WVK7	SPC24	Q8NBT2
SPC25	Q9HBM1	SPDL1	Q96EA4	TAOK1	Q7L7X3
TFAM	P51668	TMEM208	O00762	TXNIP	Q9UJX2
UBE2C	O00762	UBE2D1	P51668	UBE2E1	P51965
UBE2S	Q16763	VTI1B	Q96FJ2	XPO1	O14980
ZWILCH	Q9H900	ZWINT	O95229		

6. Amplification of signal from unattached kinetochores via a MAD2 inhibitory signal (R-HSA-141444)



Cellular compartments: cytosol.

The signal from unattached kinetochores is amplified through a Mad2 inhibitory signal that is propagated by the binding of Mad1 to the kinetochore, the association of Mad2 with Mad1, the conversion of Mad2 conformation to an inhibitory form through its association with Mad1 and finally the release of the inhibitory form of Mad2 from the kinetochore.

References

Yen TJ & Chan GK (2003). The mitotic checkpoint: a signaling pathway that allows a single unattached kinetochore to inhibit mitotic exit. *Prog Cell Cycle Res*, 5, 431-9. [🔗](#)

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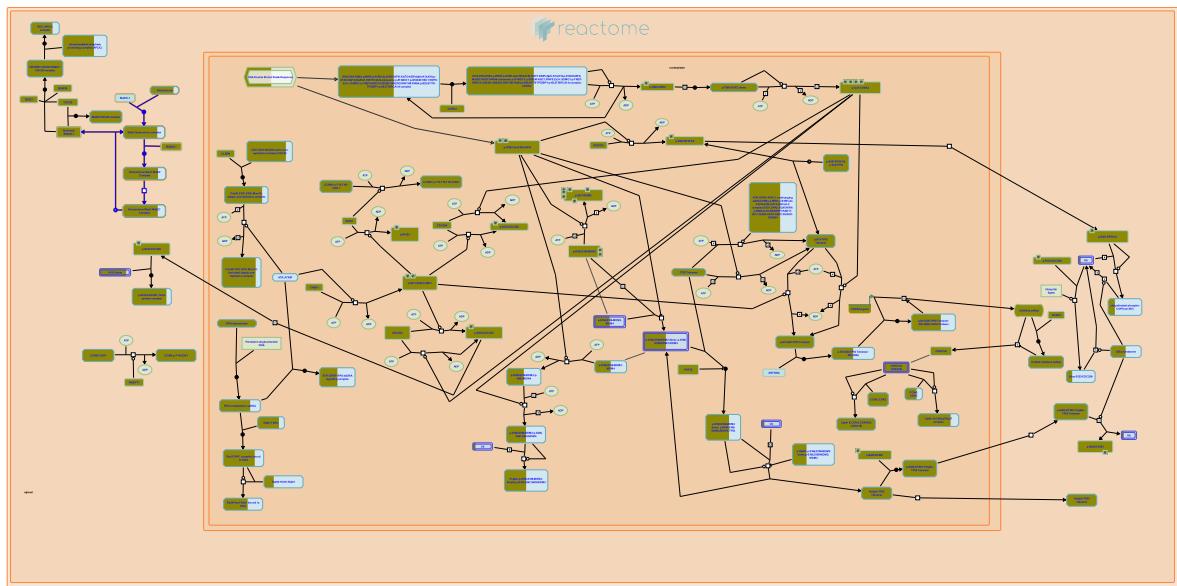
Date	Action	Author
2004-05-05	Authored	Yen TJ
2004-05-05	Created	Yen TJ
2022-09-05	Modified	Wright A

80 submitted entities found in this pathway, mapping to 83 Reactome entities

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CENPI	Q92674	CENPK	Q9BS16	CENPL	Q8N0S6
CENPM	Q9NSP4	CENPN	Q96H22	CENPO	Q9BU64
CENPP	Q6IPU0	CENPQ	Q7L2Z9	CENPT	Q96BT3
CENPU	Q71F23	CKAP5	Q14008	CLASP1	Q7Z460
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KNTC1	P50748	MAD2L1	Q13257	MAPRE1	Q15691
MIS12	Q9H081	NDC80	O14777	NDE1	Q9NXR1
NDEL1	Q9GZM8	NSL1	Q96IY1	NUDC	Q9Y266
NUF2	Q9BZD4	NUP107	P57740	NUP37	Q8NFH4
NUP43	Q8NFH3	NUP85	Q9BW27	PLK1	P53350
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RANBP2	P49792	RANGAP1	P46060	RCC2	Q9P258
SEC13	P55735	SEH1L	Q96EE3-1	SGO1	Q5FB7
SGO2	Q562F6	SKA1	Q96BD8	SKA2	Q8WVK7
SPC24	Q8NBT2	SPC25	Q9HBM1	SPDL1	Q96EA4
TAOK1	Q7L7X3	VTI1B	Q96FJ2	XPO1	O14980
ZWILCH	Q9H900	ZWINT	O95229		

7. Amplification of signal from the kinetochores (R-HSA-141424)



Cellular compartments: cytosol.

A single unattached kinetochore is capable of preventing cells from exiting mitosis. The mitotic checkpoint provides a way for a localized defect to affect the global biochemical status of the cell. In principle, the signal that is generated at an unattached kinetochore diffuses throughout the cell to affect its target. There are currently two models for how this is achieved. One model is based on the observation that the Mad2 checkpoint protein binds and is rapidly released from unattached kinetochores. The kinetochore is believed to act as a catalyst that converts Mad2 into an inhibitory state that diffuses throughout the cell upon its release from the kinetochore. A second model proposes that the signal is amplified by a kinase cascade much like a conventional signal transduction pathway. This kinase cascade is believed to be comprised of the checkpoint kinases, hBUBR1, hBUB1, hMPS1.

References

Yen TJ & Chan GK (2003). The mitotic checkpoint: a signaling pathway that allows a single unattached kinetochore to inhibit mitotic exit. *Prog Cell Cycle Res*, 5, 431-9. [\[CrossRef\]](#)

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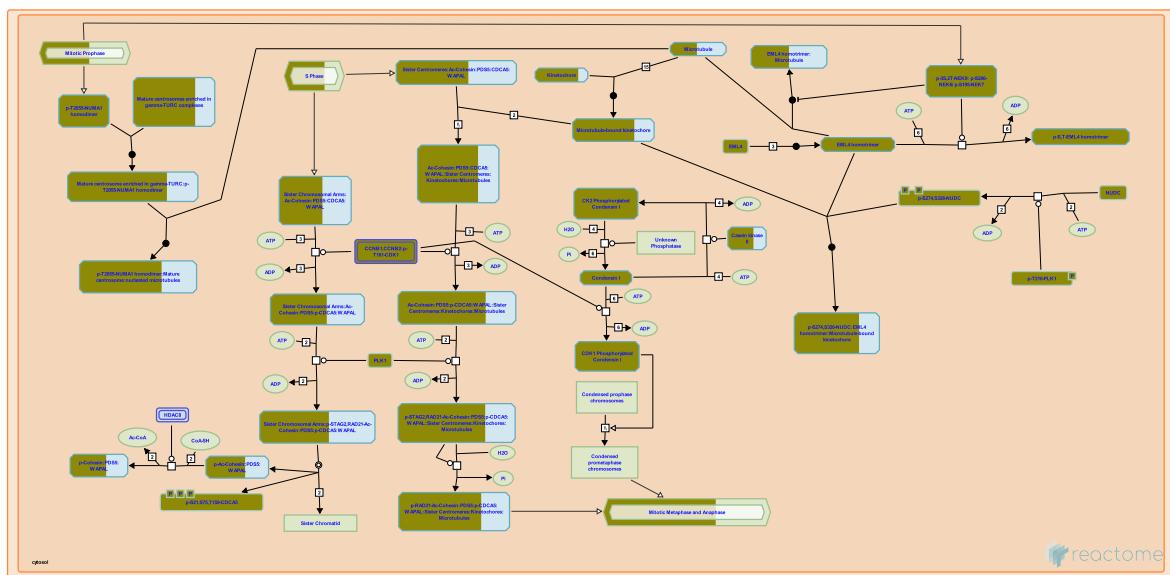
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2004-05-05	Created	Yen TJ
2022-08-25	Modified	Wright A

80 submitted entities found in this pathway, mapping to 83 Reactome entities

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CLASP2	O75122	CLIP1	P30622	DLC1	P63167
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DYNLL2	P63167, Q96FJ2	EMB	O14980	ERCC6L	Q2NKX8
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KIF2A	O00139	KIF2C	Q99661	KNL1	Q8NG31
KNTC1	P50748	MAD2L1	Q13257	MAPRE1	Q15691
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NDEL1	Q9GZM8	NSL1	Q96IY1	NUDC	Q9Y266
NUF2	Q9BZD4	NUP107	P57740	NUP37	Q8NFH4
NUP43	Q8NFH3	NUP85	Q9BW27	PLK1	P53350
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RANBP2	P49792	RANGAP1	P46060	RCC2	Q9P258
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SGO2	Q562F6	SKA1	Q96BD8	SKA2	Q8WVK7
SPC24	Q8NBT2	SPC25	Q9HBM1	SPDL1	Q96EA4
TAOK1	Q7L7X3	VTI1B	Q96FJ2	XPO1	O14980
ZWILCH	Q9H900	ZWINT	O95229		

8. Mitotic Prometaphase (R-HSA-68877)



The dissolution of the nuclear membrane marks the beginning of the prometaphase. Kinetochores are created when proteins attach to the centromeres. Microtubules then attach at the kinetochores, and the chromosomes begin to move to the metaphase plate.

References

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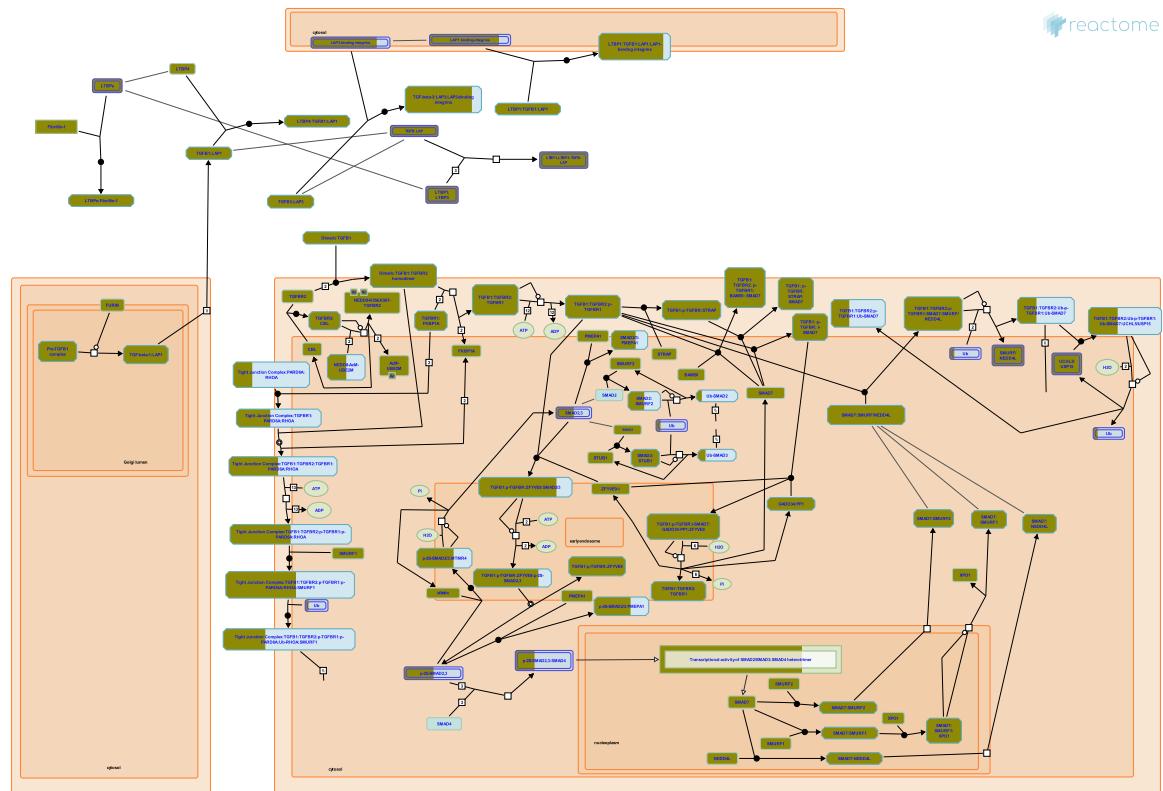
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KNL1	Q8NG31	KNTC1	P50748	MAD2L1	Q13257
MAPRE1	Q15691	MIS12	Q9H081	MZT1	Q08AG7
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NUP107	P57740	NUP37	Q8NFH4	NUP43	Q8NFH3
NUP85	Q9BW27	ODF2	Q5BJF6	PCM1	Q15154
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TUBGCP6	Q96RT7	VTI1B	Q96FJ2	XPO1	O14980
YWHAE	P62258	YWHAG	P61981	ZWILCH	Q9H900
ZWINT	O95229				

9. Signaling by TGF-beta Receptor Complex (R-HSA-170834)



The TGF-beta/BMP pathway incorporates several signaling pathways that share most, but not all, components of a central signal transduction engine. The general signaling scheme is rather simple: upon binding of a ligand, an activated plasma membrane receptor complex is formed, which passes on the signal towards the nucleus through a phosphorylated receptor SMAD (R-SMAD). In the nucleus, the activated R-SMAD promotes transcription in complex with a closely related helper molecule termed Co-SMAD (SMAD4). However, this simple linear pathway expands into a network when various regulatory components and mechanisms are taken into account. The signaling pathway includes a great variety of different TGF-beta/BMP superfamily ligands and receptors, several types of the R-SMADs, and functionally critical negative feedback loops. The R-SMAD:Co-SMAD complex can interact with a great number of transcriptional co-activators/co-repressors to regulate positively or negatively effector genes, so that the interpretation of a signal depends on the cell-type and cross talk with other signaling pathways such as Notch, MAPK and Wnt. The pathway plays a number of different biological roles in the control of embryonic and adult cell proliferation and differentiation, and it is implicated in a great number of human diseases.

TGF beta (TGFB1) is secreted as a homodimer, and as such it binds to TGF beta receptor II (TGF-BR2), inducing its dimerization. Binding of TGF beta enables TGFBR2 to form a stable hetero-tetrameric complex with TGF beta receptor I homodimer (TGFBR1). TGFBR2 acts as a serine/threonine kinase and phosphorylates serine and threonine residues within the short GS domain (glycine-serine rich domain) of TGFBR1.

The phosphorylated heterotetrameric TGF beta receptor complex (TGFBR) internalizes into clathrin coated endocytic vesicles where it associates with the endosomal membrane protein SARA. SARA facilitates the recruitment of cytosolic SMAD2 and SMAD3, which act as R-SMADs for TGF beta receptor complex. TGFBR1 phosphorylates recruited SMAD2 and SMAD3, inducing a conformational change that promotes formation of R-SMAD trimers and dissociation of R-SMADs from the TGF beta receptor complex.

In the cytosol, phosphorylated SMAD2 and SMAD3 associate with SMAD4 (known as Co-SMAD), forming a heterotrimer which is more stable than the R-SMAD homotrimers. R-SMAD:Co-SMAD heterotrimer translocates to the nucleus where it directly binds DNA and, in cooperation with other transcription factors, regulates expression of genes involved in cell differentiation, in a context-dependent manner.

The intracellular level of SMAD2 and SMAD3 is regulated by SMURF ubiquitin ligases, which target R-SMADs for degradation. In addition, nuclear R-SMAD:Co-SMAD heterotrimer stimulates transcription of inhibitory SMADs (I-SMADs), forming a negative feedback loop. I-SMADs bind the phosphorylated TGF beta receptor complexes on caveolin coated vesicles, derived from the lipid rafts, and recruit SMURF ubiquitin ligases to TGF beta receptors, leading to ubiquitination and degradation of TGFBR1. Nuclear R-SMAD:Co-SMAD heterotrimers are targets of nuclear ubiquitin ligases which ubiquitinate SMAD2/3 and SMAD4, causing heterotrimer dissociation, translocation of ubiquitinated SMADs to the cytosol and their proteasome-mediated degradation. For a recent review of TGF-beta receptor signaling, please refer to Kang et al. 2009.

References

Kang JS, Derynck R & Liu C (2009). New regulatory mechanisms of TGF-beta receptor function. Trends Cell Biol, 19, 385-94. [🔗](#)

Edit history

Date	Action	Author
2006-01-18	Created	Jassal B
2006-02-02	Authored	Jassal B, Moustakas A, Heldin CH, Huminiecki L
2006-04-18	Edited	Jassal B
2006-04-18	Reviewed	Heldin CH
2012-04-05	Revised	Orlic-Milacic M
2012-04-10	Edited	Jassal B
2012-05-14	Reviewed	Huang T
2012-11-14	Reviewed	Chen YG
2022-08-26	Modified	Wright A

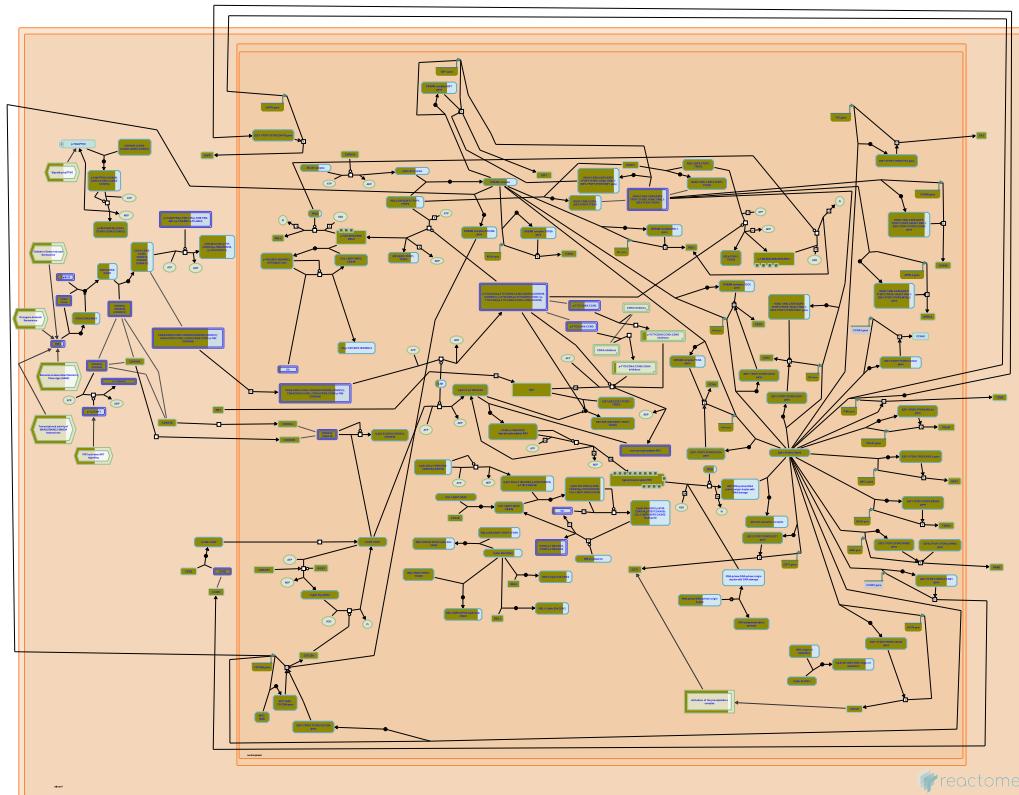
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LTBP3	Q14767, Q9NS15	LTBP4	Q8N2S1	MAPK1	P28482
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RNF111	Q6ZNA4	RPS27A	P62979, P62987	SCG2	O00255
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SMAD3	P84022	SMAD7	O15105	SMOX	P84022
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TFDP2	Q14188	TGFB1	P01137	TGFB2	P61812
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SMAD7	ENSG00000101665				

10. Mitotic G1 phase and G1/S transition (R-HSA-453279)



Mitotic G1-G1/S phase involves G1 phase of the mitotic interphase and G1/S transition, when a cell commits to DNA replication and division genetic and cellular material to two daughter cells.

During early G1, cells can enter a quiescent G0 state. In quiescent cells, the evolutionarily conserved DREAM complex, consisting of the pocket protein family member p130 (RBL2), bound to E2F4 or E2F5, and the MuvB complex, represses transcription of cell cycle genes (reviewed by Sadasivam and DeCaprio 2013).

During early G1 phase in actively cycling cells, transcription of cell cycle genes is repressed by another pocket protein family member, p107 (RBL1), which forms a complex with E2F4 (Ferreira et al. 1998, Cobrinik 2005). RB1 tumor suppressor, the product of the retinoblastoma susceptibility gene, is the third member of the pocket protein family. RB1 binds to E2F transcription factors E2F1, E2F2 and E2F3 and inhibits their transcriptional activity, resulting in prevention of G1/S transition (Chellappan et al. 1991, Bagchi et al. 1991, Chittenden et al. 1991, Lees et al. 1993, Hiebert 1993, Wu et al. 2001). Once RB1 is phosphorylated on serine residue S795 by Cyclin D:CDK4/6 complexes, it can no longer associate with and inhibit E2F1-3. Thus, CDK4/6-mediated phosphorylation of RB1 leads to transcriptional activation of E2F1-3 target genes needed for the S phase of the cell cycle (Connell-Crowley et al. 1997). CDK2, in complex with cyclin E, contributes to RB1 inactivation and also activates proteins needed for the initiation of DNA replication (Zhang 2007). Expression of D type cyclins is regulated by extracellular mitogens (Cheng et al. 1998, Depoortere et al. 1998). Catalytic activities of CDK4/6 and CDK2 are controlled by CDK inhibitors of the INK4 family (Serrano et al. 1993, Hannon and Beach 1994, Guan et al. 1994, Guan et al. 1996, Parry et al. 1995) and the Cip/Kip family, respectively.

References

Zhang H (2007). Life without kinase: cyclin E promotes DNA replication licensing and beyond. Mol. Cell, 25, 175-6. [🔗](#)

Robin P, Harel-Bellan A, Magnaghi-Jaulin L, Trouche D & Ferreira R (1998). The three members of the pocket proteins family share the ability to repress E2F activity through recruitment of a histone deacetylase. Proc Natl Acad Sci U S A, 95, 10493-8. [🔗](#)

Chittenden T, Kaelin WG & Livingston DM (1991). The T/E1A-binding domain of the retinoblastoma product can interact selectively with a sequence-specific DNA-binding protein. Cell, 65, 1073-82. [🔗](#)

Cobrinik D (2005). Pocket proteins and cell cycle control. Oncogene, 24, 2796-809. [🔗](#)

Depoortere F, Dumont JE, Van Keymeulen A, Costagliola S, Dremier S, Roger PP, ... Bartek J (1998). A requirement for cyclin D3-cyclin-dependent kinase (cdk)-4 assembly in the cyclic adenosine monophosphate-dependent proliferation of thyrocytes. J. Cell Biol., 140, 1427-39. [🔗](#)

Edit history

Date	Action	Author
2010-01-19	Edited	Matthews L
2010-01-20	Authored	Matthews L
2010-01-20	Created	Matthews L
2011-06-15	Reviewed	Grana X
2011-08-25	Reviewed	MacPherson D
2011-08-26	Revised	Orlic-Milacic M
2011-08-26	Authored	Orlic-Milacic M
2017-02-08	Edited	Orlic-Milacic M
2018-07-10	Reviewed	Manfredi JJ
2022-08-26	Modified	Wright A

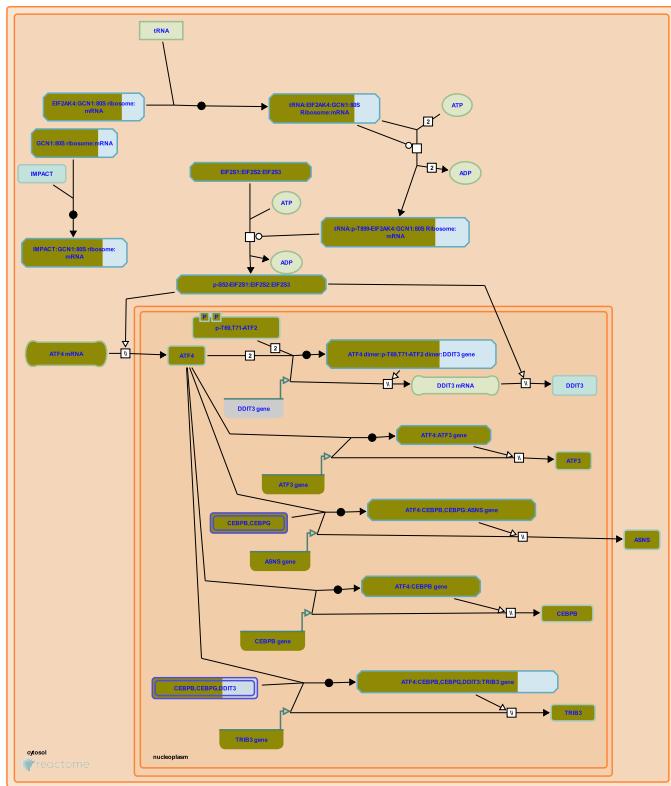
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CDC6	Q99741	CDC7	O00311	CDK1	P06493
CDK2	P24941	CDK4	P11802	CDK6	Q00534
CDKN1A	P38936	CDKN1B	P46527	CDKN1C	P49918
CDKN2B	P42771, P42772	CDKN2C	P42773	CDT1	Q9H211
CKS1B	P61024	CLN3	P24864	CUL1	Q13616
CYB561D1	P51948	DBF4	Q9UBU7	DHFR	P00374
DYRK1A	Q13627	E2F1	O00716, Q01094	E2F2	Q14209, Q16254
E2F4	Q16254	E2F6	O75461	FBXO5	Q9UKT4
FOSB	O75419	GAA	P27694	GMNN	O75496
HDAC1	Q13547	JAK2	O60674	LIN52	Q52LA3
LIN9	Q5TKA1	MAX	P61244	MCM10	Q7L590

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
MCM2	P33993, P49736	MCM3	P25205	MCM4	P33991
MCM5	P33992	MCM6	Q14566	MCM7	P33993
MCM8	Q9UJA3	MYBL2	P10244	MYC	P01106
ORC1	Q13415	ORC3	Q9UBD5	ORC4	O43929
ORC5	O43913	ORC6	Q9Y5N6	PCNA	P12004
POLA1	P09884	POLA2	Q14181	POLE	Q07864
POLE2	P56282	POLE3	Q9NRF9	PPP2CA	P67775
PPP2CB	P62714	PPP2R1A	P30153, P30154	PPP2R1B	P30154
PPP2R2A	P63151	PRIM1	P49642	PRIM2	P49643
PSMA4	P25789	PSMB10	P40306	PSMB6	P28072
PSMB7	P40306, Q99436	PSMB8	P28062	PSMC1	P62191
PSMC2	P35998	PSMC3	P17980	PSMD1	Q99460
PSMD10	O75832	PSMD11	O00231	PSMD13	Q9UNM6
PSMD14	O00487	PSMD2	Q13200	PSMD3	O43242
PSMD4	P55036	PSMD5	Q16401	PSMD6	Q15008
PSMD8	P48556	PSME1	Q06323	PSMF1	Q92530
RB1	P06400	RBBP4	Q09028	RBL1	P28749
RBL2	Q08999	RPA1	P27694	RPA2	P15927, Q13156
RPA3	P35244	RPN1	Q13200	RPS27A	P62979, P62987
RRM2	P31350	SEM1	P60896	SKP1	P63208
SKP2	Q13309	SRC	P12931-1	TFDP1	Q14186
TFDP2	Q14188	TK1	P04183	TOP2A	P11388
TYMS	P04818	WEE1	P30291		

Input	Ensembl Id	Input	Ensembl Id	Input	Ensembl Id
CCN1	ENSG00000145386	CCNA2	ENSG00000145386	CDC25A	ENSG00000164045
CDC45	ENSG00000093009	CDC6	ENSG00000094804	CDK1	ENSG00000170312
CDT1	ENSG00000167513	DHFR	ENSG00000228716	E2F1	ENSG00000101412
FBXO5	ENSG00000112029	MYBL2	ENSG00000101057	ORC1	ENSG00000085840
PCNA	ENSG00000132646	POLA1	ENSG00000101868	RBL1	ENSG00000080839
RRM2	ENSG00000171848	TK1	ENSG00000167900	TOP2A	ENSG00000131747
TYMS	ENSG00000176890				

11. Response of EIF2AK4 (GCN2) to amino acid deficiency (R-HSA-9633012)



EIF2AK4 (GCN2) senses amino acid deficiency by binding uncharged tRNAs near the ribosome and responds by phosphorylating EIF2S1, the alpha subunit of the translation initiation factor EIF2 (inferred from yeast homologs and mouse homologs, reviewed in Chaveroux et al. 2010, Castilho et al. 2014, Gallinetti et al. 2013, Bröer and Bröer 2017, Wek 2018). Phosphorylated EIF2S1 reduces translation of most mRNAs but increases translation of downstream ORFs in mRNAs such as ATF4 that contain upstream ORFs (inferred from mouse homologs in Vattem and Wek 2004, reviewed in Hinnebusch et al. 2016, Sonenberg and Hinnebusch 2009). ATF4, in turn, activates expression of genes involved in responding to amino acid deficiency such as DDIT3 (CHOP), ASNS (asparagine synthetase), CEBPB, and ATF3 (reviewed in Kilberg et al. 2012, Wortel et al. 2017). In mice, EIF2AK4 in the brain may responsible for avoidance of diets lacking essential amino acids (Hao et al. 2005, Maurin et al. 2005, see also Leib and Knight 2015, Gietzen et al. 2016, reviewed in Dever and Hinnebusch 2005).

EIF2AK4 is bound to both the ribosome and GCN1, which is required for activation of EIF2AK4 and may act by shuttling uncharged tRNAs from the A site of the ribosome to EIF2AK4. Upon binding tRNA, EIF2AK4 trans-autophosphorylates. Phosphorylated EIF2AK4 then phosphorylates EIF2S1 on serine-52, the same serine residue phosphorylated by other kinases of the integrated stress response: EIF2AK1 (HRI, activated by heme deficiency and other stresses), EIF2AK2 (PKR, activated by double-stranded RNA), and EIF2AK3 (PERK, activated by unfolded proteins) (reviewed in Hinnebusch 1994, Wek et al. 2006, Donnelly et al. 2013, Pakos-Zebrucka et al. 2016, Wek 2018),

References

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Shanmugam R, Himme BM, Sattlegger E, Silva RC, Ramesh R & Castilho BA (2014). Keeping the eIF2 alpha kinase Gcn2 in check. *Biochim. Biophys. Acta*, 1843, 1948-68. [🔗](#)

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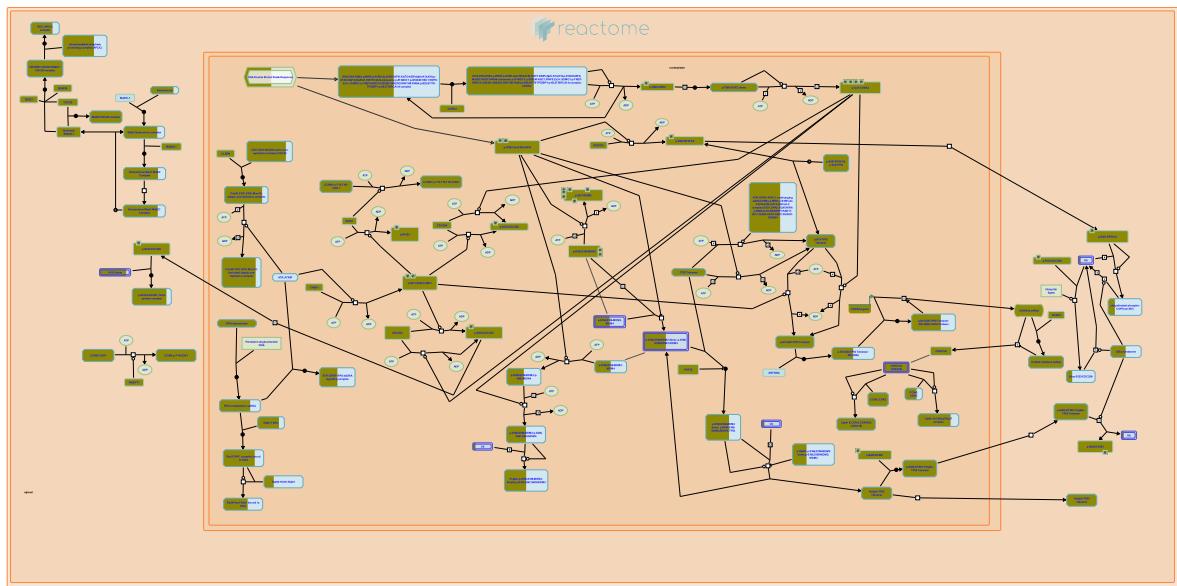
Date	Action	Author
2018-12-28	Edited	May B
2018-12-28	Authored	May B
2018-12-28	Created	May B
2019-09-15	Reviewed	Bruhat A
2019-11-20	Reviewed	Staschke KA
2019-12-10	Modified	May B

79 submitted entities found in this pathway, mapping to 104 Reactome entities

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
AGRN	P32969	ASNS	P08243	ATF2	P15336
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CEBPG	P53567	CRY2	P62263	EIF2A	P05198
EIF2AK4	Q9P2K8	EIF2S1	P05198	EIF2S2	P20042
EIF2S3	P41091	GCN1	Q92616	RPL10	P27635, Q96L21
RPL10A	P61313, P62906	RPL11	P62913	RPL12	P30050
RPL13	P26373, P40429	RPL13A	P40429, P61313	RPL14	P50914
RPL18A	Q02543, Q07020	RPL19	P84098	RPL21	P46778
RPL22L1	Q6P5R6	RPL23A	P62750, P62829, P84098	RPL24	P83731
RPL26	P61254, Q9UNX3	RPL27	P61353	RPL27A	P46776, P61353
RPL28	P46776, P46779	RPL29	P47914	RPL30	P62888
RPL31	P62899	RPL32	P62888, P62910	RPL35	P42766
RPL36	Q9Y3U8	RPL36AL	Q969Q0	RPL37	P61927
RPL37A	P18077, P61513, P61927	RPL38	P63173	RPL39	P62891, Q96EH5
RPL39L	Q96EH5	RPL4	P36578	RPL41	P62945
RPL5	P46777	RPL6	Q02878	RPL7	P18124
RPL7A	P18124, P62424	RPL8	P62424, P62917	RPL9	P32969
RPLP0	P05388	RPLP1	P05386	RPLP2	P05387
RPS12	P25398	RPS13	P62277	RPS14	P62263
RPS15	P62841	RPS16	P62249	RPS17	P08708
RPS18	P62269	RPS2	P15880, P46782	RPS20	P60866
RPS21	P62841, P63220	RPS24	P62244, P62847	RPS25	P62851
RPS26	P62854	RPS27A	P62979, P62987	RPS27L	Q71UM5
RPS29	P62273	RPS3	P23396	RPS3A	P61247

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
RPS5	P46782	RPS6	P62753	RPS7	P62081
RPS8	P62241	RPS9	P46781	RPSA	P08865
TRIB3	Q96RU7				
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ASNS	ENSG0000070669	ATF3	ENSG0000162772	ATF4	ENST00000404241
CEBPB	ENSG0000172216	TRIB3	ENSG0000101255		

12. Cell Cycle Checkpoints (R-HSA-69620)



A hallmark of the human cell cycle in normal somatic cells is its precision. This remarkable fidelity is achieved by a number of signal transduction pathways, known as checkpoints, which monitor cell cycle progression ensuring an interdependency of S-phase and mitosis, the integrity of the genome and the fidelity of chromosome segregation.

Checkpoints are layers of control that act to delay CDK activation when defects in the division program occur. As the CDKs functioning at different points in the cell cycle are regulated by different means, the various checkpoints differ in the biochemical mechanisms by which they elicit their effect. However, all checkpoints share a common hierarchy of a sensor, signal transducers, and effectors that interact with the CDKs.

The stability of the genome in somatic cells contrasts to the almost universal genomic instability of tumor cells. There are a number of documented genetic lesions in checkpoint genes, or in cell cycle genes themselves, which result either directly in cancer or in a predisposition to certain cancer types. Indeed, restraint over cell cycle progression and failure to monitor genome integrity are likely prerequisites for the molecular evolution required for the development of a tumor. Perhaps most notable amongst these is the p53 tumor suppressor gene, which is mutated in >50% of human tumors. Thus, the importance of the checkpoint pathways to human biology is clear.

References

Edit history

Date	Action	Author
2005-01-01	Authored	Walworth N, Hoffmann I, Yen TJ, O'Donnell M, Khanna KK
2005-01-01	Created	Walworth N, Hoffmann I, Yen TJ, O'Donnell M, Khanna KK
2013-11-25	Edited	Matthews L
2022-08-23	Reviewed	Sanchez Y, Knudsen E, Hardwick KG
2022-08-26	Modified	Wright A

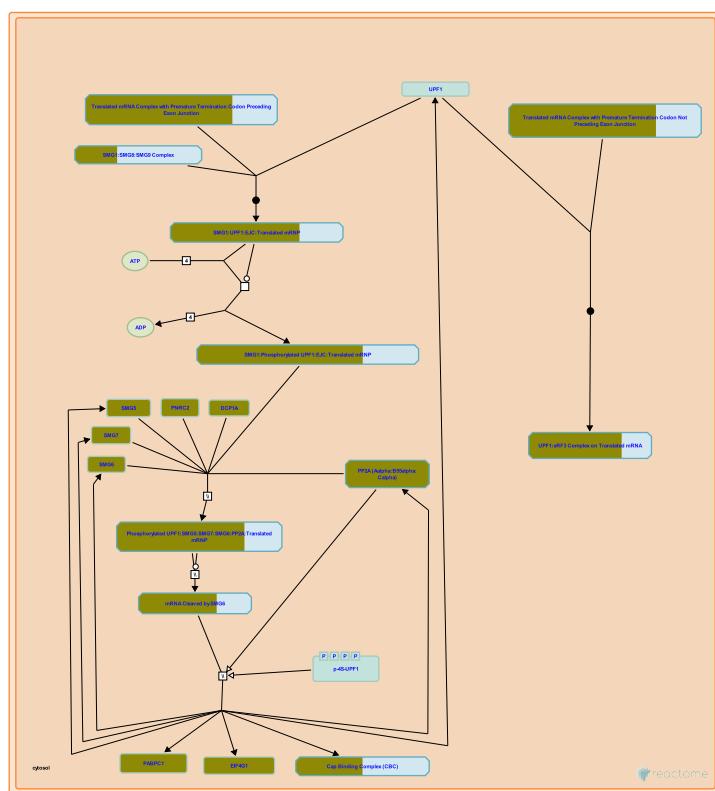
206 submitted entities found in this pathway, mapping to 222 Reactome entities

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ANAPC2	Q9UJX6	ANAPC7	Q9UJX3	ATM	Q13315
AURKB	Q96GD4	B9D2	Q9BPU9	BABAM2	Q9NXR7
BACH1	Q9BX63	BARD1	Q99728	BIRC5	O15392
BLM	P54132	BRCA1	P38398	BRIP1	Q9BX63
BUB1	O43683, O60566	BUB1B	O60566	BUB3	O43684
CCN1	P20248	CCNA2	P20248	CCNB1	P14635
CCNB2	O95067	CCNE2	O96020	CCNL1	P49736
CDC16	Q13042	CDC20	Q12834	CDC23	Q9UJX2
CDC25A	P30304	CDC25C	P30307	CDC27	P30260
CDC45	O75419	CDC6	Q99741	CDC7	O00311
CDCA8	Q53HL2	CDK1	P06493	CDK2	P24941
CDKN1A	P38936	CDKN1B	P46527	CENPA	P49450
CENPE	Q02224	CENPF	P49454	CENPH	Q9H3R5
CENPI	Q92674	CENPK	Q9BS16	CENPL	Q8N0S6
CENPM	Q9NSP4	CENPN	Q96H22	CENPO	Q9BU64
CENPP	Q6IPU0	CENPQ	Q7L2Z9	CENPT	Q96BT3
CENPU	Q71F23	CHEK1	O14757	CHEK2	O96017
CKAP5	Q14008	CLASP1	Q7Z460	CLASP2	O75122
CLIP1	P30622	CLN3	P24864	CLSPN	Q9HAW4
COP1	Q8NHY2	DBF4	Q9UBU7	DLC1	P63167
DSN1	Q9H410	DYNC1H1	Q14204	DYNC1I1	O14576
DYNC1I2	Q13409	DYNC1LI1	Q9Y6G9	DYNLL1	P63167
DYNLL2	P63167, Q96FJ2	EMB	O14980	ERCC6L	Q2NKX8
EXO1	Q9UQ84	FOSB	O75419	GAA	P27694
GTSE1	Q9NYZ3	H2AX	P16104	H2BC11	P06899
H2BC21	P06899, Q16778	H2BC5	P58876	H2BC8	P62807, Q93079
H2BC9	P58876, Q93079	H4C8	P62805	HERC2	O95714
HUS1	O60921	INCENP	Q9NQS7	ITGB3BP	Q13352
KIF18A	Q8NI77	KIF2A	O00139	KIF2C	Q99661
KNL1	Q8NG31	KNTC1	P50748	MAD2L1	Q13257
MAPRE1	Q15691	MCM10	Q7L590	MCM2	P33993, P49736
MCM3	P25205	MCM4	P33991	MCM5	P33992
MCM6	Q14566	MCM7	P33993	MCM8	Q9UJA3
MDC1	Q14676	MDM2	Q00987	MIS12	Q9H081
MRE11	P49959	NDC80	O14777	NDE1	Q9NXR1
NDEL1	Q9GZM8	NSD2	O96028	NSL1	Q96IY1
NUDC	Q9Y266	NUF2	Q9BZD4	NUP107	P57740
NUP37	Q8NFH4	NUP43	Q8NFH3	NUP85	Q9BW27
ORC1	Q13415	ORC3	Q9UBD5	ORC4	O43929
ORC5	O43913	ORC6	Q9Y5N6	PCBP4	P57723
PHF20	Q9BVI0	PIAS4	Q8N2W9	PKMYT1	Q99640
PLK1	P53350	PPP1CC	P36873	PPP2CA	P67775
PPP2CB	P62714	PPP2R1A	P30153, P30154	PPP2R1B	P30154
PPP2R5D	Q14738	PSMA4	P25789	PSMB10	P40306
PSMB6	P28072	PSMB7	P40306, Q99436	PSMB8	P28062
PSMC1	P62191	PSMC2	P35998	PSMC3	P17980
PSMD1	Q99460	PSMD10	O75832	PSMD11	O00231
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PSMD3	O43242	PSMD4	P55036	PSMD5	Q16401
PSMD6	Q15008	PSMD8	P48556	PSME1	Q06323
PSMF1	Q92530	RAD50	Q92878	RANBP2	P49792
RANGAP1	P46060	RBBP8	Q99708	RCC2	Q9P258
RFC2	P35250	RFC3	P40937, P40938	RFC4	P35249
RFC5	P40937, P40938	RHNO1	Q9BSD3	RMI1	Q9H9A7
RMI2	Q96E14	RNF168	Q8IYW5	RPA1	P27694
RPA2	P15927	RPA3	P35244	RPN1	Q13200
RPS27A	P62979, P62987	SEC13	P55735	SEH1L	Q96EE3-1
SEM1	P60896	SGO1	Q5FB7	SGO2	Q562F6
SKA1	Q96BD8	SKA2	Q8WVK7	SMG1	Q13315
SPC24	Q8NBT2	SPC25	Q9HBM1	SPDL1	Q96EA4
TAOK1	Q7L7X3	TFAM	P51668	TMEM208	O00762
TOPBP1	Q92547	TP53	P04637	TP53BP1	Q12888
TXNIP	Q9UJX2	UBE2C	O00762, P61088	UBE2D1	P51668
UBE2E1	P51965	UBE2N	P61088	UBE2S	Q16763
UIMC1	Q96RL1	VTI1B	Q96FJ2	WEE1	P30291, Q99640
XPO1	O14980	YWHAE	P62258	YWHAG	P61981
YWHAH	Q04917	YWHAQ	P27348, P31947	YWHAZ	P63104
ZWILCH	Q9H900	ZWINT	O95229		

Input	Ensembl Id
CDKN1A	ENSG00000124762, ENST00000244741

13. Nonsense-Mediated Decay (NMD) (R-HSA-927802)



Cellular compartments: cytosol.

