Supplemental Material to:

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Lim Seng Gee, Henry Yang, Leah A Vardy

RPL39L is an example of a recently evolved
ribosomal protein paralog that shows highly
specific tissue expression patterns and is upregulated
in ESCs and HCC tumors

Supplementary Figure Legends.

Supplementary figure 1. Protein sequence alignment of full length mammalian RPL39L and RPL39. A conserved R to Q amino acid change is observed among all the mammalian RPL39L shown compared to the RPL39. The corresponding residues are highlighted in yellow. Asterisks represent identical amino acid residue between 2 proteins, and colons represent similarity. Dots mean that semi-conserved substitutions are observed. All sequences were retrieved from either NCBI or Ensembl.

Supplementary figure 2. Expression variation of the 2 clusters of ribosomal protein genes across different human tissues. The 89 ribosomal protein mRNAs were categorized into 2 clusters, corresponding to stably or heterogeneously expressed groups, as suggested by hierarchical clustering. Boxplots show the 2nd and 3rd quartiles with the median of expression variations and the whiskers show the maximum and minimum values.

Supplementary figure 3. Protein sequence alignment of human RPs and their paralogs. The 8 human RPs (RPL10, RPL22, RPL26, RPL36A, RPS27, RPL7, RPL30 and RPL39) show high sequence similarity with their paralogs. The protein sequence similarities are shown. Asterisks represent identical amino acid residue between 2 proteins, and colons represent similarity. Dots mean that semi-conserved substitutions are observed. All protein sequences were retrieved from either NCBI or UCSC human genome browser.

Supplementary figure 4. Similarity analysis for promoter sequences of original RPs and their paralogs across different species. Boxplots show the 2nd and 3rd quartiles with the median and the whiskers show the maximum and minimum values. Open circles represent outliers.

Supplmentary Table 1. RPKM-normalized RNA-seq data of RP transcripts, housekeeping genes and pluripotency markers in ESCs and NPCs.

Supplementary Table 2. Normalised expression levels (log2) of all RPs analysed by qRT-PCR across 22 different tissues.

Supplementary Table 3. Evolutionary stage and expression variation of ribosomal protein mRNAs examined.

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Supplementary Table 3. Evolutionary stage and expression variation of ribosomal protein mRNAs examined.

```
Rat.RPL39L        -MASHKTFRIKRFLAKKQKQNRPIPQWIQMKTGNKIMYNSKRRHWRRTKLGL----- 51
Mouse.RPL39L      -MASHKTFRIKRFLAKKQKQNRPIPQWIQMKTGNKIMYNSKRRHWRRTKLGL----- 51
Microbat.RPL39L   -MSSHKIFRIRRFLAKKQKQNWPIPQWIQMKTGNKISYNSKRRHWRRTKLGL----- 51
Human.RPL39L      -MSSHKTFTIKRFLAKKQKQNRPIPQWIQMKPGSKIRYNSKRRHWRRTKLGL----- 51
Chimpanzee.RPL39L -MSSHKTFTIKRFLAKKQKQNRPIPQWIQMKPGSKIRSNSKRRHWRRTKLGL----- 51
Orangutan.RPL39L  -MSSHKTFTIKRFLAKKQKQNRPIPQWIQMKPGNKIRHNSKRRHWRRTKLGL----- 51
Macaque.RPL39L    -MSSHKTFTIKRFLAKKQKQNRPIPQWIQMKPGNKIRYNSKRRHWRRTKLGL----- 51
Gorilla.RPL39L    -MSSHKTFTIKRFLAKKQKQNRPIPQWIQMKPGNKIRYNSKRRHWRRTKLGL----- 51
Marmoset.RPL39L   -MSSHKTFIIKRFLAKKQKQNRPIPQWIQMKTGNKIRYNSKRRHWRRTKLGL----- 51
Elephant.RPL39L   -MSSHKTFKIKRFLAKKQKQNRPIPQWIQMKTGNKIRYNAKRRHWRRTKLGL----- 51

Marmoset.RPL39    -MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLGL----- 51
Microbat.RPL39    TMSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLGL----- 52
Macaque.RPL39     -MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLGL----- 51
Elephant.RPL39    -MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLGL----- 51
Orangutan.RPL39   -MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLG------ 50
Gorilla.RPL39     -MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLG------ 50
Rat.RPL39         -MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLG------ 50
Mouse.RPL39       -MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLG------ 50
Human.RPL39       -MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLG------ 50
Chimpanzee.RPL39  -MSSHKTFRIKRFLAKKQKQNRHIPQWIRMKTGNKS-VQLQKETLEKNQAGSIRNCT 55
                   *:*** * *:********** *****:**.*.*   : ::.  .:.: *
```

Supplementary figure 1. Protein sequence alignment of full length mammalian RPL39L and RPL39.