The Nonsense-Mediated Decay (NMD) pathway activates the destruction of mRNAs containing premature termination codons (PTCs) (reviewed in Isken and Maquat 2007, Chang et al. 2007, Behm-Ansmant et al. 2007, Neu-Yilik and Kulozik 2008, Rebbapragada and Lykke-Andersen 2009, Bhuvanagiri et al. 2010, Nicholson et al. 2010, Durand and Lykke-Andersen 2011). In mammalian cells a termination codon can be recognized as premature if it precedes an exon-exon junction by at least 50-55 nucleotides or if it is followed by an abnormal 3' untranslated region (UTR). While length of the UTR may play a part, the qualifications for being "abnormal" have not been fully elucidated. Also, some termination codons preceding exon junctions are not degraded by NMD so the criteria for triggering NMD are not yet fully known (reviewed in Rebbapragada and Lykke-Andersen 2009). While about 30% of disease-associated mutations in humans activate NMD, about 10% of normal human transcripts are also degraded by NMD (reviewed in Stalder and Muhlemann 2008, Neu-Yilik and Kulozik 2008, Bhuvanagiri et al. 2010, Nicholson et al. 2010). Thus NMD is a normal physiological process controlling mRNA stability in unmutated cells.

Exon junction complexes (EJCs) are deposited on an mRNA during splicing in the nucleus and are displaced by ribosomes during the first round of translation. When a ribosome terminates translation the A site encounters the termination codon and the eRF1 factor enters the empty A site and recruits eRF3. Normally, eRF1 cleaves the translated polypeptide from the tRNA in the P site and eRF3 interacts with Polyadenylate-binding protein (PABP) bound to the polyadenylated tail of the mRNA.

During activation of NMD eRF3 interacts with UPF1 which is contained in a complex with SMG1, SMG8, and SMG9. NMD can arbitrarily be divided into EJC-enhanced and EJC-independent pathways. In EJC-enhanced NMD, an exon junction is located downstream of the PTC and the EJC remains on the mRNA after termination of the pioneer round of translation. The core EJC is associated with UPF2 and UPF3, which interact with UPF1 and stimulate NMD. Once bound near the PTC, UPF1 is phosphorylated by SMG1. The phosphorylation is the rate-limiting step in NMD and causes UPF1 to recruit either SMG6, which is an endoribonuclease, or SMG5 and SMG7, which recruit ribonucleases. SMG6 and SMG5:SMG7 recruit phosphatase PP2A to dephosphorylate UPF1 and allow further rounds of degradation. How EJC-independent NMD is activated remains enigmatic but may involve competition between PABP and UPF1 for eRF3.

References

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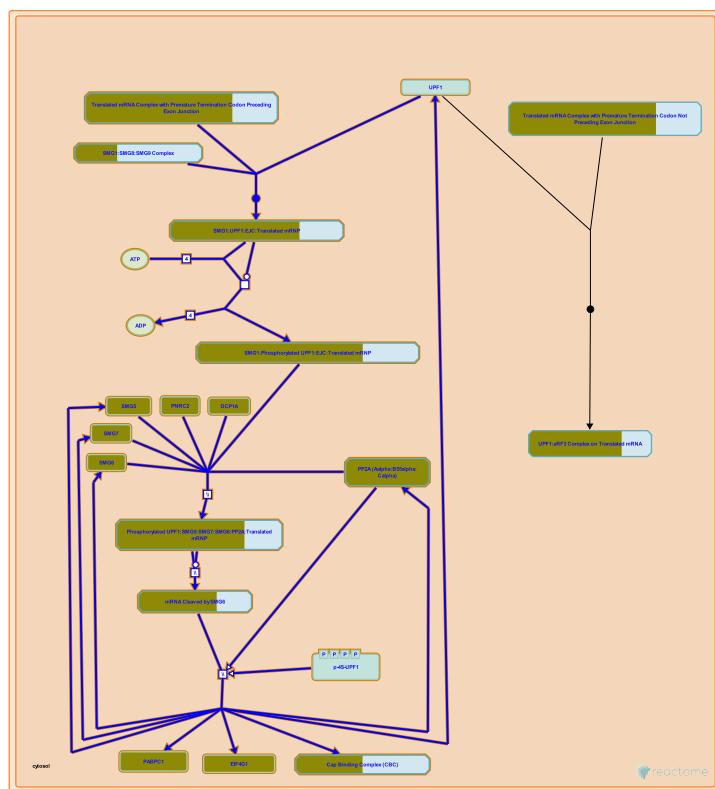
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2010-08-06	Authored	May B
2010-08-10	Created	May B
2011-05-19	Reviewed	Neu-Yilik G
2022-08-26	Modified	Wright A

88 submitted entities found in this pathway, mapping to 111 Reactome entities

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MAGOHB	Q96A72	NCBP2	P52298	PABPC1	P11940
PNRC2	Q9NPJ4	PPP2CA	P67775	PPP2R1A	P30153
PPP2R2A	P63151	RBM8A	Q9Y5S9	RNPS1	Q15287
RPL10	P27635, Q96L21	RPL10A	P61313, P62906	RPL11	P62913
RPL12	P30050	RPL13	P26373, P40429	RPL13A	P40429, P61313
RPL14	P50914	RPL18A	Q02543, Q07020	RPL19	P84098

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RPL27A	P46776, P61353	RPL28	P46776, P46779	RPL29	P47914
RPL30	P62888	RPL31	P62899	RPL32	P62888, P62910
RPL35	P42766	RPL36	Q9Y3U8	RPL36AL	Q969Q0
RPL37	P61927	RPL37A	P18077, P61513, P61927	RPL38	P63173
RPL39	P62891, Q96EH5	RPL39L	Q96EH5	RPL4	P36578
RPL41	P62945	RPL5	P46777	RPL6	Q02878
RPL7	P18124	RPL7A	P18124, P62424	RPL8	P62424, P62917
RPL9	P32969	RPLP0	P05388	RPLP1	P05386
RPLP2	P05387	RPS12	P25398	RPS13	P62277
RPS14	P62263	RPS15	P62841	RPS16	P62249
RPS17	P08708	RPS18	P62269	RPS2	P15880, P46782
RPS20	P60866	RPS21	P62841, P63220	RPS24	P62244, P62847
RPS25	P62851	RPS26	P62854	RPS27A	P62979, P62987
RPS27L	Q71UM5	RPS29	P62273	RPS3	P23396
RPS3A	P61247	RPS5	P46782	RPS6	P62753
RPS7	P62081	RPS8	P62241	RPS9	P46781
RPSA	P08865	SMG1	Q96Q15	SMG5	Q9UPR3
SMG6	Q86US8	SMG7	Q92540	UPF3A	Q9H1J1, Q9H1J1-2
UPF3B	Q9BZI7				

14. Nonsense Mediated Decay (NMD) enhanced by the Exon Junction Complex (EJC) (R-HSA-975957)



Cellular compartments: cytosol.

During normal translation termination eRF3 associates with the ribosome and then interacts with PABP bound to the polyadenylate tail of the mRNA to release the ribosome and allow a new round of translation to commence. Nonsense-mediated decay (NMD) is triggered if eRF3 at the ribosome interacts with UPF1, which may compete with PABP (reviewed in Isken and Maquat 2007, Chang et al. 2007, Behm-Ansmant et al. 2007, Rebbapragada and Lykke-Andersen 2009, Bhuvanagiri et al. 2010, Nicholson et al. 2010, Durand and Lykke-Andersen 2011). An exon junction located 50-55 nt downstream of a termination codon is observed to enhance NMD.

Exon-junction complexes (EJCs) are deposited on the mRNA during splicing in the nucleus, remain on mRNAs after transport to the cytosol, and are dislodged by the ribosome as it progresses along the mRNA during the pioneer round of translation (Gehring et al. 2009). EJCs contain the core factors eIF4A-III, Magoh-Y14, and CASC3 as well as the peripheral factors RNPS1, UPF2, and UPF3. UPF2 and UPF3 recruit UPF1 to eRF3 at the terminating ribosome. Thus an EJC downstream of a termination codon will not have been dislodged during translation and will recruit UPF1, triggering NMD.

UPF1 is believed to form a complex containing SMG1, SMG8, and SMG9. In the key regulatory step of NMD SMG1 phosphorylates UPF1. The phosphorylated UPF1 then recruits either SMG6 or SMG5 and SMG7. SMG6 is itself an endoribonuclease that cleaves the mRNA. SMG5 and SMG7 do not have endoribonuclease activity, but are thought to recruit ribonucleases. Nonsense-mediated decay has been observed to involve deadenylation, decapping, and both 5' to 3' and 3' to 5' exonuclease activities, but the exact degradative pathways taken by a given mRNA are not yet known.

UPF1 also plays roles in Staufen-mediated decay, histone mRNA decay, telomere maintenance, genome integrity, and may play a role in normal termination of translation.

References

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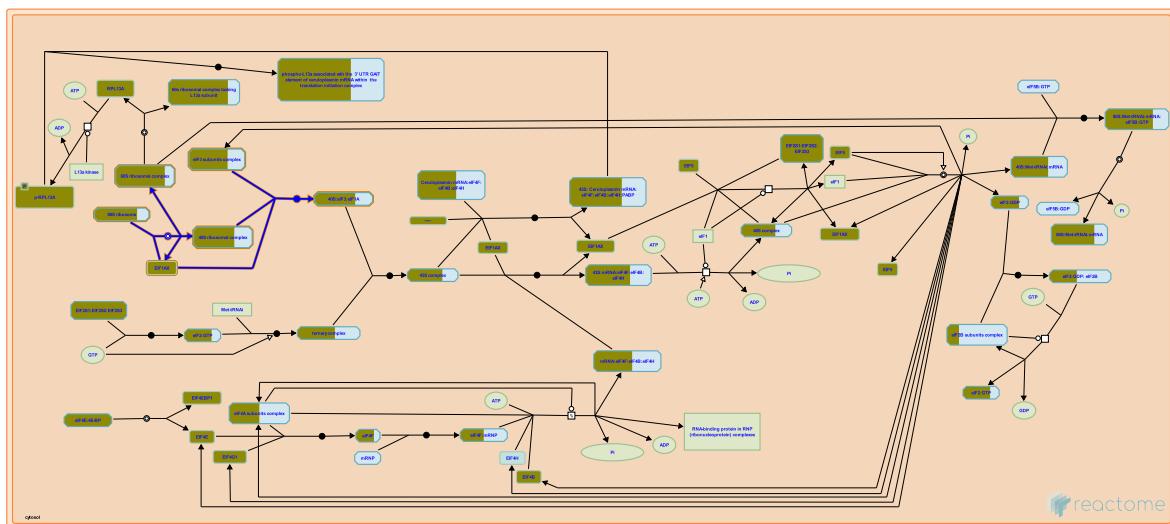
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2010-10-08	Authored	May B
2010-10-11	Created	May B
2011-05-19	Reviewed	Neu-Yilik G
2022-09-05	Modified	Wright A

88 submitted entities found in this pathway, mapping to 111 Reactome entities

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DCP1A	Q9NP16	EIF4G1	Q04637	ETF1	P62495
GSPT1	P15170, Q8IYD1	GSPT2	Q8IYD1	MAGOH	P61326, Q96A72
MAGOHB	Q96A72	NCBP2	P52298	PABPC1	P11940
PNRC2	Q9NPJ4	PPP2CA	P67775	PPP2R1A	P30153
PPP2R2A	P63151	RBM8A	Q9Y5S9	RNPS1	Q15287
RPL10	P27635, Q96L21	RPL10A	P61313, P62906	RPL11	P62913
RPL12	P30050	RPL13	P26373, P40429	RPL13A	P40429, P61313
RPL14	P50914	RPL18A	Q02543, Q07020	RPL19	P84098
RPL21	P46778	RPL22L1	Q6P5R6	RPL23A	P62750, P62829, P84098
RPL24	P83731	RPL26	P61254, Q9UNX3	RPL27	P61353
RPL27A	P46776, P61353	RPL28	P46776, P46779	RPL29	P47914
RPL30	P62888	RPL31	P62899	RPL32	P62888, P62910
RPL35	P42766	RPL36	Q9Y3U8	RPL36AL	Q969Q0
RPL37	P61927	RPL37A	P18077, P61513, P61927	RPL38	P63173
RPL39	P62891, Q96EH5	RPL39L	Q96EH5	RPL4	P36578
RPL41	P62945	RPL5	P46777	RPL6	Q02878

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
RPL7	P18124	RPL7A	P18124, P62424	RPL8	P62424, P62917
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RPLP2	P05387	RPS12	P25398	RPS13	P62277
RPS14	P62263	RPS15	P62841	RPS16	P62249
RPS17	P08708	RPS18	P62269	RPS2	P15880, P46782
RPS20	P60866	RPS21	P62841, P63220	RPS24	P62244, P62847
RPS25	P62851	RPS26	P62854	RPS27A	P62979, P62987
RPS27L	Q71UM5	RPS29	P62273	RPS3	P23396
RPS3A	P61247	RPS5	P46782	RPS6	P62753
RPS7	P62081	RPS8	P62241	RPS9	P46781
RPSA	P08865	SMG1	Q96Q15	SMG5	Q9UPR3
SMG6	Q86US8	SMG7	Q92540	UPF3A	Q9H1J1, Q9H1J1-2
UPF3B	Q9BZI7				

15. Formation of a pool of free 40S subunits (R-HSA-72689)



Cellular compartments: cytosol.

The 80S ribosome dissociates into free 40S (small) and 60S (large) ribosomal subunits. Each ribosomal subunit is constituted by several individual ribosomal proteins and rRNA.

References

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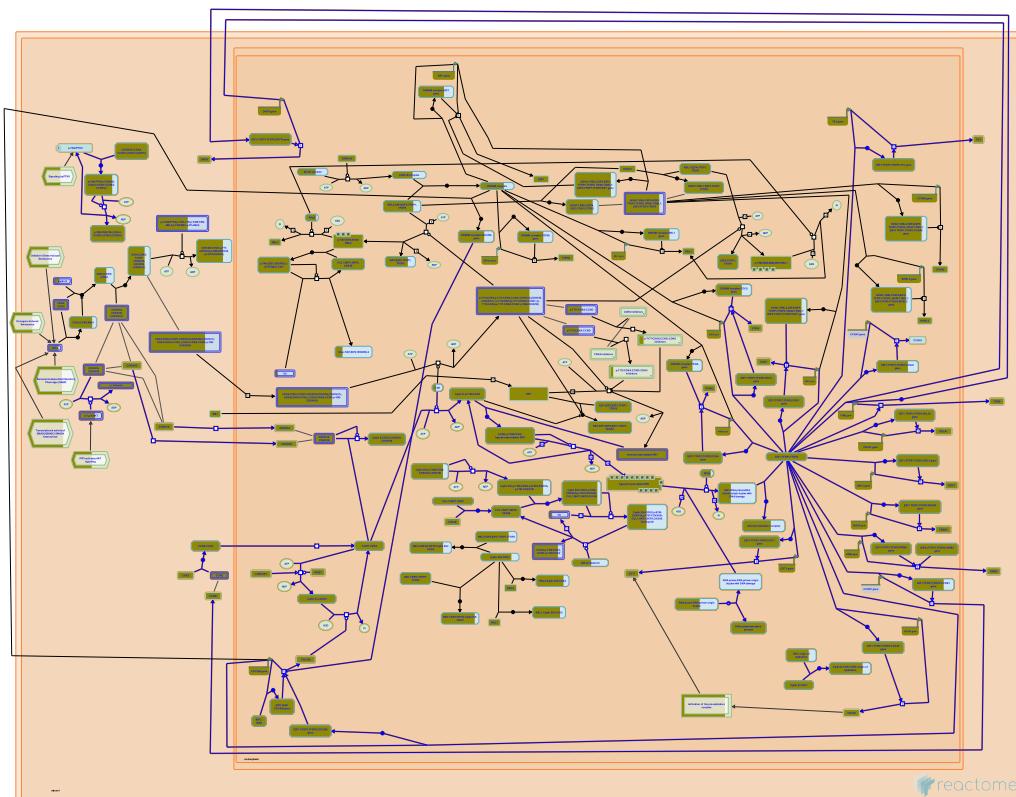
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2022-09-05	Modified	Wright A

76 submitted entities found in this pathway, mapping to 96 Reactome entities

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EIF3A	Q14152	EIF3B	P55884	EIF3C	Q99613
EIF3D	O15371	EIF3E	P60228	EIF3F	O00303
EIF3H	O15372	EIF3I	Q13347	EIF3J	O75822
RPL10	P27635, Q96L21	RPL10A	P61313, P62906	RPL11	P62913
RPL12	P30050	RPL13	P26373, P40429	RPL13A	P40429, P61313
RPL14	P50914	RPL18A	Q02543, Q07020	RPL19	P84098
RPL21	P46778	RPL22L1	Q6P5R6	RPL23A	P62750, P62829, P84098
RPL24	P83731	RPL26	P61254, Q9UNX3	RPL27	P61353
RPL27A	P46776, P61353	RPL28	P46776, P46779	RPL29	P47914
RPL30	P62888	RPL31	P62899	RPL32	P62888, P62910
RPL35	P42766	RPL36	Q9Y3U8	RPL36AL	Q969Q0
RPL37	P61927	RPL37A	P18077, P61513, P61927	RPL38	P63173
RPL39	P62891, Q96EH5	RPL39L	Q96EH5	RPL4	P36578
RPL41	P62945	RPL5	P46777	RPL6	Q02878
RPL7	P18124	RPL7A	P18124, P62424	RPL8	P62424, P62917
RPL9	P32969	RPLP0	P05388	RPLP1	P05386
RPLP2	P05387	RPS12	P25398	RPS13	P62277
RPS14	P62263	RPS15	P62841	RPS16	P62249
RPS17	P08708	RPS18	P62269	RPS2	P15880, P46782

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
RPS20	P60866	RPS21	P62841, P63220	RPS24	P62244, P62847
RPS25	P62851	RPS26	P62854	RPS27A	P62979, P62987
RPS27L	Q71UM5	RPS29	P62273	RPS3	P23396
RPS3A	P61247	RPS5	P46782	RPS6	P62753
RPS7	P62081	RPS8	P62241	RPS9	P46781
RPSA	P08865				

16. G1/S Transition (R-HSA-69206)



Cyclin E - Cdk2 complexes control the transition from G1 into S-phase. In this case, the binding of p21Cip1/Waf1 or p27kip1 is inhibitory. Important substrates for Cyclin E - Cdk2 complexes include proteins involved in the initiation of DNA replication. The two Cyclin E proteins are subjected to ubiquitin-dependent proteolysis, under the control of an E3 ubiquitin ligase known as the SCF. Cyclin A - Cdk2 complexes, which are also regulated by p21Cip1/Waf1 and p27kip1, are likely to be important for continued DNA synthesis, and progression into G2. An additional level of control of Cdk2 is reversible phosphorylation of Threonine-14 (T14) and Tyrosine-15 (Y15), catalyzed by the Wee1 and Myt1 kinases, and dephosphorylation by the three Cdc25 phosphatases, Cdc25A, B and C.

References

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2022-08-26	Modified	Wright A

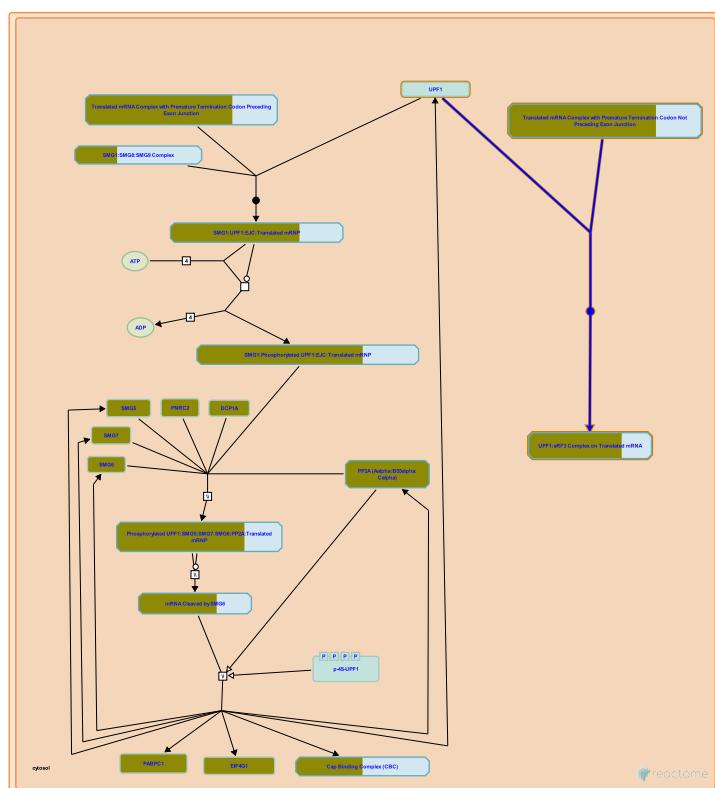
102 submitted entities found in this pathway, mapping to 120 Reactome entities

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CCN1	P20248	CCNA2	P20248	CCNB1	P14635
CCND1	P24385	CCNE2	O96020	CCNL1	P49736
CDC25A	P30304	CDC45	O75419	CDC6	Q99741
CDC7	O00311	CDK1	P06493	CDK2	P24941
CDK4	P11802	CDKN1A	P38936	CDKN1B	P46527
CDT1	Q9H211	CKS1B	P61024	CLN3	P24864

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
CUL1	Q13616	CYB561D1	P51948	DBF4	Q9UBU7
DHFR	P00374	E2F1	Q01094	E2F2	Q16254
E2F4	Q16254	E2F6	O75461	FBXO5	Q9UKT4
FOSB	O75419	GAA	P27694	GMNN	O75496
HDAC1	Q13547	LIN52	Q52LA3	LIN9	Q5TKA1
MAX	P61244	MCM10	Q7L590	MCM2	P33993, P49736
MCM3	P25205	MCM4	P33991	MCM5	P33992
MCM6	Q14566	MCM7	P33993	MCM8	Q9UJA3
MYC	P01106	ORC1	Q13415	ORC3	Q9UBD5
ORC4	O43929	ORC5	O43913	ORC6	Q9Y5N6
PCNA	P12004	POLA1	P09884	POLA2	Q14181
POLE	Q07864	POLE2	P56282	POLE3	Q9NRF9
PPP2CA	P67775	PPP2CB	P62714	PPP2R1A	P30153, P30154
PPP2R1B	P30154	PRIM1	P49642	PRIM2	P49643
PSMA4	P25789	PSMB10	P40306	PSMB6	P28072
PSMB7	P40306, Q99436	PSMB8	P28062	PSMC1	P62191
PSMC2	P35998	PSMC3	P17980	PSMD1	Q99460
PSMD10	O75832	PSMD11	O00231	PSMD13	Q9UNM6
PSMD14	O00487	PSMD2	Q13200	PSMD3	O43242
PSMD4	P55036	PSMD5	Q16401	PSMD6	Q15008
PSMD8	P48556	PSME1	Q06323	PSMF1	Q92530
RB1	P06400	RBBP4	Q09028	RBL1	P28749
RBL2	Q08999	RPA1	P27694	RPA2	P15927, Q13156
RPA3	P35244	RPN1	Q13200	RPS27A	P62979, P62987
RRM2	P31350	SEM1	P60896	SKP1	P63208
SKP2	Q13309	TFDP1	Q14186	TFDP2	Q14188
TK1	P04183	TYMS	P04818	WEE1	P30291

Input	Ensembl Id	Input	Ensembl Id	Input	Ensembl Id
CDC25A	ENSG00000164045	CDC45	ENSG00000093009	CDC6	ENSG00000094804
CDK1	ENSG00000170312	CDT1	ENSG00000167513	DHFR	ENSG00000228716
FBXO5	ENSG00000112029	ORC1	ENSG00000085840	PCNA	ENSG00000132646
POLA1	ENSG00000101868	RRM2	ENSG00000171848	TK1	ENSG00000167900
TYMS	ENSG00000176890				

17. Nonsense Mediated Decay (NMD) independent of the Exon Junction Complex (EJC) (R-HSA-975956)



Cellular compartments: cytosol.

Nonsense-mediated decay has been observed with mRNAs that do not have an exon junction complex (EJC) downstream of the termination codon (reviewed in Isken and Maquat 2007, Chang et al. 2007, Behm-Ansmant et al. 2007, Rebbapragada and Lykke-Andersen 2009, Nicholson et al. 2010). In these cases the trigger is unknown but a correlation with the length of the 3' UTR has sometimes been seen. The current model posits a competition between PABP and UPF1 for access to eRF3 at the terminating ribosome (Ivanov et al. 2008, Singh et al. 2008, reviewed in Bhuvanagiri et al. 2010). Abnormally long 3' UTRs may prevent PABP from efficiently interacting with eRF3 and allow UPF1 to bind eRF3 instead. Long UTRs with hairpin loops may bring PABP closer to eRF3 and help evade NMD (Eberle et al. 2008).

The pathway of degradation taken during EJC-independent NMD has not been elucidated. It is thought that phosphorylation of UPF1 by SMG1 and recruitment of SMG6 or SMG5 and SMG7 are involved, as with EJC-enhanced NMD, but this has not yet been shown.

References

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Rebbapragada I, Singh G & Lykke-Andersen J (2008). A competition between stimulators and antagonists of Upf complex recruitment governs human nonsense-mediated mRNA decay. PLoS Biol, 6, e111. [🔗](#)

Bhuvanagiri M, Kulozik AE, Hentze MW & Schlitter AM (2010). NMD: RNA biology meets human genetic medicine. Biochem J, 430, 365-77. [🔗](#)

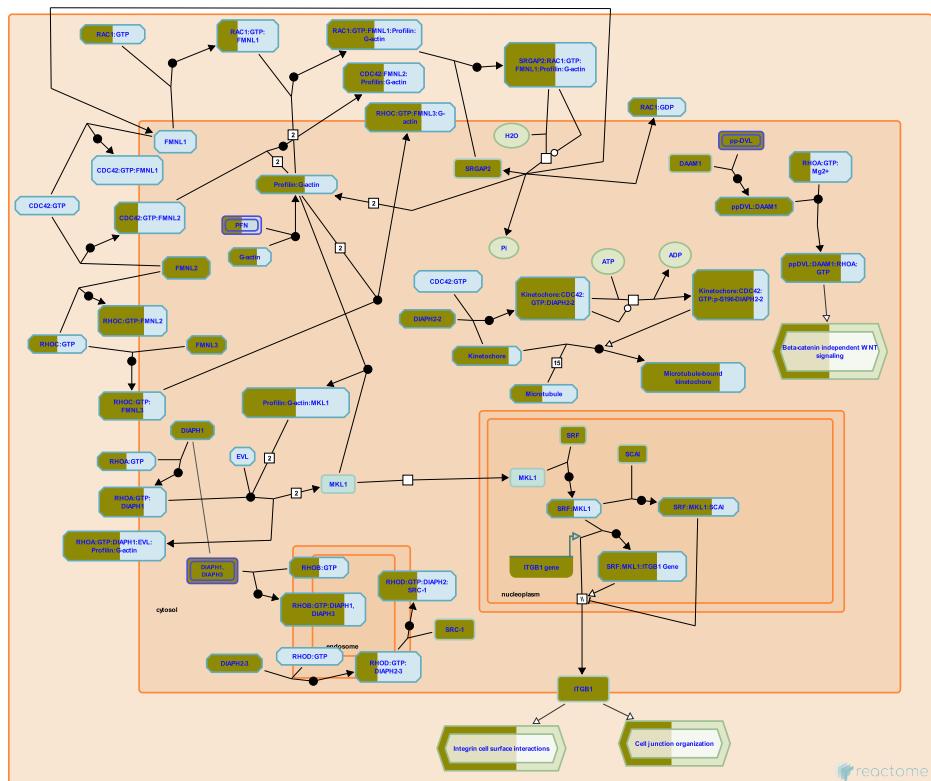
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2011-05-19	Reviewed	Neu-Yilik G
2022-09-05	Modified	Wright A

72 submitted entities found in this pathway, mapping to 93 Reactome entities

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RPL13	P26373, P40429	RPL13A	P40429, P61313	RPL14	P50914
RPL18A	Q02543, Q07020	RPL19	P84098	RPL21	P46778
RPL22L1	Q6P5R6	RPL23A	P62750, P62829, P84098	RPL24	P83731
RPL26	P61254, Q9UNX3	RPL27	P61353	RPL27A	P46776, P61353
RPL28	P46776, P46779	RPL29	P47914	RPL30	P62888
RPL31	P62899	RPL32	P62888, P62910	RPL35	P42766
RPL36	Q9Y3U8	RPL36AL	Q969Q0	RPL37	P61927
RPL37A	P18077, P61513, P61927	RPL38	P63173	RPL39	P62891, Q96EH5
RPL39L	Q96EH5	RPL4	P36578	RPL41	P62945
RPL5	P46777	RPL6	Q02878	RPL7	P18124
RPL7A	P18124, P62424	RPL8	P62424, P62917	RPL9	P32969
RPLP0	P05388	RPLP1	P05386	RPLP2	P05387
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RPS15	P62841	RPS16	P62249	RPS17	P08708
RPS18	P62269	RPS2	P15880, P46782	RPS20	P60866
RPS21	P62841, P63220	RPS24	P62244, P62847	RPS25	P62851
RPS26	P62854	RPS27A	P62979, P62987	RPS27L	Q71UM5
RPS29	P62273	RPS3	P23396	RPS3A	P61247
RPS5	P46782	RPS6	P62753	RPS7	P62081
RPS8	P62241	RPS9	P46781	RPSA	P08865

18. RHO GTPases Activate Formins (R-HSA-5663220)



Cellular compartments: cytosol, nucleoplasm, plasma membrane, endosome membrane.

Formins are a family of proteins with 15 members in mammals, organized into 8 subfamilies. Formins are involved in the regulation of actin cytoskeleton. Many but not all formin family members are activated by RHO GTPases. Formins that serve as effectors of RHO GTPases belong to different formin subfamilies but they all share a structural similarity to Drosophila protein diaphanous and are hence named diaphanous-related formins (DRFs).

DRFs activated by RHO GTPases contain a GTPase binding domain (GBD) at their N-terminus, followed by formin homology domains 3, 1, and 2 (FH3, FH1, FH2) and a diaphanous autoregulatory domain (DAD) at the C-terminus. Most DRFs contain a dimerization domain (DD) and a coiled-coil region (CC) in between FH3 and FH1 domains (reviewed by Kuhn and Geyer 2014). RHO GTPase-activated DRFs are autoinhibited through the interaction between FH3 and DAD which is disrupted upon binding to an active RHO GTPase (Li and Higgs 2003, Lammers et al. 2005, Nezami et al. 2006). Since formins dimerize, it is not clear whether the FH3-DAD interaction is intra- or intermolecular. FH2 domain is responsible for binding to the F-actin and contributes to the formation of head-to-tail formin dimers (Xu et al. 2004). The proline-rich FH1 domain interacts with the actin-binding proteins profilins, thereby facilitating actin recruitment to formins and accelerating actin polymerization (Romero et al. 2004, Kovar et al. 2006).

Different formins are activated by different RHO GTPases in different cell contexts. FMNL1 (formin-like protein 1) is activated by binding to the RAC1:GTP and is involved in the formation of lamellipodia in macrophages (Yayoshi-Yamamoto et al. 2000) and is involved in the regulation of the Golgi complex structure (Colon-Franco et al. 2011). Activation of FMNL1 by CDC42:GTP contributes to the formation of the phagocytic cup (Seth et al. 2006). Activation of FMNL2 (formin-like protein 2) and FMNL3 (formin-like protein 3) by RHOC:GTP is involved in cancer cell motility and invasiveness (Kitzing et al. 2010, Vega et al. 2011). DIAPH1, activated by RHOA:GTP, promotes elongation of actin filaments and activation of SRF-mediated transcription which is inhibited by unpolymerized actin (Miralles et al. 2003). RHOF-mediated activation of DIAPH1 is implicated in formation of stress fibers (Fan et al. 2010). Activation of DIAPH1 and DIAPH3 by RHOB:GTP leads to actin coat formation around endosomes and regulates endosome motility and trafficking (Fernandez-Borja et al. 2005, Wallar et al. 2007). Endosome trafficking is also regulated by DIAPH2 transcription isoform 3 (DIAPH2-3) which, upon activation by RHOD:GTP, recruits SRC kinase to endosomes (Tom-inaga et al. 2000, Gasman et al. 2003). DIAPH2 transcription isoform 2 (DIAPH2-2) is involved in mitosis where, upon being activated by CDC42:GTP, it facilitates the capture of astral microtubules by kinetochores (Yasuda et al. 2004, Cheng et al. 2011). DIAPH2 is implicated in ovarian maintenance and premature ovarian failure (Bione et al. 1998). DAAM1, activated by RHOA:GTP, is involved in linking WNT signaling to cytoskeleton reorganization (Habas et al. 2001).

References

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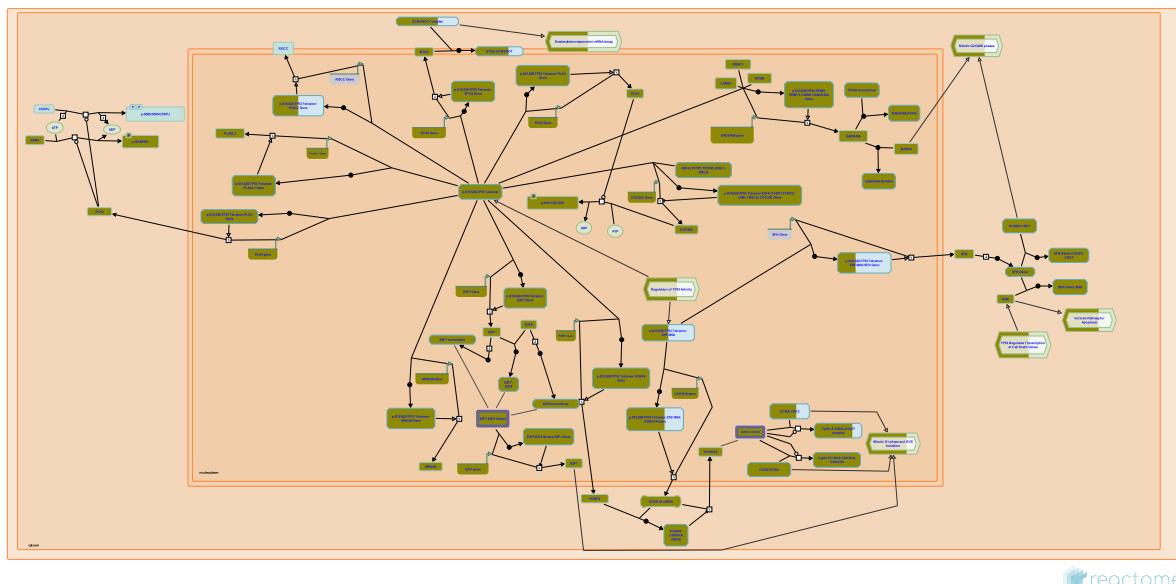
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2014-12-26	Authored	Rivero Crespo F
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2015-02-02	Edited	Orlic-Milacic M
2022-08-26	Modified	Wright A

111 submitted entities found in this pathway, mapping to 120 Reactome entities

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BUB1B	O60566	BUB3	O43684	CDC20	Q12834
CDCA8	Q53HL2	CENPA	P49450	CENPE	Q02224
CENPF	P49454	CENPH	Q9H3R5	CENPI	Q92674
CENPK	Q9BS16	CENPL	Q8N0S6	CENPM	Q9NSP4
CENPN	Q96H22	CENPO	Q9BU64	CENPP	Q6IPU0
CENPQ	Q7L2Z9	CENPT	Q96BT3	CENPU	Q71F23
CKAP5	Q14008	CLASP1	Q7Z460	CLASP2	O75122
CLIP1	P30622	DAAM1	Q9Y4D1	DIAPH1	O60610
DIAPH2	O60879-2, O60879-3	DIAPH3	Q9NSV4	DLC1	P63167
DSN1	Q9H410	DVL1	O14640	DVL2	O14641, Q92997
DVL3	Q92997	DYNC1H1	Q14204	DYNC1I1	O14576
DYNC1I2	Q13409	DYNC1LI1	Q9Y6G9	DYNLL1	P63167
DYNLL2	P63167, Q96FJ2	EMB	O14980	ERCC6L	Q2NKX8
FHOD3	Q8IVF7	FMNL2	Q96PY5	FMNL3	Q8IVF7
INCENP	Q9NQS7	ITGB1	P05556	ITGB3BP	Q13352
KIF18A	Q8NI77	KIF2A	O00139	KIF2C	Q99661
KNL1	Q8NG31	KNTC1	P50748	MAD2L1	Q13257
MAPRE1	Q15691	MIS12	Q9H081	NDC80	O14777
NDE1	Q9NXR1	NDEL1	Q9GZM8	NSL1	Q96IY1
NUDC	Q9Y266	NUF2	Q9BZD4	NUP107	P57740
NUP37	Q8NFH4	NUP43	Q8NFH3	NUP85	Q9BW27
PFN1	P07737	PLK1	P53350	PPP1CC	P36873
PPP2CA	P67775	PPP2CB	P62714	PPP2R1A	P30153, P30154
PPP2R1B	P30154	PPP2R5D	Q14738	RAC1	P63000
RANBP2	P49792	RANGAP1	P46060	RCC2	Q9P258
RHOA	P61586	RHOB	P62745	RHOC	P08134
SCAI	Q8N9R8	SEC13	P55735	SEH1L	Q96EE3-1
SGO1	Q5FBB7	SGO2	Q562F6	SKA1	Q96BD8
SKA2	Q8WVK7	SPC24	Q8NBT2	SPC25	Q9HBM1
SPDL1	Q96EA4	SRC	P12931-1	SRF	P11831
SRGAP2	O75044	TAOK1	Q7L7X3	TUBA1A	Q71U36
TUBA1B	P68363	TUBA1C	Q9BQE3	TUBA4A	P68366
TUBB2A	Q13885, Q9BVA1	TUBB2B	Q9BVA1	TUBB3	Q13509
TUBB4B	P68371, Q3ZCM7	TUBB6	Q9BUF5	VTI1B	Q96FJ2
XPO1	O14980	ZWILCH	Q9H900	ZWINT	O95229

Input	Ensembl Id
ITGB1	ENSG00000150093

19. TP53 Regulates Transcription of Cell Cycle Genes ([R-HSA-6791312](#))



Under a variety of stress conditions, TP53 (p53), stabilized by stress-induced phosphorylation at least on S15 and S20 serine residues, can induce the transcription of genes involved in cell cycle arrest. Cell cycle arrest provides cells an opportunity to repair the damage before division, thus preventing the transmission of genetic errors to daughter cells. In addition, it allows cells to attempt a recovery from the damage and survive, preventing premature cell death.