$p<0.0001***$

Stably-expressed gene cluster

Heterogeneously-expressed gene cluster
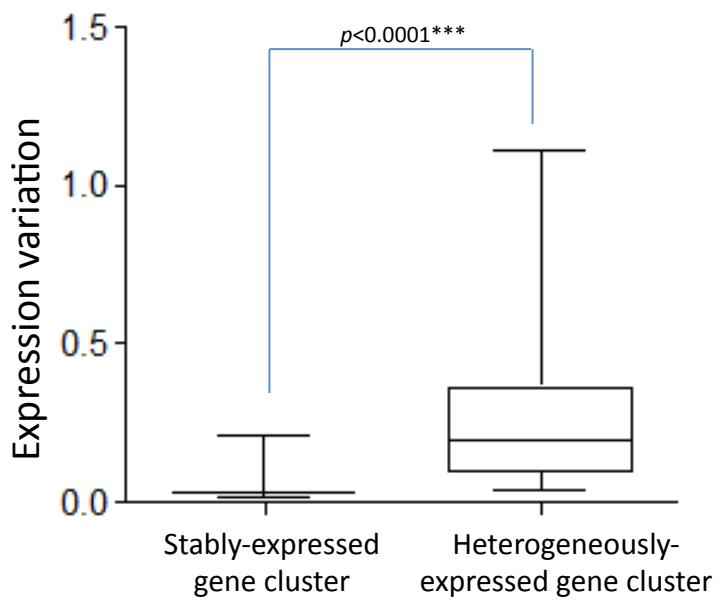
Supplementary figure 2. Expression variation of the 2 clusters of ribosomal protein genes across different human tissues.

A) **RPL10 and paralog (56.60%)**

```
RPL10     MGRRPARCYRYCKNKPYPKSRFCRGVPDAKIRIFDLGRKKAKVDEFPLCGHMVSDEYEQL 60
RPL10L    MGRRPARCYRYCKNKPYPKSRFCRGVPDAKIRIFDLGRKKAKVDEFPLGGHMVSDEYEQL 60
          *********************************************** **********

RPL10     SSEALEAARICANKYMVKSCGKDGFHIRVRLHPFHVIRINKMLSCAGADRSTSQRSGASP 120
RPL10L    SSEALEAARICANKYMVKSCGRDGFHMRVRLHPFHVIRINKMLSCAGADRLQTGMRGAFG 120
          *********************:****:*************************:     **

RPL10     SSMLMNLKTWWLKSGSSQMAVGSSTSPIVALWTSGGPCTHEGFQCAAPLLILTNK-FYFL 179
RPL10L    KPQGTVAR---VHIGQVIMSIRTKLQNEEHVIEALRRAKFK-FPGRQKIHISKKWGFTKF 176
          ..    :   ::*.*. *::*:..   : : ...:*    :*.:  * :

RPL10     STYVFVSTFLTGKELPLGT-FGSLPFHFRNRLTTQPCS 216
RPL10L    NADEFEDMVAKKCLIPDGCGVKYVPSHGPLDKWRVLHS 214
          .:  *  .  . :** . :* *         *
```

B) **RPL22 and paralog (73.77%)**

```
RPL22     MAPVKKLVVKGGKKKKQVLKFTLDCTHPVEDGIMDAANFEQFLQERIKVNGKAGNLGGGV 60
RPL22L    MAPQK-----DRKPKRSTWRFNLDLTHPVEDGIFDSGNFEQFLREKVKVNGKTGNLG-NV 54
          *** *     . * *:.. :*.** ********:*:. ******:*::*****:**** .*

RPL22     VTIERSKSKITVTSEVPFSKRYLKYLTKKYLKKNNLRDWLRVVANSKESYELRYFQINQD 120
RPL22L    VHIERFKNKITVVSEKQFSKRYLKYLTKKYLKKNNLRDWLRVVASDKETYELRYFQISQD 114
          * *** *.****.** **************************..**:********.**

RPL22     EEEEEDED 128
RPL22L    EDESESED 122
          *:*.*.**
```

C) **RPL26 and paralog (98.62%)**

```
RPL26     MKFNPFVTSDRSKNRKRHFNAPSHIRRKIMSSPLSKELRQKYNVRSMPIRKDDEVQVVRG 60
RPL26L1   MKFNPFVTSDRSKNRKRHFNAPSHVRRKIMSSPLSKELRQKYNVRSMPIRKDDEVQVVRG 60
          ***********************:************************************

RPL26     HYKGQQIGKVVQVYRKKYVIYIERVQREKANGTTVHVGIHPSKVVITRLKLDKDRKKILE 120
RPL26L1   HYKGQQIGKVVQVYRKKYVIYIERVQREKANGTTVHVGIHPSKVVITRLKLDKDRKKILE 120
          ************************************************************

RPL26     RKAKSRQVGKEKGKYKEETIEKMQE 145
RPL26L1   RKAKSRQVGKEKGKYKEELIEKMQE 145
          ****************** ******
```

D) **RPL36A & paralog (99.06% for variant 1 & 84.29% for variant 2)**

```
RPL36Avar1   MIAPTDSHEEVRSGTSYILPFASRFLSFRADSAHASMVNVPKTRRTFCKKCGKHQPHKVT 60
RPL36AL      ----------------------------------MVNVPKTRRTFCKKCGKHQPHKVT 24
RPL36Avar2   MIAPTDSHEEVRSGTSYILPFASRFLSFRADSAHASMVNVPKTRRTFCKKCGKHQPHKVT 60
                                               ************************

RPL36Avar1   QYKKGKDSLYAQGKRRYDRKQSGYGGQTKPIFRKKAKTTKKIVLRLECVEPNCRSKRMLA 120
RPL36AL      QYKKGKDSLYAQGRRRYDRKQSGYGGQTKPIFRKKAKTTKKIVLRLECVEPNCRSKRMLA 84
RPL36Avar2   QYKKGKDSLYAQGKRRYDRKQSGYGGQTKPIFRKKVSGSYYLTF------PS-------- 106
             *************:******************** .. : :.:       *.

RPL36Avar1   IKRCKHFELGGDKKRKGQVIQF 142
RPL36AL      IKRCKHFELGGDKKRKGQVIQF 106
RPL36Avar2   ---------------------- 
```

E) RPS27 & paralog (96.43%)

```
RPS27        MPLAKDLLHPSPEEEKRKHKKKRLVQSPNSYFMDVKCPGCYKITTVFSHAQTVVLCVGCS 60
RPS27L       MPLARDLLHPSLEEEKKKHKKKRLVQSPNSYFMDVKCPGCYKITTVFSHAQTVVLCVGCS 60
             ****:******  ****:***********************************************

RPS27        TVLCQPTGGKARLTEGCSFRRKQH 84
RPS27L       TVLCQPTGGKARLTEGCSFRRKQH 84
             ************************
```

F) RPL7 & paralog (42.28%)

```
RPL7         MEGVEEKKKEVPAVPETLKKKRRNFAELKIKRLRKKFAQKMLRKARRKLIYEKAKHYHKE 60
RPL7L1       --MAEQEQRKIPLVPENLLKKRKAYQALKATQAKQALLAKKEQKKGKGLRFKRLESFLHD 58
               .*::::::* ***.* ***: :  ** .: ::  *  :*  : * ::: : ::

RPL7         YRQMYRTEIRMARMARKAGNFYVPAEPKLAFVIRIRGINGVSPKVRKVLQLLRLRQIFNG 120
RPL7L1       SWRQKRDKVRLRRLEVKPHALELPDKHSLAFVVRIERIDGVSLLVQRTIARLRLKKIFSG 118
               :  * ::*: *:  *.  : :* : .****:**. *:*** *::.:  ***::**.*

RPL7         TFVKLNKASINMLRIVEPYIAWGYPNLKSVNELIYKRGYGKINKKRIALTDNALIARSLG 180
RPL7L1       VFVKVTPQNLKMLRIVEPYVTWGFPNLKSVRELILKRGQAKVKNKTIPLTDNTVIEEHLG 178
             .***: .::*********::**:****** *** *** .*:::* *.****::* . **

RPL7         KYGIICMEDLIHEIYTVGKRFKEANNFLWPFKLSSPRGGMKKKTTHFVEGGDAGNREDQI 240
RPL7L1       KFGVICLEDLIHEIAFPGKHFQEISWFLCPFHLSVARHATKNRVGFLKEMGTPGYRGERI 238
             *:*:**:****** **:*:* . ** **:** .* . *::. .: * * .* * ::*

RPL7         NRLIRRMN 248
RPL7L1       NQLIRQLN 246
             *:***::*
```

G) RPL30 & paralog (85.09%)

```
RPL30                 --------------------------------------------------MVAAKKTKK 9
RPL30L(LOC100652953)  MAAFSELLADKSQDAPPVKMEVNPEFEEGHKRNGDITFLTPQPSWQLLLTGAIPTKEMKN 60
                                                                        :.:*: *:

RPL30                 SLESINSRLQLVMKSGKYVLGYKQTLKMIRQGKAKLVILANNCPALRKSEIEYYAMLAKT 69
RPL30L(LOC100652953)  SLESINYRLQL-MKSGKYMLGYKQTLKMIRQGTAKLVILAYNCPALRKSEVEYYAMLAKI 119
                      ****** **** ******:************* .******* ********:********

RPL30                 GVHHYSGNNIELGTACGKYYRVCTLAIIDPGDSDIIRSMPEQTGEK 115
RPL30L(LOC100652953)  GVHHYSGNNIELGTACGKYYRVCTLALTDPGDSAIIRSMPEQTGGK 165
                      **************************: ***** ********** *
```

H) RPL39 & paralog (92%)

```
RPL39        MSSHKTFRIKRFLAKKQKQNRPIPQWIRMKTGNKIRYNSKRRHWRRTKLG- 50
RPL39L       MSSHKTFTIKRFLAKKQKQNRPIPQWIQMKPGSKIRYNSKRRHWRRTKLGL 51
             ******* ********************:** .* .*************** 
```