TP53 controls transcription of genes involved in both G1 and G2 cell cycle arrest. The most prominent TP53 target involved in G1 arrest is the inhibitor of cyclin-dependent kinases CDKN1A (p21). CDKN1A is one of the earliest genes induced by TP53 (El-Deiry et al. 1993). CDKN1A binds and inactivates CDK2 in complex with cyclin A (CCNA) or E (CCNE), thus preventing G1/S transition (Harper et al. 1993). Nevertheless, under prolonged stress, the cell destiny may be diverted towards an apoptotic outcome. For instance, in case of an irreversible damage, TP53 can induce transcription of an RNA binding protein PCBP4, which can bind and destabilize CDKN1A mRNA, thus alleviating G1 arrest and directing the affected cell towards G2 arrest and, possibly, apoptosis (Zhu and Chen 2000, Scoumanne et al. 2011). Expression of E2F7 is directly induced by TP53. E2F7 contributes to G1 cell cycle arrest by repressing transcription of E2F1, a transcription factor that promotes expression of many genes needed for G1/S transition (Aksoy et al. 2012, Carvajal et al. 2012). ARID3A is a direct transcriptional target of TP53 (Ma et al. 2003) that may promote G1 arrest by cooperating with TP53 in induction of CDKN1A transcription (Lestari et al. 2012). However, ARID3A may also promote G1/S transition by stimulating transcriptional activity of E2F1 (Suzuki et al. 1998, Peeper et al. 2002).

TP53 contributes to the establishment of G2 arrest by inducing transcription of GADD45A and SFN, and by inhibiting transcription of CDC25C. TP53 induces GADD45A transcription in cooperation with chromatin modifying enzymes EP300, PRMT1 and CARM1 (An et al. 2004). GADD45A binds Aurora kinase A (AURKA), inhibiting its catalytic activity and preventing AURKA-mediated G2/M transition (Shao et al. 2006, Sanchez et al. 2010). GADD45A also forms a complex with PCNA. PCNA is involved in both normal and repair DNA synthesis. The effect of GADD45 interaction with PCNA, if any, on S phase progression, G2 arrest and DNA repair is not known (Smith et al. 1994, Hall et al. 1995, Sanchez et al. 2010, Kim et al. 2013). SFN (14-3-3-sigma) is induced by TP53 (Hermeking et al. 1997) and contributes to G2 arrest by binding to the complex of CDK1 and CCNB1 (cyclin B1) and preventing its translocation to the nucleus. Phosphorylation of a number of nuclear proteins by the complex of CDK1 and CCNB1 is needed for G2/M transition (Chan et al. 1999). While promoting G2 arrest, SFN can simultaneously inhibit apoptosis by binding to BAX and preventing its translocation to mitochondria, a step involved in cytochrome C release (Samuel et al. 2001). TP53 binds the promoter of the CDC25C gene in cooperation with the transcriptional repressor E2F4 and represses CDC25C transcription, thus maintaining G2 arrest (St Clair et al. 2004, Benson et al. 2014).

Several direct transcriptional targets of TP53 are involved in cell cycle arrest but their mechanism of action is still unknown. BTG2 is induced by TP53, leading to cessation of cellular proliferation (Rouault et al. 1996, Duriez et al. 2002). BTG2 binds to the CCR4-NOT complex and promotes mRNA deadenylation activity of this complex. Interaction between BTG2 and CCR4-NOT is needed for the antiproliferative activity of BTG2, but the underlying mechanism has not been elucidated (Rouault et al. 1998, Mauxion et al. 2008, Horiuchi et al. 2009, Doidge et al. 2012, Ezzeddine et al. 2012). Two polo-like kinases, PLK2 and PLK3, are direct transcriptional targets of TP53. TP53-mediated induction of PLK2 may be important for prevention of mitotic catastrophe after spindle damage (Burns et al. 2003). PLK2 is involved in the regulation of centrosome duplication through phosphorylation of centrosome-related proteins CENPJ (Chang et al. 2010) and NPM1 (Krause and Hoffmann 2010). PLK2 is frequently transcriptionally silenced through promoter methylation in B-cell malignancies (Syed et al. 2006). Induction of PLK3 transcription by TP53 (Jen and Cheung 2005) may be important for coordination of M phase events through PLK3-mediated nuclear accumulation of CDC25C (Bahassi et al. 2004). RGCC is induced by TP53 and implicated in cell cycle regulation, possibly through its association with PLK1 (Saigusa et al. 2007). PLAGL1 (ZAC1) is a zinc finger protein directly transcriptionally induced by TP53 (Rozenfeld-Granot et al. 2002). PLAGL1 expression is frequently lost in cancer (Varrault et al. 1998) and PLAGL1 has been implicated in both cell cycle arrest and apoptosis (Spengler et al. 1997), but its mechanism of action remains unknown.

The zinc finger transcription factor ZNF385A (HZF) is a direct transcriptional target of TP53 that can form a complex with TP53 and facilitate TP53-mediated induction of CDKN1A and SFN (14-3-3 sigma) transcription (Das et al. 2007).

For a review of the role of TP53 in cell cycle arrest and cell cycle transcriptional targets of TP53, please refer to Riley et al. 2008, Murray-Zmijewski et al. 2008, Bieging et al. 2014, Kruiswijk et al. 2015.

References

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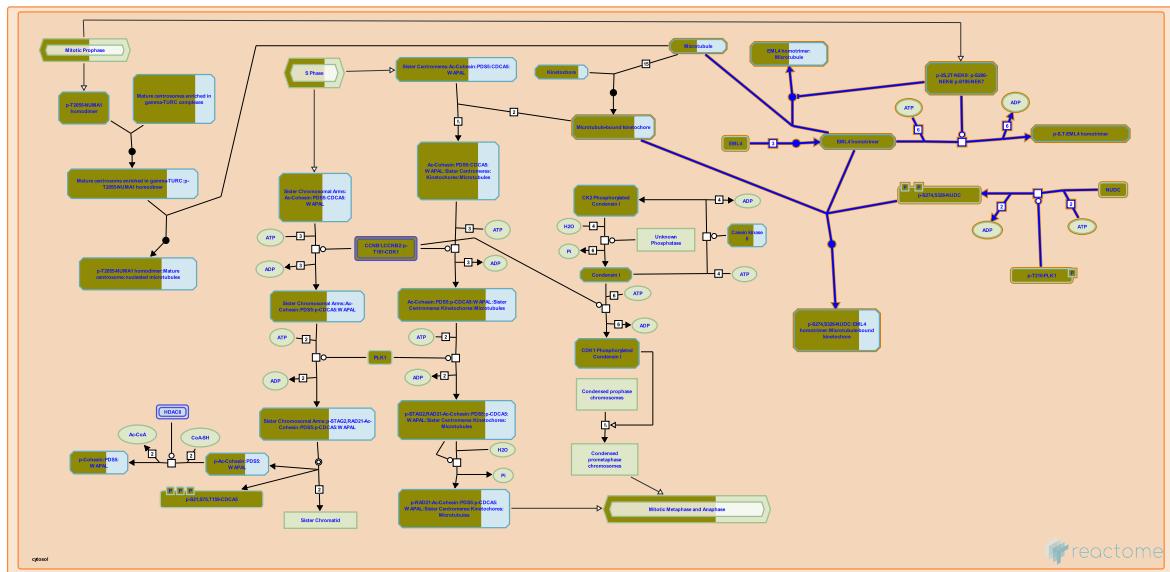
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2015-08-20	Created	Orlic-Milacic M
2015-10-14	Edited	Orlic-Milacic M
2015-10-14	Authored	Orlic-Milacic M
2016-02-04	Reviewed	Zaccara S, Inga A
2022-08-26	Modified	Wright A

43 submitted entities found in this pathway, mapping to 55 Reactome entities

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BTG2	P78543	CCN1	P20248	CCNA2	P20248
CCNB1	P14635	CCNE2	O96020	CDC25C	P30307
CDK1	P06493	CDK2	P24941	CDKN1A	P38936
CDKN1B	P46527	CLN3	P24864	CNOT1	A5YKK6
CNOT10	Q9H9A5	CNOT11	Q9UKZ1	CNOT2	Q9NZN8
CNOT6	Q9ULM6	CNOT6L	Q96LI5	CNOT8	Q9UFF9
CNOT9	Q92600	E2F1	Q01094	E2F2	Q16254
E2F4	Q16254	E2F7	Q96AV8	E2F8	A0AVK6
EP300	Q09472	GADD45A	P24522	NPM1	P06748
PCBP4	P57723	PCNA	P12004	PLAGL1	Q9UM63
PLK2	Q9NYY3	PLK3	Q9H4B4	PRMT1	Q99873
RBL1	P28749	RBL2	Q08999	TFDP1	Q14186
TFDP2	Q14188	TP53	P04637	YWHAQ	P31947
ZC3H12C	Q86X55				

Input	Ensembl Id	Input	Ensembl Id	Input	Ensembl Id
ARID3A	ENSG00000116017	BTG2	ENSG00000159388	CDC25C	ENSG00000158402
CDKN1A	ENSG00000124762, ENST00000244741	E2F1	ENSG00000101412	E2F7	ENSG00000165891
GADD45A	ENSG00000116717	PCBP4	ENSG00000090097	PLAGL1	ENSG00000118495
PLK2	ENSG00000145632	PLK3	ENSG00000173846		

20. EML4 and NUDC in mitotic spindle formation (R-HSA-9648025)



EML4 and NUDC proteins are required for mitotic spindle formation, attachment of spindle microtubule ends to kinetochores, and alignment of mitotic chromosome at the metaphase plate. EML4 is a WD40 family protein that binds to interphase microtubules and stabilizes them (Houtman et al. 2007, Adib et al. 2019). At mitotic entry, EML4 undergoes phosphorylation (Pollmann et al. 2006, Adib et al. 2019) by serine/threonine kinases NEK6 and NEK7, leading to its dissociation from microtubules, which is necessary for the assembly of a dynamic mitotic spindle (Adib et al. 2019). EML4, through its WD40 repeats, interacts with NUDC and recruits it to the kinetochores of the mitotic spindle (Chen et al. 2015). It is possible that other mitotic kinases, besides NEK6 and NEK7, also phosphorylate EML4. Phosphorylation of different residues of EML4 could reduce or increase affinity of EML4 for specific subpopulations of microtubules in mitosis.

A recurrent genomic rearrangement, reported in about 5% cases of non-small cell lung cancer (NSCLC) fuses the N-terminal portion of EML4 with the C-terminal portion of ALK (anaplastic lymphoma kinase), resulting in a constitutively active ALK (Soda et al. 2007, Richards et al. 2015).

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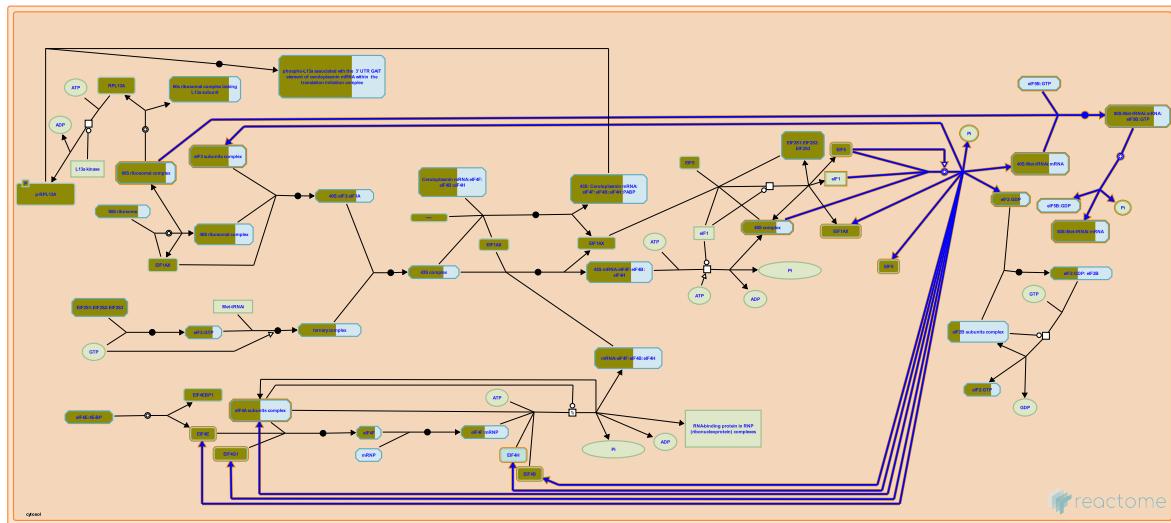
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Date	Action	Author
2019-06-04	Created	Orlic-Milacic M
2019-06-25	Authored	Orlic-Milacic M
2019-09-30	Reviewed	O'Regan L, Fry AM, Lucken KJ
2019-10-03	Reviewed	Bechstedt S
2019-10-07	Edited	Orlic-Milacic M
2022-08-26	Modified	Wright A

93 submitted entities found in this pathway, mapping to 98 Reactome entities

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AURKB	Q96GD4	B9D2	Q9BPU9	BIRC5	O15392
BUB1	O43683, O60566	BUB1B	O60566	BUB3	O43684
CDC20	Q12834	CDCA8	Q53HL2	CENPA	P49450
CENPE	Q02224	CENPF	P49454	CENPH	Q9H3R5
CENPI	Q92674	CENPK	Q9BS16	CENPL	Q8N0S6
CENPM	Q9NSP4	CENPN	Q96H22	CENPO	Q9BU64
CENPP	Q6IPU0	CENPQ	Q7L2Z9	CENPT	Q96BT3
CENPU	Q71F23	CKAP5	Q14008	CLASP1	Q7Z460
CLASP2	O75122	CLIP1	P30622	DLC1	P63167
DSN1	Q9H410	DYNC1H1	Q14204	DYNC1I1	O14576
DYNCL1I2	Q13409	DYNC1LI1	Q9Y6G9	DYNLL1	P63167
DYNLL2	P63167, Q96FJ2	EMB	O14980	EML4	Q9HC35
ERCC6L	Q2NKKX8	INCENP	Q9NQS7	ITGB3BP	Q13352
KIF18A	Q8NI77	KIF2A	O00139	KIF2C	Q99661
KNL1	Q8NG31	KNTC1	P50748	MAD2L1	Q13257
MAPRE1	Q15691	MIS12	Q9H081	NDC80	O14777
NDE1	Q9NXR1	NDEL1	Q9GZM8	NEK6	Q9HC98
NEK7	Q8TDX7	NEK8	Q8TD19	NSL1	Q96IY1
NUDC	Q9Y266	NUF2	Q9BZD4	NUP107	P57740
NUP37	Q8NFH4	NUP43	Q8NFH3	NUP85	Q9BW27
PLK1	P53350	PPP1CC	P36873	PPP2CA	P67775
PPP2CB	P62714	PPP2R1A	P30153, P30154	PPP2R1B	P30154
PPP2R5D	Q14738	RANBP2	P49792	RANGAP1	P46060
RCC2	Q9P258	SEC13	P55735	SEH1L	Q96EE3-1
SGO1	Q5FBB7	SGO2	Q562F6	SKA1	Q96BD8
SKA2	Q8WVK7	SPC24	Q8NBT2	SPC25	Q9HBM1
SPDL1	Q96EA4	TAOK1	Q7L7X3	TUBA1A	Q71U36
TUBA1B	P68363	TUBA1C	Q9BQE3	TUBA4A	P68366
TUBB2A	Q13885, Q9BVA1	TUBB2B	Q9BVA1	TUBB3	Q13509
TUBB4B	P68371, Q3ZCM7	TUBB6	Q9BUF5	VTI1B	Q96FJ2
XPO1	O14980	ZWILCH	Q9H900	ZWINT	O95229

21. GTP hydrolysis and joining of the 60S ribosomal subunit (R-HSA-72706)



Hydrolysis of eIF2-GTP occurs after the Met-tRNA_i has recognized the AUG. This reaction is catalyzed by eIF5 (or eIF5B) and is thought to cause dissociation of all other initiation factors and allow joining of the large 60S ribosomal subunit. The 60S subunit joins - a reaction catalyzed by eIF5 or eIF5B - resulting in a translation-competent 80S ribosome. Following 60S subunit joining, eIF5B hydrolyzes its GTP and is released from the 80S ribosome, which is now ready to start elongating the polypeptide chain.

References

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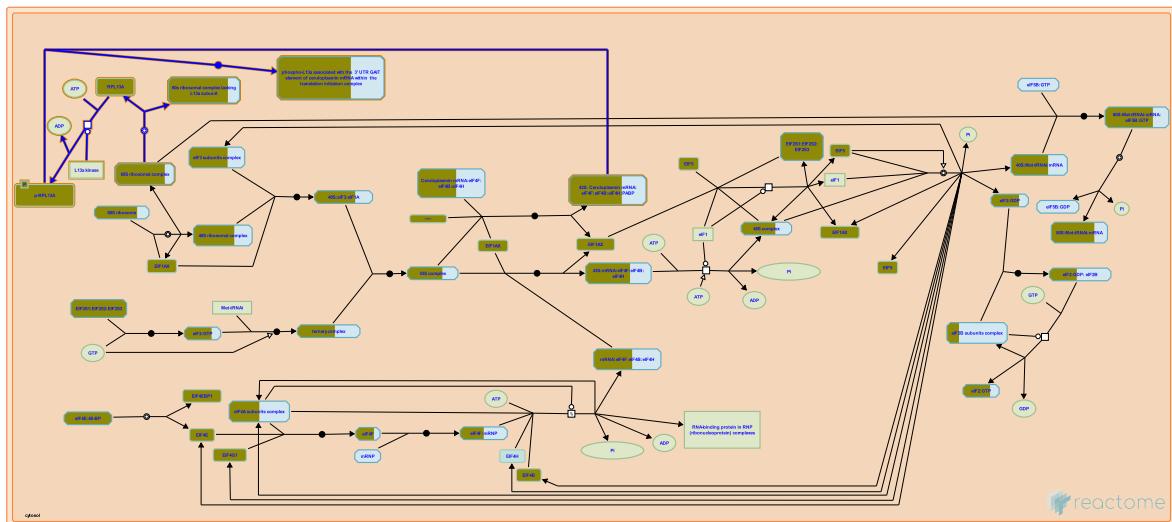
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2002-12-16	Created	Merrick WC
2022-09-05	Modified	Wright A

85 submitted entities found in this pathway, mapping to 105 Reactome entities

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EIF2A	P05198	EIF2S1	P05198	EIF2S2	P20042

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
EIF2S3	P41091	EIF3A	Q14152	EIF3B	P55884
EIF3C	Q99613	EIF3D	O15371	EIF3E	P60228
EIF3F	O00303	EIF3H	O15372	EIF3I	Q13347
EIF3J	O75822	EIF4A2	Q14240	EIF4B	P23588
EIF4E	P06730	EIF4G1	Q04637	EIF5	P55010
RPL10	P27635, Q96L21	RPL10A	P61313, P62906	RPL11	P62913
RPL12	P30050	RPL13	P26373, P40429	RPL13A	P40429, P61313
RPL14	P50914	RPL18A	Q02543, Q07020	RPL19	P84098
RPL21	P46778	RPL22L1	Q6P5R6	RPL23A	P62750, P62829, P84098
RPL24	P83731	RPL26	P61254, Q9UNX3	RPL27	P61353
RPL27A	P46776, P61353	RPL28	P46776, P46779	RPL29	P47914
RPL30	P62888	RPL31	P62899	RPL32	P62888, P62910
RPL35	P42766	RPL36	Q9Y3U8	RPL36AL	Q969Q0
RPL37	P61927	RPL37A	P18077, P61513, P61927	RPL38	P63173
RPL39	P62891, Q96EH5	RPL39L	Q96EH5	RPL4	P36578
RPL41	P62945	RPL5	P46777	RPL6	Q02878
RPL7	P18124	RPL7A	P18124, P62424	RPL8	P62424, P62917
RPL9	P32969	RPLP0	P05388	RPLP1	P05386
RPLP2	P05387	RPS12	P25398	RPS13	P62277
RPS14	P62263	RPS15	P62841	RPS16	P62249
RPS17	P08708	RPS18	P62269	RPS2	P15880, P46782
RPS20	P60866	RPS21	P62841, P63220	RPS24	P62244, P62847
RPS25	P62851	RPS26	P62854	RPS27A	P62979, P62987
RPS27L	Q71UM5	RPS29	P62273	RPS3	P23396
RPS3A	P61247	RPS5	P46782	RPS6	P62753
RPS7	P62081	RPS8	P62241	RPS9	P46781
RPSA	P08865				

22. L13a-mediated translational silencing of Ceruloplasmin expression (R-HSA-156827)



Cellular compartments: cytosol.

While circularization of mRNA during translation initiation is thought to contribute to an increase in the efficiency of translation, it also appears to provide a mechanism for translational silencing. This might be achieved by bringing inhibitory 3' UTR-binding proteins into a position in which they interfere either with the function of the translation initiation complex or with the assembly of the ribosome (Mazumder et al 2001). Translational silencing of Ceruloplasmin (Cp) occurs 16 hrs after its induction by INF-gamma (Mazumder et al., 1997). Although the mechanism by which silencing occurs has not yet been determined, this process is mediated by the L13a subunit of the 60s ribosome and thought to require circularization of the Cp mRNA (Sampath et al., 2003; Mazumder et al., 2001; Mazumder et al., 2003). Between 14 and 16 hrs after INF gamma induction, the L13a subunit of the 60s ribosome is phosphorylated and released from the 60s subunit. Phosphorylated L13a then associates with the GAIT element in the 3' UTR of the Cp mRNA inhibiting its translation.

References

Seshadri V, Sampath P, DiCorleto PE, Maitra RK, Fox PL & Mazumder B (2003). Regulated release of L13a from the 60S ribosomal subunit as a mechanism of transcript-specific translational control . *Cell*, 115, 187-98. [\[link\]](#)

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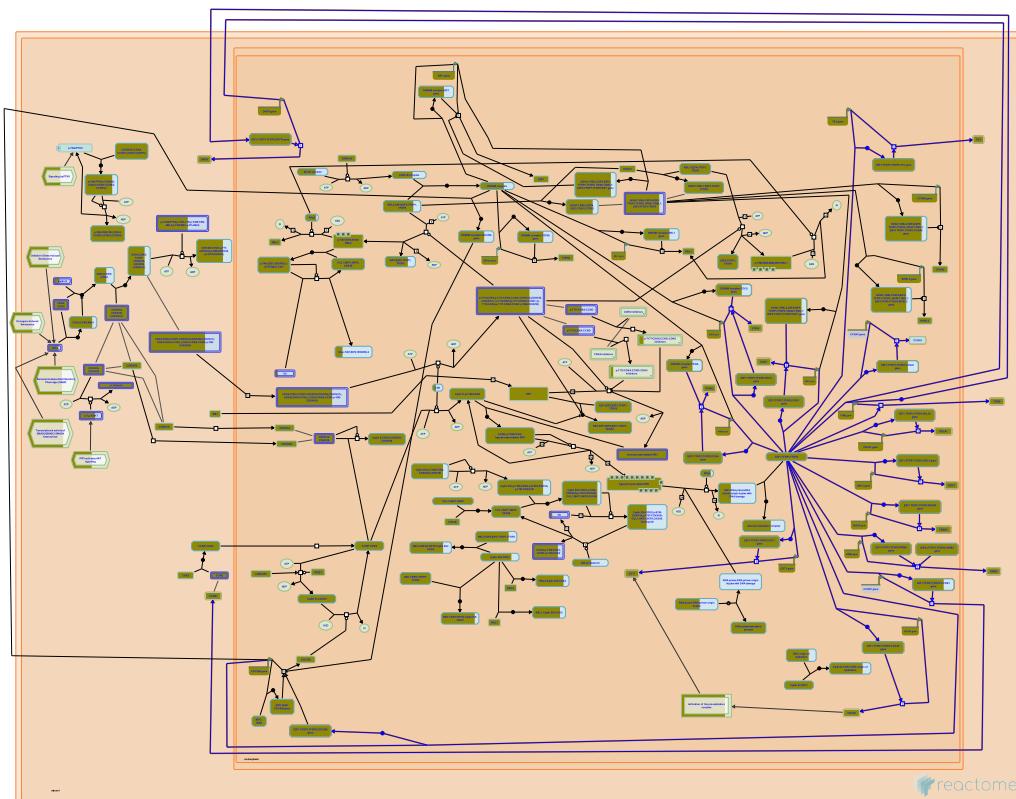
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2004-12-20	Created	Gebauer F
2013-11-25	Edited	Matthews L
2022-09-05	Modified	Wright A

85 submitted entities found in this pathway, mapping to 105 Reactome entities

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Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
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EIF3C	Q99613	EIF3D	O15371	EIF3E	P60228
EIF3F	O00303	EIF3H	O15372	EIF3I	Q13347
EIF3J	O75822	EIF4A2	Q14240	EIF4B	P23588
EIF4E	P06730	EIF4G1	Q04637	PABPC1	P11940
RPL10	P27635, Q96L21	RPL10A	P61313, P62906	RPL11	P62913
RPL12	P30050	RPL13	P26373, P40429	RPL13A	P40429, P61313
RPL14	P50914	RPL18A	Q02543, Q07020	RPL19	P84098
RPL21	P46778	RPL22L1	Q6P5R6	RPL23A	P62750, P62829, P84098
RPL24	P83731	RPL26	P61254, Q9UNX3	RPL27	P61353
RPL27A	P46776, P61353	RPL28	P46776, P46779	RPL29	P47914
RPL30	P62888	RPL31	P62899	RPL32	P62888, P62910
RPL35	P42766	RPL36	Q9Y3U8	RPL36AL	Q969Q0
RPL37	P61927	RPL37A	P18077, P61513, P61927	RPL38	P63173
RPL39	P62891, Q96EH5	RPL39L	Q96EH5	RPL4	P36578
RPL41	P62945	RPL5	P46777	RPL6	Q02878
RPL7	P18124	RPL7A	P18124, P62424	RPL8	P62424, P62917
RPL9	P32969	RPLP0	P05388	RPLP1	P05386
RPLP2	P05387	RPS12	P25398	RPS13	P62277
RPS14	P62263	RPS15	P62841	RPS16	P62249
RPS17	P08708	RPS18	P62269	RPS2	P15880, P46782
RPS20	P60866	RPS21	P62841, P63220	RPS24	P62244, P62847
RPS25	P62851	RPS26	P62854	RPS27A	P62979, P62987
RPS27L	Q71UM5	RPS29	P62273	RPS3	P23396
RPS3A	P61247	RPS5	P46782	RPS6	P62753
RPS7	P62081	RPS8	P62241	RPS9	P46781
RPSA	P08865				

23. G1/S-Specific Transcription (R-HSA-69205)



Cellular compartments: nucleoplasm.

The E2F family of transcription factors regulate the transition from the G1 to the S phase in the cell cycle. E2F activity is regulated by members of the retinoblastoma protein (pRb) family, resulting in the tight control of the expression of E2F-responsive genes. Phosphorylation of pRb by cyclin D:CDK complexes releases pRb from E2F, inducing E2F-targeted genes such as cyclin E.

E2F1 binds to E2F binding sites on the genome activating the synthesis of the target proteins. For annotation purposes, the reactions regulated by E2F1 are grouped under this pathway and information about the target genes alone are displayed for annotation purposes.

Cellular targets for activation by E2F1 include thymidylate synthase (TYMS) (DeGregori et al. 1995), Rir2 (RRM2) (DeGregori et al. 1995, Giangrande et al. 2004), Dihydrofolate reductase (DHFR) (DeGregori et al. 1995, Wells et al. 1997, Darbinian et al. 1999), Cdc2 (CDK1) (Furukawa et al. 1994, DeGregori et al. 1995, Zhu et al. 2004), Cyclin A1 (CCNA1) (DeGregori et al. 1995, Liu et al. 1998), CDC6 (DeGregori et al. 1995, Yan et al. 1998; Ohtani et al. 1998), CDT1 (Yoshida and Inoue 2004), CDC45 (Arata et al. 2000), Cyclin E (CCNE1) (Ohtani et al. 1995), Emi1 (FBXO5) (Hsu et al. 2002), and ORC1 (Ohtani et al. 1996, Ohtani et al. 1998). The activation of TK1 (Dnk1) (Dou et al. 1994, DeGregori et al. 1995, Giangrande et al. 2004) and CDC25A (DeGregori et al. 1995, Vigo et al. 1999) by E2F1 is conserved in Drosophila (Duronio and O'Farrell 1994, Reis and Edgar 2004).

RRM2 protein is involved in dNTP level regulation and activation of this enzyme results in higher levels of dNTPs in anticipation of S phase. E2F activation of RRM2 has been shown also in Drosophila by Duronio and O'Farrell (1994). E2F1 activation of CDC45 is shown in mouse cells by using human E2F1 construct (Arata et al. 2000). Cyclin E is also transcriptionally regulated by E2F1. Cyclin E protein plays important role in the transition of G1 to S phase by associating with CDK2 (Ohtani et al. 1996). E2F1-mediated activation of PCNA has been demonstrated in Drosophila (Duronio and O'Farrell 1994) and in some human cells by using recombinant adenovirus constructs (DeGregori et al. 1995). E2F1-mediated activation of the DNA polymerase alpha subunit p180 (POLA1) has been demonstrated in some human cells. It has also been demonstrated in Drosophila by Ohtani and Nevins (1994). It has been observed in Drosophila that E2F1 induced expression of Orc1 stimulates ORC1 6 complex formation and binding to the origin of replication (Asano and Wharton 1999). ORC1 6 recruit CDC6 and CDT1 that are required to recruit the MCM2 7 replication helicases. E2F1 regulation incorporates a feedback mechanism wherein Geminin (GMNN) can inhibit MCM2 7 recruitment of ORC1 6 complex by interacting with CDC6/CDT1. The activation of CDC25A and TK1 (Dnk1) by E2F1 has been inferred from similar events in Drosophila (Duronio RJ and O'Farrell 1994; Reis and Edgar 2004). E2F1 activates string (CDC25) that in turn activates the complex of Cyclin B and CDK1. A similar phenomenon has been observed in mouse NIH 3T3 cells and in Rat1 cells.

References

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Edit history

Date	Action	Author
2003-06-05	Created	Walworth N, O'Donnell M
2018-12-21	Modified	D'Eustachio P

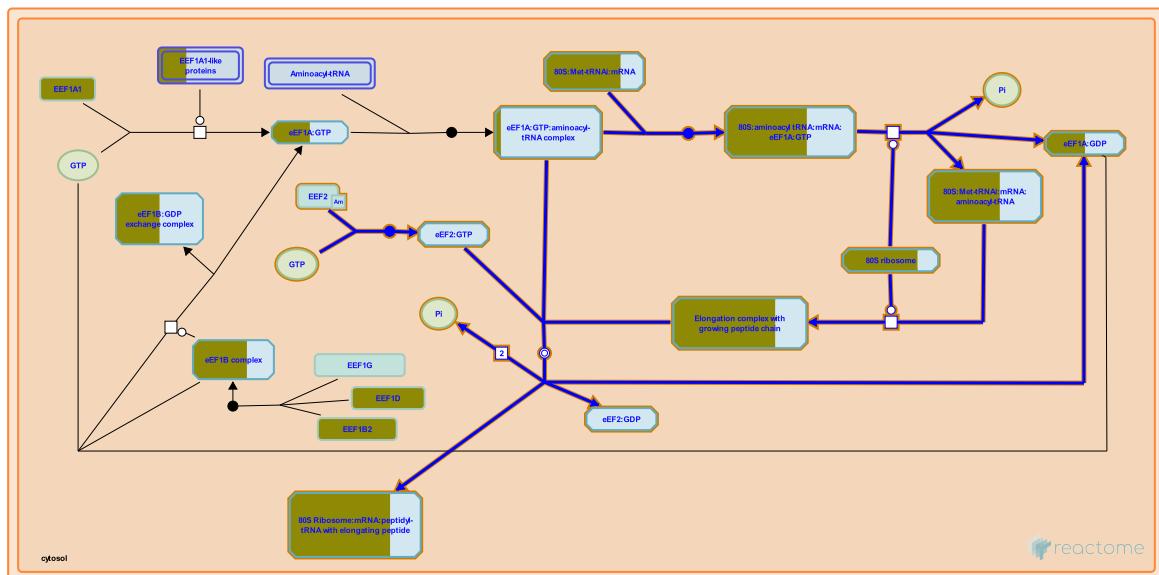
27 submitted entities found in this pathway, mapping to 39 Reactome entities

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CDT1	Q9H211	CLN3	P24864	DHFR	P00374
E2F1	Q01094	E2F2	Q16254	E2F4	Q16254

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
E2F6	O75461	FBXO5	Q9UKT4	FOSB	O75419
HDAC1	Q13547	LIN52	Q52LA3	LIN9	Q5TKA1
ORC1	Q13415	PCNA	P12004	POLA1	P09884
RBBP4	Q09028	RBL1	P28749	RBL2	Q08999
RRM2	P31350	TFDP1	Q14186	TFDP2	Q14188
TK1	P04183	TYMS	P04818		

Input	Ensembl Id	Input	Ensembl Id	Input	Ensembl Id
CDC25A	ENSG00000164045	CDC45	ENSG00000093009	CDC6	ENSG00000094804
CDK1	ENSG00000170312	CDT1	ENSG00000167513	DHFR	ENSG00000228716
FBXO5	ENSG00000112029	ORC1	ENSG00000085840	PCNA	ENSG00000132646
POLA1	ENSG00000101868	RRM2	ENSG00000171848	TK1	ENSG00000167900
TYMS	ENSG00000176890				

24. Peptide chain elongation (R-HSA-156902)



Cellular compartments: cytosol.

The mechanism of a peptide bond requires the movement of three protons. First the deprotonation of the ammonium ion generates a reactive amine, allowing a nucleophilic attack on the carbonyl group. This is followed by the loss of a proton from the reaction intermediate, only to be taken up by the oxygen on the leaving group (from the end of the amino acid chain bound to the tRNA in the P-site). The peptide bond formation results in the net loss of one water molecule, leaving a deacylated-tRNA in the P-site, and a nascent polypeptide chain one amino acid larger in the A-site.

For the purpose of illustration, the figures used in the section show one amino acid being added to a peptidyl-tRNA with a growing peptide chain.

References

Lorsch JR & Green R (2002). The path to perdition is paved with protons. *Cell*, 110, 665-8. [🔗](#)

Edit history

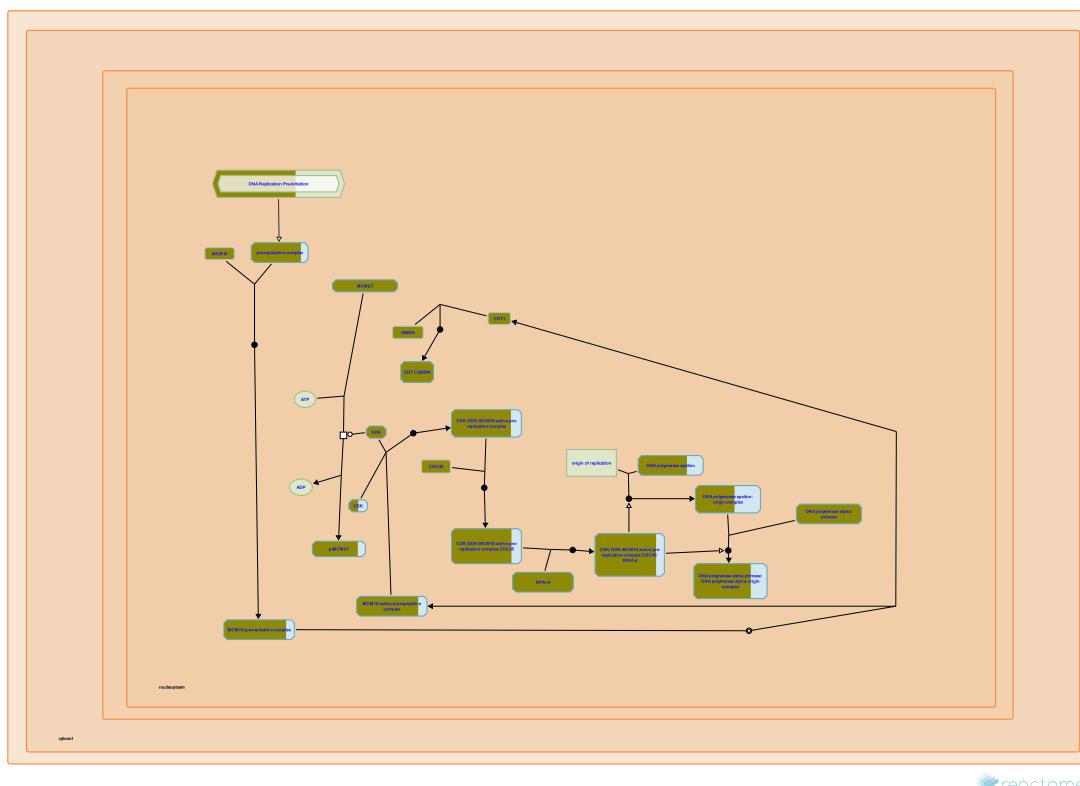
Date	Action	Author
2005-03-13	Authored	Gopinathrao G
2005-03-17	Created	Balar B, Ulloque R, Kinzy TG
2022-09-05	Modified	Wright A

67 submitted entities found in this pathway, mapping to 87 Reactome entities

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AGRN	P32969	CRY2	P62263	EEF1A1	P68104
RPL10	P27635, Q96L21	RPL10A	P61313, P62906	RPL11	P62913
RPL12	P30050	RPL13	P26373, P40429	RPL13A	P40429, P61313
RPL14	P50914	RPL18A	Q02543, Q07020	RPL19	P84098
RPL21	P46778	RPL22L1	Q6P5R6	RPL23A	P62750, P62829, P84098
RPL24	P83731	RPL26	P61254, Q9UNX3	RPL27	P61353
RPL27A	P46776, P61353	RPL28	P46776, P46779	RPL29	P47914

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
RPL30	P62888	RPL31	P62899	RPL32	P62888, P62910
RPL35	P42766	RPL36	Q9Y3U8	RPL36AL	Q969Q0
RPL37	P61927	RPL37A	P18077, P61513, P61927	RPL38	P63173
RPL39	P62891, Q96EH5	RPL39L	Q96EH5	RPL4	P36578
RPL41	P62945	RPL5	P46777	RPL6	Q02878
RPL7	P18124	RPL7A	P18124, P62424	RPL8	P62424, P62917
RPL9	P32969	RPLP0	P05388	RPLP1	P05386
RPLP2	P05387	RPS12	P25398	RPS13	P62277
RPS14	P62263	RPS15	P62841	RPS16	P62249
RPS17	P08708	RPS18	P62269	RPS2	P15880, P46782
RPS20	P60866	RPS21	P62841, P63220	RPS24	P62244, P62847
RPS25	P62851	RPS26	P62854	RPS27A	P62979, P62987
RPS27L	Q71UM5	RPS29	P62273	RPS3	P23396
RPS3A	P61247	RPS5	P46782	RPS6	P62753
RPS7	P62081	RPS8	P62241	RPS9	P46781
RPSA	P08865				

25. Activation of the pre-replicative complex (R-HSA-68962)



Cellular compartments: nucleoplasm.

In *S. cerevisiae*, two ORC subunits, Orc1 and Orc5, both bind ATP, and Orc1 in addition has ATPase activity. Both ATP binding and ATP hydrolysis appear to be essential functions *in vivo*. ATP binding by Orc1 is unaffected by the association of ORC with origin DNA (ARS) sequences, but ATP hydrolysis is ARS-dependent, being suppressed by associated double-stranded DNA and stimulated by associated single-stranded DNA. These data are consistent with the hypothesis that ORC functions as an ATPase switch, hydrolyzing bound ATP and changing state as DNA unwinds at the origin immediately before replication. It is attractive to speculate that ORC likewise functions as a switch as human pre-replicative complexes are activated, but human Orc proteins are not well enough characterized to allow the model to be critically tested. mRNAs encoding human orthologs of all six Orc proteins have been cloned, and ATP-binding amino acid sequence motifs have been identified in Orc1, Orc4, and Orc5. Interactions among proteins expressed from the cloned genes have been characterized, but the ATP-binding and hydrolyzing properties of these proteins and complexes of them have not been determined.