Supplementary figure 3. Protein sequence alignment of human RP and their paralogs.
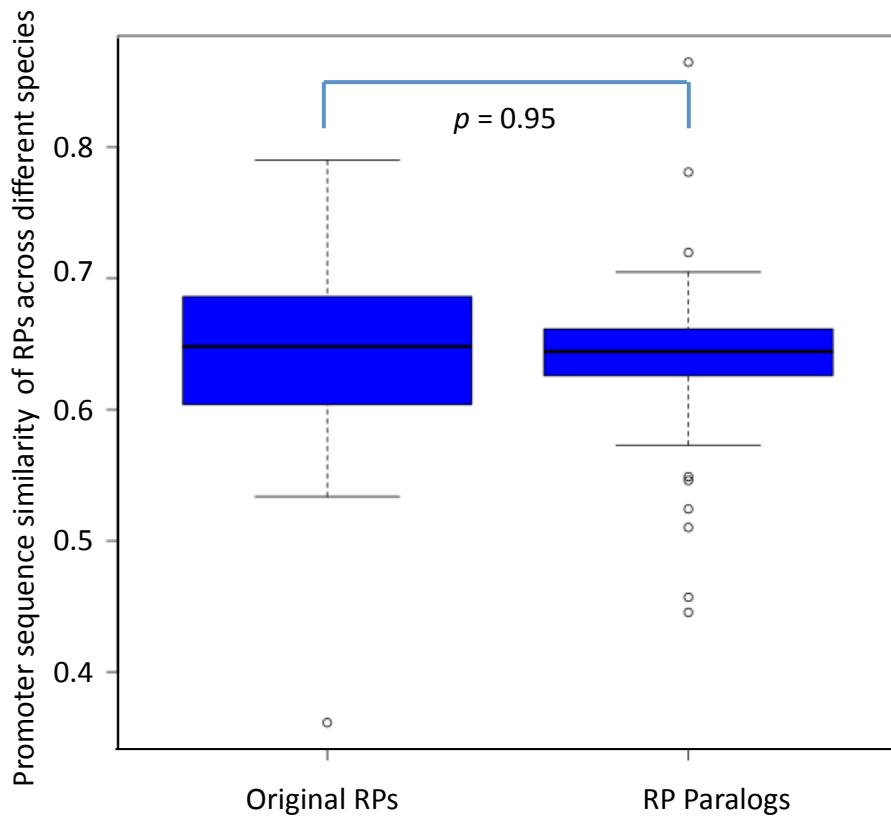
Supplementary figure 4. Similarity analysis for promoter sequences of original RPs and their paralogs across different species.

Supplementary Table 1. RPKM-normalized RNA-seq data of RP transcripts, housekeeping genes and pluripotency markers in ESCs and NPCs.

Transcript	Gene symbol	RPKM ESC	RPKM NPC	Fold change (ESC/NPC)	Log2 Fold Change
NM_001162933	Rpl10l	37.326	0.520	71.802	6.166
NM_026594	Rpl39l	25.981	1.759	14.774	3.885
NR_003634	Rps4y2	134.804	18.481	7.294	2.867
NM_001163945	Rpl3l	0.199	0.064	3.128	1.645
NM_001163485	Rpl30 var 2	15.608	5.220	2.990	1.580
NM_021338	Rpl35a var 1	21.685	8.844	2.452	1.294
NM_001252218	Rpl31 var 1	12.502	5.796	2.157	1.109
NM_207634	Rps24 var 2	288.779	137.845	2.095	1.067
NM_025433	Rpl7l1	67.512	33.537	2.013	1.009
NM_025589	Rpl36al	219.798	115.235	1.907	0.932
NM_025974	Rpl14	27.073	15.734	1.721	0.783
NM_009081	Rpl28	0.500	0.467	1.072	0.100
NM_001159483	Rpl19 var 2	128.304	80.651	1.591	0.670
NM_001033865	Rps27a var 2	62.768	42.565	1.475	0.560
NM_009083	Rpl30 var 1	13.613	9.010	1.511	0.595
NM_012053	Rpl8	400.377	265.989	1.505	0.590
NM_009438	Rpl13a	384.156	257.513	1.492	0.577
NM_019647	Rpl21	49.260	33.423	1.474	0.560
NM_023372	Rpl38 var 2	3.134	2.871	1.091	0.126
NM_026020	Rplp2	135.001	93.438	1.445	0.531
NM_001005859	Rpl34 var 2	46.358	34.235	1.354	0.437
NM_009095	Rps5	854.674	604.501	1.414	0.500
NM_025586	Rpl15	79.186	57.782	1.370	0.455
NM_011290	Rpl6	108.488	79.689	1.361	0.445
NM_011975	Rpl27a	30.589	22.577	1.355	0.438
NM_018853	Rplp1	621.147	462.672	1.343	0.425
NM_026069	Rpl37	162.325	122.444	1.326	0.407
NM_016959	Rps3a	83.523	63.582	1.314	0.394
NM_024175	Rps23	237.628	179.919	1.321	0.401
NM_029751	Rpl18a	134.547	103.398	1.301	0.380
NM_007475	Rplp0	301.216	235.447	1.279	0.355
NM_013725	Rps11	207.921	162.734	1.278	0.354
NM_011295	Rps12	82.526	64.816	1.273	0.349
NM_001130484	Rpl35a var 2	43.468	34.907	1.245	0.316
NM_009078	Rpl19 var 1	244.819	193.527	1.265	0.339
NM_013721	Rpl7a	136.836	108.534	1.261	0.334
NM_026533	Rps13	86.098	68.598	1.255	0.328
NM_024218	Rpl24	288.743	230.255	1.254	0.327
NM_011292	Rpl9	63.196	51.185	1.235	0.304
NM_009092	Rps17	358.679	290.494	1.235	0.304
NM_009077	Rpl18	43.613	35.801	1.218	0.285
NM_011289	Rpl27	105.292	85.931	1.225	0.293
NM_026724	Rpl34 var 1	8.949	7.237	1.237	0.306
NM_011287	Rpl10a	539.459	442.378	1.219	0.286
NM_009076	Rpl12	168.409	138.509	1.216	0.282
NM_009080	Rpl26	116.317	96.661	1.203	0.267
NM_016738	Rpl13	49.529	41.068	1.206	0.270
NM_025587	Rps21	232.528	193.540	1.201	0.265
NM_009093	Rps29	219.265	183.496	1.195	0.257
NM_026147	Rps20	457.655	387.402	1.181	0.240
NM_020600	Rps14	455.565	386.798	1.178	0.236

Supplementary Table 1 continued. RPKM-normalized RNA-seq data of RP transcripts, housekeeping genes and pluripotency markers in ESCs and NPCs.

NM_026467	Rps27l	212.252	180.917	1.173	0.230
NM_012052	Rps3	386.921	331.057	1.169	0.225
NM_009091	Rps15	537.714	463.228	1.161	0.215
NM_025919	Rpl11	76.003	66.217	1.148	0.199
NM_011029	Rpsa	67.131	58.555	1.146	0.197
NM_018730	Rpl36	110.682	96.844	1.143	0.193
NM_027015	Rps27 var 1	69.076	60.692	1.138	0.187
NM_011291	Rpl7	393.532	347.191	1.133	0.181
NM_029767	Rps9	657.147	587.831	1.118	0.161
NM_170669	Rps15a	35.648	32.176	1.108	0.148
NM_013647	Rps16	119.829	107.404	1.116	0.158
NM_011296	Rps18	56.816	51.273	1.108	0.148
NM_026517	Rpl22l1	188.587	172.381	1.094	0.130
NM_207523	Rpl23a	236.011	214.961	1.098	0.135
NM_024266	Rps25	69.465	63.387	1.096	0.132
NM_016980	Rpl5	184.700	170.722	1.082	0.114
NM_001048058	Rpl38 var 3	329.762	304.612	1.083	0.114
NM_008503	Rps2	115.204	106.457	1.082	0.114
NM_022891	Rpl23	591.187	552.643	1.070	0.097
NM_013762	Rpl3	221.973	207.303	1.071	0.099
NM_009096	Rps6	42.067	39.545	1.064	0.089
NM_009084	Rpl37a	42.482	39.961	1.063	0.088
NM_011300	Rps7	165.311	156.092	1.059	0.083
NM_025592	Rpl35	83.543	79.820	1.047	0.066
NM_016844	Rps28	35.643	34.406	1.036	0.051
NM_013765	Rps26	297.884	287.961	1.034	0.049
NM_024212	Rpl4	589.666	588.250	1.002	0.003
NM_025963	Rps10	134.537	136.081	0.989	-0.016
NM_009098	Rps8	92.300	93.471	0.987	-0.018
NM_009079	Rpl22	112.681	115.407	0.976	-0.034
NM_009094	Rps4x	103.883	107.649	0.965	-0.051
NM_023133	Rps19	63.113	65.477	0.964	-0.053
NM_009082	Rpl29	12.414	12.992	0.956	-0.066
NM_172086	Rpl32	1034.820	1087.300	0.952	-0.071
NM_018860	Rpl41	619.042	674.364	0.918	-0.123
NM_052835	Rpl10	9.585	10.562	0.908	-0.140
NM_019865	Rpl36a	3.998	4.524	0.884	-0.178
NM_001002239	Rpl17	118.102	135.805	0.870	-0.201
NM_024277	Rps27a var 1	291.456	351.353	0.830	-0.270
NM_053257	Rpl31 var 3	60.953	74.325	0.820	-0.286
NM_026055	Rpl39	201.707	254.678	0.792	-0.336
NM_207635	Rps24 var 3	1.394	1.872	0.744	-0.426
NM_001130485	Rpl35a var 3	28.846	40.156	0.718	-0.477
NM_001048057	Rpl38 var 1	26.343	41.638	0.633	-0.660
NR_033727	Rps27 var 2	2.427	3.656	0.664	-0.592
NM_001252219	Rpl31 var 2	2.683	5.112	0.525	-0.930
NM_011297	Rps24 var 1	24.324	89.461	0.272	-1.879
NM_008084	Gapdh	105.534	141.752	0.744	-0.426
NM_008907	Ppia	504.451	404.085	1.248	0.320
NM_011443	Sox2	52.890	24.876	2.126	1.088
NM_028016	Nanog	205.002	13.505	15.180	3.924
NM_013684	Tbp	10.217	8.654	1.181	0.240

Supplementary Table 2. Normalized expression levels (log2) of all RPs analyzed by qRT-PCR across 22 different tissues.