References

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Lane WS, Tully T, Hou ZH, Jones CJ, Velinzon K, Quintana DG, ... Hendricks M (1999). latheo encodes a subunit of the origin recognition complex and disrupts neuronal proliferation and adult olfactory memory when mutant. *Neuron*, 23, 45-54. [🔗](#)

Bell SP & Lee DG (2000). ATPase switches controlling DNA replication initiation. *Curr Opin Cell Biol*, 12, 280-5. [🔗](#)

Edit history

Date	Action	Author
2003-06-05	Created	Davey MJ, O'Donnell M
2022-08-26	Modified	Wright A

33 submitted entities found in this pathway, mapping to 35 Reactome entities

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CCNL1	P49736	CDC45	O75419	CDC6	Q99741
CDC7	O00311	CDK2	P24941	CDT1	Q9H211
DBF4	Q9UBU7	FOSB	O75419	GAA	P27694
GMNN	O75496	MCM10	Q7L590	MCM2	P33993, P49736
MCM3	P25205	MCM4	P33991	MCM5	P33992
MCM6	Q14566	MCM7	P33993	MCM8	Q9UJA3
ORC1	Q13415	ORC3	Q9UBD5	ORC4	O43929
ORC5	O43913	ORC6	Q9Y5N6	POLA1	P09884
POLA2	Q14181	POLE	Q07864	POLE2	P56282
POLE3	Q9NRF9	PRIM1	P49642	PRIM2	P49643
RPA1	P27694	RPA2	P15927, Q13156	RPA3	P35244

6. Identifiers found

Below is a list of the input identifiers that have been found or mapped to an equivalent element in Reactome, classified by resource.

5189 of the submitted entities were found, mapping to 6072 Reactome entities

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AASDHPPPT	Q9NRN7	ABAT	P80404	ABCA1	O95477
ABC A2	Q9BZC7	ABC A3	Q99758	ABC A6	Q8N139
ABC A7	Q8IZY2	ABC B1	P08183	ABC B10	Q9NRK6
ABC B7	Q9NWR8	ABC B8	Q9NUT2	ABC C1	P33527
ABC C10	Q5T3U5	ABC C3	O15438	ABC C4	O15439
ABC C5	O15440	ABC C9	O60706	ABC D4	O14678
ABC E1	P61221	ABC G1	P45844	ABC G2	Q9UNQ0
ABHD10	Q9NUJ1	ABHD12	Q8N2K0	ABHD13	Q9P2W7
ABHD14B	Q96IU4	ABHD17A	Q96GS6	ABHD17B	Q5VST6
ABHD17C	Q6PCB6	ABHD4	Q8TB40	ABHD5	Q8WTS1
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ABLIM3	O94929	ABR	Q12979	ABRAXAS2	Q15018
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ACE	P12821	ACER2	Q5QJU3	ACER3	Q9NUN7
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ACOT9	Q9Y305	ACOX1	Q15067	ACOX2	Q99424
ACOX3	O15254	ACP1	P47755	ACP2	P47756
ACP5	P13686	ACSF2	Q96CM8	ACSL1	P33121
ACSL3	O95573	ACSL4	O60488	ACSL5	Q9ULC5
ACSS1	Q9NUB1	ACSS2	Q9NR19	ACTA2	P62736
ACTB	P60709, P63261	ACTG1	P63261	ACTG2	P63267
ACTL6A	O96019	ACTN1	P12814	ACTN4	O43707
ACTR2	P61160	ACTR3	P61158	ACTR5	Q9H9F9
ACTR8	Q9H981	ACVR1B	P36896	ACVR2B	Q13705
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ADAM19	Q9H013	ADAM23	Q96QD9	ADAM9	Q13443
ADAMTS1	Q9UHI8	ADAMTS12	P58397	ADAMTS19	Q8TE59
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ADAMTS7	Q9UKP4	ADAMTS8	Q9UP79	ADAMTS9	Q9P2N4
ADAMTSL1	Q8N6G6	ADAMTSL5	Q6ZMM2	ADAP1	O75689
ADAR	P55265	ADARB1	P78563	ADAT3	Q96EY9
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ADIPOR2	Q86V24	ADK	P55263	ADM	P35318
ADM2	Q7Z4H4	ADO	Q96SZ5	ADORA1	P30542
ADORA2B	P29275	ADPGK	Q9BRR6	ADPRM	Q3LIE5
ADRA1B	P35368	ADRA1D	P25100	ADRB2	P07550
ADSS2	P30520	AEBP2	Q6ZN18	AFDN	P55196-2
AFMID	Q63HM1	AFP	P02771	AGBL5	Q8NDL9
AGK	Q53H12	AGO2	Q9UKV8	AGO4	Q9HCK5
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AGPAT4	Q9NRZ7	AGPS	O00116	AGRN	P32969
AGT	P01019	AGTPBP1	Q9UPW5	AGTRAP	Q6RW13
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AHR	P35869	AHRR	A9YTQ3	AIFM2	Q9BRQ8
AIMP1	Q12904	AIMP2	Q13155	AJUBA	Q96IF1
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AK5	Q9Y6K8	AKAP12	Q02952	AKAP5	P24588
AKAP9	Q99996	AKR1B1	P15121	AKR1B10	O60218
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ALDH7A1	P49419	ALDH8A1	Q9H2A2	ALDH9A1	P49189
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ALKBH8	Q96BT7	ALOX12	P18054	ALPK1	Q96QP1
ALPL	P05186	ALS2CL	Q60I27	ALYREF	Q86V81
AMBRA1	Q9C0C7	AMDHD2	Q9Y303	AMFR	Q9UKV5
AMIGO2	Q86SJ2	AMOT	Q4VCS5-1	AMOTL2	Q9Y2J4
AMPD3	Q01432	AMPH	Q9UBW5	ANAPC1	Q9H1A4
ANAPC10	Q9UM13	ANAPC16	Q96DE5	ANAPC2	Q9UJX6
ANAPC7	Q9UJX3	ANGPT1	Q15389	ANGPT2	O15123
ANGPTL4	Q9BY76	ANK2	Q01484	ANK3	Q12955
ANKH	Q9HCJ1	ANKRD1	Q15327	ANKRD26	Q9UPS8
ANKRD27	Q96NW4	ANKRD28	O15084	ANKRD52	Q9Y575
ANLN	Q9NQW6	ANO1	Q5XXA6	ANO4	Q32M45
ANO6	Q4KMQ2	ANO7	Q6IWH7	ANO8	Q9HCE9
ANP32A	P39687	ANTXR1	Q9H6X2-1, Q9H6X2-2	ANXA1	P04083
ANXA2	P07355	ANXA5	P08758	ANXA6	P08133
AOC2	O75106	AOPEP	Q8N6M6	AOX1	Q06278
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AP1S2	P56377	AP1S3	Q96PC3	AP2A1	O95782
AP2B1	P63010	AP2M1	Q96CW1	AP2S1	P53680
AP3B1	O00203	AP3S1	Q92572	AP4B1	Q9Y6B7
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APPL2	Q06481	APRT	P07741	AQP1	P29972
AQP3	Q92482	ARAP1	Q96P48	AREG	P15514
AREL1	O15033	ARF1	P61204, P84077	ARF5	P84085
ARFGAP1	Q9NP61	ARFGAP2	Q8N6H7	ARFGAP3	Q9NP61
ARFGEF2	Q9Y6D5	ARHGAP1	Q07960	ARHGAP10	A1A4S6, Q5T5U3
ARHGAP11A	Q6P4F7	ARHGAP17	Q68EM7	ARHGAP18	Q8N392
ARHGAP19	Q14CB8	ARHGAP20	Q9P2F6	ARHGAP21	Q5T5U3
ARHGAP22	Q7Z5H3	ARHGAP23	Q9P227	ARHGAP27	Q6ZUM4
ARHGAP28	Q9P2N2	ARHGAP29	Q52LW3	ARHGAP32	A7KAX9
ARHGAP33	O14559	ARHGAP35	Q9NRY4	ARHGAP39	Q9C0H5
ARHGAP42	A6NI28	ARHGAP45	Q92619	ARHGAP6	O43182
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ARID1B	Q8NFD5	ARID2	Q68CP9	ARID3A	Q99856
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ARPC1A	Q92747	ARPC2	O15144	ARPC5	O15511
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ARSJ	Q5FYB0	ARSK	Q6UWY0	ARSL	P51690
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ASB6	Q9NWX5	ASB8	Q9H765	ASCC1	Q8N9N2
ASCC3	Q8N3C0	ASF1A	Q9Y294	ASGR1	P07306
ASIC1	P78348	ASL	P04424	ASNS	P08243
ASPH	Q12797	ASS1	P00966	ASXL1	Q8IXJ9
ASXL2	Q76L83	ATAD1	Q8NBU5	ATAD2	Q6PL18
ATAD3A	Q5T9A4	ATAD3B	Q5T9A4	ATAT1	Q5SQI0
ATF1	P18846	ATF2	P15336	ATF3	P18847
ATF4	P18848	ATF6	P18850	ATF6B	P18850
ATG10	Q9H0Y0	ATG101	Q9BSB4	ATG12	O94817
ATG13	O75143	ATG14	Q6ZNE5	ATG4A	Q8WYN0, Q9Y4P1
ATG4B	Q96DT6, Q9Y4P1	ATG4D	Q86TL0	ATG7	O95352
ATG9A	Q7Z3C6	ATIC	P31939	ATM	Q13315
ATOX1	O00244	ATP10A	O60312	ATP10D	Q9P241
ATP13A2	Q9NQ11	ATP1A1	P05023	ATP1B1	P05026
ATP1B3	P54709	ATP2A2	P16615	ATP2A3	Q93084
ATP2B1	P20020	ATP2B4	P23634, Q01814	ATP2C1	P98194
ATP5F1A	P25705	ATP5F1C	P36542	ATP5MC1	P05496, Q06055
ATP5MC3	P48201	ATP5MF	P56134	ATP5MG	O75964
ATP5PF	P18859	ATP5PO	P48047	ATP6	P00846

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ATP6V1A	P38606	ATP6V1B2	P21281	ATP6V1C1	P21283
ATP6V1E1	P36543	ATP6V1E2	Q96A05	ATP6V1F	Q16864
ATP6V1G1	O75348	ATP6V1H	Q9UI12	ATP7A	Q04656
ATP8	P03928	ATP8A1	Q9Y2Q0	ATP8B1	O43520
ATP8B2	P98198	ATP8B4	Q8TF62	ATP9A	O75110
ATRX	P46100	ATXN3	P54252, Q9H3M9	ATXN7	O15265
ATXN7L3	Q14CW9	AUH	Q13825	AURKA	O14965
AURKB	Q96GD4	AVEN	Q9NQS1	AXIN1	O15169
AXL	P30530	AZIN1	O14977	B2M	P61769
B3GALNT1	O75752	B3GALT1	Q9Y5Z6	B3GALT2	O43825
B3GALT6	Q96L58	B3GAT3	O94766	B3GLCT	Q6Y288
B3GNT2	Q9NY97	B3GNT9	Q6UX72	B3GNTL1	Q67FW5
B4GALT1	P15291	B4GALT2	O60909	B4GALT3	O60512
B4GALT4	O60513	B4GALT5	O43286	B4GALT7	Q9UBV7
B9D1	Q9UPM9	B9D2	Q9BPU9	BAALC	Q06210
BABAM2	Q9NXR7	BACE1	P56817	BACH1	Q9BX63
BAG1	Q99933	BAG2	O95816	BAG3	O95817
BAG5	Q9UL15	BAG6	P46379	BAIAP2L1	Q9UHR4
BAK1	Q16611	BAMBI	Q13145	BANF1	O75531
BAP1	Q99496	BARD1	Q99728	BAX	Q07812
BAZ1B	Q9UIG0	BAZ2A	Q9UIF9	BBC3	Q9BXH1
BBS10	Q8TAM1	BBS12	Q6ZW61	BBS2	Q9BC9
BBS7	Q8IWZ6	BBS9	Q3SYG4	BCAM	Q15109
BCAP31	P51572	BCAR1	P56945	BCAS2	O75934
BCAT1	P54687	BCAT2	O15382	BCKDHB	P21953
BCKDK	O14874	BCL10	O95999	BCL2	P10415
BCL2L1	Q07817	BCL2L11	O43521	BCR	P11274
BCS1L	Q9Y276	BDH2	Q9BUT1	BDKRB2	P30411, P46663
BDNF	P23560	BDP1	A6H8Y1	BECN1	Q14457
BET1	O15155	BEX3	Q00994	BGN	P21810
BID	P55957	BIRC2	Q13489, Q13490	BIRC3	Q13489, Q13490
BIRC5	O15392	BIRC6	Q9NR09	BLM	P54132
BLMH	Q13867	BLOC1S4	Q9NUP1	BLOC1S6	Q9UL45
BLVRA	P53004	BLVRB	P30043	BLZF1	Q9H2G9
BMF	Q96LC9	BMP1	P13497	BMP2	P12643
BMP4	P12644	BMPR1A	P36894	BMPR1B	O00238
BMS1	Q14692	BMT2	Q1RMZ1	BNIP1	Q12981
BNIP2	Q12982	BNIP3L	O60238	BOC	Q9BWV1
BOP1	Q14137	BORA	Q6PGQ7	BPBM	P07738
BPHL	Q86WA6	BPNT2	Q9NX62	BRCA1	P38398
BRCA2	P51587	BRD1	O95696	BRD2	P25440
BRD4	O60885	BRI3	O95415	BRINP3	P19474
BRIP1	Q9BX63	BRK1	Q8WUW1	BRPF1	P55201
BRWD1	Q9NSI6	BSG	P35613	BTBD1	Q9H0C5
BTBD2	Q9H0C5	BTBD6	Q96KE9	BTG1	P62324
BTG2	P78543	BTN2A1	Q7KYR7	BTN2A2	Q8WVV5

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
BTN3A1	O00481	BTN3A2	P78410	BTN3A3	O00478
BTRC	Q9Y297	BUB1	O43683, O60566	BUB1B	O60566
BUB3	O43684	BUD23	O43709	C19orf47	Q8NG27
C1GALT1	Q9NS00	C1GALT1C1	Q96EU7	C1QBP	Q07021
C1QTNF1	Q8NFI3	C1S	P09871	C2CD3	Q4AC94
C2CD5	Q86YS7	C5	P01031	C6orf120	Q7Z4R8
C7	P10643	CA12	O43570	CA5B	P35218, Q9Y2D0
CAB39	Q9Y376	CABIN1	Q9Y6J0	CABLES1	Q8TDN4
CABLES2	Q9BTV7	CACNA1A	O00555	CACNA1C	Q13936
CACNA1H	O95180	CACNA2D3	Q8IZS8	CACNB1	Q02641
CACNB3	P54284	CACNG7	P62955	CACUL1	Q9Y5Y5
CAD	O76075	CADM1	Q96DZ1	CALCB	P01258, P10092
CALCRL	Q16602	CALD1	Q05682	CALM1	P0DP23
CALR	P27797	CALU	O43852	CAMK1	Q14012
CAMK2D	Q13557	CAMK4	Q16566	CAMKK1	Q8N5S9
CAMKK2	Q96RR4	CAMKMT	Q7Z624	CAMLG	P49069
CAND1	Q86VP6	CANT1	Q8WVQ1	CANX	P27824
CAP1	Q01518	CAP2	P47756	CAPG	Q9BPX3
CAPN1	P07384	CAPN10	Q9HC96	CAPN15	O75808
CAPN2	P17655	CAPN5	O15484	CAPNS1	P04632
CAPZA1	P52907	CAPZA2	P47755	CAPZB	P47756
CARD11	Q9BXL7	CARD8	Q9Y2G2	CARNMT1	Q8N4J0
CARS1	P49589	CARS2	Q9HA77	CASC3	O15234
CASK	O14936	CASP1	P29466	CASP3	O15519
CASP4	P49662, P51878	CASP7	P55210	CASP8	Q92851
CAST	P20810	CAT	P04040	CAV1	Q03135
CAV2	P51636	CAVIN1	Q6NZI2	CBL	P22681
CBLB	Q13191	CBLL1	Q8N7E2	CBR1	P16152
CBR3	P16152	CBS	Q92805	CBX1	P83916
CBX3	Q13185	CBX5	P45973	CC2D1A	Q5T0F9
CC2D1B	Q5T0F9	CCAR1	Q8IX12	CCDC115	Q96NT0
CCDC71L	P19838	CCDC8	Q9H0W5	CCDC88A	Q3V6T2
CCN1	P20248	CCN2	P29279	CCNA2	P20248
CCNB1	P14635	CCNB2	O95067	CCNC	P24863
CCND1	P24385	CCNE2	O96020	CCNF	P41002
CCNG1	P51959	CCNG2	Q16589	CCNK	O75909
CCNL1	P49736	CCNT1	O60563	CCNT2	O60583
CCT3	P49368	CCT4	P50991	CCT5	P48643
CCT6A	P40227	CCT7	Q99832	CD109	Q6YHK3
CD1D	P15813	CD226	Q15762	CD248	Q9NPY3
CD274	Q9NZQ7	CD276	O75144	CD2AP	Q9Y5K6
CD36	P16671	CD44	P16070	CD46	P15529
CD47	Q08722	CD55	P08174	CD58	P19256
CD59	P13987	CD63	P08962	CD81	P60033
CD9	P21926	CDA	P32320	CDC14A	Q9UNH5
CDC14B	O60729	CDC16	Q13042	CDC20	Q12834
CDC23	Q9UJX2	CDC25A	P30304	CDC25B	P30305
CDC25C	P30307	CDC27	P30260, Q15054	CDC34	P49427
CDC37	Q16543	CDC37L1	Q7L3B6	CDC40	O60508

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
CDC42BPA	Q5VT25	CDC42BPB	Q9Y5S2	CDC42EP1	Q00587, Q6NZY7
CDC42EP3	Q9UKI2	CDC42EP4	Q9H3Q1	CDC42SE2	Q9NRR3
CDC45	O75419	CDC6	Q99741	CDC7	O00311
CDC73	Q6P1J9	CDCA5	Q96FF9	CDCA8	Q53HL2
CDCP1	Q9UBR1	CDH11	P55287	CDH24	Q86UP0
CDH4	P55283	CDH6	P55285	CDIPT	O14735
CDK1	P06493	CDK12	Q9NYV4	CDK19	Q9BWU1
CDK2	P24941	CDK4	P11802	CDK5	Q00535
CDK5R1	Q15078	CDK5RAP2	Q96SN8	CDK6	Q00534
CDK9	P50750	CDKAL1	Q5VV42	CDKL5	Q53GT1
CDKN1A	P38936	CDKN1B	P46527	CDKN1C	P49918
CDKN2B	P42771, P42772	CDKN2C	P42773	CDON	Q4KMG0
CDS2	O95674	CDT1	Q9H211	CEPB	P17676
CEBDP	P49716	CEBPG	P53567	CENPA	P49450
CENPE	Q02224	CENPF	P49454	CENPH	Q9H3R5
CENPI	Q92674	CENPK	Q9BS16	CENPL	Q8N0S6
CENPM	Q9NSP4	CENPN	Q96H22	CENPO	Q9BU64
CENPP	Q6IPU0	CENPQ	Q7L2Z9	CENPT	Q96BT3
CENPU	Q71F23	CENPW	Q5EE01	CEP131	Q9UPN4
CEP135	Q66GS9	CEP152	O94986	CEP162	Q5TB80
CEP164	Q9UPV0	CEP170	P35869	CEP192	Q8TEP8
CEP41	Q9BYV8	CEP55	Q92753	CEP70	Q8NHQ1
CEP76	Q8TAP6	CEP78	Q5JTW2	CEP83	Q9Y592
CEP97	Q8IW35	CERK	Q8TCT0	CERS1	P27544
CERS5	Q8N5B7	CERT1	Q9Y5P4-2	CES2	P23141
CFL1	P23528	CFLAR	O15519	CHAC1	Q9BUX1
CHAC2	Q8WUX2	CHCHD10	Q8WYQ3	CHCHD2	Q9Y6H1
CHCHD3	Q9NX63	CHCHD6	Q9BRQ6	CHCHD7	Q9BUK0
CHD1	O14646	CHD1L	Q86WJ1	CHD3	Q12873
CHD4	Q14839	CHD9	Q3L8U1	CHEK1	O14757
CHEK2	O96017	CHI3L1	P36222	CHID1	Q9BWS9
CHKA	P35790	CHL1	O00533	CHML	P26374
CHMP2A	O43633	CHMP2B	Q9UQN3	CHMP4B	Q9H444
CHMP5	Q9NZZ3	CHMP7	Q8WUX9	CHN1	P15882
CHP1	Q99653	CHPF	Q8IZ52, Q9P2E5	CHPF2	Q9P2E5
CHPT1	Q8WUD6	CHRM2	P08172	CHST11	Q9NPF2
CHST12	Q9NRB3	CHST14	Q8NCH0	CHST2	Q9Y4C5
CHST3	Q7LGC8	CHSY3	Q70JA7, Q9P2E5	CHTF18	Q8WVB6
CHUK	O15111	CIAO1	O76071	CIR1	P38117
CISH	Q9NSE2	CIT	O14578, O14578-3	CITED4	Q96RK1
CKAP4	Q07065	CKAP5	Q14008	CKS1B	P61024
CLASP1	Q7Z460	CLASP2	O75122	CLCA2	Q9UQC9
CLCF1	Q9UBD9	CLCN2	P51788	CLCN3	P51790
CLCN5	P51795	CLCN6	P51797	CLCN7	P51798
CLDN1	O95832	CLDN11	Q9Y547	CLDN12	P56749
CLDN23	Q96B33	CLDN4	O14493	CLEC2B	Q92478
CLEC2D	Q9UHP7	CLINT1	Q14677	CLIP1	P30622
CLIP3	Q96DZ5	CLN3	P24864	CLN8	Q8IUC4
CLNS1A	P54105	CLOCK	O15516	CLSPN	Q9HAW4

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
CLTA	P09496	CLTB	P09497	CLTCL1	P53675
CLU	P10909	CMAS	Q8NFW8	CMBL	Q96DG6
CMC2	Q9NRP2	CMTM6	Q9NX76	CMTM7	Q9NX76
CNDP2	Q96KP4	CNIH1	O95406	CNIH3	Q8TBE1
CNN2	Q99439	CNOT1	A5YKK6	CNOT10	Q9H9A5
CNOT11	Q9UKZ1	CNOT2	Q9NZN8	CNOT6	Q9ULM6
CNOT6L	Q96LI5	CNOT8	Q9UFF9	CNOT9	Q92600
CNPY2	P11474	CNPY3	Q9BT09	CNTN1	Q12860
CNTN4	O94779, Q8IWV2	CNTNAP1	P78357	CNTRL	Q7Z7A1
COA1	Q9GZY4	COA4	Q9NYJ1	COASY	Q13057
COG1	Q8WTW3	COG4	Q9H9E3	COG5	Q9UP83
COL12A1	Q99715	COL13A1	Q5TAT6, Q86Y22	COL14A1	Q05707
COL15A1	P39059	COL16A1	Q07092	COL17A1	Q9UMD9
COL18A1	P39060	COL1A1	P02452	COL1A2	P08123
COL24A1	Q17RW2	COL27A1	Q8IZC6	COL3A1	P02461
COL4A1	P02462, Q03692	COL4A2	P08572	COL4A5	P29400
COL4A6	Q14031	COL5A1	P20908	COL5A2	P05997
COL5A3	P12107, P25940	COL6A1	P12109	COL6A2	P12110
COL7A1	Q02388	COL8A1	P27658	COL8A2	P25067
COLEC10	Q9Y6Z7	COLEC12	Q5KU26	COLGALT2	Q8IYK4
COMMD1	Q8N668	COMMD10	Q9Y6G5	COMMD2	Q86X83
COMMD3	Q9UBI1	COMMD5	Q9GZQ3	COMMD7	Q86VX2
COMP	P49747	COMT	P21964	COP1	Q8NHY2
COPA	P53621	COPB1	P53618	COPG1	Q9Y678
COPRS	Q9NQ92	COPS2	P61201	COPS3	Q9UNS2
COPS4	Q9BT78	COPS6	Q7L5N1	COPS8	Q99627
COPZ1	P61923	COPZ2	Q9P299	COQ10A	Q96MF6
COQ10B	Q9H8M1	COQ3	Q9NZJ6	COQ5	Q5HYK3
COQ9	Q75208	CORIN	Q9Y5Q5	CORO1A	P31146
COTL1	Q14019	COX1	P00395	COX14	Q96I36
COX15	Q7KZN9	COX3	P00414	COX4I1	P13073
COX6B1	P14854	COX6C	P09669	COX7A2L	O14548
CPD	O75976	CPE	P16870	CPM	P14384
CPNE3	Q75131	CPOX	P36551	CPPED1	Q9BRF8
CPSF1	Q10570	CPSF2	Q9P2I0	CPSF4	O95639
CPT1A	P50416	CPT2	P23786	CRABP2	P29373
CRADD	P78560	CRAT	P43155	CRBN	Q96SW2
CRCP	Q75575	CREB3L2	Q70SY1	CREBBP	Q92793
CREBRF	Q8IUR6	CREG1	O75629	CREM	Q03060-6
CRH	P06850	CRISPLD2	Q9H0B8	CRK	P46108
CRKL	P46109	CRLF1	O75462	CRNKL1	Q9BZJ0
CROT	Q9UKG9	CRTAP	O75718	CRTC1	Q6UVV9
CRTC2	Q53ET0	CRTC3	Q6UU7	CRY1	Q16526
CRY2	P62263	CRYAB	P02511	CS	O75390
CSE1L	Q02338	CSF1	P09603	CSF3	P09919
CSGALNACT1	Q8TDX6	CSGALNACT2	Q8N6G5	CSK	P41240
CSNK1A1	P48729	CSNK1D	P48730	CSNK1E	P49674
CSNK1G2	P78368	CSNK2A2	P19784	CSNK2B	P67870
CSPG4	Q6UVK1	CSRP1	P21291	CST3	P01034

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
CSTF1	Q05048	CSTF2	P33240	CTBP1	Q13363
CTBP2	P56545	CTC1	Q2NKJ3	CTCF	P49711
CTDP1	Q9Y5B0	CTDSP2	O14595	CTF1	Q16619
CTHRC1	Q6UX04	CTNNA1	P35221	CTNNB1	P35222
CTNNBIP1	Q9NSA3	CTNNBL1	Q8WYA6	CTNS	O60931
CTPS1	P17812, Q9NRF8	CTPS2	Q9NRF8	CTSA	P10619
CTSB	P07858	CTSC	P53634	CTSD	P07339
CTSF	Q9UBX1	CTSK	P43235	CTSL	O60911, P07711
CTSO	P43235	CTSS	P25774	CTSV	O60911, P07711
CTTN	Q14247	CTU2	Q2VPK5	CUL1	Q13616
CUL2	Q13617	CUL7	Q14999	CUL9	Q8IWT3
CUX1	Q13948	CX3CL1	P16619	CXADR	P78310
CXCL1	P09341	CXCL12	P48061	CXCL2	P09341, P19875
CXCL3	P09341	CXCL5	P42830, P80162	CXCL6	P80162
CXCL8	P10145	CXXC1	Q9P0U4	CXXC5	Q7LFL8
CYB561D1	P51948	CYB5A	P00167-1	CYB5B	P00167
CYB5R1	Q9UHQ9	CYB5R4	Q7L1T6	CYB5RL	Q6IPT4
CYBA	P13498	CYBRD1	Q53TN4	CYC1	P08574
CYCS	P99999	CYFIP1	Q7L576	CYFIP2	Q96F07
CYGB	Q8WWM9	CYP1A1	P04798	CYP1B1	Q16678
CYP26B1	Q9NR63	CYP27A1	Q02318	CYP2S1	Q96SQ9
CYP2U1	Q7Z449	CYP4V2	Q6ZWL3	CYSTM1	Q9H1C7
CYTB	P00156	CYTH1	Q15438, Q99418	CYTH2	P05106
D2HGDH	Q8N465	DAAM1	Q9Y4D1	DAB1	O75553
DAB2	P98082	DAB2IP	Q5VWQ8	DACT1	Q9NYF0
DACT3	Q9UK08	DAD1	P61803	DAG1	Q14118
DAGLA	Q9Y4D2	DAGLB	Q8NCG7	DAP	P46527
DAP3	P51398	DAPK3	O43293	DARS1	P14868
DARS2	Q6PI48	DAXX	Q9UER7	DBF4	Q9UBU7
DBI	P07108	DBNL	Q9UJU6	DBT	P49674
DCAF11	Q8TEB1	DCAF13	Q9NV06	DCAF16	Q9NXF7
DCAF17	Q5H9S7	DCAF4	Q8WV16	DCAF5	Q96JK2
DCAF6	Q58WW2	DCAF7	P61962	DCAF8	Q5TAQ9
DCC	P43146	DCLRE1A	Q6JPJ8	DCLRE1B	Q9H816
DCN	P07585	DCP1A	Q9NPI6	DCP2	Q8IU60
DCPS	Q96C86	DCTN1	Q14203-2	DCTN2	Q13561
DCTN3	O75935	DCTN4	Q9UJW0	DCTN5	Q9BTE1
DCTN6	O00399	DCTPP1	Q9H773	DCUN1D1	Q96GG9
DCUN1D3	Q8IWE4	DCUN1D5	Q9BTE7	DDA1	Q9BW61
DDAH1	O94760	DDAH2	O95865	DDB1	Q16531
ddb2	Q92466	DDHD1	Q8NEL9	DDHD2	O94830
DDOST	P39656	DDR1	Q08345	DDR2	Q16832
DDRGK1	Q96HY6	DDX1	Q92499	DDX11	Q96FC9
DDX17	Q92841	DDX21	Q9NR30	DDX23	Q9BUQ8
DDX39A	O00148	DDX39B	Q13838	DDX46	Q7L014
DDX5	P17844	DDX52	Q9Y2R4	DDX58	O95786
DDX6	P26196	DECR1	Q16698	DECR2	Q9NU11
DEF6	Q9H4E7	DEGS1	O15121	DEK	P35659
DENND1B	Q6P3S1	DENND2B	P78524	DENND2C	Q68D51

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
DENND2D	Q9H6A0	DENND3	A2RUS2	DENND4C	Q5VZ89
DENND5A	Q6IQ26	DENND5B	Q6ZUT9	DENND6A	Q8IWF6
DENND6B	Q8NEG7	DEPDC1B	Q8WUY9	DERA	Q9Y315
DERL2	Q9GZP9	DES	P17661	DFFA	O00273
DGAT1	O75907	DGKA	P23743, P52429	DGKD	Q16760
DGKE	P52429	DGKG	P49619	DGKH	Q86XP1
DGKI	O75912	DGKQ	P52824	DHCR24	Q15392
DHCR7	Q9UBM7	DHDDS	Q86SQ9	DHFR	P00374
DHFR2	Q86XF0	DHODH	Q02127	DHPS	P49366
DHRS3	O75911	DHRS7B	Q6IAN0	DHX15	O43143
DHX36	Q9H2U1	DHX9	Q08211	DIAPH1	O60610
DIAPH2	O60879-2, O60879-3	DIAPH3	Q9NSV4	DICER1	Q9UPY3
DIDO1	Q9BTC0-1	DIMT1	Q9UNQ2	DIO2	Q92813
DIS3	Q9Y2L1	DKC1	O60832	DKK1	O94907
DKK2	Q9UBU2	DLAT	P10515	DLC1	P63167
DLD	P09622	DLG1	Q12959, Q92796	DLG4	P78352
DLG5	Q8TDM6	DLGAP5	Q15398	DLK1	P80370
DLL1	O00548	DLL4	Q9NR61	DLST	P36957
DMD	P11532	DNAJA1	P31689	DNAJA2	O60884
DNAJB11	Q9UBS4	DNAJB6	O75190	DNAJB9	Q9UBS3
DNAJC11	Q9NVH1	DNAJC13	O75165	DNAJC19	Q96DA6
DNAJC3	Q13217	DNAJC5	Q9H3Z4	DNAJC7	Q99615
DNAJC8	O75937	DNAL4	O96015	DNASE2	O00115
DNER	Q8NFT8	DNM1	Q05193	DNM2	P50570
DNM3	Q9UQ16	DNMBP	Q6XZF7	DNMT1	P26358
DNMT3B	Q9UBC3	DOCK1	Q14185	DOCK10	Q96BY6
DOCK4	Q8N1I0	DOCK5	Q9H7D0	DOCK6	Q96HP0
DOCK7	Q96N67	DOK1	Q99704	DOK5	Q9P104
DOK6	Q6PKX4	DOLPP1	Q86YN1	DOT1L	Q8TEK3
DPAGT1	Q9H3H5	DPH2	Q9BQC3	DPH3	Q96FX2
DPM2	O94777	DPP4	P27487	DPP7	Q9UHL4
DPYD	Q12882	DPYSL2	Q16555	DPYSL3	Q14195
DPYSL4	O14531	DR1	Q01658	DRAP1	Q14919
DRD1	P21728	DRG1	Q92597	DROSHA	Q9NRR4
DSCAM	O60469	DSCC1	Q9BVC3	DSE	Q9UL01
DSEL	Q8IZU8	DSG2	Q14126	DSN1	Q9H410
DSP	P15924	DTL	Q9NZJ0	DTX2	Q86UW9
DTX3	Q8TDB6	DTX3L	Q8TDB6	DTX4	Q9Y2E6
DTYMK	P23919	DUSP1	P28562	DUSP10	Q9Y6W6
DUSP16	Q9BY84	DUSP3	P51452	DUSP4	Q13115
DUSP5	Q16690	DUSP6	Q16828	DUSP7	Q16829
DUSP8	Q13202	DUT	P33316-2	DVL1	O14640
DVL2	O14641, Q92997	DVL3	Q92997	DYNC1H1	Q14204
DYNC1I1	O14576	DYNC1I2	Q13409	DYNC1LI1	Q9Y6G9
DYNC2H1	Q8NCM8	DYNC2I2	Q96EX3	DYNLL1	P63167
DYNLL2	P63167, Q96FJ2	DYNLRB1	Q9NP97	DYNLT1	P63172
DYRK1A	Q13627	DYSF	Q8IUM7	DZIP1	Q86YF9
DZIP3	Q86Y13	E2F1	O00716, Q01094	E2F2	Q14209, Q16254
E2F4	Q16254	E2F6	Q75461	E2F7	Q96AV8

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
E2F8	A0AVK6	EAF1	Q96CJ1, Q96JC9	EARS2	Q5JPH6
EBAG9	O00559	EBF1	Q9UH73	EBNA1BP2	Q99848
ECE1	P42892	ECE2	P0DPD6	ECH1	Q13011
ECI2	O75521-2	ECM1	Q16610	ECSIT	Q9BQ95
ECT2	Q9H8V3	EDA2R	Q9HAV5	EDC3	Q96F86
EDC4	Q6P2E9	EDEM1	Q92611	EDEM2	Q9BV94
EDNRA	P25101	EDNRB	P24530	EEA1	Q15075
EED	O75530	EEF1A1	P68104	EEF1B2	P24534
EEF1D	P29692	EEF2K	O00418	EEF2KMT	Q96G04
EEFSEC	P57772	EEPD1	Q7L9B9	EFEMP1	Q12805
EFHD2	Q96C19	EFNA4	P52798	EFNA5	P52803
EFNB1	P98172	EFNB3	Q15768	EGF	P01133
EGFR	P00533	EGLN2	Q96KS0	EGR1	P18146
EGR2	P11161	EGR3	Q06889	EHD1	Q9H4M9
EHD2	Q9NZN3, Q9NZN4	EHADH	Q08426	EHMT2	Q96KQ7
EI24	Q9HBX9	EIF1AX	P47813	EIF2A	P05198
EIF2AK1	Q9BQI3	EIF2AK2	P19525	EIF2AK3	Q9NZJ5
EIF2AK4	Q9P2K8	EIF2B1	Q14232	EIF2S1	P05198
EIF2S2	P20042	EIF2S3	P41091	EIF3A	Q14152
EIF3B	P55884	EIF3C	Q99613	EIF3D	O15371
EIF3E	P60228	EIF3F	O00303	EIF3H	O15372
EIF3I	Q13347	EIF3J	Q75822	EIF4A2	Q14240
EIF4B	P23588	EIF4E	P06730	EIF4E2	O60573
EIF4EBP1	Q13541	EIF4G1	Q04637	EIF4G2	O43432, P78344
EIF4G3	O43432	EIF5	P55010	EIF5A	P63241, Q9GZV4
EIF5A2	Q9GZV4	ELAC2	Q9BQ52	ELAVL1	Q15717
ELF1	O43921	ELL	P55199	ELL2	O00472
ELN	P15502	ELOA	Q14241	ELOVL1	Q96G25
ELOVL2	Q9NXB9, Q9NYP7	ELOVL3	Q9HB03	ELOVL4	Q9GZR5
ELOVL5	Q9NYP7	ELOVL6	Q9H5J4	ELP1	O95163
ELP2	Q6IA86	ELP4	Q96EB1	ELP6	Q0PNE2
EMB	O14980	EMC3	Q9P0I2	EME1	A4GXAA9, Q96AY2
EME2	A4GXAA9	EMG1	Q92979	EMILIN1	Q9Y6C2
EMILIN2	Q01968	EML4	Q9HC35	ENAH	Q8N8S7
ENDOD1	O94919	ENO1	P06733	ENO2	P09104
ENOPH1	Q9UHY7	ENPP1	P22413	ENPP2	Q13822
ENTPD1	P49961	ENTPD4	Q9Y227	ENTPD6	O75354
ENTPD7	Q9NQZ7	ENY2	Q9NPA8	EP300	Q09472
EP400	Q96L91	EPAS1	Q99814	EPB41	P11171
EPB41L1	Q9H4G0	EPB41L2	O43491	EPB41L3	Q9Y2J2
EPB41L5	Q9HCM4	EPHA2	P29317	EPHA3	P29320
EPHA4	P54764	EPHA5	P54756	EPHA7	Q15375
EPHB1	P54762	EPHB3	P54753	EPHB4	P54760
EPHX1	P07099	EPN1	Q9Y6I3	EPRS1	P07814
EPS15	P42566	EPS15L1	Q9UBC2	EPS8	Q12929
EPS8L2	Q9H6S3	EPSTI1	Q96J88	ERAL1	O75616
ERBB2	P04626	ERC1	Q96FL8	ERCC1	P07992
ERCC2	P18074	ERCC3	P19447	ERCC6L	Q2NKX8
ERCC8	Q13216	EREG	O14944	ERI1	Q8IV48

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
ERLEC1	Q96DZ1	ERLIN1	Q75477	ERLIN2	O94905
ERN1	O75460	ERO1A	Q96HE7	ERO1B	Q86YB8
ERP44	Q9BS26	ESCO1	Q5FWF5	ESCO2	Q56NI9
ESD	P10768	ESPL1	Q14674	ESPNL	Q6ZVH7
ESRRA	P11474	ESRRG	P62508	ESYT1	Q9BSJ8
ESYT2	A0FGR8, A0FGR9	ETF1	P62495	ETFA	P13804
ETFB	P38117	ETFDH	Q16134	ETHE1	O95571
ETNK1	Q9HBU6	ETNK2	Q9NVF9	ETS1	P14921
ETS2	P15036	ETV4	P43268	ETV6	P41212
EVA1A	Q9H8M9	EVC	P57679	EXO1	Q9UQ84
EXOC2	Q96KP1	EXOC4	Q96A65	EXOC5	O00471
EXOC6	Q8TAG9	EXOC7	Q9UPT5	EXOC8	Q8IYI6
EXOSC10	Q01780	EXOSC2	Q13868	EXOSC4	Q9NPD3
EXOSC7	Q15024	EXOSC8	Q96B26	EXOSC9	Q06265
EXT1	Q16394	EXTL1	Q92935	EXTL2	Q9UBQ6
EXTL3	O43909	EYA2	O00167	EYA3	Q99504
EYA4	O95677	EZH2	Q15910	EZR	P15311
F10	P00742	F2R	P25116	F2RL1	P55085
F2RL2	O00254	F3	P13726	F8	P00451
FAAP100	Q0VG06	FAAP20	Q6NZ36	FAAP24	Q9BTP7
FABP4	P15090	FABP5	Q01469	FADD	Q13158
FADS1	O60427	FADS2	O95864	FAF2	Q96CS3
FAH	P16930	FAM114A2	Q9NRY5	FAM120B	Q96EK7
FAM131B	Q86XD5	FAM135A	Q9P2D6	FAM13A	O94988
FAM13B	Q9NYF5	FAM20C	Q8IXL6	FAM83G	P35408
FAM91A1	Q658Y4	FAM98B	Q52LJ0	FANCA	O15360
FANCB	Q8NB91	FANCD2	Q9BXW9	FANCE	Q9HB96
FANCG	O15287	FANCI	Q9NVI1	FANCM	Q8IYD8
FAP	P27487	FAR1	Q8WVX9	FARP2	O94887
FARSA	Q9Y285	FARSB	Q9NSD9	FAS	P49327
FASN	P49327	FBF1	Q8TES7	FBL	P22087
FBLIM1	Q8WUP2	FBLN1	P23142	FBLN5	Q12805, Q9UBX5
FBN1	P35555	FBN2	P35556	FBXL14	Q8N1E6
FBXL16	Q8N461	FBXL17	Q9UF56	FBXL19	Q6PCT2
FBXL20	Q96IG2	FBXL3	Q9UKT7	FBXL4	Q9UKA2
FBXL5	Q9UKA1	FBXL8	Q96CD0	FBXO10	Q9UK96
FBXO11	Q86XK2	FBXO15	Q8NCQ5	FBXO17	Q96EF6
FBXO2	Q9UK22	FBXO22	Q8NEZ5	FBXO27	Q8NI29, Q96EF6
FBXO30	Q8TB52	FBXO31	Q5XUX0	FBXO32	Q969P5
FBXO41	Q8TF61	FBXO5	Q9UKT4	FBXO7	Q9Y3I1
FBXW11	Q9UKB1	FBXW4	P57775	FBXW5	Q969U6
FBXW7	Q969H0-1, Q969H0-4	FBXW8	Q8N3Y1	FBXW9	Q5XUX1
FCGR1A	P12314	FCHO2	Q0JRZ9	FDFT1	P37268
FDPS	P14324	FDX1	P10109	FDXR	P22570
FEM1A	Q9BSK4	FEM1B	Q9UK73	FEM1C	Q96JP0
FEN1	P39748	FERMT2	Q96AC1	FES	P07332
FGD4	Q96M96	FGF1	P05230	FGF2	P09038
FGF5	P12034-1	FGF7	P21781	FGFR1	P11362-1
FGFRL1	Q8N441	FGL2	Q14314	FH	Q16595