normalized expression level	Adipose	Bladder	Brain	Cervix	Colon	Esophagus	Heart	Kidney	Liver	Lung	Ovary
RPLP0	11.02	10.67	9.98	11.36	11.06	11.42	10.76	11.09	11.45	11.28	10.93
RPL2B	10.00	9.87	10.23	10.38	10.13	9.67	10.31	9.67	9.87	10.23	10.08
RPL3	10.64	10.59	10.89	11.05	10.61	10.62	9.58	10.58	10.47	10.64	11.48
RPL4	11.06	10.96	10.99	10.90	10.69	10.79	10.85	10.45	10.59	10.63	11.08
RPL5	10.34	10.59	10.19	10.33	10.82	10.08	10.21	10.11	9.83	10.14	10.66
RPL6	9.56	9.44	9.69	9.63	9.76	9.57	9.40	9.51	9.54	9.18	9.36
RPL6 var1	2.82	1.92	4.79	3.64	2.40	3.06	3.17	4.02	4.24	2.78	2.89
RPL7	10.42	10.47	10.28	10.15	10.56	10.04	10.23	10.07	9.87	9.97	10.29
RPL7A	10.50	10.28	10.55	10.46	10.65	10.56	10.13	10.41	10.47	10.19	10.72
RPL7L1	4.93	4.18	5.90	4.34	4.48	3.83	4.86	4.90	5.61	3.48	3.61
RPL8	9.67	9.78	9.56	9.69	9.96	9.71	9.75	9.68	9.50	9.70	9.98
RPL9	10.92	10.76	10.55	10.56	11.18	10.37	10.39	10.59	10.19	10.63	10.75
RPL10	9.91	9.27	9.22	9.41	9.76	9.17	9.64	9.40	9.15	9.48	9.83
RPL10L	4.48	4.58	4.48	3.80	4.35	4.36	4.32	3.71	3.77	4.26	4.57
RPL10A	8.79	9.43	9.02	9.44	9.44	9.21	8.83	8.93	8.72	8.88	9.26
RPL11	11.47	11.23	10.99	11.54	11.58	11.23	11.16	10.87	10.77	11.37	11.20
RPL12	9.34	9.50	8.83	9.75	9.69	9.45	8.98	9.09	9.11	9.45	9.31
RPL13	6.26	6.67	6.11	6.57	6.43	6.41	5.89	5.62	5.34	5.99	6.19
RPL13A	10.73	10.81	10.72	11.16	11.02	10.73	10.91	10.73	10.46	10.74	11.00
RPL14	9.29	9.25	9.26	9.37	9.39	9.19	9.43	9.11	8.96	9.06	9.20
RPL15	8.53	8.57	9.13	8.83	8.83	8.49	8.86	8.82	8.47	8.52	8.62
RPL17	10.82	11.29	10.95	11.27	11.47	11.10	11.01	11.30	10.78	11.62	10.73
RPL18	10.86	10.96	11.02	11.40	11.11	11.17	10.33	10.44	10.43	11.05	10.79
RPL18A	10.64	10.46	10.10	10.68	10.63	10.84	10.40	10.30	10.43	10.93	10.59
RPL19	10.43	10.16	10.30	10.24	10.37	10.09	10.49	10.38	10.10	10.53	10.12
RPL21	12.21	12.65	12.89	12.77	13.00	12.54	12.74	12.60	12.44	13.29	12.47
RPL22	10.18	10.20	10.34	10.35	10.48	10.07	10.29	10.13	9.69	10.44	9.93
RPL22L	9.15	8.91	9.30	9.06	9.18	9.59	9.40	9.29	11.09	9.91	8.49
RPL23	10.44	10.30	9.92	10.15	10.39	9.94	10.44	10.12	9.72	10.63	10.11
RPL23A	11.15	11.02	11.66	11.36	11.17	11.04	11.45	10.85	10.92	10.99	11.03
RPL24	9.31	9.26	9.94	9.51	9.61	9.32	9.80	9.34	9.21	9.41	9.19
RPL26	10.15	9.81	10.32	10.07	10.24	10.08	10.27	9.70	9.47	9.95	9.54
RPL26L1	3.97	3.09	5.48	3.73	3.39	3.85	5.29	5.34	4.88	3.60	3.24
RPL27	9.05	8.63	8.94	8.83	8.96	8.79	9.22	8.67	8.68	8.91	8.34
RPL27A	7.03	6.66	6.89	7.09	7.02	6.96	6.93	6.61	6.48	7.05	6.67
RPL28	10.88	10.34	11.29	10.99	10.67	11.21	10.52	10.72	11.04	11.05	10.44
RPL29	12.71	12.17	12.28	12.62	12.58	12.88	12.83	12.49	12.24	12.31	12.40
RPL30	10.76	10.37	10.21	10.30	10.47	10.04	10.56	10.21	10.33	10.68	10.82
RPL30L (LOC100652953)	10.46	9.99	10.12	9.73	10.57	9.68	10.17	9.82	9.33	10.01	9.90
RPL31	9.86	9.82	9.97	9.67	9.94	9.54	9.78	9.86	9.33	10.06	9.97
RRPL13L	1.56	1.06	3.79	1.68	1.06	0.58	1.38	3.30	1.43	2.90	1.39
RPL32	11.07	10.66	10.61	10.70	10.79	10.60	10.63	10.61	10.71	10.96	10.96
RPL34	2.22	2.32	3.11	2.07	2.54	2.09	2.96	3.74	3.14	2.78	2.34
RPL35	9.53	9.27	9.24	9.48	9.64	9.43	9.31	9.61	9.70	9.65	9.35

Supplementary Table 2 continued. Normalized expression levels (log2) of all RPs analyzed by qRT-PCR across 22 different tissues.