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
FHL2	Q14192	FHOD3	Q8IVF7	FIG4	Q92562
FIP1L1	Q6UN15	FKBP14	Q9NWM8	FKBP1A	P62942
FKBP4	Q02790	FKBP5	Q13451	FKBP8	Q14318
FKBP9	O95302	FLAD1	Q8NFF5	FLCN	Q8NFG4
FLI1	Q01543	FLNA	P21333	FLNB	O75369
FLNC	Q14315	FLOT1	O75955	FLOT2	Q14254
FLRT2	O43155	FLRT3	Q9NZU0	FLT1	P17948
FMNL2	Q96PY5	FMNL3	Q8IVF7	FMOD	Q06828
FN1	P02751	FN3KRP	Q9HA64	FNIP1	Q8TF40
FNIP2	Q9P278	FNTA	P49354	FOS	P01100
FOSB	O75419	FOSL1	P15407	FOXL2	P58012
FOXM1	Q08050	FOXO1	Q12778	FOXO3	O43524
FOXO4	P98177	FPGT	O14772	FRAT1	Q92837
FRAT2	O75474	FRMPD3	Q5JV73	FRS2	Q8WU20
FSCN1	Q16658	FST	P19883	FSTL3	O95633
FTH1	P02794	FTL	P02792	FTO	Q9C0B1
FTSJ1	Q9UET6	FUCA1	P04066	FUCA2	Q9BTY2
FUND1	Q8IVP5	FURIN	P09958	FUS	P35637
FUT11	Q495W5	FXN	Q16595	FYN	P06241, P06241-1
FYTTD1	Q96QD9	FZD1	Q9UP38	FZD2	Q14332
FZD3	Q9NPG1	FZD7	O75084	FZD8	Q9H461
FZR1	Q9UM11	G0S2	P27469	G3BP1	Q13283
G3BP2	Q9UN86	G6PC3	Q9BUM1	G6PD	P11413
GAA	P27694	GAB1	Q13480	GAB2	Q9UQC2
GABARAPL1	Q9H0R8	GABARAPL2	P60520	GABBR2	O75899
GABPA	Q06546	GABRA2	P47869	GABRA4	P48169
GABRA5	P31644	GABRB1	P18505	GADD45A	P24522
GADD45B	P41440	GADD45GIP1	Q8TAE8	GAK	O14976
GAL	P22466	GALC	P54803	GALE	Q14376
GALK1	P51570	GALNT1	Q10472	GALNT11	Q8NCW6
GALNT12	Q8IXK2	GALNT15	Q7Z4T8, Q8N3T1	GALNT16	Q8N428
GALNT18	Q6P9A2	GALNT2	Q10471	GALNT3	Q14435
GALNT6	Q8NCL4	GALNT7	Q86SF2	GAMT	Q14353
GAP43	P17677	GAPDH	P04406	GARRE1	O15063
GARS1	P41250	GART	P22102	GAS1	P54826
GAS6	Q14393	GAS8	O95995	GATA2	P23769
GATA3	P23771	GATA6	Q92908	GATAD2A	Q86YP4
GATAD2B	Q8WXI9	GBA	P04062	GBA2	Q9HCG7
GBE1	Q04446	GBF1	Q92538	GBP1	P32455
GBP2	P32456	GCC2	Q8IWJ2	GCFC2	P16383
GCLC	P48506	GCLM	P48507	GCN1	Q92616
GCNT1	Q02742	GCSH	P23434	GDAP1	Q8TB36
GDE1	Q9NZC3	GDF5	P43026	GDI1	P31150, P50395
GDI2	P50395	GDNF	P39905	GDPD1	Q8N9F7
GDPD5	Q8WTR4	GEM	P55040	GEMIN4	P57678
GEMIN5	Q8TEQ6	GEMIN7	Q9H840	GET1	O00258
GET3	O43681	GFM2	Q969S9	GFOD1	Q9NXC2
GFPT1	Q06210	GFPT2	O94808	GFRA1	P56159
GFUS	Q13630	GGA2	Q9UJY4	GGA3	Q9NZ52

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
GGCX	P38435	GGH	Q92820	GGT5	P36269
GHR	P10912	GINS1	Q14691	GINS2	Q9Y248
GIN3S	Q9BRX5	GINS4	Q9BRT9	GIT1	Q9Y2X7
GIT2	Q14161	GJA1	P17302	GJA3	Q9Y6H8
GJC1	P36383, Q8N144	GK	P32189, Q14409	GLA	P06280
GLB1	P16278	GLCE	O94923	GLE1	Q53GS7
GLI1	P08151	GLI2	P10070	GLI4	Q6ZR52
GLO1	Q04760	GLRX	P35754	GLRX5	Q86SX6
GLS	O94925	GLTP	Q9NZD2	GMDS	O60547
GMFG	O60234	GMNN	O75496	GMPPA	Q96IJ6
GMPR	P36959	GMPS	P49915	GNA11	P29992
GNA12	Q03113	GNA13	Q14344	GNA11	P63096
GNA12	P04899	GNA13	P08754	GNAL	P38405
GNAQ	P50148	GNAS	P63092, Q5JWF2	GNAZ	P19086
GNG11	P61952	GNG12	Q9UBI6	GNG2	P59768
GNG5	P63218	GNL3L	Q8IY37	GNPDA1	P46926, Q8TDQ7
GNPDA2	Q8TDQ7	GNPNAT1	Q96EK6	GNS	P15586
GOLGA4	Q13439	GOLGA5	Q8TBA6	GOLGA7	Q7Z5G4
GOLIM4	O00461	GOPC	Q9HD26	GORASP1	Q9BQQ3
GORASP2	Q9H8Y8	GOSR1	O95249	GOT1	P17174
GPAM	Q9HCL2	GPAT3	Q53EU6	GPAT4	Q53EU6, Q86UL3
GPC1	P35052	GPC2	Q8N158	GPC4	O75487
GPC6	Q9Y625	GPCPD1	Q9NPB8	GPD1L	Q8N335
GPD2	P43304	GPER1	Q99527	GPHN	Q9NQX3
GPI	P06744	GPKOW	Q92917	GPR161	Q8N6U8
GPR173	Q9NS67	GPR176	Q14439	GPR20	Q99678
GPR37	P01023	GPR39	O43194	GPR68	Q15743
GPS1	Q13098	GPSM2	P81274	GPT2	P24298, Q8TD30-1
GPX3	O75715, P22352	GPX4	P36969	GPX8	Q8TED1
GRB10	Q13322	GRB2	P62993-1	GREB1	Q4ZG55
GRHPR	Q9UBQ7	GRIA1	P42261	GRIA4	P48058
GRIK4	Q16099	GRIN2A	Q12879	GRK2	P25098
GRK5	P34947	GRK6	P43250	GRM4	Q14833
GRN	P15976	GRPEL2	Q8TAA5	GRPR	P30550
GRSF1	Q12849	GSDME	O60443	GSK3A	P49840
GSK3B	P49841	GSN	P06396	GSPT1	P15170, Q8IYD1
GSPT2	Q8IYD1	GSR	P00390-2	GSS	P48637
GSTM2	P28161	GSTO1	P78417	GSTO2	P78417
GSTP1	P09211	GTF2A1	P52655	GTF2B	Q00403
GTF2E1	P29083	GTF2H1	P32780	GTF2H3	Q13889
GTF3A	Q92664	GTF3C2	Q8WUA4	GTF3C4	Q9UKN8
GTF3C5	Q9Y5Q8	GTF3C6	Q969F1	GTPBP2	Q9BX10
GTPBP3	Q969Y2	GTSE1	Q9NYZ3	GUCY1A2	P33402
GUCY1B1	Q02153	GYG1	P46976	GYS1	P13807
H2AC6	Q93077	H2AJ	Q9BTM1	H2AW	Q7L7L0
H2AX	P16104	H2AZ1	P0C0S5	H2AZ2	Q71UI9
H2BC11	P06899	H2BC21	P06899, Q16778	H2BC5	P58876
H2BC8	P62807, Q93079	H2BC9	P58876, Q93079	H3-3A	P84243
H3-3B	P84243	H4C8	P62805	HACD1	B0YJ81, Q6Y1H2

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
HACD2	Q6Y1H2, Q9P035	HACD3	Q9P035	HACD4	Q5VWC8
HACE1	Q8IYU2	HA CL1	Q9UJ83	HADH	P40939, Q16836
HADHB	P55084	HAP1	P27695	HARS1	P12081
HAS2	Q92819	HAT1	O14929	HAUS2	Q9NVX0
HAUSS	O94927	HAUS6	Q7Z4H7	HAUS8	Q9BT25
HBEGF	Q99075	HBP1	Q8IV16	HBS1L	Q9Y450
HCN2	Q9UL51	HCN3	Q9P1Z3, Q9Y3Q4	HDAC1	Q13547
HDAC2	Q92769	HDAC5	Q9UQL6	HDAC6	Q9UBN7
HDAC7	Q8WUI4, Q9UKV0	HDAC9	Q9UKV0	HDLBP	Q00341
HEATR1	Q9H583	HEBP1	Q9NRV9	HECTD2	Q5U5R9
HECTD3	Q5T447	HECW2	Q9P2P5	HELZ2	Q9BYK8
HEPH	P26599	HERC2	O95714	HERC3	Q15034
HERC4	Q15034, Q5GLZ8	HERC6	Q8IVU3	HERPUD1	Q15011
HES1	Q14469	HEXA	P06865, P07686	HEXB	P07686
HEY1	Q9Y5J3	HEYL	Q9NQ87	HFE	Q30201
HGF	P14210	HGSNAT	Q68CP4	HHAT	Q5VTY9
HHIP	Q96QV1	HIC1	Q14526	HIF1A	Q16665
HIF1AN	Q9NWT6	HIGD1A	Q9Y241	HINT1	Q9BX68
HINT2	Q9BX68	HIP1	O00291	HIP1R	O75146
HIPK1	Q86Z02	HIPK2	Q9H2X6	HIVEP3	Q5T1R4
HJURP	Q8NCD3	HK1	P19367	HK2	P52789, P52790
HLA-A	P01891, P01892, P04439, P05534, P10314, P10316, P13746, P16188, P16189, P16190, P18462, P30443, P30447, P30450, P30453, P30455, P30456, P30457, P30459, P30512, Q09160	HLA-B	P01889, P03989, P10319, P18463, P18464, P18465, P30460, P30461, P30462, P30464, P30466, P30475, P30479, P30480, P30481, P30483, P30484, P30485, P30486, P30487, P30488, P30490, P30491, P30492, P30493, P30495, P30498, P30685, Q04826, Q29718, Q29836, Q29940, Q31610, Q31612, Q95365	HLA-C	P04222, P10321, P30499, P30501, P30504, P30505, P30508, P30510, Q07000, Q29865, Q29960, Q29963, Q95604, Q9TNN7
HLA-DMA	P28067	HLA-DMB	P28068	HLA-E	P13747
HLCS	P50747	HLTF	Q14527	HM13	Q8TCT9
HMBS	P08397	HMCN1	P32004	HMG20B	Q9P0W2
HMGA1	P17096	HMGA2	P52926	HMGB1	P09429
HMGB2	P26583	HMGCL	P35914	HMGCR	P04035-1
HMGCS1	Q01581	HMGN2	P05114	HMMR	O75330
HMOX2	P30519	HNMT	P50135	HNRNPA0	Q13151
HNRNPA1	P09651	HNRNPA2B1	P22626	HNRNPA3	P51991
HNRNPC	P07910	HNRNPD	Q14103	HNRNPF	P52597
HNRNPH1	P31943, P55795	HNRNPH2	P55795	HNRNPK	P61978
HNRNPL	P14866	HNRNPM	P52272	HNRNPR	O43390
HNRNPUL1	Q9BUJ2	HOMER1	Q86YM7	HOMER2	Q9NSB8
HOMEZ	Q9UJS0	HOXA1	P49639	HOXA2	O43364
HOXA3	O43365	HOXA4	Q00056	HOXB2	P14652
HOXB3	P14651	HPRT1	P00492	HPS1	Q92902
HPS4	Q9NQG7	HRH1	P35367	HS3ST3A1	Q9Y663
HS6ST1	O60243	HSBP1	O75506	HSCB	Q8IWL3
HSD11B1	P28845	HSD17B1	P14061	HSD17B10	Q99714
HSD17B11	Q8NBQ5	HSD17B14	Q9BPX1	HSD17B2	P37059
HSD17B4	P51659	HSD17B7	P56937	HSF1	Q00613

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
HSP90AA1	P07900	HSP90AB1	P08238	HSP90B1	P14625
HSPA12A	O43301	HSPA14	Q0VDF9	HSPA1A	P0DMV8
HSPA1B	P0DMV9	HSPA2	P54652	HSPA4	P34932
HSPA4L	O95757	HSPA5	P11021	HSPA8	P11142
HSPA9	P38646	HSPB1	P04792	HSPB8	Q9UJY1
HSPD1	P10809	HSPE1	P61604	HSPG2	P98160
HSPH1	Q92598	HTR7	P34969-2	HTRA1	Q92743
HTT	P42858	HUS1	O60921	HYAL2	Q12891
HYKK	A2RU49	HYOU1	Q9Y4L1	IARS1	P41252
ICAM1	P05362	ICAM5	Q9UMF0	ICE1	Q9Y2F5
ICMT	O60725	ID1	P41134	ID2	Q02363
ID3	Q02535	ID4	P47928	IDE	P20700
IDH1	O75874	IDH2	P48735	IDH3A	P50213
IDI1	Q13907	IDS	P22304	IDUA	P35475
IER3	P46695	IFI16	Q16666	IFIT1	P09914
IFIT2	P09913	IFIT5	Q13325	IFITM1	P13164
IFITM3	P13164, Q01628	IFNGR2	P38484	IFT140	Q96RY7
IFT172	Q9UG01	IFT20	Q8IY31	IFT27	Q9BW83
IFT46	Q9NQC8	IGF1R	P08069	IGF2	P01344
IGF2BP1	Q9NZI8	IGF2BP2	Q9Y6M1	IGF2BP3	O00425
IGF2R	P11717	IGFBP2	P18065	IGFBP3	P17936
IGFBP4	P22692	IGFBP5	P24593	IGFBP7	Q16270
IKBKB	O14920	IKBKE	Q14164	IL11	P20809
IL12A	P29459	IL13RA1	P78552	IL13RA2	Q14627
IL15	P40933	IL15RA	Q13261	IL17RD	Q8NFM7
IL17RE	Q8NFR9	IL18	Q14116	IL18R1	Q13478
IL1A	P01583	IL1B	P01584	IL1R1	Q9HB29
IL1RAP	Q9NPH3-1	IL1RAPL1	Q9NZN1	IL1RL1	Q01638, Q01638-2
IL1RL2	Q9HB29	IL21R	Q9HBE5	IL24	Q13007
IL27RA	Q6UWB1	IL31RA	Q8NI17	IL32	P24001
IL33	O95760	IL34	Q6ZMJ4	IL3RA	P26951
IL4R	Q01113	IL6	P05231	IL6ST	P40189-1
IL7R	P16871	ILF2	Q12905	IMMT	Q16891
IMP3	Q9NV31	IMP4	Q96G21	IMPA1	P29218
IMPA2	O14732	IMPDH1	P20839	IMPDH2	P12268
INCENP	Q9NQS7	ING2	Q9H160	ING4	Q9UNL4
INHBA	P08476	INHBE	P58166	INO80	Q9ULG1
INO80C	Q6PI98	INO80D	Q53TQ3	INPP1	P49441
INPP4B	O15327	INPP5B	P32019	INPP5D	Q92835
INPP5E	Q9NRR6	INPP5J	Q15735	INPP5K	Q9BT40
INPPL1	O15357	INSIG1	O15503	INSR	P06213
INTS11	Q5TA45	INTS13	Q9NVM9	INTS14	Q96SY0
INTS3	Q68E01	INTS4	Q96HW7	INTS5	Q6P9B9
INTS7	Q9NVH2	INTS8	Q75QN2	INTU	Q9ULD6
IP6K1	Q92551	IP6K2	Q9UHH9	IPMK	Q8NFU5
IPO5	O00410	IPP	Q9BT40	IQCE	Q6IPM2
IQGAP1	P46940	IQGAP2	Q13576	IQGAP3	P46940, Q86VI3
IQSEC3	Q9UPP2	IRAG1	Q9Y6F6	IRAK1	P51617
IRAK2	O43187	IRAK4	Q9NWZ3	IREB2	P48200

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
IRF1	P10914	IRF3	Q14653	IRF7	Q92985
IRS2	Q9Y4H2	ISCA1	Q9BUE6	ISCU	Q9H1K1
ISG15	P05161	ISG20L2	Q9H9L3	ISYNA1	Q9NPH2
ITCH	Q96J02	ITFG2	Q969R8	ITGA1	P56199
ITGA10	O75578	ITGA11	Q9UKX5	ITGA2	P17301
ITGA4	P13612	ITGA5	P08648	ITGA6	P23229
ITGA7	Q13683	ITGA8	P53708	ITGAV	P06756
ITGB1	P05556	ITGB3BP	Q13352	ITGB5	P18084
ITGB8	P26012	ITGBL1	O95965	ITM2B	Q9Y287
ITPA	Q9BY32	ITPK1	Q13572	ITPKC	Q96DU7
ITPR3	Q14573	ITSN1	Q15811	ITSN2	Q9NZM3
IVD	P26440	JADE1	Q6IE81	JADE3	Q92613
JAG1	P78504	JAK1	P23458	JAK2	O60674
JAM2	P57087	JAM3	Q9BX67	JARID2	Q92833
JMJD1C	Q15652	JMY	Q8N9B5	JOSD1	Q15040
JOSD2	Q8TAC2	JUN	P05412	JUNB	P17275
JUND	P17535	JUP	P14923	KALRN	O60229
KANK1	Q14678	KANSL2	Q9H9L4	KANSL3	Q9P2N6
KARS1	Q15046	KAT2A	Q92830	KAT2B	Q92831
KAT6B	Q8WYB5	KAZN	Q674X7	KBTBD6	Q86V97, Q8WVZ9
KBTBD7	Q8WVZ9	KBTBD8	Q8NFY9	KCMF1	Q9P0J7
KCNA3	P22001	KCNAB1	Q14722	KCND1	Q9NSA2
KCND2	Q9NZV8	KCND3	Q9UK17	KCNE4	Q8WWG9
KCNF1	Q9H3M0	KCNH1	O95259	KCNH2	Q12809
KCNH5	Q8NCM2	KCNH6	Q9H252	KCNJ15	Q99712
KCNJ4	P48050	KCNJ5	P48544	KCNJ6	P48051
KCNJ8	Q15842	KCNK2	O95069	KCNN4	O15554
KCNQ5	Q9NR82	KCNS1	Q96KK3	KCNS2	Q9ULS6
KCTD13	Q8WZ19	KCTD15	Q96SI1	KCTD3	Q9Y597
KCTD6	Q8NC69	KDELR1	P24390	KDELR3	O43731
KDM1A	O60341	KDM1B	Q8NB78	KDM2B	Q8NHM5
KDM3A	Q9Y4C1	KDM5A	P29375	KDM5B	Q9UGL1
KDM5C	P41229, Q9BY66	KDM6A	O15550	KDM6B	O15054
KDM7A	Q6ZMT4	KDR	P35968	KDSR	Q06136
KEAP1	Q14145	KHDRBS1	Q07666	KHDRBS3	Q75525
KHSRP	Q92945	KIAA1549	Q9HCM3	KIDINS220	Q9ULH0
KIF11	P52732	KIF13B	Q9NQT8	KIF14	Q15058
KIF15	Q9NS87	KIF16B	Q96L93	KIF17	Q9P2E2
KIF18A	Q8NI77	KIF18B	Q86Y91	KIF1B	O60333
KIF1C	O43896	KIF20A	O95235	KIF20B	Q96Q89
KIF21B	O75037	KIF22	Q14807	KIF23	Q02241
KIF24	Q5T7B8	KIF27	Q86VH2	KIF2A	O00139
KIF2C	Q99661	KIF3A	Q9Y496	KIF3B	O15066
KIF3C	O14782	KIF4A	O95239	KIF5A	Q12840
KIF5B	P33176	KIF7	Q2M1P5	KIFAP3	Q92845
KIFC1	Q9BW19	KIFC2	Q96AC6	KIRREL1	Q96J84
KIRREL3	Q6UWL6, Q8IZU9	KISS1	Q15726	KIT	P10721
KITLG	P21583-1	KLC2	Q6P597, Q9H0B6	KLC4	Q9NSK0
KLF4	O43474	KLF5	Q13887	KLHDC3	Q9BQ90

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
KLHL12	Q53G59	KLHL13	Q9P2J3, Q9P2N7	KLHL21	Q92529
KLHL22	Q53GT1	KLHL42	Q9P2K6	KLHL5	Q96PQ7
KLHL9	Q9P2J3	KMT2A	Q03164	KMT2C	Q8NEZ4
KMT2D	O14686	KMT2E	Q8IZD2	KMT5A	Q9NQR1
KMT5B	Q4FZB7	KMT5C	Q86Y97	KNL1	Q8NG31
KNTC1	P50748	KPNA1	P52294	KPNA2	P52292
KPNA3	O00505	KPNA4	O00629	KPNA5	O15131
KPNA6	O60684	KPNB1	Q14974	KRAS	P01116-1, P01116-2
KRBOX5	Q7Z2F6	KRR1	Q13601	KRT15	P19012
KRT18	P05783	KRT19	P08727	KRT3	P12035
KRT34	O76011, Q14525, Q92764	KRT8	P13647	KRT80	Q6KB66
KRTAP1-1	Q07627	KRTAP1-5	Q9BYS1	KRTAP2-3	P0C7H8
KTN1	Q86UP2	KYAT1	Q16773	KYAT3	Q6YP21
KYNU	Q16719	L1CAM	P32004	LAG3	P18627
LAGE3	Q14657	LAMA1	P25391	LAMA2	P24043
LAMA4	Q16363	LAMA5	O15230	LAMB1	P07942
LAMB3	Q13751	LAMC1	P11047	LAMP1	P13473
LAMP2	P13473	LAMTOR1	Q6IAA8	LAMTOR2	Q9Y2Q5
LAMTOR3	Q9UHA4	LAMTOR5	O43504	LAP3	Q13867
LARGE1	O95461	LARS1	Q9P2J5	LATS2	Q9NRM7
LBR	Q14739	LCLAT1	Q6UWP7	LDB1	Q86U70
LDHA	P00338	LDHB	P07195	LDLR	P01130, P98164
LEF1	Q9UJU2	LEMD2	Q8NC56	LEMD3	Q9Y2U8
LEPROTL1	P43351	LGALS1	P09382	LGALS3BP	Q08380
LGALS9	O00182	LGMN	Q99538	LGR4	Q9BXB1, Q9HBX8
LHFPL2	Q6ZUX7	LIF	P15018	LIFR	P42702
LIG1	P18858	LIG3	P49916	LIG4	P49917
LIMD1	Q9UGP4	LIMD2	Q8TDZ2	LIMS1	P48059
LIMS2	Q7Z4I7	LIN52	Q52LA3	LIN7A	O14910
LIN7C	Q9NUP9	LIN9	Q5TKA1	LIPG	Q9Y5X9
LIPH	Q8WWY8	LMAN1	P49257	LMAN2	Q12907
LMAN2L	Q9H0V9	LMBRD1	Q9NUN5	LMBRD2	Q0JRZ9
LMCD1	Q9NZU5	LMF1	Q96S06	LMF2	Q9BU23
LMNA	P02545-1, P02545-2	LMNB1	P20700	LMO2	P25791
LMO7	Q8WWI1	LMOD1	P29536	LNPEP	Q9UIQ6
LNX1	Q8TBB1	LONRF1	Q17RB8	LOX	P28300
LOXL1	P58215, Q08397	LOXL2	P28300, Q9Y4K0	LOXL4	Q96JB6
LPAR2	Q9HBW0	LPAR3	Q9UBY5	LPAR6	P43657
LPCAT1	Q8NF37	LPCAT2	Q7L5N7	LPCAT3	Q6P1A2
LPCAT4	Q643R3	LPGAT1	Q92604	LPIN2	Q92539
LRFN1	Q9P244	LRIG1	Q96JA1	LRP1	Q13901
LRP10	O75096	LRP12	Q9Y561	LRP4	O75096
LRP6	O75581	LRP8	Q9NPF0	LRPPRC	P42704
LRR1	Q96L50	LRRC1	Q9BTT6	LRRC49	Q8IUZ0
LRRC8A	Q8IWT6	LRRC8C	Q8TDW0	LRRC8D	Q7L1W4
LRRFIP1	Q32MZ4	LSAMP	Q13449	LSM11	P83369
LSM3	P62310	LSM4	Q9Y4Z0	LSM5	Q9Y4Y9
LSM8	O95777	LSS	P48449	LTB4R	Q15722
LTBP1	Q14766	LTBP2	Q14767	LTBP3	Q14767, Q9NS15

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
LTBP4	Q8N2S1	LTBR	P36941	LTN1	O94822
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LYPD1	Q8N2G4	LYPD3	O95274	LYPLA1	O75608
LYPLA2	O95372	LYRM4	Q9HD34	M6PR	P20645
MACO1	Q8N5G2	MAD2L1	Q13257	MAD2L2	Q9UI95
MADD	Q8WXG6-3, Q8WXG6-5	MAF1	Q9H063	MAFB	Q9Y5Q3
MAFF	Q9ULX9	MAFG	O15525	MAFK	O60675
MAGI2	Q86UL8	MAGOAH	P61326, Q96A72	MAGOHB	Q96A72
MAGT1	Q9H0U3	MAML1	Q92585	MAML3	Q96JK9
MAMLD1	Q13495	MAN1A1	P33908	MAN1A2	O60476
MAN1C1	Q9NR34	MAN2A1	Q16706	MAN2A2	P49641
MAN2B1	O00754	MAN2B2	Q9Y2E5	MANBA	O00462
MANF	P55145	MAOA	P21397	MAP1LC3A	Q9H492
MAP1LC3B	Q9GZQ8	MAP2K1	Q02750	MAP2K2	P36507
MAP2K3	P46734	MAP2K4	P45985	MAP2K5	Q13163
MAP3K14	Q99558	MAP3K3	Q99759	MAP3K5	Q99683
MAP3K8	P41279	MAP4K4	O95819	MAPK1	P28482
MAPK10	P53779	MAPK12	P53778	MAPK13	O15264
MAPK3	P27361-3, P28482	MAPK6	Q16659	MAPK8	P45983
MAPKAPK2	P49137	MAPKAPK3	Q16644	MAPKAPK5	Q8IW41
MAPRE1	Q15691	MARCKS	P29966	MARS1	P56192
MARS2	Q96GW9	MARVELD1	Q14117	MASP1	P48740
MASTL	Q96GX5	MAT2A	P31153	MAT2B	Q9NZL9
MAU2	Q9Y6X3	MAVS	Q7Z434	MAX	P61244
MBD2	Q9UBB5	MBD4	O95243	MBD5	Q9P267
MBD6	Q96DN6	MBIP	Q9NS73	MLBLAC1	Q9GZV5
MBNL2	Q9C0H2	MBOAT1	Q6ZNC8	MBOAT2	Q6ZWT7
MBOAT7	Q96N66	MBTPS1	Q14703	MBTPS2	O43462
MCAM	P43121	MCFD2	Q8NI22	MCHR1	Q99705
MCL1	Q07820	MCM10	Q7L590	MCM2	P33993, P49736
MCM3	P25205	MCM4	P33991	MCM5	P33992
MCM6	Q14566	MCM7	P33993	MCM8	Q9UJA3
MCOLN1	Q9GZU1	MCUB	Q9NWR8	MDC1	Q14676
MDGA1	Q8NFP4	MDH1	P40925	MDH2	P40926
MDK	P21741	MDM2	Q00987	ME1	P48163
ME2	P15923	MEAF6	Q9HAF1	MECOM	Q03112
MECP2	P51608-1, P51608-2	MED1	Q15648	MED10	Q9BTT4
MED12	Q93074	MED13	Q9UHV7	MED14	O60244
MED15	Q96RN5	MED16	Q9Y2X0	MED17	Q9NVC6
MED18	Q9BUE0	MED19	A0JLT2	MED21	Q13503
MED22	Q15528	MED23	Q9ULK4	MED25	Q71SY5, Q9NWA0
MED27	Q6P2C8	MED28	Q9H204	MED29	Q9NX70
MED31	Q9Y3C7	MED8	Q96G25	MEF2A	Q02078
MEF2C	Q06413	MEF2D	Q14814	MEN1	O00255
MET	P08581	METAP1	P53582	METTL1	Q9UBP6
METTL7A	Q9H8H3	MEX3C	Q5U5Q3	MFAP2	P55001
MFAP3	P55082	MFAP4	P55083	MFGE8	Q08431
MFN1	Q8IWA4	MFN2	O95140	MFSD2A	Q8NA29
MFSD4B	O75380	MGA	Q8IW19	MGAT3	Q09327

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
MGAT4A	Q9UM21, Q9UQ53	MGAT4B	Q9UM21, Q9UQ53	MGAT5	Q09328
MGLL	Q99685	MGRN1	O60291	MGST1	P10620
MIA2	Q96PC5	MIA3	Q5JRA6	MIB1	Q86YT6
MIB2	Q96AX9	MICA	P04439	MICB	Q29980
MICOS13	Q5XKP0	MICU1	Q9BPX6	MICU3	Q86XE3, Q8IYU8
MID1	Q9NQW6	MID1IP1	Q9NPA3	MIGA1	Q8NAN2
MIGA2	Q7L4E1	MINK1	Q8N4C8	MINPP1	Q9UNW1
MIOS	Q9NXC5	MIS12	Q9H081	MIS18A	Q9NYP9
MIS18BP1	Q6P0N0	MITF	O75030	MKLN1	Q96EK6
MKRN1	Q9UHC7	MKS1	Q9NXB0	MLEC	Q14165
MLH1	P40692	MLST8	Q9BVC4	MLX	Q9UH92
MMACHC	Q9Y4U1	MMADHC	Q9H3L0	MMD	Q3B726
MME	P39900	MMP1	P08253	MMP10	P03956
MMP11	P24347	MMP13	P45452	MMP14	P50281
MMP15	P51511	MMP16	P51512	MMP17	Q9ULZ9
MMP2	P08253	MMP24	Q9Y5R2	MMP3	P08254
MMS19	Q96T76	MND1	Q9BWT6	MOB1A	Q9H8S9
MOB1B	Q7L9L4	MOCOS	Q96EN8	MOCS1	Q9NZB8-1, Q9NZB8-5
MON1B	Q7L1V2	MORC2	Q9Y6X9	MORF4L1	Q9UBU8
MORF4L2	Q15014	MOSPD2	Q8NHP6	MOV10	Q9HCE1
MPDU1	O75352	MPG	P29372	MPHOSPH6	Q99547
MPI	P34949	MPPP1	Q00013	MPP2	Q08050
MPP7	Q5T2T1	MPZ	P25189	MRAS	O14807
MRC2	Q9UBG0	MRE11	P49959	MRI1	Q9BV20
MRPL1	Q9BYD6	MRPL11	Q9Y3B7	MRPL13	Q9BYD1
MRPL14	Q6P1L8	MRPL16	Q9NX20	MRPL17	Q9NRX2
MRPL19	P49406	MRPL2	Q5T653, Q9BZE1	MRPL23	Q16540
MRPL24	Q96A35	MRPL28	Q13084, Q8TCC3	MRPL3	P09001
MRPL30	Q8TCC3	MRPL34	Q9BQ48	MRPL36	Q9P0J6
MRPL37	Q9BZE1	MRPL39	Q9NYK5	MRPL4	Q9BYD3
MRPL40	Q9NQ50	MRPL42	Q9Y6G3	MRPL43	Q8N983
MRPL45	Q9BRJ2	MRPL46	Q9H2W6	MRPL51	Q4U2R6
MRPL52	Q86TS9	MRPL9	Q9BYD2	MRPS14	O60783
MRPS16	Q9Y3D3	MRPS17	Q9Y2R5	MRPS18A	Q9NVS2
MRPS21	P82921	MRPS23	Q9Y3D9	MRPS25	P82663
MRPS27	Q92552	MRPS34	P82930	MRPS35	P82673, Q9Y2Q9
MRPS36	P82909	MRPS6	P82932	MRPS7	Q9Y2R9
MRPS9	P82933	MRS2	Q9HD23	MSH2	P43246
MSH3	P20585	MSH6	P52701	MSL2	Q9HCI7
MSMO1	Q15800	MSN	P26038	MSRB2	Q9Y3D2
MSRB3	Q8IXL7	MST1	Q13043	MSX2	P35548
MT1E	P04732	MT1F	P04733	MT1X	P80297
MT2A	P02795	MTA3	Q9BTC8	MTAP	Q13126
MTARC2	Q969Z3	MTF1	Q14872	MTF2	Q9Y483
MTFMT	Q96DP5	MTHFD1	P11586	MTHFD1L	Q6UB35
MTHFD2	P13995	MTHFR	P42898	MTMR1	Q13613
MTMR10	Q9NXD2	MTMR14	O00268	MTMR2	Q13614
MTMR3	Q13615	MTMR4	Q9NYA4	MTMR9	Q96QG7
MTO1	Q9Y2Z2	MTRF1L	Q9UGC7	MTRR	Q9UBK8

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
MVB12B	Q9H7P6	MVP	Q14764	MXD4	Q14582
MXRA8	Q9BRK3	MYBBP1A	Q9BQG0	MYBL1	P10243
MYBL2	P10244	MYC	P01106	MYD88	Q99836
MYH10	P35580	MYH11	P35749	MYH9	P35579
MYL12A	P19105	MYL12B	O14950	MYL6	P60660
MYL6B	P14649	MYL9	P24844	MYLK	Q15746
MYO10	Q9HD67	MYO18A	Q92614	MYO19	Q96H55
MYO1C	O00159-3	MYO5A	Q9Y4I1	MYO6	Q9UM54
MYO9B	Q13459	MYSM1	Q5VVJ2	MZT1	Q08AG7
MZT2A	Q6P582	MZT2B	Q6NZ67	NA	P03468
NAA30	Q147X3	NAAA	Q02083	NAB2	Q15742
NAGK	Q9UJ70	NAGLU	P54802	NALCN	Q8IZF0
NAMPT	P43490	NANS	Q9NR45	NAPA	Q9Y2A7
NAPB	Q9H115	NAPEPLD	Q6IQ20	NAPG	Q99747
NAPRT	Q6XQN6	NARF	Q8WVD3	NARS1	O43776
NAT10	Q9H0A0	NAT8L	Q8N9F0	NBAS	A2RRP1
NBEA	Q8NFP9	NBEAL2	Q6ZNJ1	NBR1	Q14596
NCAPD2	Q15021	NCAPD3	P42695	NCAPG	Q9BPX3
NCAPG2	Q86XI2	NCAPH	Q15003	NCAPH2	Q6IBW4
NCBP2	P52298	NCEH1	Q6PIU2	NCF2	P19878
NCK1	O43639, P16333	NCK2	O43639	NCKAP1	Q9Y2A7
NCKIPSD	Q9NZQ3	NCL	P19338	NCOA2	Q15596
NCOA3	Q9Y6Q9	NCOA6	Q14686	NCOR1	O75376
NCOR2	Q9Y618	NCR3LG1	Q68D85	NCSTN	Q92542
ND1	P03886	ND2	P03891	ND3	P03897
ND4	P03905	ND5	P03915	ND6	P03923
NDC1	Q9BTX1	NDC80	O14777	NDE1	Q9NXR1
NDEL1	Q9GZM8	NDN	Q99608	NDRG1	Q92597
NDST1	P52848	NDUFA10	O95299	NDUFA12	Q9UI09
NDUFA3	O95167	NDUFA4	O00483	NDUFA5	Q16718
NDUFA6	P56556	NDUFA8	P51970	NDUFAF1	Q9Y375
NDUFAF2	Q8N183	NDUFAF3	Q9BU61	NDUFAF4	Q9P032
NDUFB10	O96000	NDUFB4	O95168	NDUFC1	O43677
NDUFS5	O43920	NDUFS8	O00217	NECTIN1	Q15223
NECTIN2	Q92692	NECTIN3	Q9NQS3	NEDD1	Q8NHV4
NEDD4L	Q96PU5	NEFL	P07196	NEGR1	Q7Z3B1
NEIL2	Q969S2	NEIL3	Q8TAT5	NEK2	P51955
NEK6	Q9HC98	NEK7	Q8TDX7	NEK8	Q8TD19
NELFA	Q9H3P2	NELFB	Q8WX92	NELFCD	Q8IXH7
NELFE	P18615	NEO1	Q92859	NES	Q6P1A2
NET1	Q7Z628	NEU1	Q99519	NEU3	Q9UQ49
NEURL1B	A8MQ27	NF1	P21359	NF2	P35240
NFASC	O94856	NFATC1	O95644	NFATC2	Q12968, Q13469
NFATC3	Q12968	NFE2L2	Q16236	NFIA	Q12857
NFIB	O00712	NFIC	P08651	NFIL3	Q16649
NFIX	Q14938	NFKB1	P19838	NFKB2	Q00653
NFKBIB	Q15653	NFS1	Q9Y697-1	NFYB	P25208
NGF	P01138	NID1	P14543	NID2	Q14112
NINL	Q9Y2I6	NIP7	Q9Y221	NIPA1	Q7RTP0

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
NIPAL1	Q6NVV3	NIPAL3	Q6P499	NIPAL4	Q0D2K0
NIPBL	Q6KC79	NIPSNAP2	O75323	NISCH	Q9Y2I1
NKIRAS2	Q9NYR9	NLE1	Q6Q0C0	NLGN2	Q8NFZ4
NLN	Q9BYT8	NLRC3	Q7RTR2	NLRX1	Q86UT6
NME1	P15531	NME4	O00746	NMI	Q13287
NMNAT1	Q9HAN9	NMT1	P30419	NMT2	O60551
NNMT	P40261	NNT	Q13423	NOC2L	Q9Y3T9
NOC4L	Q9BVI4	NOCT	Q9UK39	NOD1	Q9Y239
NOG	Q13253	NOL11	Q9H8H0	NOL6	Q9H6R4
NOL9	Q5SY16	NOP10	Q9NPPE3	NOP2	P46087
NOP58	Q9Y2X3	NOSTRIN	Q8IVI9	NOTCH1	P46531
NOTCH2	Q04721	NOX4	Q9NPH5	NPAS2	Q99743
NPAS4	Q8IUM7	NPC1	O15118	NPC1L1	Q9UHC9-2
NPC2	P61916	NPDC1	Q9NQX5	NPEPPS	P55786
NPHP4	O75161	NPM1	P06748	NPPC	P23582
NPRL3	Q12980	NQO1	P15559	NQO2	P16083
NR1D1	P20393	NR1D2	Q14995	NR1H2	P55055
NR2C2	P49116	NR2F1	P10589	NR2F2	P24468
NR2F6	P10588	NR3C1	P04150	NR3C2	P08235
NR4A1	P22736	NR4A2	P43354	NR4A3	Q92570
NR5A2	O00482-2	NRBP1	Q9UHY1	NRG1	Q02297, Q02297-10
NRGN	Q92686	NRIP1	P48552	NRP1	O14786
NRXN3	Q9HDB5, Q9Y4C0	NSD1	Q96L73	NSD2	O96028
NSD3	Q9BZ95	NSDHL	Q15738	NSF	P46459
NSFL1C	Q9UNZ2	NSL1	Q96IY1	NSMAF	Q92636
NSMCE2	Q96MF7	NSMCE3	Q96MG7	NSUN2	Q08J23
NSUN4	Q96CB9	NT5C2	P49902	NT5C3A	Q9H0P0-4
NT5E	P21589	NTF3	P20783	NTM	Q9P121
NTN1	O95631	NTN3	O00634	NTN4	Q9HB63
NTNG1	Q9Y2I2	NTNG2	Q96CW9	NUAK1	O60285
NUB1	Q9Y5A7-1, Q9Y5A7-2	NUBP2	Q9Y5Y2	NUBPL	Q8TB37
NUCB1	Q02818	NUDC	Q9Y266	NUDT1	P36639-1, P36639-2, P36639-3, P36639-4
NUDT12	Q9BQG2	NUDT14	O95848	NUDT15	Q9NV35
NUDT19	A8MXV4	NUDT21	O43809	NUDT4	Q96G61, Q9NZJ9
NUDT9	Q9BW91-1	NUF2	Q9BZD4	NUMA1	Q14980
NUP107	P57740	NUP155	O75694	NUP188	Q5SRE5
NUP205	Q92621	NUP214	P35658, Q96HA1	NUP35	Q8NFH5
NUP37	Q8NFH4	NUP43	Q8NFH3	NUP50	Q9UKX7
NUP54	Q7Z3B4	NUP62	P37198	NUP85	Q9BW27
NUP88	Q99567	NUP93	Q8N1F7	NUS1	Q96E22
NXF1	Q9GZY0, Q9UBU9	OAS3	Q9Y6K5	OAZ1	P54368
OAZ2	O95190, Q9UMX2	OBSCN	Q5VST9	OBSL1	Q5VST9
ODC1	P11926	ODF2	Q5BJF6	OGDH	Q02218
OGG1	O15527, O15527-4	OGT	O15294	OIP5	O43482
OLA1	Q9NTK5	OLR1	P78380	OPA1	O60313
OPTN	Q96CV9	OR1J2	Q8NGS2	OR1J4	Q8NGS1
OR1Q1	Q15612	OR51E2	Q9H255	ORAI2	Q96SN7
ORC1	Q13415	ORC3	Q9UBD5	ORC4	O43929

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OS9	Q13438	OSBP	P22059	OSBPL6	Q9BZF3
OSBPL7	Q9BZF2	OSBPL8	Q9BZF1	OSBPL9	Q96SU4
OSMR	Q99650	OTUD5	Q96G74	OVGP1	Q12889
OXA1L	Q15070	OXCT1	P55809, Q9BYC2	OXTR	P30559
P2RX7	Q99572	P2RY1	P47900	P2RY11	Q96G91
P3H1	Q32P28	P3H2	Q8IVL5	P4HA1	P13674
P4HA3	Q7Z4N8	P4HB	P07237	PA2G4	Q9UQ80
PABPC1	P11940	PABPN1	Q86U42	PACS1	Q6VY07
PACSin2	Q9UNF0	PACSin3	Q9UKS6	PAFAH1B2	P68402
PAFAH1B3	Q15102	PAFAH2	Q99487	PAG1	Q9NWQ8
PAICS	P22234	PAIP1	Q9H074	PAIP2B	Q96HY6
PAK1	Q13153, Q16512	PAK2	Q13177	PAK3	Q75914
PALB2	Q86YC2	PALM	P08567	PALS1	Q8N3R9
PAN3	Q58A45	PANK1	Q8TE04	PANK2	Q9BZ23
PANK3	Q9H999	PANX1	Q96RD7	PAPOLA	P51003
PAPPA	Q13219	PAPPA2	Q9BXP8	PAPSS1	O43252
PAPSS2	O95340	PAQR3	Q6TCH7	PARD3	Q8TEW0
PARD6B	Q9BYG5	PARD6G	Q9BYG4	PARK7	Q99497
PARN	O95453	PARP1	P09874	PARP14	Q460N5
PARP16	Q8N5Y8	PARP2	Q9UGN5	PARP6	Q2NL67
PARP9	Q8IXQ6	PARS2	Q7L3T8	PARVA	Q9NVD7
PARVB	Q9HBI1	PATJ	Q8TBB1	PATL1	Q86TB9
PBRM1	Q86U86	PBX1	P40424	PC	O95503
PCBD1	P61457	PCBP1	Q15365	PCBP4	P57723
PCCA	P05165	PCCB	P05166	PCDH7	O60245
PCGF2	P35227	PCGF5	Q86SE9	PCGF6	Q9BYE7
PCK2	Q16822	PCLAF	Q15004	PCM1	Q15154
PCMT1	P22061	PCNA	P12004	PCNT	O95613
PCOLCE	Q15113	PCOLCE2	Q9UKZ9	PCSK5	Q92824
PCTP	Q9UKL6	PCYOX1L	Q8NBM8	PCYT1A	P49585
PCYT2	Q99447	PDAP1	Q13442	PDCD11	Q14690
PDCD1LG2	Q9BQ51	PDCL	Q13371	PDE10A	Q9Y233
PDE11A	Q9HCR9	PDE12	Q6L8Q7	PDE1A	P54750
PDE3A	Q14432	PDE3B	Q13370	PDE4A	P27815
PDE4B	Q07343	PDE4C	Q08493	PDE6D	O43924
PDE7A	Q13946	PDE8A	O60658	PDGFA	P04085
PDGFB	P01127	PDGFC	Q9NRA1-1	PDGFD	Q9GZP0
PDGFRA	P16234	PDGFRB	P09619	PDHA1	P08559, P29803
PDHB	P11177	PDHX	O00330	PDIA3	P30101
PDK1	O15530	PDK2	Q15119	PDK4	Q16654
PDLM5	Q96HC4	PDLM7	Q9NR12	PDP2	Q9P2J9
PDPK1	O15530	PDPN	Q86YL7	PDS5B	Q9NTI5
PDSS1	Q5T2R2	PDXK	O00764	PDZD11	Q5EBL8
PEA15	Q15121	PEAK1	Q9H792	PEBP1	P30086
PECR	Q9BY49	PELI1	Q96FA3	PELI2	Q9HAT8
PELP1	Q8IZL8	PENK	P01210	PER1	O15534
PER2	O15055	PERP	Q96FX8	PEX1	O43933
PEX11A	O75192	PEX11B	O96011	PEX12	O00623

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
PEX16	Q9Y5Y5	PEX2	P28328	PEX26	Q7Z412
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PFAS	O15067	PFDN1	O60925	PFDN5	Q99471
PFKFB2	O60825	PFKFB3	Q16875	PFKL	P17858
PFKM	P08237	PFKP	Q01813	PFN1	P07737
PGAM1	P18669	PGAP1	Q75T13	PGD	P52209
PGF	P49763	PGK1	P00558	PGM1	P36871
PGM2	Q96G03	PGM2L1	Q6PCE3	PGM3	O95394
PGP	A6NDG6	PGRMC1	O00264	PGRMC2	O15173
PGS1	Q32NB8	PHACTR2	P41226	PHAX	Q9H814
PHB1	P35232	PHC1	P78364	PHC2	Q8IXK0
PHF19	Q5T6S3	PHF2	O75151	PHF20	Q9BVI0
PHGDH	O43175	PHIP	Q8WWQ0	PHKA1	P46020
PHKA2	P46019, P46020	PHKB	Q93100	PHLDA1	Q8WV24
PHLPP1	O60346	PHLPP2	Q6ZVD8	PHYH	Q02447
PI4K2A	Q9BTU6	PI4K2B	Q8TCG2	PI4KA	P42356
PI4KB	Q9UBF8	PIAS1	Q9HBH0	PIAS3	Q9Y6X2
PIAS4	Q8N2W9	PICALM	Q13492	PIDD1	Q9HB75
PIEZ01	P07741	PIF1	Q9H611	PIGF	Q07326
PIGG	Q5H8A4	PIGK	Q92643	PIGM	Q9H3S5
PIGQ	Q9BRB3-2	PIGS	Q96S52	PIGT	Q969N2
PIGV	Q9NUD9	PIGX	Q8TBF5	PIK3C2A	O00443
PIK3C2B	O00750	PIK3C3	Q8NEB9	PIK3CA	P42336
PIK3CB	P42338	PIK3CD	O00329	PIK3R1	P27986
PIK3R3	Q92569	PIK3R4	Q99570	PIKFYVE	Q9Y2I7
PIM1	P18754	PIN1	Q13526	PINK1	Q9BXM7
PINLYP	Q6UX82	PIP4K2A	P48426	PIP4K2C	Q8TBX8
PIP4P1	Q86T03	PIP5K1C	O60331	PISD	Q9UG56
PITPNB	P48739	PITPNM1	O00562	PITPNM2	O00562, Q9BZ72
PITRM1	Q5JRX3	PITX2	Q99697	PJA1	Q8NG27
PJA2	O43164	PKD1	P98161	PKD2	Q13563
PKM	P14618-1, P14618-2	PKMYT1	Q99640	PKN1	Q16512
PKN2	Q16513	PKN3	Q6P5Z2	PKP2	Q99959
PKP3	Q9Y446	PKP4	Q99569	PLA2G15	Q8NCC3
PLA2G4A	P47712	PLAGL1	Q9UM63	PLAT	P00750
PLAU	P00749	PLCE1	Q9P212	PLCG1	P19174
PLD1	O14939, Q13393	PLD2	O14939	PLD3	Q8IV08, Q96BZ4
PLEC	Q15149	PLEKHA1	Q9HB21	PLEKHA2	Q9HB19
PLEKHA3	Q9HB20	PLEKHA5	Q9HAU0	PLEKHA6	Q9Y2H5
PLEKHA8	Q96JA3	PLEKHG1	Q9ULL1	PLEKHG2	Q9H7P9
PLEKHG4	Q58EX7	PLEKHG5	O94827	PLEKHO2	Q8TD55
PLIN3	O60664	PLK1	P53350	PLK2	Q9NYY3
PLK3	Q9H4B4	PLK4	O00444	PLN	P26678
PLOD2	O00469	PLOD3	O60568	PLPP1	O14494
PLPP2	O43688	PLPP3	O14495	PLPP5	Q8NEB5
PLPP6	Q8IY26	PLPPR3	Q6T4P5	PLPPR4	Q7Z2D5
PLPPR5	Q32ZL2	PLRG1	O43660	PLTP	P55058-1, P55058-2
PLXNA1	Q9UIW2	PLXNA3	P51805	PLXNB1	O43157
PLXNC1	O60486	PMEPA1	Q969W9	PML	P29590

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PNPLA2	Q96AD5	PNPLA4	P41247	PNPLA6	Q8IY17
PNPLA7	Q6ZV29	PNPLA8	Q9NP80	PNPO	Q9NVS9
PNRC2	Q9NPJ4	POC1B	O14775	POFUT1	Q9H488
POFUT2	Q9Y2G5	POLA1	P09884	POLA2	Q14181
POLB	P06746	POLD1	P28340	POLD2	P49005
POLD3	Q15054	POLD4	Q9HCU8	POLDIP3	Q9BY77
POLE	Q07864	POLE2	P56282	POLE3	Q9NRF9
POLG	P27958	POLH	Q9Y253	POLQ	Q75417
POLR1B	Q9H9Y6	POLR1D	P0DPB5	POLR1E	O15160
POLR1F	Q3B726	POLR1H	Q9P1U0	POLR2A	P24928
POLR2B	P30876	POLR2D	O15514	POLR2E	P19388
POLR2G	P62487	POLR2H	P52434	POLR2K	P53803
POLR2L	P62875	POLR3A	O14802	POLR3B	Q9NW08
POLR3C	Q9BUI4	POLR3D	P05423	POLR3F	Q9H1D9
POLR3G	O15318, Q9BT43	POLRMT	O00411	POM121	Q96HA1
POM121C	A8CG34, Q96HA1	POMGNT1	Q8WZA1	POMGNT2	Q8NAT1
POMK	Q9H5K3	POMT1	Q9Y6A1	POMT2	Q9UKY4
PON2	Q15165	POP1	Q99575	POP4	O95707
POR	P16435	POT1	Q9NUX5	POU2F1	P14859
POU2F2	P09086	PPA1	Q15181, Q9H2U2	PPA2	Q15181, Q9H2U2
PPARG	P37231	PPARGC1B	Q86YN6	PPAT	Q06203
PPCS	Q9HAB8	PPFIA4	O75335	PPFIBP1	Q86W92
PPIA	Q9UNP9	PIB	P23284	PPID	Q08752
PPIE	Q9UNP9	PPIH	O43447	PPIL1	Q9Y3C6
PPIL2	Q13356	PPIL3	Q9H2H8	PPIP5K1	P20783
PPM1A	P35813	PPM1B	O75688	PPM1D	O15297
PPM1F	P49593	PPM1L	Q5SGD2	PPP1CA	P62136
PPP1CB	P62140	PPP1CC	P36873	PPP1R12A	O14974
PPP1R12B	O60237-4	PPP1R13B	Q96KQ4	PPP1R13L	Q8WUF5
PPP1R15A	O75807	PPP1R3C	Q9UQK1	PPP2CA	P67775
PPP2CB	P62714	PPP2R1A	P30153, P30154	PPP2R1B	P30154
PPP2R2A	P63151	PPP2R5D	Q14738	PPP3CA	Q08209
PPP3CB	P16298	PPP3R1	P63098	PPP4C	P60510
PPP5C	P53041	PPP6C	O00743	PPP6R3	Q5H9R7
PPRC1	Q5VV67	PPT1	Q96H96	PPT2	Q9UMR5
PQBP1	O60828	PRAG1	Q86YV5	PRC1	O43663
PRDM1	O75626	PRDM5	Q08AG7	PRDX1	P32119, Q06830
PRDX2	P32119	PRDX3	P30048	PRDX5	P30044-2
PREB	Q9HCU5	PRELID1	Q9Y255	PRELID3A	Q96N28
PRG4	Q96GM1	PRICKLE1	Q96MT3	PRIM1	P49642
PRIM2	P49643	PRKAA1	Q13131	PRKAA2	P54646
PRKAB1	Q9Y478	PRKAB2	O43741	PRKACA	P17252, P17612
PRKACB	P22694	PRKAG2	Q9UGJ0	PRKAR1A	P10644
PRKAR1B	P31321	PRKAR2B	P31323	PRKCA	P17252
PRKCD	Q05655	PRKCE	Q02156	PRKCI	P41743
PRKCSh	P14314	PRKD2	Q9BZL6	PRKD3	O94806
PRKDC	P78527	PRKG1	Q13976-1	PRKG2	Q13237

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
PRKX	P51817	PRLR	P42702	PRMT1	Q99873
PRMT5	O14744	PRMT7	Q9NVM4	PRNP	P04156
PROCR	Q9UNN8	PROS1	P07225	PROSER1	Q9H816
PRPF19	Q9UMS4	PRPF31	Q8WWY3	PRPF6	O94906
PRPF8	Q6P2Q9	PRPS1	P60891	PRPS2	Q9NYK1
PRPSAP2	A0PJK1	PRR11	Q86W47	PRSS23	O95084
PRXL2B	Q8TBF2	PSAP	Q8IWL1	PSAT1	Q9Y617
PSEN1	P49768	PSENEN	Q9NZ42	PSG4	Q00888
PSG5	Q15238	PSIP1	O75475	PSMA4	P25789
PSMB10	P40306	PSMB6	P28072	PSMB7	P40306, Q99436
PSMB8	P28062	PSMC1	P62191	PSMC2	P35998
PSMC3	P17980	PSMC3IP	Q9P2W1	PSMD1	Q99460
PSMD10	O75832	PSMD11	O00231	PSMD13	Q9UNM6
PSMD14	O00487	PSMD2	Q13200	PSMD3	O43242
PSMD4	P55036	PSMD5	Q16401	PSMD6	Q15008
PSMD8	P48556	PSME1	Q06323	PSMF1	Q92530
PSPH	P78330	PTBP1	P26599	PTCH1	Q13635
PTCH2	Q9Y6C5	PTDSS1	P48651	PTDSS2	Q9BVG9
PTEN	P60484	PTGDR2	Q9Y5Y4	PTGDS	P41222
PTGER2	P35408, P43116	PTGER4	P35408	PTGES2	Q9H7Z7
PTGFR	P43088	PTGIS	Q16647	PTGR1	Q14914
PTGS1	P23219	PTGS2	P35354	PTHLH	P12272
PTK2	Q05397	PTK2B	Q14289	PTN	P21246
PTPA	P18433	PTPN1	P18031	PTPN11	Q06124
PTPN12	Q05209	PTPN13	Q12923	PTPN14	Q15678
PTPN18	Q99952	PTPN2	P17706-2	PTPN23	Q9H3S7
PTPN3	P26045	PTPN4	P29074	PTPN9	P43378
PTPRB	P23467	PTPRF	P10586	PTPRJ	Q12913
PTPRK	Q15262	PTPRS	Q13332	PTPRU	Q92729
PTS	Q03393	PTTG1	O95997	PTX3	P26022
PUDP	Q08623	PUM1	Q14671	PUM2	Q8TB72
PUS3	Q9BZE2	PVR	P15151	PWP1	Q9NP94
PXDN	Q92626	PXK	Q8NC69	PXMP2	Q9NR77
PXMP4	Q9Y6I8	PXN	P49023	PYCARD	Q9ULZ3
PYCR1	P32322, Q96C36	PYCR2	Q53H96, Q96C36	PYCR3	Q53H96
PYGB	P11216, P11217	PYGL	P06737	PYGO1	Q9Y3Y4
PYGO2	Q9BRQ0	QARS1	P47897	QDPR	P09417
QKI	Q96PU8	RAB11B	Q15907	RAB11FIP3	O75154
RAB12	Q6IQ22	RAB13	P51153	RAB18	Q9NP72
RAB1A	P62820	RAB21	Q9UL25	RAB22A	Q9UL26
RAB24	Q969Q5	RAB27B	O00194	RAB29	O14966
RAB2B	Q8WUD1	RAB30	Q15771	RAB31	Q13636
RAB34	Q9BZG1	RAB35	Q15286	RAB36	O95755
RAB38	P57729	RAB39B	Q96DA2	RAB3A	P20336
RAB3B	P20337	RAB3D	O95716	RAB3GAP1	Q15042
RAB3GAP2	Q9H2M9	RAB40C	Q96S21	RAB43	Q9ULR0
RAB4B	P61018	RAB5A	P20339	RAB5C	P51148
RAB6A	P20340	RAB6B	Q9NRW1	RAB7A	P51149
RAB7B	Q96AH8	RAB8A	P61006	RAB8B	Q92930

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
RAB9A	P51151	RABEP1	Q15276	RABEPK	Q7Z6M1
RABGGTA	Q92696	RAC1	P63000	RAC2	P15153
RAC3	P60763	RACGAP1	Q9H0H5	RACK1	P63244
RAD18	Q9NS91	RAD21	O60216	RAD23A	P54725
RAD23B	P54727	RAD50	Q92878	RAD51	Q06609
RAD51AP1	Q96B01	RAD51C	O43502	RAD51D	O75771
RAD54L	P46100	RAET1G	Q6H3X3	RAF1	P04049
RAG1	P15918	RALA	P11233	RALB	P11234
RALBP1	Q15311	RALGAPA1	Q6GYQ0	RALGAPB	Q86X10
RALGDS	Q12967	RAMP1	O60894	RAN	P62826
RANBP1	P43487	RANBP10	Q6VN20	RANBP2	P49792
RANBP9	Q96S59	RANGAP1	P46060	RAP1GAP	P47736
RAP1GDS1	P52306	RAP2C	Q9Y3L5	RAPGEF1	Q13905
RAPGEF3	O95398	RAPGEF4	Q8WZA2	RARA	P10276
RARS1	P54136	RARS2	Q5T160	RASA1	P20936
RASA2	Q15283	RASAL2	Q9UJF2	RASGRF2	O14827
RASGRP1	O95267	RASGRP3	Q8IV61	RASSF4	Q8WYP3
RB1	P06400	RB1CC1	Q8TDY2	RBBP4	Q09028
RBBP6	Q7Z6E9	RBBP7	Q16576	RBBP8	Q99708
RBCK1	Q9BYM8	RBFOX2	O43251	RBL1	P28749
RBL2	Q08999	RBM10	P52756	RBM14	Q96PK6
RBM23	Q9Y2U8	RBM39	Q9Y2U8	RBM42	Q9BTD8
RBM5	P52756	RBM8A	Q9Y5S9	RBMX	P38159
RBP1	Q16629	RBPJ	Q06330	RBX1	P62877
RCAN3	Q9UKA8	RCC2	Q9P258	RCN1	Q15293
RDH10	Q8IZV5	RDH11	Q8TC12	RDH13	Q8NBN7
RDH5	Q92781	RDX	P35241	RECK	O95980
RELA	Q04206	RELN	P78509	RENBP	P51606
REST	Q13127	RET	P07949	RETSAT	Q6NUM9
REV3L	O60673	RFC1	P35251	RFC2	P35250
RFC3	P40937, P40938	RFC4	P35249	RFC5	P40937, P40938
RFFL	Q8WZ73	RFK	Q969G6	RFT1	Q96AA3
RGL1	Q9NZL6	RGL2	Q9UL45	RGMB	Q6NW40
RGP1	Q92546	RGS10	O43665	RGS11	O94810
RGS12	O14924	RGS16	O15492	RGS17	Q9UGC6
RGS18	Q9NS28	RGS19	P49795	RGS2	P41220, Q9NS28
RGS4	P49798	RGS5	O15539	RHBDF1	Q96L42
RHBDF2	Q6PJF5	RHNO1	Q9BSD3	RHOA	P61586
RHOB	P62745	RHOBTB2	Q9BYZ6	RHOBTB3	O94955
RHOC	P08134	RHOG	P84095	RHOJ	Q9H4E5
RHOT1	Q8IXI2	RHPN2	Q8IUC4	RIC1	Q4ADV7
RICTOR	Q6R327	RIF1	Q5UIP0	RILP	Q96MT3
RIMKLB	Q9ULI2	RIMS1	Q86UR5	RIN1	Q13671
RIN2	Q8WYP3	RING1	Q06587	RINT1	Q6NUQ1
RIOK2	Q9BVS4	RIOK3	O14730	RIOX2	Q8IUF8
RIPK2	O43353	RIT1	Q92963	RMI1	Q9H9A7
RMI2	Q96E14	RND2	P52198	RND3	P61587
RNF103	O00237	RNF111	Q6ZNA4	RNF112	P55083
RNF114	Q9Y508	RNF123	Q5XPI4	RNF126	Q9BV68

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
RNF13	Q9Y252	RNF135	Q8IUD6	RNF138	Q8WVD3
RNF139	Q8WU17	RNF14	Q9UBS8	RNF144B	Q7Z419
RNF146	Q9NTX7	RNF152	Q8N8N0	RNF168	Q8IYW5
RNF182	Q8N6D2	RNF185	Q96GF1	RNF19B	Q6ZMZ0
RNF20	Q5VTR2	RNF216	Q9NWF9	RNF217	Q8TC41
RNF220	Q5VTB9	RNF31	Q96EP0	RNF38	Q9P000
RNF4	P78317	RNF40	O75150	RNF5	Q99942
RNF6	Q9Y252	RNGTT	O60942	RNMT	O43148
RNPS1	Q15287	ROBO1	Q9HCK4, Q9Y6N7	ROBO2	Q9HCK4
ROBO3	Q96MS0-1	ROCK1	Q13464	ROCK2	O75116
ROR1	Q01973	RORA	P35398	RPA1	P27694
RPA2	P15927, Q13156	RPA3	P35244	RPE	Q96AT9
RPGRIP1L	Q68CZ1	RPIA	P49247	RPL10	P27635, Q96L21
RPL10A	P61313, P62906	RPL11	P62913	RPL12	P30050
RPL13	P26373, P40429	RPL13A	P40429, P61313	RPL14	P50914
RPL18A	Q02543, Q07020	RPL19	P84098	RPL21	P46778
RPL22L1	Q6P5R6	RPL23A	P62750, P62829, P84098	RPL24	P83731
RPL26	P61254, Q9UNX3	RPL27	P61353	RPL27A	P46776, P61353
RPL28	P46776, P46779	RPL29	P47914	RPL30	P62888
RPL31	P62899	RPL32	P62888, P62910	RPL35	P42766
RPL36	Q9Y3U8	RPL36AL	Q969Q0	RPL37	P61927
RPL37A	P18077, P61513, P61927	RPL38	P63173	RPL39	P62891, Q96EH5
RPL39L	Q96EH5	RPL4	P36578	RPL41	P62945
RPL5	P46777	RPL6	Q02878	RPL7	P18124
RPL7A	P18124, P62424	RPL8	P62424, P62917	RPL9	P32969
RPLP0	P05388	RPLP1	P05386	RPLP2	P05387
RPN1	Q13200	RPP38	P78345	RPRD1A	Q96P16
RPS12	P25398	RPS13	P62277	RPS14	P62263
RPS15	P62841	RPS16	P62249	RPS17	P08708
RPS18	P62269	RPS19BP1	Q86WX3	RPS2	P15880, P46782
RPS20	P60866	RPS21	P62841, P63220	RPS24	P62244, P62847
RPS25	P62851	RPS26	P62854	RPS27A	P62979, P62987
RPS27L	Q71UM5	RPS29	P62273	RPS3	P23396
RPS3A	P61247	RPS5	P46782	RPS6	P62753
RPS6KA1	Q15418	RPS6KA2	Q15349	RPS6KA3	P51812
RPS6KA4	O75676	RPS6KA6	Q9UK32	RPS6KB1	P23443
RPS6KB2	Q9UBS0	RPS7	P62081	RPS8	P62241
RPS9	P46781	RPSA	P08865	RPTOR	Q8N122
RRAGB	Q5VZM2	RRAGC	Q9HB90	RRAGD	Q9NQL2
RRAS	P62070	RRAS2	P62070	RRBP1	Q9P2E9
RRM1	P23921	RRM2	P31350	RRM2B	Q7LG56
RRP7A	Q9Y3A4	RRP8	O43159	RRP9	O43818
RSF1	Q96T23	RSPO3	Q9BXY4	RSU1	Q15404
RTCB	Q9Y3I0	RTF1	Q92541	RTF2	P19823
RTN3	O95197	RTN4	Q9NQC3	RUFY1	Q96T51
RUNX1	Q01196	RUNX2	Q13950-1, Q13950-2	RUNX3	Q13761
RUVBL1	Q9Y265	RUVBL2	Q9Y230	RWDD2B	Q9Y3V2
RXRA	P19793	RXRB	P28702	RYBP	Q8N488
S100A10	P60903	S100A11	P31949	S1PR1	P21453

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
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SALL1	Q9NSC2	SAMD8	Q96LT4	SAMHD1	Q9Y3Z3
SAP30L	Q9HAJ7	SARDH	Q9UL12	SARM1	Q6SZW1-1
SARS1	P49591	SART1	O43290	SAT1	Q92546
SAT2	Q96QD8	SATB1	Q01826	SATB2	Q9UPW6
SAV1	Q9H4B6	SBF1	O95248	SC5D	O75845
SCAI	Q8N9R8	SCAMP1	O15126	SCAP	Q12770
SCARB1	Q8WTVO-2	SCARB2	Q14108	SCCPDH	Q8NBX0
SCD	O00767	SCD5	Q86SK9	SCG2	O00255
SCLT1	Q96NL6	SCMH1	Q96GD3-2	SCN2A	Q15858, Q99250
SCN4B	Q8IWT1	SCN7A	Q01118	SCN8A	Q9UQD0
SCN9A	Q15858	SCNN1D	P51172	SCO1	O75880
SCP2	Q9BX26	SCRIB	Q14160	SCUBE3	Q8IX30
SDC1	P18827	SDC2	P34741	SDC3	O75056
SDC4	P31431	SDCBP	O00560	SDCCAG8	Q86SQ7
SDHA	P31040	SDHB	P21912	SDHC	Q99643
SDK1	Q7Z5N4	SEC11A	P67812	SEC13	P55735
SEC22A	Q96IW7	SEC22C	Q9BRL7	SEC24B	O95487
SEC24C	P53992	SEC24D	O94855	SEC31A	O94979
SEC61A1	P61619	SECISBP2	Q96T21	SEH1L	Q96EE3-1, Q96EE3-2
SEL1L	Q9UBV2	SELENOI	Q9C0D9	SELENOS	Q9BQE4
SELPLG	Q14242	SEM1	P60896	SEMA3A	Q14563
SEMA4D	Q92854	SEMA4F	O95754	SEMA5A	Q13591
SEMA6A	Q9H2E6	SEMA6D	Q8NFY4	SEMA7A	O75326
SENP1	Q9P0U3	SENP2	Q9HC62	SENP5	Q96HI0
SEPHS2	Q99611	SEPTIN2	Q15019	SERINC1	Q9NRX5
SERINC2	Q96SA4	SERINC3	Q13530	SERINC5	Q86VE9
SERPINB1	P30740	SERPINB8	P50452	SERPINE1	P05121
SERPINE2	P07093	SERPING1	P05155	SERPINH1	P50454
SESN1	Q9Y6P5	SESN3	P58005	SETD1A	O15047, Q9UPS6
SETD1B	Q9UPS6	SETD2	Q9BYW2	SETD3	Q86TU7
SETD7	Q8WTS6	SF1	Q13285	SF3A1	Q15459
SF3A3	Q12874	SF3B2	Q13435	SF3B3	Q15393
SF3B6	Q9Y3B4	SFI1	A8K8P3	SFPQ	P23246
SFRP1	Q8N474	SGIP1	Q9BQI5	SGK1	O00141
SGMS1	Q86VZ5	SGMS2	Q8NHU3	SGO1	Q5FBB7
SGO2	Q562F6	SGPP1	Q9BX95	SGSH	P51688
SH2B2	O14492	SH2B3	Q9UQQ2	SH3BP1	Q9Y3L3
SH3D19	Q5HYK7	SH3KBP1	Q96B97	SH3PXD2A	Q5TCZ1
SH3RF1	Q7Z6J0	SHANK1	Q9Y566	SHANK2	Q9UPX8
SHB	Q15464	SHC1	P29353-2, P29353-3	SHC2	P98077
SHC3	Q92529	SHF	Q15464	SHH	Q15465
SHKBP1	Q8TBC3	SHMT1	P34896	SHMT2	P34897
SHOC2	Q9UQ13	SHPRH	Q149N8	SHQ1	Q6PI26
SHTN1	A0MZ66	SIGMAR1	Q99720	SIK1	O00567
SIKE1	Q9BRV8	SIPA1L1	O43166	SIRPA	P78324, Q9P1W8
SIRT1	Q96EB6	SIRT2	Q8IXJ6	SIRT5	Q9NXA8
SKA1	Q96BD8	SKA2	Q8WVK7	SKAP2	O75563
SKI	P12755	SKIL	P12757	SKP1	P63208

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
SKP2	Q13309	SLA	Q13239	SLBP	Q14493
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SLC12A6	Q9UHW9	SLC12A7	Q9Y666	SLC14A1	Q13336
SLC15A4	Q8N697	SLC16A1	P53985	SLC16A2	P36021
SLC16A3	O15427	SLC17A5	Q9NRA2	SLC19A1	P41440
SLC19A2	O60779	SLC1A1	P43005	SLC1A2	P43004
SLC1A4	P43007	SLC1A5	Q15758	SLC20A2	Q08357
SLC22A17	Q8WUG5	SLC22A18	Q96BI1	SLC22A23	Q86Y46
SLC22A4	O76082	SLC22A5	O76082	SLC23A2	Q9UGH3
SLC24A1	O60721	SLC25A10	Q9UBX3	SLC25A12	Q75746
SLC25A13	Q9UJS0	SLC25A14	O95258	SLC25A15	Q9Y619
SLC25A16	P16260	SLC25A21	Q9BQT8	SLC25A22	Q9H936
SLC25A26	Q70HW3	SLC25A28	Q96A46	SLC25A29	Q8N8R3
SLC25A32	Q9H2D1	SLC25A37	Q9NYZ2	SLC25A4	P12235
SLC25A5	P12236	SLC25A6	P12236	SLC26A11	Q86WA9
SLC26A2	P50443	SLC26A6	Q9BXS9	SLC27A1	Q6PCB7
SLC27A3	O14975	SLC27A6	Q9Y2P4	SLC28A3	Q9HAS3
SLC29A1	Q99808	SLC29A3	Q9BZD2	SLC29A4	Q7RTT9
SLC2A1	P11166	SLC2A10	O95528	SLC2A12	Q8TD20
SLC2A13	Q96QE2	SLC2A14	Q8TDB8	SLC2A3	P11169
SLC2A8	Q9NY64	SLC30A1	Q9Y6M5	SLC30A5	Q8TAD4
SLC30A6	Q6NXT4	SLC31A1	O15431	SLC35A2	P78381
SLC35A3	Q9Y2D2	SLC35B2	Q8TB61	SLC35B3	Q9H1N7
SLC35B4	Q969S0	SLC35C1	Q96A29	SLC35D1	Q9NTN3
SLC35D2	Q9NTN3	SLC36A1	Q7Z2H8	SLC36A4	Q6YBV0
SLC37A1	P57057	SLC37A2	Q8TED4-2	SLC37A4	O43826
SLC38A1	Q9H2H9	SLC38A2	Q96QD8	SLC38A5	Q8WUX1
SLC38A9	Q8NBW4	SLC39A1	Q9NP94, Q9NY26	SLC39A10	Q9ULF5
SLC39A14	Q15043	SLC39A3	Q9BRY0	SLC39A6	Q13433
SLC39A7	Q92504	SLC3A2	P08195	SLC40A1	Q9NP59
SLC41A2	Q96JW4	SLC43A1	O75387	SLC44A1	Q8WWI5
SLC44A2	Q8IWA5	SLC45A3	Q96JT2	SLC46A1	Q96NT5
SLC4A2	P04920	SLC4A4	Q9Y6R1	SLC4A7	Q9Y6M7
SLC4A8	Q2Y0W8	SLC50A1	Q9BRV3	SLC52A2	Q9HAB3
SLC5A3	P53794	SLC5A6	Q9Y289	SLC66A1	Q6ZP29
SLC6A15	Q9H2J7	SLC6A8	P48029	SLC6A9	P48067
SLC7A1	P30825	SLC7A11	Q9UPY5	SLC7A2	P52569-1, P52569-2
SLC7A5	Q01650	SLC7A6	Q92536	SLC7A8	Q9UHI5
SLC8A1	P32418	SLC8B1	Q6J4K2	SLC9A3	P48764
SLC9A5	Q14940	SLC9A6	Q92581	SLC9A7	Q96T83
SLC9A8	Q9Y2E8	SLC9B2	Q4ZJI4, Q86UD5	SLCO2A1	Q92959
SLCO3A1	Q9UIG8-1	SLCO4A1	Q96BD0	SLIT2	O94813
SLIT3	O75094	SLITRK6	Q9H5Y7	SLU7	O95391
SMAD1	Q15797	SMAD3	P84022	SMAD7	O15105
SMARCA2	P51531	SMARCA5	O60264	SMARCC1	Q92922
SMARCD2	Q92925	SMARCD3	Q6STE5	SMARCE1	Q969G3
SMC1A	Q14683	SMC2	O95347	SMC3	Q9UQE7
SMC4	Q9NTJ3	SMC5	Q8IY18	SMG1	Q13315
SMG5	Q9UPR3	SMG6	Q86US8	SMG7	Q92540

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
SMN1	Q16637	SMO	Q99835	SMOX	P84022
SMPD1	P17405	SMPD4	Q9NXE4	SMS	P52788
SMURF1	Q9HCE7	SMURF2	Q9HAU4	SMYD2	Q9NRG4
SMYD3	Q9NRG4	SNAI1	O95863	SNAI2	O43623
SNAP25	P60880	SNAP29	O95721	SNAPC1	Q16533
SNAPC3	Q92966	SNAPC4	Q5SXM2	SNAPC5	O75971
SNCA	P37840	SNCB	Q16143	SND1	Q7KZF4
SNED1	Q99466	SNRNP25	Q9BV90	SNRNP40	Q96DI7
SNRPA	P09012	SNRPA1	P09661	SNRPB	P14678
SNRPC	P09234	SNRPD2	P62316	SNRPD3	P62318
SNRPE	P62304	SNRPF	P62306	SNRPN	P63162
SNU13	P55769	SNUPN	O95149	SNW1	Q13573
SNX18	Q96RF0	SNX2	O60749	SNX3	O60493
SNX5	Q9Y5X3	SNX9	Q9Y5X1	SOCS1	O15524
SOCS2	O14508	SOCS3	O14543	SOCS5	O75159
SOCS6	O14544	SOCS7	Q8WXH5	SOD2	P04179
SORBS3	O60504	SORD	Q00796	SORL1	Q92673
SORT1	Q99523	SOS1	Q07889	SOWAHC	Q53LP3
SOX4	Q06945	SOX6	P35712	SOX9	P48436
SP1	P08047	SP100	P23497	SP3	Q02447
SPATA13	Q96N96	SPATA2	Q9UM82	SPC24	Q8NBT2
SPC25	Q9HBM1	SPDL1	Q96EA4	SPIDR	Q14159
SPINT1	O43278	SPOCK3	Q9BQ16	SPON2	Q9BUD6
SPOP	O43791	SPOPL	Q6IQ16	SPP1	P10451
SPPL2B	Q8TCT7	SPRED1	Q7Z699	SPRED2	Q7Z698
SPRN	Q5BIV9	SPRTN	Q9H040	SPRY1	O43609
SPRY2	O43597	SPSB1	Q96BD6	SPTAN1	Q13813
SPTBN1	Q01082	SPTBN4	Q9H254	SPTLC1	O15269
SPTLC2	O15270	SPTLC3	Q9NUV7	SPTSSA	Q969W0
SQLE	Q14534	SQOR	Q9Y6N5	SQSTM1	Q13501
SRC	P12931-1	SRD5A1	P18405	SREBF1	P36956-1, P36956-3
SREBF2	Q12772	SRF	P11831	SRGAP1	Q7Z6B7
SRGAP2	O75044	SRGAP3	O43295	SRGN	P10124
SRI	P30626	SRM	P19623	SRP14	P37108
SRP68	Q9UHB9	SRP72	O76094	SRPK2	P78362
SRPRA	P08240	SRR	Q9GZT4	SRRM1	Q8IYB3
SRRT	Q9BXP5	SRSF1	Q07955	SRSF10	O75494
SRSF11	Q05519	SRSF2	Q01130	SRSF3	P84103
SRSF4	Q08170	SRSF5	Q13243	SRSF6	Q13247
SRSF7	Q16629	SSBP1	Q04837	SSC5D	A1L4H1
SSNA1	O43805	SSR1	P43307	SSR3	Q9UNL2
SSR4	P51571	SSRP1	Q08945	SSTR1	P30872
SSTR2	P30874	ST13	P50502	ST3GAL1	Q11201
ST3GAL2	Q16842	ST3GAL3	Q11203	ST6GAL1	P15907
ST6GAL2	Q96JF0	ST6GALNAC4	Q9H4F1	ST6GALNAC5	Q9BVH7
ST8SIA1	Q92185	ST8SIA5	O15466	STAG2	Q8N3U4
STAM	O75886, Q92783	STAM2	O75886	STAMBPF	O95630
STAMBPL1	Q96FJ0	STARD10	Q9Y365	STARD13	Q9Y3M8
STARD3	Q14849	STARD3NL	O95772	STARD4	Q96DR4

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
STARD5	Q9NSY2	STARD7	Q9NQZ5	STARD8	Q92502
STAT1	P42224-1	STAT2	P52630	STAT3	P40763
STAT5A	P42229	STAT5B	P51692	STAT6	P42226
STEAP3	Q658P3	STIM1	Q13586	STING1	Q86WV6
STIP1	P31948	STK10	O94804	STK11	Q15831
STK11IP	Q8N1F8	STK24	Q9Y6E0	STK3	Q13188
STK4	O75914	STMN1	P16949	STN1	Q9H668
STOM	P27105	STOML2	Q9UJZ1	STON1	Q9Y6Q2
STRADB	Q9C0K7	STRAP	Q9Y3F4	STRN	O43815
STS	P08842	STT3A	P46977	STUB1	Q9UNE7
STX16	O14662	STX18	Q9P2W9	STX1B	P61266
STX3	Q13277	STX4	Q12846	STX6	O43752
STXBP1	P61764-1	SUCLA2	Q9P2R7	SUCLG1	P53597
SUCLG2	Q96I99	SUDS3	Q9H7L9	SUGT1	Q9Y2Z0
SUMF1	Q8NBK3	SUMF2	Q8NBJ7	SUMO1	P63165
SUMO3	P55854	SUN1	O94901	SUN2	Q9UH99
SUPT5H	O00267	SUPT7L	O94864	SURF1	Q15526
SUV39H1	O43463	SUV39H2	Q9H5I1	SUZ12	Q15022
SV2A	Q7L0J3	SVBP	Q8N300	SYDE2	Q5VT97
SYF2	O95926	SYNE1	Q8NF91	SYNE2	Q8WXH0
SYNGAP1	Q9UJF2	SYngr2	Q14781	SYNJ2	O15056
SYS1	Q8N2H4	SYT1	Q99418	SYT12	Q8IV01
SYVN1	Q86TM6	TAB2	Q9NYJ8	TACC3	Q9Y6A5
TACR1	P25103	TADA1	Q96BN2	TADA2A	O75478
TADA3	O75528	TAF11	Q15544	TAF12	Q16514
TAF13	Q15543	TAF1C	Q15572	TAF1D	Q9H5J8
TAF5L	O75529	TAF6L	Q9Y6J9	TAF7	Q15545, Q5H9L4
TAF9	Q16594	TAF9B	Q16594, Q9HBM6	TAGLN2	P37802
TANK	Q92844	TAOK1	Q7L7X3	TAOK3	Q9H2K8
TAP1	Q03518	TAP2	Q03519	TAPBP	O15533
TARS1	P26639	TATDN2	Q93075	TAX1BP1	Q86VP1
TAX1BP3	O14907	TBC1D1	Q86TI0	TBC1D15	Q8TC07
TBC1D16	Q8TBP0	TBC1D17	Q9HA65	TBC1D2	Q9BYX2
TBC1D4	O60343	TBC1D7	Q9P0N9	TBC1D8B	Q0IIIM8
TBCA	O75347	Tbcc	Q15814	TBK1	Q9UHD2
TBL1X	O60907	TBL1XR1	Q9BZK7	TBL3	Q12788
TBX5	Q99593	TBXA2R	P21731, P21731-2, P21731-3	TBXAS1	P24557
TCEA1	P23193	TCF12	Q99081	TCF3	Q9HCS4
TCF4	Q9NQB0	TCF7	P36402	TCIRG1	Q13488
TCN2	P20062	TCP1	P17987	TCTN2	Q96GX1
TCTN3	Q6NUS6	TDP1	Q9NUW8	TDP2	O95551
TEAD1	P28347	TEAD2	Q15562	TEAD3	Q99594
TEAD4	Q15561, Q15562	TECR	Q5VVJ2	TEK	Q02763
TENT4A	Q5XG87	TEP1	P60484	TERF1	P54274
TERF2	Q15554	TES	Q9NZU5	TET2	Q6N021
TET3	O43151	TEX10	Q9NXF1	TEX2	Q8IWBB9
TEX264	Q9Y6I9	TFAM	P51668	TFAP2A	P05549-1
TFAP2C	Q92754	TFB1M	Q8WVM0	TFB2M	Q9H5Q4
TFDP1	Q14186	TFDP2	Q14188	TFG	Q92734