normalized expression level	Placenta	Prostate	Skeletal muscle	Small intestine	Spleen	Testes	Thymus	Thyroid	Trachea	Skin	H7.514 hES
RPLP0	11.28	11.33	11.43	11.44	11.07	11.12	11.07	11.01	11.18	11.07	11.54
RPL2B	10.46	10.13	10.18	9.68	10.39	10.14	10.42	9.67	10.23	9.72	10.04
RPL3	10.39	11.09	9.59	10.96	10.57	10.88	10.68	10.79	11.03	11.44	11.28
RPL4	10.06	10.79	11.12	10.60	10.44	10.70	10.92	10.69	10.89	10.85	10.70
RPL5	10.24	10.53	9.82	10.53	10.14	10.32	10.50	10.91	10.26	10.62	10.79
RPL6	9.44	9.76	9.24	9.67	8.96	8.89	9.47	10.02	9.57	10.10	10.15
RPL6 var1	4.23	2.98	3.49	3.33	3.30	4.13	3.33	3.14	4.14	3.96	6.41
RPL7	9.99	10.45	9.74	10.49	9.88	9.92	10.25	10.58	10.36	10.76	10.70
RPL7A	10.46	10.59	10.24	10.68	10.36	10.60	10.74	10.61	10.57	10.98	11.19
RPL7L1	5.05	4.47	4.18	4.52	4.06	4.59	4.78	4.78	4.64	3.82	5.37
RPL8	9.78	10.06	9.22	10.02	9.38	9.41	9.13	9.85	9.75	10.29	9.92
RPL9	10.52	10.90	10.07	11.01	10.81	10.46	10.34	11.17	10.67	10.89	10.73
RPL10	9.50	9.70	9.52	9.70	9.55	8.98	9.96	9.57	9.62	9.80	9.24
RPL10L	4.26	3.84	4.76	3.51	4.29	7.18	4.43	3.57	4.15	1.92	4.27
RPL10A	9.21	9.61	9.26	8.99	9.00	8.88	9.21	9.60	9.24	9.91	9.50
RPL11	11.09	11.80	11.23	11.37	11.09	10.99	11.02	11.49	11.63	11.62	11.18
RPL12	9.09	9.99	10.12	9.49	9.50	9.38	9.16	9.53	9.50	9.99	9.67
RPL13	5.28	6.71	6.67	6.09	6.26	6.61	7.57	6.71	7.08	7.07	6.95
RPL13A	10.91	11.10	11.19	11.03	11.02	10.89	10.83	11.10	11.06	11.66	11.33
RPL14	9.36	9.61	9.79	9.28	8.94	8.93	9.19	9.48	9.33	9.32	9.44
RPL15	8.88	8.91	9.16	8.57	8.76	9.34	9.08	9.27	8.85	9.01	9.37
RPL17	10.99	11.55	10.28	11.55	11.05	10.89	10.60	11.42	11.17	11.55	11.20
RPL18	10.91	11.18	10.59	11.48	10.81	10.98	11.36	11.24	11.33	12.08	10.92
RPL18A	10.54	10.73	10.67	10.79	10.78	10.56	11.15	10.69	10.61	11.56	10.78
RPL19	10.32	10.26	10.34	10.73	10.42	10.42	10.58	10.23	10.44	10.74	10.30
RPL21	12.59	12.89	12.33	12.84	12.76	12.26	12.53	12.70	12.74	12.63	12.07
RPL22	10.18	10.35	9.66	10.41	10.00	9.97	10.23	10.18	10.14	10.69	10.39
RPL22L	8.67	9.57	9.36	9.54	10.35	9.07	4.54	4.56	5.79	4.78	6.24
RPL23	10.24	10.30	9.79	10.13	10.07	9.96	10.04	10.13	10.13	10.64	10.27
RPL23A	11.45	11.02	11.39	11.52	11.37	11.24	11.75	10.98	11.16	11.62	11.19
RPL24	9.33	9.45	9.69	9.76	8.72	9.32	9.44	9.82	9.24	9.44	9.68
RPL26	9.95	10.03	10.02	10.42	9.99	9.79	9.78	10.03	9.93	10.23	9.54
RPL26L1	4.73	3.45	4.97	4.77	4.13	6.56	4.09	4.42	4.34	4.00	5.02
RPL27	9.10	8.44	9.28	8.95	8.98	8.78	8.95	8.65	8.62	9.34	8.74
RPL27A	7.24	6.85	7.01	7.41	7.17	6.65	6.81	7.10	6.89	7.49	7.35
RPL28	10.76	10.76	10.36	11.15	11.27	11.05	12.00	10.42	11.00	11.58	10.69
RPL29	12.20	12.31	13.33	13.05	12.65	12.55	12.71	12.49	12.52	13.21	12.67
RPL30	10.14	10.75	10.44	10.14	10.65	10.39	10.86	10.44	10.46	10.69	10.31
RPL30L (LOC100652953)	9.76	9.55	9.59	9.63	9.94	9.29	9.69	9.09	9.02	7.67	7.64
RPL31	9.38	10.15	9.46	9.43	9.70	9.57	9.89	9.71	9.69	9.79	9.23
RRPL13L	1.04	1.41	0.38	1.13	1.15	3.06	1.99	2.11	1.87	0.40	2.03
RPL32	10.41	11.11	11.06	10.47	10.86	10.77	11.18	10.47	10.80	11.02	10.39
RPL34	2.09	3.41	2.08	3.82	3.05	3.04	2.93	4.07	3.01	2.84	3.27
RPL35	8.95	9.70	9.94	9.21	9.57	9.35	9.37	9.36	9.53	9.91	9.62