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
TFIP11	Q9UBB9	TFPI	P10646	TFPT	P0C1Z6
TGFB1	P01137	TGFB1I1	P49023	TGFB2	P61812
TGFB3	P10600	TGFBI	Q15582	TGFBR1	P36897
TGFBR2	P37173	TGIF1	Q15583	TGIF2	Q9GNZ2
TGOLN2	O43493	TGS1	Q96RS0	THBS1	P07996
THOC1	Q96FV9	THOC2	Q8NI27	THOC3	Q96J01
THOC7	Q6I9Y2	THOP1	P52888	THRA	P10827-2
THSD1	Q9NS62	THSD4	Q6ZMP0	THSD7A	Q9UPZ6
THUMPD1	Q9NXG2	THY1	P04216	TIA1	P31483
TICAM1	Q8IUC6	TIFA	Q96CG3	TIGAR	Q9NQ88
TIMELESS	Q9UNS1	TIMM10	P62072	TIMM17A	Q99595
TIMM44	O43615	TIMM50	Q3ZCQ8	TIMM8B	Q9Y5J9
TIMMDC1	Q9NPL8	TIMP3	P35625	TINF2	Q9BSI4
TIPIN	Q9BVW5	TJP1	Q07157	TJP2	Q9UDY2
TK1	P04183	TK2	O00142	TKFC	Q3LXA3
TKT	Q16832	TLE3	Q04726-3	TLE4	Q04727
TLE5	Q08117	TLN1	Q9Y490	TLR3	O15455
TLR6	Q9Y2C9	TM2D3	O43396	TM7SF2	O76062
TMBIM1	Q969X1	TMED10	P49755	TMED2	Q15363
TMED5	Q9Y3A6	TMED7	Q9Y3B3	TMED8	Q9H3P7
TMEM115	Q12893	TMEM126A	Q8IUX1	TMEM126B	Q8IUX1
TMEM129	A0AVI4	TMEM132A	Q24JP5	TMEM170A	O60783
TMEM179B	Q7Z7N9	TMEM208	O00762	TMEM30A	Q9NV96
TMEM59	Q9BXS4	TMEM67	Q5HYA8	TMEM87A	Q8NBN3
TMEM87B	Q8NBN3	TMF1	P82094	TMLHE	Q9NVH6
TMOD1	P28289	TMOD2	Q9NZR1	TMOD3	Q9NYL9
TMPO	P42167-1	TMSB4X	P62328	TMX3	Q96JJ7
TNC	P24821	TNFAIP1	Q13829	TNFAIP3	P21580
TNFAIP6	P98066	TNFAIP8	O95379	TNFAIP8L1	Q8WVP5
TNFRSF10A	O00220	TNFRSF10B	O00220, O14763, Q9UBN6	TNFRSF10C	O14798
TNFRSF10D	Q9UBN6	TNFRSF11B	Q86YS6	TNFRSF12A	Q9NP84
TNFRSF14	Q92956	TNFRSF1A	P19438	TNFRSF1B	P20333
TNFRSF21	O75509	TNFRSF25	Q93038	TNFSF12	O43508
TNFSF13B	Q9Y275	TNFSF15	O95150	TNFSF18	Q9UNG2
TNFSF4	P23510	TNFSF9	P41273	TNIK	Q9UKE5
TNIP1	Q15025	TNIP2	Q8NFZ5	TNKS	O95271
TNKS2	Q9H2K2	TNPO1	Q92973	TNRC6A	Q8NDV7
TNRC6B	Q9UPQ9	TNRC6C	Q9HCJ0	TNS3	Q68CZ2
TOLLIP	Q9H0E2	TOM1	Q8IYU2	TOMM20	Q15388
TOMM40	O96008	TOMM70	O94826	TOP1	P11387
TOP2A	P11388	TOPBP1	Q92547	TOPORS	Q9NS56
TOR1A	O14656	TOR1AIP2	Q5JTV8	TOR1B	O14657
TOR3A	Q86Y01	TP53	P04637	TP53BP1	Q12888
TP53I3	Q53FA7	TP53INP1	Q96A56	TP53RK	Q96S44
TPCN1	Q9ULQ1	TPCN2	Q8NHX9	TPD52L1	Q16890
TPGS1	Q6ZTW0	TPGS2	Q68CL5	TPI1	P60174
TPM1	P06753	TPM2	P07951	TPM3	P06753
TPM4	P67936	TPMT	P51580	TPP1	Q96AP0
TPP2	P29144	TPR	P12270	TPST1	O60507

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TRAK1	Q9UPV9	TRAM1	Q15629	TRAP1	Q12931
TRAPPC2	P0DI81	TRAPPC5	Q8IUR0	TRAPPC6B	O75865, Q86SZ2
TRAPPC8	Q9Y2L5	TRAPPC9	Q96Q05	TRIAP1	O43715
TRIB1	Q96RU8	TRIB3	Q96RU7	TRIM11	Q96F44
TRIM13	O60858	TRIM14	Q14142	TRIM2	Q9C040
TRIM22	Q8IYM9	TRIM24	O15164	TRIM25	Q14258
TRIM27	P14373	TRIM32	Q13049	TRIM33	Q9UPN9
TRIM37	O94972	TRIM38	O00635	TRIM4	Q9C037
TRIM41	Q8WV44	TRIM45	Q9H8W5	TRIM5	Q9C035
TRIM56	Q9BRZ2	TRIM58	P19474	TRIM6	Q9C030
TRIM68	Q6AZZ1	TRIM69	Q86WT6	TRIM8	Q9BZR9
TRIO	O75962, Q96PX9	TRIOBP	Q9H2D6-4, Q9H2D6-5	TRIT1	Q9H3H1
TRMT10C	Q7L0Y3	TRMT13	Q9NUP7	TRMT9B	Q9P272
TRPA1	O75762	TRPC3	Q13507	TRPC4	Q9UBN4
TRPC4AP	Q8TEL6	TRPC5	Q9UL62	TRPC6	Q9Y210
TRPM4	Q8TD43	TRPM7	Q96QT4	TRPV2	Q9Y5S1
TRPV4	Q9HBA0	TRRAP	Q9Y4A5	TSC2	P49815
TSC22D3	Q99576	TSC22D4	Q99576	TSEN15	Q8WW01
TSEN34	Q9BSV6	TSG101	Q99816	TSHZ1	Q00403
TSKU	O15455	TSLP	Q969D9	TSN	Q15631
TSNAX	Q99598	TSPAN14	Q8NG11	TSPO	P30536
TSR1	Q2NL82	TTC26	A0AVF1	TTLL11	Q8NHH1
TTLL3	Q9Y4R7	TTLL4	Q14679	TTLL5	Q6EMB2
TTLL7	Q6ZT98	TTYH2	Q9BSA4	TTYH3	Q9C0H2
TUBA1A	Q71U36	TUBA1B	P68363	TUBA1C	Q9BQE3
TUBA4A	P68366	TUBB	P07437	TUBB2A	Q13885, Q9BVA1
TUBB2B	Q9BVA1	TUBB3	Q13509	TUBB4B	P68371, Q3ZCM7
TUBB6	Q9BUF5	TUBG1	P23258, Q9NRH3	TUBG2	Q9NRH3
TUBGCP2	Q9BSJ2	TUBGCP3	Q96CW5	TUBGCP4	Q9UGJ1
TUBGCP5	Q96RT8	TUBGCP6	Q96RT7	TULP3	O75386
TUSC3	Q13454	TUT7	P54652	TWF1	Q12792
TWIST1	Q15672	TXLNA	P40222	TXN	P10599
TXNDC5	Q8NBS9	TXNIP	Q9UJX2	TXNL1	O43396
TXNRD1	Q16881	TYMS	P04818	TYRP1	P17643
TYW3	Q6IPR3	U2AF2	P26368	U2SURP	O15042
UACA	Q9BZF9	UAP1	Q16222	UBA1	P22314
UBA2	Q9UBT2	UBA5	Q9GZZ9	UBA7	P41226
UBE2A	P49459	UBE2B	P63146	UBE2C	O00762
UBE2D1	P51668	UBE2D3	P61077	UBE2E1	P51965
UBE2E2	Q96LR5	UBE2E3	Q969T4	UBE2F	Q969M7
UBE2G2	P60604, P62253	UBE2H	P62256	UBE2I	P63279
UBE2J1	Q9Y385	UBE2J2	Q8N2K1, Q8N2K1-1	UBE2K	P61086
UBE2L6	O14933	UBE2M	P61081	UBE2N	P61088
UBE2O	Q9C0C9	UBE2Q1	Q7Z7E8	UBE2Q2	Q8WVN8
UBE2R2	Q712K3	UBE2S	Q16763	UBE2T	Q9NPD8
UBE2W	Q96B02	UBE2Z	Q9H832	UBE3C	Q15386

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UBIAD1	Q9Y5Z9	UBL4A	P11441	UBN1	Q9NPG3
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UBQLN2	Q9UHD9	UBR1	Q8IWV7	UBR2	Q8IWV8
UBXN1	Q04323	UCHL1	P09936	UCHL3	P15374
UCHL5	Q9Y5K5	UCKL1	Q9NWZ5	UCP2	P55851
UFL1	O94874	UGCG	Q16739	UGGT1	Q9NYU2
UGGT2	Q9NYU1	UGP2	Q16851	UHMK1	Q8TAS1
UHRF1	Q96T88	UHRF1BP1L	A0JNW5	UIMC1	Q96RL1
ULBP1	Q9BZM5	ULBP2	Q9BZM5	ULK3	Q6PHR2
UNC119B	A6NIH7	UNC13B	O14795	UNC5B	Q8IZJ1
UNC5C	O95185	UNC93B1	Q9H1C4	UNG	P13051-1
UNK	Q9H9P5	UNKL	Q9H9P5	UPF3A	Q9H1J1, Q9H1J1-2
UPF3B	Q9BZI7	UPP1	Q16831	UQCRC2	P22695
UROD	P06132	UROS	P10746	USF1	P22415
USF2	Q15853	USO1	O60763	USP1	O94782
USP10	Q14694	USP11	P51784	USP12	O75317, Q86T82
USP13	Q92995	USP14	P54578	USP15	Q9Y4E8
USP18	Q3LFD5, Q9UMW8	USP19	P50281	USP21	Q9UK80
USP22	Q9UPT9	USP24	Q9UPU5	USP28	Q96RU2
USP31	Q86UV5	USP33	Q8TEY7	USP34	Q70CQ2
USP37	Q86T82	USP39	Q53GS9	USP4	Q13107
USP44	Q9H0E7	USP45	Q70EL2	USP5	P45974
USP6NL	Q92738	USP7	Q93009	UTP14C	Q5TAP6
UTP18	Q9Y5J1	UTP20	O75691	UTP25	Q68CQ4
UTP4	Q969X6	UTRN	P46939	UVRAG	Q9P2Y5
VAC14	Q08AM6	VAMP2	P63027	VAMP3	Q15836
VAMP4	O75379	VANGL1	Q8TAA9	VANGL2	Q9ULK5
VAPA	Q9P0L0	VAPB	O95292	VARS1	P26640
VASH1	Q7L8A9	VASH2	Q86V25	VASP	P50552
VAT1	Q99536	VAV2	P52735	VCAM1	P19320
VCAN	P13611	VCL	P18206	VCP	P55072
VDAC1	P21796	VDAC3	Q9Y277	VDR	P11473
VEGFA	P15692	VEGFC	P49767	VGF	O15240
VHL	P40337	VIM	P08670	VKORC1L1	Q8N0U8
VLDLR	P98155	VPS18	Q9P253	VPS26A	O75436
VPS29	Q9UBQ0	VPS33A	Q96AX1	VPS35	Q96QK1
VPS35L	Q7Z3J2	VPS37A	Q8NEZ2	VPS37B	A5D8V6, Q9H9H4
VPS39	Q96JC1	VPS41	P49754	VPS4A	Q9UN37
VPS4B	O75351	VPS53	Q5VIR6	VPS54	Q9P1Q0
VRK1	Q99986	VRK2	Q86Y07-2	VRK3	Q8IV63
VTA1	Q9NP79	VTI1B	Q96FJ2	WARS1	P23381
WASF2	Q9Y6W5	WASF3	Q9UPY6	WASL	O00401
WBP1	P39656	WDR1	O75083	WDR11	Q8WWQ0, Q9BZH6
WDR12	Q9GZL7	WDR18	Q9BV38	WDR19	Q8NEZ3
WDR24	Q96S15	WDR35	Q9P2L0	WDR36	Q8NI36
WDR43	Q15061	WDR45	Q9Y484	WDR46	O15213
WDR48	Q8TAF3	WDR5	P61964	WDR6	Q9NNW5
WDR77	Q9BQA1	WDR81	Q562E7	WDTC1	Q8N5D0
WEE1	P30291, Q99640	WHRN	Q9P202	WIPF1	O43516

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
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WLS	Q5T9L3	WNK1	Q9H4A3	WNK4	Q96J92
WNT16	Q9UBV4	WNT2	O00755, P09544	WNT5A	P41221
WNT5B	Q9H1J7	WNT7B	P56706	WSB2	Q9NYS7
WWC1	Q8IX03	WWP2	O00308	XBP1	P17861-2
XDH	P47989	XIAP	P98170	XPA	P23025
XPO1	O14980	XPO5	Q9HAV4	XPO6	Q9NY97
XPOT	O43592	XRCC2	O43543	XRCC3	O43542
XRCC6	P12956	XRN1	Q8IZH2	XRN2	Q9H0D6
XYLB	O75191	XYLT1	Q86Y38	YAF2	Q8IY57
YARS1	P54577	YBX1	P67809	YES1	P07947
YPEL5	P62699	YWHAE	P62258	YWHAG	P61981
YWHAH	Q04917	YWHAQ	P27348, P31947	YWHAZ	P63104
YY1	P25490	ZBED1	O96006	ZBTB40	O00219
ZBTB8OS	Q8IWT0	ZC3H11A	O75152	ZC3H12C	Q86X55
ZC3HAV1	Q7Z2W4	ZC3HC1	Q86WB0	ZDHHC2	Q9UIJ5
ZDHHC21	Q8IVQ6	ZDHHC3	Q9NYG2	ZDHHC5	Q9C0B5
ZDHHC7	Q9NXF8	ZDHHC9	Q9Y397	ZEB1	P37275
ZFAND6	Q6FIF0	ZFHX3	Q15911	ZFP1	Q6P2D0
ZFP14	Q9HCL3	ZFP30	Q9Y2G7	ZFP36	P26651
ZFP36L1	Q07352	ZFP69	Q49AA0	ZFP69B	Q9UJL9
ZFP91	Q6PHW0	ZFPM1	Q8IX07	ZFPM2	Q8WW38
ZFYVE16	Q7Z3T8	ZFYVE9	O95405-1	ZIK1	Q3SY52, Q9BWM5
ZKSCAN8	Q15776	ZMYM2	Q9UBW7	ZNF10	P21506
ZNF100	Q8IYN0	ZNF101	Q8IZC7	ZNF12	P17014
ZNF124	Q15973	ZNF136	P52737	ZNF140	P52738
ZNF154	Q13106	ZNF160	Q9HCG1	ZNF175	Q9Y473
ZNF184	Q99676	ZNF189	O75820	ZNF195	O14628
ZNF208	O43345, Q14590	ZNF211	Q13398	ZNF212	Q9BV97, Q9UDV6
ZNF213	O14771	ZNF217	O75362	ZNF22	Q8TAW3
ZNF221	Q9UK13	ZNF224	Q9NZL3	ZNF225	P18146
ZNF226	O14628, Q9NYT6	ZNF227	Q6IV72, Q86WZ6	ZNF230	Q9UIE0
ZNF234	Q14588	ZNF235	Q14590, Q86WZ6	ZNF24	Q96I27
ZNF248	Q8NDW4	ZNF250	P15622, Q8IZC7	ZNF253	O75346
ZNF254	O75437	ZNF26	P17031	ZNF263	O14978
ZNF264	O43296	ZNF267	Q14586	ZNF274	Q96GC6
ZNF28	P17035	ZNF282	Q9UDV7	ZNF286A	Q9HBT8
ZNF3	P17036, Q6ZN57	ZNF302	Q8NA42, Q9NR11	ZNF304	Q5VV52, Q9HCX3
ZNF317	Q96PQ6	ZNF320	A2RRD8	ZNF324	O75467
ZNF329	Q12901	ZNF33A	Q06730	ZNF33B	Q06730, Q06732
ZNF345	Q8NA42	ZNF347	Q96SE7	ZNF354A	O60765
ZNF354B	Q96LW1	ZNF354C	Q86Y25	ZNF383	Q8NA42, Q9BR84
ZNF394	Q53GI3	ZNF426	Q9BUY5	ZNF43	P17038
ZNF431	Q8TF32	ZNF432	O94892	ZNF433	Q8N7K0
ZNF436	Q9C0F3	ZNF440	Q8IYI8	ZNF441	Q8N8Z8
ZNF45	Q02386	ZNF451	Q96I27	ZNF454	Q8N9F8
ZNF468	Q5VIY5	ZNF470	Q6ECI4	ZNF473	Q8WTR7
ZNF480	Q8WV37	ZNF486	Q96H40	ZNF493	Q6ZR52
ZNF500	O60304	ZNF517	Q6ZMY9	ZNF519	Q96EZ8

Input	UniProt Id	Input	UniProt Id	Input	UniProt Id
ZNF521	Q96K83	ZNF524	Q03112	ZNF528	Q3MIS6
ZNF529	Q6P280	ZNF543	Q08ER8	ZNF544	Q6NX49
ZNF549	Q6P9A3	ZNF550	Q7Z398	ZNF555	O60304, Q8NEP9
ZNF557	Q8N988, Q96NG5	ZNF558	Q96NG5	ZNF559	Q9BR84
ZNF561	Q8N587	ZNF562	Q6V9R5	ZNF566	Q969W8
ZNF568	Q3ZCX4, Q8N3J9	ZNF569	Q5MCW4	ZNF570	Q96NI8
ZNF577	Q9BSK1	ZNF582	Q96NG8	ZNF583	Q96ND8
ZNF584	Q8IVC4	ZNF585A	Q6P3V2	ZNF585B	Q52M93
ZNF597	Q96LX8	ZNF600	Q6ZNG1	ZNF605	Q86T29
ZNF606	Q8WXB4	ZNF610	Q8N9Z0	ZNF611	Q8N823
ZNF614	Q8N883	ZNF616	Q08AN1	ZNF626	Q68DY1
ZNF627	Q7L945	ZNF638	Q14966	ZNF641	Q96N77
ZNF664	Q8N3J9	ZNF667	Q5HYK9	ZNF669	Q96BR6
ZNF677	Q86XU0	ZNF678	Q5SXM1	ZNF680	Q8NEM1
ZNF688	P0C7X2	ZNF689	Q96CS4	ZNF697	Q5TEC3
ZNF699	Q32M78	ZNF701	Q9NV72	ZNF703	Q9H7S9
ZNF706	Q9Y5V0	ZNF707	Q96C28	ZNF708	P17019
ZNF711	Q9NQZ8	ZNF710	Q8N1W2	ZNF713	Q8N859
ZNF714	Q96N38	ZNF721	Q8TF20	ZNF736	B4DX44
ZNF737	O75373	ZNF738	Q8NE65	ZNF74	Q16587
ZNF740	Q8NDX6	ZNF749	O43361	ZNF75D	P51815, Q92670
ZNF764	Q96H86	ZNF770	Q6IQ21	ZNF776	Q68DI1
ZNF777	Q9ULD5	ZNF785	A8K8V0	ZNF79	Q15937
ZNF790	Q6PG37	ZNF791	Q3KP31	ZNF792	Q3KQV3
ZNF793	Q6ZN11	ZNF805	Q6NX49	ZNF830	Q96NB3
ZNF865	Q9GZX5	ZNF875	P10072	ZNF91	Q9NQW5
ZNF92	Q03936	ZNRF3	Q9ULT6	ZP3	P21754
ZRANB1	Q9UGI0	ZSCAN25	Q6NSZ9	ZSWIM8	A7E2V4
ZWILCH	Q9H900	ZWINT	O95229	ZYX	Q8WUP2

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ABCG1	ENSG00000160179	ACACA	ENSG00000132142	ACACB	ENSG00000076555
ACADM	ENSG00000117054	ACADVL	ENSG00000072778	ACLY	ENSG00000131473
ACOX1	ENSG00000161533	ACSL1	ENSG00000151726	ACTA2	ENSG00000107796
ACTB	ENST00000331789	ADAP1	ENSG00000105963	ADAR	ENSG00000160710
AGT	ENSG00000135744	AIFM2	ENSG00000042286	ALAD	ENST00000409155
ALAS1	ENSG00000023330	ANGPTL4	ENSG00000167772	ANKRD1	ENSG00000148677
ANXA1	ENSG00000135046	ANXA2	ENSG00000182718	APP	ENSG00000142192
ARF1	ENSG00000143761	ARFGAP1	ENSG00000101199	ARID3A	ENSG00000116017
ARL4C	ENSG00000188042, ENST00000339728	ARNTL	ENSG00000133794	ASNS	ENSG00000070669
ATF3	ENSG00000162772	ATF4	ENST00000404241	ATM	ENSG00000149311, ENST00000278616
AXIN1	ENSG00000103126	B2M	ENSG00000166710	BACH1	ENSG00000156273
BAX	ENSG00000087088	BBC3	ENSG00000105327	BCL2	ENSG00000171791
BCL2L1	ENSG00000171552	BCL2L11	ENSG00000153094	BDNF	ENSG00000176697
BDP1	ENSG00000072135	BID	ENSG00000015475	BIRC5	ENSG00000089685
BNIP3L	ENSG00000104765	BOC	ENSG00000144857	BRCA1	ENSG00000012048, ENST00000357654

Input	Ensembl Id	Input	Ensembl Id	Input	Ensembl Id
BRWD1	ENSG00000185658	BTG1	ENSG00000133639	BTG2	ENSG00000159388
CALR	ENSG00000179218	CAPZA1	ENSG00000116489	CASP1	ENSG00000137752
CAT	ENSG00000121691	CAV1	ENSG00000105974	CBX5	ENSG00000094916
CCN1	ENSG00000145386	CCN2	ENSG00000118523	CCNA2	ENSG00000145386
CCNB1	ENSG00000134057	CCNB2	ENSG00000157456	CCND1	ENSG00000110092
CCNG1	ENSG00000113328	CCNG2	ENSG00000138764	CCNK	ENSG00000090061
					ENST00000263398, ENST00000278385,
CD274	ENSG00000120217	CD36	ENSG00000135218	CD44	ENST00000278386, ENST00000279452, ENST00000352818
CDC25A	ENSG00000164045	CDC25C	ENSG00000158402	CDC45	ENSG00000093009
CDC6	ENSG00000094804	CDC7	ENSG00000097046	CDK1	ENSG00000170312
CDK5	ENSG00000164885	CDK5R1	ENSG00000176749	CDKN1A	ENSG00000124762, ENST00000244741
CDKN1B	ENSG00000111276	CDKN2B	ENSG00000147883	CDT1	ENSG00000167513
CEBPB	ENSG00000172216	CEBPD	ENSG00000221869	CENPF	ENSG00000117724
CFL1	ENSG00000172757	CHAC1	ENSG00000128965	CHD1	ENSG00000153922, ENST00000284049.7
CHEK1	ENSG00000149554, ENST00000438015	CHL1	ENSG00000013573	CISH	ENSG00000114737
CLOCK	ENSG00000134852	CNN2	ENSG00000064666	CNOT6L	ENST00000264903
COL1A1	ENSG00000108821	COL1A2	ENSG00000164692	COL4A6	ENSG00000197565
CPT1A	ENSG00000110090	CPT2	ENSG00000157184	CRH	ENSG00000147571
CRY1	ENSG0000008405	CRY2	ENSG00000121671	CSF1	ENSG00000184371
CSF3	ENSG00000108342	CSRP1	ENSG00000159176	CTDSP2	ENSG00000175215
CTSD	ENSG00000117984	CUL7	ENSG00000044090	CXCL1	ENSG00000163739
CXCL12	ENSG00000107562	CXCL2	ENSG00000081041	CXCL8	ENSG00000169429
CXXC1	ENSG00000154832	CXXC5	ENSG00000171604	CYCS	ENSG00000172115
CYP1A1	ENSG00000140465	DCTN1	ENSG00000204843	DCUN1D3	ENST00000324344
DDB2	ENSG00000134574	DDX11	ENSG00000013573	DEDD2	ENSG00000160570
DHCR7	ENSG00000172893	DHFR	ENSG00000228716	DKK1	ENSG00000107984
DLGAP5	ENSG00000126787	DLL1	ENSG00000198719	DNAJB11	ENSG00000090520
DNAJB6	ENSG00000105993	DNAJB9	ENSG00000128590	DNAJC3	ENSG00000102580
DRG1	ENSG00000104419	E2F1	ENSG00000101412	E2F7	ENSG00000165891
EBAG9	ENSG00000147654	EBF1	ENSG00000164330	EDEM1	ENSG00000134109
EED	ENSG00000074266	EEPD1	ENSG00000122547	EGFR	ENSG00000146648
EGR1	ENSG00000120738	EGR2	ENSG00000122877	ELOVL3	ENSG00000119915
ELOVL6	ENSG00000170522	ENPP2	ENST00000427067	EPAS1	ENSG00000116016
ERBB2	ENSG00000141736	ESRRRA	ENSG00000173153	ETS2	ENSG00000157557
EXTL1	ENSG00000158008	EXTL2	ENSG00000162694	EXTL3	ENSG0000012232
EZH2	ENSG00000106462	F3	ENSG00000117525	FABP4	ENSG00000170323
FADS1	ENSG00000149485	FANCD2	ENSG00000144554, ENST00000419585	FANCI	ENSG00000140525, ENST00000310775
FAS	ENSG00000169710	FASN	ENSG00000169710	FBXO32	ENSG00000156804
FBXO5	ENSG00000112029	FCGR1A	ENSG00000150337	FDFT1	ENSG00000079459
FDPS	ENSG00000160752	FGF2	ENSG00000138685	FHL2	ENSG00000115641
FKBP14	ENSG00000106080	FKBP4	ENSG0000004478	FKBP5	ENSG00000096060
FN1	ENSG00000115414	FOS	ENSG00000170345	FOXL2	ENSG00000183770
FOXO1	ENSG00000150907	FOXO3	ENSG00000118689	FSCN1	ENSG00000075618
FTH1	ENST00000273550	FTL	ENST00000331825	FURIN	ENSG00000140564
G0S2	ENSG00000123689	G6PD	ENSG00000160211	GABPA	ENSG00000154727

Input	Ensembl Id	Input	Ensembl Id	Input	Ensembl Id
GADD45A	ENSG00000116717	GAMT	ENSG00000130005	GATA3	ENSG00000107485
GATA6	ENSG00000141448	GBP1	ENSG00000117228	GBP2	ENSG00000162645
GCLC	ENSG00000001084	GCLM	ENSG00000023909	GEM	ENSG00000164949
GFPT1	ENSG00000198380	GLI1	ENSG00000111087	GLI2	ENSG00000074047
GPAM	ENSG00000119927	GPRC5A	ENST00000014914	GRB10	ENSG00000106070
GREB1	ENSG00000196208, ENST00000381486.6	GRIN2A	ENSG00000183454	GSDME	ENSG00000105928
GSK3A	ENSG00000105723	GSR	ENSG00000104687	GSTO1	ENSG00000148834
HERPUD1	ENSG00000051108	HES1	ENSG00000114315	HEY1	ENSG00000164683
HEYL	ENSG00000163909	HGF	ENSG00000019991	HHEX	ENSG00000152804
HHIP	ENSG00000164161	HIF1A	ENSG00000100644	HIGD1A	ENSG00000181061
HLA-A	ENSG00000206503	HLA-B	ENSG00000234745	HLA-C	ENSG00000204525
HLA-E	ENSG00000204592	HMGCR	ENSG00000113161	HMGCS1	ENSG00000112972
HNRNPA2B1	ENSG00000122566	HNRNPFL	ENSG00000169813	HOXA1	ENSG00000105991, ENST00000343060
HOXA2	ENSG00000105996, ENST00000222718	HOXA3	ENSG00000105997, ENST00000317201	HOXA4	ENSG00000197576, ENST00000360046
HOXB2	ENSG00000173917, ENST00000330070	HOXB3	ENSG00000120093, ENST00000311626	HSBP1	ENSG00000106211
HSP90AA1	ENSG00000080824	HSP90B1	ENSG00000166598	HSPA1A	ENSG00000204389, ENSG00000215328, ENSG00000234475, ENSG00000235941, ENSG00000237724
HSPA1B	ENSG00000204388, ENSG00000212866, ENSG00000224501, ENSG00000231555, ENSG00000232804	HSPA5	ENSG00000044574	HSPA8	ENSG00000109971
		HSPB1	ENSG00000106211	HSPD1	ENSG00000144381
HSPH1	ENSG00000120694	HYOU1	ENSG00000149428	ICAM1	ENSG00000090339
ID1	ENSG00000125968	ID2	ENSG00000115738	ID3	ENSG00000117318
ID4	ENSG00000172201	IDH1	ENSG00000138413	IDI1	ENSG00000067064
IFIT1	ENSG00000185745	IFIT2	ENSG00000119922	IFIT5	ENSG00000152778
IFITM1	ENSG00000185885	IFITM3	ENSG00000142089	IGF2	ENST00000337883, ENST00000381406
IGFBP3	ENSG00000146674	IGFBP7	ENSG00000163453	IL12A	ENSG00000168811
IL18	ENSG00000150782	IL1A	ENSG00000115008	IL1B	ENSG00000125538, ENST00000263341
IL1R1	ENSG00000115594	IL4R	ENSG00000077238	IL6	ENSG00000136244
IP6K2	ENSG00000068745	IQSEC3	ENSG00000120645	IRAK1	ENSG00000184216
IRF1	ENSG00000125347	IRF3	ENSG00000126456	IRF7	ENSG00000185507
ISG15	ENSG00000187608	ITCH	ENSG00000078747	ITGA4	ENSG00000115232
ITGA5	ENSG00000161638	ITGB1	ENSG00000150093	ITGBL1	ENSG00000198542
JAG1	ENSG00000101384	JUNB	ENSG00000171223	KCTD6	ENSG00000168301
KDELR3	ENSG00000100196	KDM6B	ENSG00000132510	KIT	ENSG00000157404
KLF4	ENSG00000136826	KLF5	ENSG00000102554	KLHDC3	ENSG00000124702
KPNA2	ENSG00000182481, ENST00000330459.7	LAMA5	ENSG00000130702	LIF	ENSG00000128342
LIFR	ENSG00000113594	LMNA	ENSG00000160789	LMNB1	ENSG00000113368
LSS	ENSG00000160285	MAOA	ENSG00000189221	MAP4K4	ENSG00000071054
MAPK6	ENSG00000069956	MAPKAPK5	ENSG00000089022	MCL1	ENSG00000143384
MDC1	ENSG00000137337, ENST00000376406	MDM2	ENSG00000135679	ME1	ENSG00000065833

Input	Ensembl Id	Input	Ensembl Id	Input	Ensembl Id
MECP2	ENST00000303391, ENST00000453960	MEF2C	ENSG0000081189	MET	ENSG00000105976
MID1	ENSG00000101871	MINK1	ENSG00000141503	MLH1	ENSG0000076242
MMP1	ENSG00000196611	MMP10	ENSG00000166670	MMP13	ENSG00000137745
MMP2	ENSG0000087245	MMP3	ENSG00000149968	MPZ	ENSG00000158887
MSH2	ENSG00000095002	MSN	ENSG00000147065	MT2A	ENSG00000125148
MTAP	ENSG00000099810	MXD4	ENSG00000123933	MYBL2	ENSG00000101057
MYC	ENSG00000136997	MYL9	ENSG00000101335	NAB2	ENSG00000166886
NAMPT	ENSG00000105835	NDN	ENSG00000182636	NDRG1	ENSG00000104419
NFE2L2	ENSG00000116044	NOCT	ENSG00000151014	NOP2	ENSG00000111641
NOTCH1	ENSG00000148400, ENST00000277541	NOTCH2	ENSG00000134250, ENST00000256646	NOX4	ENSG00000086991
NPAS2	ENSG00000170485	NPAS4	ENSG00000174576, ENST00000311034	NQO1	ENSG00000181019
NR1D1	ENSG00000126368	NR4A3	ENSG00000119508	NR5A2	ENSG00000116833
OAS3	ENSG00000111331	OR1J2	ENSG00000197233	OR1J4	ENSG00000239590
OR1Q1	ENSG00000165202	OR51E2	ENSG00000167332	ORC1	ENSG00000085840
PAK2	ENSG00000180370	PBX1	ENSG00000185630	PCBP4	ENSG00000090097
PCNA	ENSG00000132646	PER1	ENSG00000179094, ENST00000317276	PER2	ENSG00000132326
PERP	ENSG00000112378	PEX11A	ENSG00000166821	PGD	ENSG00000142657
PIDD1	ENSG00000177595	PIK3R1	ENSG00000145675	PIM1	ENSG00000137193
PINK1	ENSG00000158828	PITX2	ENSG00000164093	PLAGL1	ENSG00000118495
PLK1	ENSG00000166851	PLK2	ENSG00000145632	PLK3	ENSG00000173846
PLTP	ENSG00000100979	PML	ENSG00000140464	PMP22	ENSG00000109099
PMS2	ENSG00000122512	PMVK	ENSG00000163344	POLAI	ENSG00000101868
POLRMT	ENSG00000099821	POU2F1	ENSG00000143190	PPARG	ENSG00000132170
PPIA	ENSG00000196262	PPP1R15A	ENSG00000087074, ENST00000200453	PRDM1	ENSG00000057657
PRDX1	ENSG00000117450	PREB	ENSG00000138073	PSAP	ENSG00000122852, ENSG00000185303
PSMB8	ENSG00000204264	PTCH1	ENSG00000185920	PTCH2	ENSG00000117425
PTEN	ENSG00000171862, ENST00000371953	PTGDS	ENSG00000107317	PTGS2	ENSG00000073756
PTPN1	ENSG00000196396	PTPN11	ENSG00000179295	PTPN12	ENSG00000127947
PTPN13	ENSG00000163629	PTPN14	ENSG00000152104	PTPN18	ENSG00000072135
PTPN2	ENSG00000175354	PTPN23	ENSG00000076201	PTPN4	ENSG00000088179
PTPN9	ENSG00000169410	RABGGTA	ENSG00000100949	RAD51	ENSG00000051180
RAD51D	ENSG00000185379, ENST00000345365	RAG1	ENSG00000166349	RALA	ENSG00000006451
RBBP4	ENSG00000162521	RBBP8	ENSG00000101773	RBL1	ENSG00000080839
RBL2	ENSG00000103479	RET	ENSG00000165731	RGL1	ENSG00000143344
ROBO1	ENSG00000169855	ROBO2	ENSG00000185008	ROBO3	ENSG00000154134
RORA	ENSG00000069667	RPLP0	ENSG00000089157	RRM2	ENSG00000171848
RRM2B	ENSG00000048392	RSPO3	ENSG00000146374	RUNX1	ENSG00000159216, ENST00000344691
RUNX2	ENSG00000124813	S1PR1	ENSG00000170989	SALL1	ENSG00000103449
SAMHD1	ENSG00000101347	SC5D	ENSG00000109929	SCD	ENSG00000099194
SCD5	ENSG00000145284	SCP2	ENSG00000175215	SEC31A	ENSG00000138674
SERPINE1	ENSG00000106366	SERPINH1	ENSG00000149257	SESN1	ENSG00000080546
SESN3	ENSG00000149212	SGK1	ENSG00000118515	SHC1	ENSG00000160691
SLC27A1	ENSG00000130304	SLC2A3	ENSG00000059804	SLC7A11	ENSG00000151012

Input	Ensembl Id	Input	Ensembl Id	Input	Ensembl Id
SLIT2	ENSG00000145147	SMAD7	ENSG00000101665	SMURF1	ENSG00000198742
SNAI1	ENSG00000124216	SNCB	ENSG00000074317	SNRPA1	ENSG00000131876
SOCS1	ENSG00000185338	SOCS2	ENSG00000120833	SOCS3	ENSG00000184557
SOCS7	ENSG00000180008	SOD2	ENSG00000112096	SOX9	ENSG00000125398
SP100	ENSG00000067066	SPP1	ENSG00000118785	SQLE	ENSG00000104549
SQSTM1	ENSG00000161011	SREBF1	ENSG00000072310	SRPRA	ENSG00000182934
SSBP1	ENSG00000106028	SSR1	ENSG00000124783	STAT1	ENSG00000115415
STAT3	ENSG00000168610	STAT5A	ENSG00000126561	STEAP3	ENSG00000115107
STK11	ENSG00000118046	STMN1	ENSG00000117632	SUZ12	ENSG00000178691
SYVN1	ENSG00000162298	TATDN2	ENSG00000157014	TCF4	ENSG00000196628
TCP1	ENSG00000120438	TEP1	ENSG00000171862	TFAM	ENSG00000108064
TFB1M	ENSG00000029639	TFB2M	ENSG00000162851	TGFB1	ENSG00000105329
THBS1	ENSG00000137801	TIGAR	ENSG00000078237	TJP1	ENSG00000104067
TK1	ENSG00000167900	TKT	ENSG00000163931	TLN1	ENSG00000137076
TM7SF2	ENSG00000149809	TNFRSF10A	ENSG00000104689	TNFRSF10B	ENSG00000120889
TNFRSF10C	ENSG00000173535	TNFRSF10D	ENSG00000173530	TNFRSF1A	ENSG00000067182
TNFRSF1B	ENSG00000028137	TNFRSF21	ENSG00000146072	TNIK	ENSG00000154310
TOP2A	ENSG00000131747	TP53	ENSG00000141510	TP53I3	ENSG00000115129
TP53INP1	ENSG00000164938	TPP1	ENSG00000166340	TRIAP1	ENSG00000170855
TRIB1	ENSG00000173334	TRIB3	ENSG00000101255	TRIM14	ENSG00000106785
TRIM2	ENSG00000109654	TRIM22	ENSG00000132274	TRIM25	ENSG00000121060
TRIM38	ENSG00000112343	TRIM45	ENSG00000134253	TRIM5	ENSG00000132256
TRIM6	ENSG00000121236	TRIM68	ENSG00000167333	TRIM8	ENSG00000171206
TRPC3	ENSG00000138741	TSC22D1	ENSG00000102804	TWIST1	ENSG00000122691
TXNRD1	ENSG00000198431	TYMS	ENSG00000176890	USP46	ENSG00000109189
VAPA	ENST00000340541	VCAM1	ENSG00000162692	VEGFA	ENSG00000112715
VGF	ENSG00000128564	VIM	ENSG00000026025	WIP1	ENSG00000070540
WWC1	ENSG00000113645	XBP1	ENSG00000100219, ENST00000216037, ENST00000344347	ZEB1	ENSG00000148516
ZNF225	ENSG00000120738				

7. Identifiers not found

These 2941 identifiers were not found neither mapped to any entity in Reactome.

A4GALT	AAGAB	AAMDC	ABCF2	ABHD11	ABHD14A	ABHD16A	ABI3BP
ABITRAM	ABRACL	ABTB1	ABTB2	ACAP2	ACAP3	ACTBL2	ACTR3B
ACTR6	ACVR1	ADAM32	ADAP2	ADCK2	ADGRA2	ADGRA3	ADGRB3
ADGRL1	ADGRL2	ADGRL3	ADGRL4	ADNP	AEBP1	AEN	AFAP1
AFAP1L1	AFAP1L2	AFF1	AFF3	AGAP1	AGAP3	AGFG2	AHDC1
AHNAK	AHNAK2	AHSA2P	AIDA	AIG1	AKAP11	AKAP6	AKAP8
AKIP1	AKIRIN1	AKIRIN2	AKNA	AKTIP	ALKAL1	ALPK2	AMIGO1
AMMECR1	AMMECR1L	AMN1	AMZ1	ANGEL2	ANGPTL2	ANKEF1	ANKMY2
ANKRA2	ANKRD10	ANKRD12	ANKRD13A	ANKRD13B	ANKRD13D	ANKRD17	ANKRD18B
ANKRD29	ANKRD34A	ANKRD35	ANKRD36	ANKRD36C	ANKRD39	ANKRD40	ANKRD42
ANKRD44	ANKRD46	ANKRD50	ANKRD55	ANKS1B	ANKS3	ANKZF1	ANP32B
ANP32E	ANXA10	ANXA11	ANXA3	ANXA4	ANXA7	AP1AR	AP3D1
AP3M2	AP3S2	AP5Z1	APBB2	APCDD1	APCDD1L	API5	APLP1
APOBEC3F	APOL2	APOL6	APOLD1	APPBP2	ARFIP1	ARL10	ARL15
ARL4A	ARL4D	ARL5A	ARL5B	ARL6IP1	ARL8B	ARMC1	ARMC5
ARMC6	ARMC9	ARMCX1	ARMCX2	ARMCX6	ARMH3	ARMT1	ARPIN
ARRDC1	ARRDC2	ARRDC3	ARRDC4	ARVCF	ASAH2B	ASAP2	ASF1B
ASNSD1	ASPHD1	ASPM	ASTE1	ASTN2	ASXL3	ATAD2B	ATAD5
ATCAY	ATF7	ATG2A	ATG2B	ATL1	ATL2	ATL3	ATOH8
ATP13A3	ATPAF1	ATRAID	ATRN	ATRNL1	ATXN1	ATXN10	ATXN1L
ATXN2	ATXN7L1	ATXN7L3B	AUNIP	AUP1	AVL9	AVPI1	BACE2
BAHCC1	BAIAP3	BATF3	BAZ1A	BAZ2B	BBLN	BBOF1	BBX
BCAR3	BCAS3	BCAS4	BCCIP	BCL2L12	BCL2L2	BCL7A	BCL7C
BCLAF1	BCOR	BCORL1	BEND3	BEND6	BEND7	BICCI	BLCAP
BLOC1S2	BMERB1	BMPER	BNC2	BOD1	BOD1L1	BOK	BOLA3
BORCS6	BORCS7	BORCS8	BRAT1	BRD3	BRD9	BRI3BP	BRSK1
BSDC1	BTAF1	BTBD10	BTBD19	BTBD3	BTBD7	BTBD9	BTG3
BVES	BZW1	C10orf55	C11orf24	C11orf68	C11orf80	C11orf94	C11orf96
C12orf4	C12orf43	C12orf57	C12orf73	C12orf75	C12orf76	C14orf119	C16orf72
C16orf87	C18orf32	C18orf54	C19orf12	C19orf18	C19orf25	C19orf48	C19orf54
C1QL4	C1QTNF2	C1QTNF6	C1orf112	C1orf122	C1orf198	C1orf21	C1orf216
C1orf226	C1orf43	C1orf52	C1orf54	C1orf74	C20orf27	C20orf96	C21orf58
C21orf91	C2CD2	C2CD2L	C2orf69	C3orf33	C3orf38	C3orf62	C3orf70
C3orf80	C4orf3	C4orf33	C4orf46	C4orf48	C5orf15	C5orf24	C5orf34
C6orf132	C6orf226	C6orf47	C6orf62	C7orf50	C8orf33	C8orf82	C8orf88
C9orf40	C9orf72	C9orf78	CA11	CAAP1	CACFD1	CACNA2D4	CACYBP
CADM4	CALB2	CALCOCO1	CALCOCO2	CALHM5	CALM2	CALM3	CAMK1D
CAMK1G	CAMK2N1	CAMSAP2	CAMTA2	CAND2	CAPRIN1	CAPRIN2	CARD10
CARD16	CARD19	CASD1	CASS4	CAVIN2	CAVIN3	CAVIN4	CBFA2T2
CBLN2	CCBE1	CCDC102A	CCDC102B	CCDC106	CCDC110	CCDC117	CCDC120
CCDC121	CCDC124	CCDC126	CCDC134	CCDC136	CCDC138	CCDC14	CCDC146
CCDC149	CCDC15	CCDC150	CCDC157	CCDC167	CCDC18	CCDC25	CCDC28A
CCDC34	CCDC40	CCDC50	CCDC57	CCDC6	CCDC61	CCDC68	CCDC69
CCDC71	CCDC77	CCDC80	CCDC81	CCDC82	CCDC85A	CCDC85B	CCDC85C
CCDC89	CCDC90B	CCDC91	CCDC92	CCDC97	CCDC9B	CCHCR1	CCIN
CCN3	CCN4	CCNB1IP1	CCN1L	CCNL2	CCNQ	CCNY	CCNYL1

CCSER2	CD163L1	CD37	CD69	CD82	CD83	CDAN1	CDC123
CDC42BPG	CDC42SE1	CDCA2	CDCA3	CDCA4	CDCA7	CDCA7L	CDIN1
CDK10	CDK15	CDK16	CDK2AP1	CDK2AP2	CDK5RAP1	CDKN2AIPNL	CDKN3
CDR2	CDR2L	CDV3	CDYL	CDYL2	CEBPZOS	CELF1	CELF2
CELSR3	CEMIP2	CEND1	CENPBD1P	CENPV	CEP104	CEP112	CEP120
CEP128	CEP170B	CEP19	CEP350	CEP57L1	CEP68	CEP85	CEP85L
CERCAM	CERKL	CETN3	CFAP157	CFAP20	CFAP20DC	CFAP251	CFAP36
CFAP418	CFAP44	CFAP45	CFAP69	CFAP97	CFDP1	CFL2	CGGBP1
CHAF1A	CHAF1B	CHAMP1	CHD6	CHFR	CHIC2	CHMP1B	CHORDC1
CHRAC1	CHURC1	CIAO2A	CIB1	CIBAR1	CILK1	CILP2	CINP
CIP2A	CIPC	CISD2	CKAP2	CKAP2L	CKS2	CLASRP	CLCC1
CLDND1	CLEC11A	CLEC14A	CLGN	CLIC1	CLIC4	CLIP2	CLK1
CLK2	CLK3	CLK4	CLN6	CLPB	CLPP	CLPTM1	CLPTM1L
CLSTN1	CLSTN3	CMIP	CMKLR2	CMSS1	CMTM3	CMTR1	CMTR2
CNKS3R3	CNN1	CNN3	CNNM1	CNNM2	CNNM3	CNNM4	CNP
CNPY4	CNRIP1	CNST	CNTLN	CNTROB	COA5	COA7	COBLL1
COQ4	CORO1B	CORO1C	CORO2A	CORO2B	CORO6	COX7A2	CPA4
CPEB2	CPEB4	CPED1	CPLANE1	CPLANE2	CPNE2	CPQ	CRACD
CREB5	CREBL2	CREBFZ	CREG2	CRELD1	CRELD2	CRIM1	CRIP2
CRLF3	CROCC	CRYBG1	CRYZ	CSDC2	CSMD3	CSNK1G1	CSNK1G3
CSPP1	CSRNP1	CSRNP2	CSTPP1	CTBS	CTDSP1	CTDSPL2	CTIF
CTNNAL1	CTTNBP2	CTTNBP2NL	CTXN1	CUEDC1	CUEDC2	CXorf38	CYB561
CYB561A3	CYB5D2	CYBC1	CYHR1	CYP20A1	CYRIA	CYTL1	CZIB
DAAM2	DACH1	DAW1	DAZAP2	DBF4B	DBNDD1	DCAF15	DCAF4L1
DCBLD1	DCBLD2	DCLK2	DDI2	DDIAS	DDIT4L	DDX10	DDX24
DDX50	DDX51	DDX54	DDX56	DDX59	DDX60	DEAF1	DEDD
DEF8	DENN10D	DEPDC1	DEPP1	DESI2	DGCR2	DGLUCY	DHRS1
DHRS7	DHRSX	DHX29	DHX30	DHX32	DHX57	DHX8	DIP2B
DIP2C	DIPK2A	DIRAS1	DIRAS3	DIS3L	DIXDC1	DKK3	DLEU1
DLX2	DMAC1	DMRTA1	DMXL2	DNAAF2	DNAAF9	DNAH1	DNAH5
DNAI3	DNAI4	DNAJA3	DNAJB14	DNAJB2	DNAJB4	DNAJB5	DNAJC10
DNAJC12	DNAJC15	DNAJC16	DNAJC17	DNAJC18	DNAJC21	DNAJC22	DNAJC25
DNAJC4	DNAJC9	DNPEP	DNTTIP1	DNTTIP2	DONSON	DOP1A	DOP1B
DPF1	DPF2	DPF3	DPP8	DPP9	DPY19L1	DPY19L2	DPY19L3
DRAM1	DRAM2	DRAXIN	DSTN	DTD1	DTD2	DTNA	DTWD1
DUSP12	DUSP14	DUSP18	DYM	DYNLT3	DYNLT4	DYRK1B	DYRK3
DZANK1	DZIP1L	EAPP	ECHDC1	ECHDC3	ECPAS	EDF1	EDIL3
EFCAB14	EFCC1	EFHC1	EFR3A	EGFL7	EHBP1L1	EHD4	EHF
EID1	EIF1	EIF1AD	EIF1B	EIF2D	EIF4EBP2	EIF5AL1	EIF6
ELAPOR1	ELF4	ELFN1	ELMOD2	EMC1	EMC10	EMC4	EMC7
EMC8	EMC9	EMID1	EML1	EML2	EML3	EML5	EML6
EMP2	EMP3	ENC1	ENDOV	ENG	ENKD1	ENOX1	EOGT
EPC2	EPG5	EPHX4	EPM2AIP1	EPPK1	EPS8L1	ERFE	ERG28
ERGIC1	ERGIC2	ERGIC3	ERH	ERI2	ERMP1	ERP29	ERRFI1
ERV3-1	ERVMER34-1	ESF1	ESM1	ESS2	ETV1	ETV3	ETV5
EVA1B	EVI2A	EVI5	EVI5L	EWSR1	EXD2	EXOG	FADS3
FAF1	FAHD2A	FAM102A	FAM102B	FAM104A	FAM107B	FAM110A	FAM111A
FAM111B	FAM114A1	FAM117B	FAM118A	FAM118B	FAM120A	FAM120C	FAM126A
FAM126B	FAM136A	FAM149B1	FAM162B	FAM167A	FAM168A	FAM168B	FAM171A2
FAM171B	FAM174A	FAM174C	FAM177A1	FAM180A	FAM189B	FAM199X	FAM200A
FAM200B	FAM20B	FAM210B	FAM214A	FAM214B	FAM216A	FAM217B	FAM219A

FAM219B	FAM220A	FAM222A	FAM222B	FAM227A	FAM229A	FAM234A	FAM241A
FAM32A	FAM3A	FAM43A	FAM50A	FAM50B	FAM53B	FAM53C	FAM72A
FAM72B	FAM72C	FAM72D	FAM76B	FAM83D	FAM83H	FAM86B1	FAM86C1P
FAM89A	FAM89B	FAM8A1	FAM98A	FANK1	FASTK	FASTKD2	FASTKD5
FAT1	FAT4	FAXDC2	FBH1	FBRSL1	FBXL2	FBXO25	FBXO28
FBXO33	FBXO34	FBXO38	FBXO43	FBXO46	FCGBP	FCGRT	FCHSD1
FCMR	FER1L6	FEZ2	FGD6	FHIP2A	FHIP2B	FHL1	FHL3
FIBCD1	FIBP	FICD	FIGN	FIGNL1	FILIP1L	FJX1	FKBP10
FKBP15	FKBP2	FKBP3	FKBP7	FKRP	FKTN	FLII	FLVCR2
FLYWCH1	FLYWCH2	FMN1	FMN2	FMR1	FNBP4	FNDC10	FNDC3A
FNDC3B	FOCAD	FOSL2	FOXC1	FOXC2	FOXF1	FOXF2	FOXJ2
FOXL1	FOXL2NB	FOXN2	FOXN3	FOXQ1	FOXRED1	FOXRED2	FRA10AC1
FRMD4A	FRMD4B	FRMD5	FRMD6	FRMD8	FRRS1	FRY	FRZB
FSD1	FSD1L	FUBP1	FUBP3	FUND2	FXR2	FXYD5	GAB3
GAREM1	GAREM2	GAS2L1	GAS2L3	GATB	GATC	GCNA	GCNT2
GDAP2	GDF11	GDF15	GDF6	GFOD2	GGACT	GID4	GID8
GIGYF1	GIGYF2	GIPC1	GIPC2	GIPC3	GLCCI1	GLIPR2	GLIS2
GLMP	GLT8D2	GLYR1	GMCL1	GMEB1	GMEB2	GMFB	GNL2
GNPTG	GOLGA8A	GOLGA8B	GOLPH3	GOLT1B	GON7	GPANK1	GPATCH1
GPATCH2L	GPATCH3	GPATCH4	GPBP1	GPBP1L1	GPM6B	GPN1	GPR107
GPR108	GPR137	GPR137B	GPR155	GPR157	GPR162	GPR180	GPR3
GPRASP2	GPRC5B	GPRC5C	GPRIN3	GRAMD1A	GRAMD1B	GRAMD1C	GRAMD2B
GRAMD4	GREM1	GRINA	GRWD1	GSAP	GSE1	GSG1	GSKIP
GSTCD	GTDC1	GTF2I	GTPBP1	GTPBP4	GTPBP8	GULP1	GXYLT1
GXYLT2	GZF1	H6PD	HAGHL	HAPLN3	HASPIN	HAX1	HCFC2
HDDC2	HDDC3	HDGFL2	HDHD2	HEATR3	HEATR5B	HEATR6	HECA
HECTD4	HEG1	HELLS	HELZ	HERPUD2	HES2	HES4	HES6
HES7	HEXD	HEXIM1	HGH1	HIGD2A	HINFP	HINT3	HIPK3
HIRIP3	HIVEP2	HMGN3	HMGN4	HMGXB3	HMGXB4	HNRNPA1L2	HNRNPAB
HNRNPH3	HNRNPU2	HOPX	HOXA5	HOXB5	HOXB7	HOXC8	HP1BP3
HPCAL1	HPF1	HPS3	HPS5	HPS6	HR	HRCT1	HROB
HS1BP3	HSBP1L1	HSD11B1L	HSDL1	HSDL2	HSPB6	HSPB7	HSPBAP1
HUNK	HYLS1	IAH1	IBA57	IDNK	IER2	IER3IP1	IER5
IER5L	IFFO1	IFI27L2	IFI44L	IFITM10	IFNE	IFRD2	IGIP
IGSF10	IGSF8	IK	IKZF2	ILF3	ILRUN	INA	INAFM1
INF2	ING1	INIP	INKA2	INSC	INSYN2B	INTS15	INVS
IPO11	IQCK	IQSEC1	IRAK1BP1	IRF2BPL	IRGQ	ITFG1	ITGB1BP1
ITGB1BP2	ITM2C	ITPRIP	ITPRIPL1	ITPRIPL2	IVNS1ABP	JAZF1	JCAD
JDP2	JHY	JKAMP	JPH2	JPT1	JPT2	KANK3	KANSL1L
KATNA1	KATNAL1	KATNB1	KATNBL1	KAZALD1	KBTBD2	KCNJ5-AS1	KCNT2
KCTD10	KCTD12	KCTD16	KCTD2	KCTD20	KCTD21	KCTD4	KCTD5
KCTD8	KHDC4	KHNYN	KIAA0232	KIAA0319L	KIAA0513	KIAA0753	KIAA0895L
KIAA0930	KIAA1109	KIAA1191	KIAA1328	KIAA1522	KIAA1549L	KIAA1755	KIAA1958
KIAA2012	KIAA2026	KIFBP	KLF10	KLF11	KLF12	KLF13	KLF2
KLF3	KLF6	KLF7	KLF9	KLHDC10	KLHDC4	KLHDC8B	KLHL17
KLHL18	KLHL24	KLHL28	KLHL29	KLHL36	KLHL4	KLHL7	KNSTRN
KRI1	KRTAP4-12	KTI12	L3HYPDH	L3MBTL3	LACC1	LACTB	LANCL1
LAPTM4A	LARP4	LARP4B	LARP6	LASP1	LAYN	LBH	LCA5
LCOR	LCORL	LCTL	LDAF1	LDB2	LDB3	LDLRAD3	LDOC1
LENG8	LENG9	LEPROT	LETMD1	LGALS8	LHFPL6	LIMA1	LIMCH1
LINC02693	LITAF	LIX1L	LLPH	LMBR1L	LMNB2	LMNTD1	LMO4

LMTK2	LNP1	LNPK	LNX2	LOC100288637	LOC102723996	LOC102724250	LOC344065
LONP1	LPP	LPXN	LRATD1	LRBA	LRCH1	LRCH2	LRCH4
LRFN5	LRP11	LRP1B	LRP3	LRPAP1	LRRC15	LRRC17	LRRC2
LRRC20	LRRC27	LRRC3	LRRC42	LRRC47	LRRC56	LRRC57	LRRC58
LRRC59	LRRC66	LRRC73	LRRFIP2	LRRIQ1	LRRN1	LRRN3	LRWD1
LSM14B	LUC7L	LUC7L2	LUC7L3	LURAP1L	LUZP1	LUZP2	LXN
LY6G5C	LYAR	LYNX1	LYPD6	LYRM1	LYRM7	LYSMD1	LYSMD2
LYSMD3	LYSMD4	LYST	LZIC	LZTS2	LZTS3	MAB21L2	MACIR
MACROH2A1	MAGEF1	MAGEH1	MAGEL2	MAGI1	MAGI3	MAK16	MAL2
MALL	MALSU1	MAMDC2	MAMSTR	MANBAL	MAP1A	MAP1B	MAP1S
MAP3K10	MAP3K12	MAP3K2	MAP3K20	MAP3K4	MAP3K6	MAP3K7CL	MAP4
MAP4K2	MAP4K3	MAP4K5	MAP6D1	MAP7	MAP7D3	MAPK1IP1L	MAPK8IP3
MAPRE2	MARCHF3	MARCHF4	MARCHF5	MARCHF8	MARCHF9	MARCKSL1	MARVELD2
MAST2	MAST4	MATN2	MB21D2	MBLAC2	MBNL1	MBTD1	MCC
MCM3AP	MCMBP	MCRIP1	MCTP1	MCTP2	MCUR1	MDFIC	MDN1
MEAK7	MED12L	MEDAG	MEGF8	MEGF9	MEIS2	MEIS3	MELK
MEPCE	MEST	METAP1D	METRNL	METRNL	METTL13	METTL15	METTL23
METTL25	METTL25B	METTL27	METTL2A	METTL2B	METTL5	METTL7B	METTL8
METTL9	MEX3A	MEX3D	MFAP1	MFF	MFHAS1	MFSD1	MFSD11
MFSD12	MFSD14A	MFSD14B	MFSD5	MFSD8	MFSD9	MGARP	MICAL2
MICAL3	MICALL1	MICALL2	MIDEAS	MIDN	MIEF1	MIEN1	MIER1
MIER3	MIIP	MINDY1	MINDY2	MINDY3	MIPEP	MIR1915HG	MIX23
MKI67	MKNK2	MKRN2	MLF2	MLLT10	MLLT11	MLLT6	MLPH
MLXIP	MMS22L	MNS1	MNT	MOAP1	MOB2	MOB3A	MOB4
MOK	MORC3	MORC4	MORN4	MOSMO	MOSPD1	MOSPD3	MOXD1
MPHOSPH8	MPLKIP	MPP4	MPPE1	MPV17L2	MPZL1	MR1	MREG
MRFAP1	MRFAP1L1	MRGPRF	MRNIP	MROH1	MROH6	MRTFB	MRTO4
MSANTD2	MSANTD3	MSANTD4	MSC	MSS51	MSTO1	MTBP	MTCH1
MTCH2	MTCL1	MTFR1	MTFR2	MTPN	MTSS1	MTSS2	MTURN
MTUS1	MTX3	MXD3	MXI1	MXRA5	MXRA7	MYADM	MYCBP
MYCT1	MYEF2	MYEOV	MYG1	MYH15	MYLK2	MYO15B	MYO1B
MYO1D	MYO1E	MYO1F	MYOCD	MYOF	MYORG	MYPN	MYPOP
MYRF	MZF1	N4BP2	N4BP2L1	NAA15	NAA20	NAA25	NAA40
NAA60	NAA80	NAALADL2	NACAD	NACC2	NAGA	NALF1	NAP1L4
NAP1L5	NASP	NAT14	NATD1	NAV1	NAV2	NAV3	NBEAL1
NBL1	NBPF12	NBPF14	NBPF15	NBPF26	NCAM2	NCBP2AS2	NCBP3
NCDN	NCKAP5	NCKAP5L	NCOA4	NCOA5	NCOA7	NCS1	ND4L
NDFIP1	NDRG3	NDRG4	NECAB1	NECAB3	NEDD9	NEFH	NEK1
NEK10	NEK4	NEMF	NEMP2	NETO1	NEURL4	NEXN	NFAT5
NFATC2IP	NFATC4	NFE2L1	NFE2L3	NFKBIZ	NFX1	NFXL1	NGRN
NHLRC4	NHSL2	NIBAN1	NIBAN3	NIM1K	NIN	NINJ1	NIPSNAP1
NIPSNAP3A	NKAP	NKD1	NKD2	NKRF	NKTR	NKX3-1	NLRP10
NMD3	NME6	NNAT	NOA1	NOC3L	NOL10	NOL7	NOLC1
NOMO1	NONO	NOP53	NOP9	NOS1AP	NOTCH2NLA	NPAS3	NPAT
NPIPB11	NPM3	NPR3	NPTX1	NREP	NRIP3	NRK	NRM
NRRROS	NRSN2	NSG1	NSMF	NSUN3	NT5DC2	NT5DC3	NTAQ1
NTMT1	NUAK2	NUCB2	NUCKS1	NUCDC1	NUDT22	NUFIP2	NUPR1
NUSAP1	NVL	NXN	NXNL2	NXPE3	OAF	OARD1	OBSCN-AS1
OCEL1	OCIAD1	ODAD2	ODF2L	ODR4	OGA	OGFOD1	OGFOD3
OGFR	OGFRL1	OLFM2	OPA3	ORA13	OSBP2	OSCP1	OSER1
OSGIN1	OSGIN2	OSR1	OSR2	OST4	OSTC	OTUD1	OTUD6B

OTULINL	OVCH1	OXLD1	OXNAD1	OXR1	OXSR1	P4HTM	PABIR1
PABIR2	PABPC3	PABPC4	PABPC4L	PACC1	PACS2	PALM3	PALS2
PAM	PAMR1	PAPOLG	PAQR5	PAQR7	PARD3B	PARM1	PARP11
PARP12	PARP3	PARPBP	PASK	PAWR	PAXBP1	PAXX	PBK
PBLD	PBX2	PBX4	PBXIP1	PCDH10	PCDH18	PCDH19	PCDH9
PCDHA4	PCDHA7	PCDHB10	PCDHB11	PCDHB12	PCDHB13	PCDHB14	PCDHB15
PCDHB16	PCDHB2	PCDHB3	PCDHB5	PCDHB7	PCDHB8	PCDHB9	PCDHGA1
PCDHGA10	PCDHGA2	PCDHGA3	PCDHGA4	PCDHGA5	PCDHGA6	PCDHGA7	PCDHGB1
PCDHGB2	PCDHGB3	PCDHGB4	PCDHGB5	PCDHGB6	PCDHGB7	PCDHGC3	PCDHGC5
PCGF1	PCGF3	PCID2	PCMTD1	PCMTD2	PCNX1	PCNX2	PCNX3
PCNX4	PCYOX1	PDCD10	PDCD5	PDCD6	PDE4DIP	PDGFRL	PDIA4
PDLIM1	PDLIM2	PDLIM3	PDLIM4	PDRG1	PDXDC1	PDZD2	PDZD8
PDZK1	PDZRN3	PEAR1	PEDS1	PEF1	PEG10	PEPD	PGAP2
PGAP4	PGAP6	PGBD1	PGBD2	PGGT1B	PGM5	PGPEP1	PHACTR4
PHAF1	PHETA1	PHETA2	PHEX	PHF10	PHF11	PHF12	PHF14
PHF20L1	PHF23	PHF6	PHLDA3	PHLDB1	PHLDB2	PHLDB3	PHPT1
PHRF1	PHTF1	PHYHD1	PIBF1	PIEZO2	PIFO	PIK3IP1	PIM3
PIMREG	PITHD1	PITPNC1	PITX1	PKD1L1	PKDCC	PKIA	PKIG
PKNOX2	PLAA	PLAC9	PLAG1	PLBD2	PLCXD1	PLCXD2	PLEKHB2
PLEKHF2	PLEKHH2	PLEKHM1	PLEKHM2	PLEKHO1	PLLP	PLP2	PLPBP
PLPP7	PLS3	PLSCR1	PLSCR4	PLXDC2	PLXNB2	PM20D2	PMEL
PNISR	PNKD	PNMA1	PNMA8A	PNN	PNRC1	POC1A	PODN
POGK	POGLUT2	POGLUT3	POLDIP2	POLR2M	POMP	POSTN	POTEF
POU6F1	PPDPF	PPM1G	PPM1H	PPM1J	PPM1M	PPP1R10	PPP1R11
PPP1R12C	PPP1R15B	PPP1R18	PPP1R2	PPP1R26	PPP1R8	PPP1R9B	PPP2R3A
PPP2R3C	PPP4R1	PPP4R3A	PPP4R3B	PPP4R4	PPTC7	PRADC1	PRAF2
PRDM2	PRDM6	PRDM8	PRELID2	PRELID3B	PREPL	PRICKLE2	PRICKLE3
PRIMPOL	PROSER2	PROX1	PRPF39	PRPF40B	PRPF4B	PRPSAP1	PRR12
PRR14L	PRR16	PRRC1	PRRC2A	PRRC2C	PRRG1	PRRT2	PRRT3
PRRX1	PRRX2	PRSS12	PRSS22	PRSS35	PRTFDC1	PRUNE1	PRUNE2
PRXL2A	PRXL2C	PSD3	PSKH1	PSMG1	PSRC1	PSTPIP2	PTBP2
PTBP3	PTCD2	PTCHD4	PTGES3L	PTGFRN	PTGR3	PTK7	PTMA
PTMS	PTOV1	PTP4A1	PTPN21	PTPRE	PTPRG	PTPRH	PTPRM
PTPRQ	PURA	PURB	PURG	PUS7L	PWWP2A	PWWP3A	PWWP3B
PXDC1	PXYLP1	PYM1	PYROXD2	QRS1L	QSER1	QSOX2	R3HCC1
R3HCC1L	R3HDM1	RAB11FIP1	RAB11FIP4	RAB11FIP5	RAB5IF	RABGAP1L	RABIF
RABL2A	RABL2B	RABL3	RABL6	RAD54B	RAD54L2	RAI14	RALGPS2
RALY	RAMAC	RANBP3	RANBP6	RAP2A	RAPH1	RASL10B	RASL11B
RASSF1	RASSF2	RASSF3	RASSF5	RASSF7	RASSF8	RAVER2	RBAK
RBFA	RBM15B	RBM18	RBM19	RBM27	RBM3	RBM41	RBM48
RBM4B	RBM6	RBM7	RBMS1	RBMS3	RBMXL1	RBPMS	RBPMS2
RC3H1	RC3H2	RCAN1	RCAN2	RCBTB2	RCCD1	RCN2	RCN3
RECQL4	REEP2	REEP5	RELCH	RELL1	RELT	REPIN1	RERE
RESF1	RETREG2	RETREG3	REXO2	REXO4	REXO5	RFLNB	RFTN1
RFTN2	RFWD3	RFX2	RFX3	RFX5	RFXANK	RFXAP	RHBDD1
RHBDD2	RHBDD3	RHBDL2	RIC8A	RILPL2	RIMOC1	RIOX1	RIPOR3
RITA1	RMDN2	RMND5A	RMND5B	RNASEH2A	RNASEH2B	RNASEH2C	RNF10
RNF11	RNF122	RNF141	RNF145	RNF150	RNF167	RNF169	RNF187
RNF215	RNF24	RNF26	RNF44	RNH1	ROBO4	ROGDI	ROMO1
RPAIN	RPF1	RPF2	RPGR	RPL7L1	RPS6KC1	RPUSD1	RPUSD3
RRP12	RRP15	RRP1B	RSBN1	RSL1D1	RSPRY1	RSRC2	RSRP1

RTKN2	RTL3	RTL8A	RTL8B	RTL8C	RTN4IP1	RUFY2	RUSC1
RUSC2	RWDD1	RWDD2A	RWDD4	S100A13	S100A16	S100A2	S100A4
S100A6	S100PBP	SAAL1	SACS	SALL2	SAMD1	SAMD10	SAMD11
SAMD12	SAMD14	SAMD4B	SAMD5	SANBR	SAPCD2	SAR1A	SARAF
SART3	SASS6	SAYSD1	SBDS	SBNO1	SBNO2	SBSN	SCAF1
SCAF4	SCAF8	SCAMP2	SCAMP3	SCAMP4	SCAMP5	SCAND1	SCARA3
SCG5	SCML2	SCPEP1	SCRN1	SCRN3	SCYL2	SCYL3	SDAD1
SDE2	SDF2	SDF2L1	SDF4	SEC14L1	SEC14L2	SEC23B	SEC62
SEC63	SECISBP2L	SECTM1	SEL1L3	SELENBP1	SELENOF	SELENOH	SELENOK
SELENON	SELENOT	SELENOW	SEMA3B	SEMA3C	SEMA3D	SEMA3F	SEMA4B
SEMA4C	SEMA6B	SEMA6C	SEPHS1	SEPTIN10	SEPTIN6	SEPTIN8	SEPTIN9
SERAC1	SERBP1	SERF1A	SERPINB7	SERTAD1	SERTAD2	SERTAD3	SESTD1
SETD5	SETX	SEZ6L2	SFMBT1	SFMBT2	SFSWAP	SFT2D1	SFT2D2
SFXN1	SFXN2	SFXN3	SFXN4	SFXN5	SGCD	SGCE	SGSM3
SGTB	SH2D4A	SH2D5	SH3BGRL	SH3BGRL3	SH3BP5L	SH3D21	SH3GLB1
SH3RF2	SH3RF3	SH3TC1	SH3TC2	SHCBP1	SHFL	SHISA2	SHISA7
SHLD2	SHROOM2	SHROOM3	SHROOM4	SIAE	SIK2	SIK3	SIM2
SIMC1	SINHCAF	SIPA1L2	SIX1	SIX5	SKA3	SKIDA1	SLC10A3
SLC12A8	SLC16A12	SLC16A14	SLC16A6	SLC17A9	SLC25A23	SLC25A24	SLC25A25
SLC25A3	SLC25A30	SLC25A36	SLC25A38	SLC25A39	SLC25A43	SLC25A46	SLC25A51
SLC2A4RG	SLC30A4	SLC35A4	SLC35B1	SLC35C2	SLC35E1	SLC35E2A	SLC35E2B
SLC35F1	SLC35F3	SLC35F5	SLC35F6	SLC35G6	SLC38A10	SLC38A6	SLC38A7
SLC39A11	SLC39A13	SLC39A9	SLC41A3	SLC48A1	SLC49A4	SLC4A11	SLC66A2
SLC6A16	SLC7A14	SLC7A6OS	SLC9A3R2	SLF1	SLF2	SLFN11	SLFN13
SLFN5	SLIRP	SLMAP	SLX9	SMAGP	SMAP1	SMARCAD1	SMARCAL1
SMCHD1	SMCO4	SMCR8	SMIM10	SMIM12	SMIM13	SMIM14	SMIM15
SMIM19	SMIM26	SMIM29	SMIM3	SMIM7	SMOC1	SMPDL3A	SMTN
SMYD5	SNAP47	SNCG	SNHG32	SNIP1	SNN	SNPH	SNRK
SNTB1	SNTB2	SNX13	SNX14	SNX16	SNX19	SNX24	SNX27
SNX29	SNX33	SNX7	SNX8	SOBP	SON	SOX11	SOX12
SOX5	SP140L	SP2	SP6	SPACA9	SPAG1	SPAG16	SPAG5
SPART	SPATA18	SPATA2L	SPATA33	SPATA4	SPATA5L1	SPATA6	SPATA7
SPATC1L	SPATS2	SPATS2L	SPECC1L	SPEF2	SPEG	SPG21	SPICE1
SPINDOC	SPIRE1	SPIRE2	SPOCD1	SPOCK1	SPPL3	SPRING1	SPRY4
SPRYD3	SRBD1	SRCAP	SREK1IP1	SRGAP2C	SRPX	SRPX2	SRRM3
SRSF8	SS18	SS18L1	SSBP2	SSBP4	SSH2	SSPN	SSX2IP
STAU1	STAU2	STC1	STEAP1	STEAP1B	STIL	STIM2	STK17A
STK17B	STK19	STK25	STK32B	STK36	STK38L	STK40	STMN3
STOML1	STOX2	STPG1	STRIP2	STT3B	STX2	STXBP5	STXBP6
STYK1	STYX	STYXL1	SUB1	SUCO	SUGCT	SULF1	SULF2
SUPV3L1	SUSD1	SUSD2	SUSD4	SUSD5	SUSD6	SVEP1	SVIL
SWT1	SYBU	SYNC	SYNE3	SYNM	SYNPO	SYNPO2	SYNPO2L
SYNRG	SYPL1	SYPL2	SYT14	SYTL2	SYTL5	SZRD1	TACC1
TACC2	TAFA3	TAGLN	TAGLN3	TAMALIN	TANC1	TANC2	TANGO6
TAOK2	TAPT1	TARBP1	TARDBP	TARS3	TASOR	TASOR2	TATDN3
TBC1D19	TBC1D22A	TBC1D23	TBC1D2B	TBC1D31	TBC1D8	TBC1D9B	TBCCD1
TBCEL	TBCK	TBPL1	TBRG1	TBX2	TBX3	TCAF2	TCAIM
TCEA2	TCEA3	TCEAL3	TCEAL4	TCEAL7	TCEAL8	TCEAL9	TCERG1
TCF19	TCF21	TCHP	TCIM	TCOF1	TCP11L1	TCP11L2	TDRP
TECPR1	TECPR2	TEDC1	TEDC2	TEKT3	TEKTIP1	TELO2	TENM1
TENM3	TENM4	TENT2	TENT5A	TENT5B	TENT5C	TESK2	TESMIN

TFCP2	TFEB	TFPI2	TG	TGFBR3	TGM2	THAP12	THAP3
THAP4	THAP5	THEMIS2	TICRR	TIE1	TIGD2	TIGD5	TIGD7
TIPARP	TIPRL	TLCD2	TLCD3A	TLCD5	TLK2	TLNRD1	TM2D1
TM4SF1	TM6SF1	TM7SF3	TM9SF1	TM9SF2	TM9SF3	TM9SF4	TMBIM4
TMBIM6	TMC5	TMC7	TMCC1	TMCC2	TMCO1	TMCO3	TMCO4
TMC06	TMED1	TMED4	TMEFF2	TMEM101	TMEM106A	TMEM106B	TMEM106C
TMEM109	TMEM117	TMEM119	TMEM120B	TMEM121B	TMEM123	TMEM127	TMEM130
TMEM131	TMEM132B	TMEM134	TMEM140	TMEM147	TMEM14A	TMEM14B	TMEM14C
TMEM150A	TMEM154	TMEM156	TMEM158	TMEM161B	TMEM164	TMEM165	TMEM167A
TMEM167B	TMEM168	TMEM17	TMEM171	TMEM177	TMEM18	TMEM181	TMEM184B
TMEM185A	TMEM19	TMEM192	TMEM198	TMEM199	TMEM200A	TMEM200B	TMEM200C
TMEM203	TMEM204	TMEM205	TMEM214	TMEM222	TMEM231	TMEM237	TMEM242
TMEM243	TMEM245	TMEM250	TMEM251	TMEM255B	TMEM258	TMEM259	TMEM26
TMEM260	TMEM263	TMEM267	TMEM33	TMEM35A	TMEM38B	TMEM42	TMEM43
TMEM44	TMEM45A	TMEM47	TMEM50A	TMEM50B	TMEM51	TMEM54	TMEM60
TMEM63B	TMEM64	TMEM65	TMEM68	TMEM69	TMEM70	TMEM71	TMEM86A
TMEM88	TMEM8B	TMEM94	TMEM98	TMEM9B	TMPPE	TMSB10	TMSB15A
TMTC1	TMTC2	TMTC3	TMX1	TNFRSF19	TNK1	TNK2	TNPO2
TNRC18	TNS1	TNS2	TOB1	TOB2	TOGARAM1	TOM1L1	TOM1L2
TOMM40L	TONSL	TOX	TOX2	TOX4	TP53I11	TP53I13	TP53INP2
TPBG	TPRA1	TPRG1L	TRA2A	TRABD2A	TRAF3IP2	TRAF4	TRAF5
TRAFD1	TRAM2	TRAPPC14	TRERF1	TRHDE	TRIB2	TRIM16	TRIM23
TRIM44	TRIM47	TRIM55	TRIM59	TRIM65	TRIP13	TRIP4	TRIP6
TRMO	TRMT2B	TROAP	TRPS1	TSC22D2	TSHZ2	TSNARE1	TSPAN11
TSPAN12	TSPAN13	TSPAN18	TSPAN19	TSPAN3	TSPAN4	TSPAN6	TSPAN9
TSPYL1	TSTD2	TTC1	TTC12	TTC13	TTC14	TTC17	TTC19
TTC21A	TTC23	TTC27	TTC28	TTC29	TTC3	TTC4	TTC7A
TTC7B	TTC9C	TTF2	TTI1	TTK	TUB	TUBE1	TUFT1
TUSC1	TWSG1	TXND11	TXND12	TXND15	TXND16	TYRO3	UAP1L1
UBAC2	UBALD1	UBALD2	UBAP2	UBAP2L	UBASH3B	UBE4B	UBFD1
UBL3	UBL5	UBLCP1	UBR3	UBR5	UBR7	UBTD1	UBXN2A
UBXN2B	UBXN4	UBXN6	UEVLD	UFC1	UFM1	UFSP2	UHRF1BP1
ULK2	UNC13A	UNC13C	UNC45A	UNC50	UPRT	UQCC2	UQCC3
URI1	USB1	USP32	USP36	USP38	USP40	USP53	USPL1
UTP23	VAMP5	VASN	VAT1L	VEPH1	VEZF1	VEZT	VGLL3
VIRMA	VMA21	VMP1	VN1R1	VPS13A	VPS13B	VPS13C	VPS13D
VPS26B	VPS26C	VPS50	VPS8	VPS9D1	VSIG10	VSIG10L	VSIR
VSTM2L	VSTM4	VSTM5	VWA5A	VWCE	WASHC2A	WASHC2C	WASHC3
WASHC4	WASHC5	WBP2	WDFY1	WDFY2	WDFY3	WDHD1	WDR13
WDR26	WDR27	WDR37	WDR47	WDR62	WDR7	WDR76	WDR83OS
WFDC1	WIZ	WRNIP1	WWC2	WWC3	XIRP1	XKR5	XKR8
XKRX	XPNPEP3	XPO4	XPO7	XRRA1	YBX3	YIF1B	YIPF1
YIPF2	YIPF3	YIPF4	YJU2B	YPEL1	YPEL2	YPEL3	YRDC
YTHDF2	YTHDF3	YY1AP1	ZACN	ZBED3	ZBED4	ZBED6	ZBED8
ZBTB1	ZBTB10	ZBTB18	ZBTB2	ZBTB21	ZBTB22	ZBTB25	ZBTB33
ZBTB34	ZBTB37	ZBTB38	ZBTB39	ZBTB4	ZBTB41	ZBTB42	ZBTB44
ZBTB45	ZBTB46	ZBTB6	ZBTB7A	ZBTB7B	ZC2HC1A	ZC3H10	ZC3H12A
ZC3H13	ZC3H14	ZC3H3	ZC3H7B	ZC3HAV1L	ZC4H2	ZCCHC10	ZCCHC12
ZCCHC14	ZCCHC17	ZCCHC2	ZCCHC3	ZCCHC4	ZCCHC8	ZDBF2	ZDHHC1
ZDHHC16	ZDHHC17	ZDHHC18	ZDHHC4	ZEB2	ZER1	ZFAND1	ZFAND2A
ZFAND3	ZFAND5	ZFC3H1	ZFHX2	ZFHX4	ZFP3	ZFP36L2	ZFP41

ZFP64	ZFP82	ZFR	ZFTA	ZFYVE1	ZFYVE19	ZFYVE21	ZFYVE26
ZFYVE27	ZGRF1	ZHX1	ZHX3	ZKSCAN2	ZMAT2	ZMAT3	ZMIZ2
ZMYM3	ZMYM4	ZNF106	ZNF117	ZNF121	ZNF132	ZNF134	ZNF146
ZNF148	ZNF207	ZNF219	ZNF229	ZNF232	ZNF239	ZNF251	ZNF260
ZNF276	ZNF277	ZNF280C	ZNF281	ZNF283	ZNF286B	ZNF292	ZNF316
ZNF318	ZNF32	ZNF322	ZNF330	ZNF346	ZNF358	ZNF365	ZNF367
ZNF385D	ZNF395	ZNF397	ZNF404	ZNF423	ZNF428	ZNF438	ZNF44
ZNF469	ZNF48	ZNF503	ZNF507	ZNF512	ZNF513	ZNF516	ZNF518A
ZNF518B	ZNF532	ZNF575	ZNF576	ZNF578	ZNF580	ZNF581	ZNF587B
ZNF598	ZNF608	ZNF609	ZNF618	ZNF622	ZNF629	ZNF639	ZNF644
ZNF646	ZNF654	ZNF69	ZNF695	ZNF7	ZNF765	ZNF766	ZNF780B
ZNF783	ZNF787	ZNF8	ZNF804A	ZNF808	ZNF81	ZNF814	ZNF816
ZNF827	ZNF83	ZNF836	ZNF84	ZNF841	ZNF844	ZNF850	ZNF862
ZNF880	ZNF93	ZNFX1	ZNHIT1	ZNHIT3	ZRANB2	ZRANB3	ZSCAN12
ZSCAN18	ZSCAN2	ZSCAN22	ZSCAN29	ZSCAN30	ZSCAN9	ZSWIM1	ZSWIM4
ZSWIM5	ZSWIM6	ZUP1	ZXDC	ZYG11A			