Supplementary Table 2 continued. Normalized expression levels (log2) of all RPs analyzed by qRT-PCR across 22 different tissues.

normalized expression level	Adipose	Bladder	Brain	Cervix	Colon	Esophagus	Heart	Kidney	Liver	Lung	Ovary
RPL35A	9.10	8.90	8.63	8.85	9.11	8.63	9.20	8.91	8.23	9.16	9.35
RPL36	9.80	9.43	9.46	9.74	9.86	9.63	9.44	9.72	9.67	9.76	10.12
RPL36A var1	9.43	9.36	9.10	9.49	9.69	9.33	8.94	9.42	8.98	9.54	9.67
RPL36A var2	0.56	0.29	1.26	0.60	1.07	0.14	0.12	0.06	0.15	0.14	1.20
RPL36AL	8.72	9.12	9.27	8.78	8.72	8.50	9.06	9.08	9.60	8.75	9.16
RPL37	11.44	11.52	11.26	11.47	11.28	11.87	10.94	11.24	11.63	11.59	11.66
RPL37A	11.74	12.07	11.93	11.75	11.67	12.18	11.75	11.53	11.79	11.70	11.81
RPL38	6.26	6.33	6.80	5.78	6.00	6.20	6.96	6.21	6.84	6.23	6.35
RPL39	11.75	11.65	10.77	11.50	11.52	11.71	11.55	11.09	12.47	11.86	11.43
RPL39L	0.58	0.32	2.32	0.96	1.27	0.42	1.37	0.23	2.35	0.87	0.07
RPL41	4.03	4.21	5.88	3.57	4.01	3.89	5.48	4.81	5.04	3.82	3.49
RPLP1	12.40	12.70	11.73	12.49	12.30	12.72	12.65	12.09	12.59	12.47	12.68
RPLP2	12.29	11.79	11.13	11.38	11.51	11.67	11.28	11.28	11.56	11.81	11.82
RPSA	1.60	2.13	2.75	2.48	2.01	2.96	2.09	2.98	2.70	2.35	2.43
RPS2	11.55	11.91	10.87	11.71	11.62	12.28	11.28	11.45	12.78	11.85	11.90
RPS3	10.68	11.41	10.27	11.10	11.22	11.43	10.38	10.57	10.95	11.33	11.53
RPS3A	10.01	10.40	9.26	10.24	10.12	10.18	9.94	9.93	9.61	10.04	10.51
RPS4X	9.86	9.78	9.21	10.09	9.56	9.86	9.27	9.52	8.85	9.26	10.51
RPS5	5.12	5.47	4.38	5.11	4.75	5.49	4.88	5.02	5.74	4.90	5.93
RPS6	15.78	15.71	15.19	15.45	15.97	15.35	14.95	15.22	14.60	15.86	15.42
RPS7	11.18	11.39	10.76	11.05	11.30	11.52	11.12	11.38	11.60	11.16	11.30
RPS8	9.11	9.38	8.44	9.17	9.11	9.46	8.70	8.71	8.95	8.79	9.91
RPS9	10.23	10.54	9.74	10.14	9.99	10.38	9.86	10.33	10.35	10.25	10.47
RPS10	10.97	11.56	10.95	11.32	11.15	11.55	10.98	11.36	11.32	11.22	11.46
RPS11	12.66	12.83	12.22	12.55	12.35	12.52	12.24	12.53	12.47	12.50	12.74
RPS12	9.44	9.72	8.92	9.24	9.16	9.53	9.09	9.14	9.51	9.45	9.72
RPS13	9.62	9.81	9.01	9.25	9.19	9.49	9.64	9.52	9.38	9.15	9.63
RPS14	12.19	12.38	11.87	12.05	11.91	12.14	11.85	12.08	11.79	12.20	12.03
RPS15	4.75	4.66	6.10	5.13	4.20	5.32	5.61	5.88	5.98	4.43	4.41
RPS15A	9.55	9.74	8.44	9.44	9.28	9.57	9.39	9.26	9.45	9.42	9.55
RPS16	11.95	12.41	11.37	12.04	11.84	12.21	11.95	11.94	12.31	11.94	12.50
RPS18	10.99	11.25	10.34	11.30	10.67	11.40	10.47	10.56	10.80	10.96	11.45
RPS19	12.33	12.85	12.12	12.87	12.69	13.27	12.07	12.45	13.33	12.77	12.89
RPS20	9.76	9.54	8.79	9.24	9.13	9.25	9.23	9.04	9.12	9.35	9.60
RPS21	11.40	11.88	11.56	11.69	11.60	11.75	11.31	11.42	11.53	11.62	11.77
RPS23	12.40	12.82	12.32	12.50	12.27	12.45	12.64	12.31	12.09	12.37	12.91
RPS24	2.91	2.77	4.42	3.37	2.47	3.76	4.12	3.83	5.53	3.28	2.74
RPS25	11.57	12.05	11.33	11.50	11.63	11.67	11.68	11.31	11.54	11.50	11.48
RPS26	3.14	1.71	4.31	2.74	2.98	2.11	5.11	5.09	5.21	3.11	1.88
RPS27	11.65	11.90	11.17	11.79	11.79	11.65	11.34	11.66	11.48	11.84	11.71
RPS27A	11.44	11.72	11.46	11.35	11.46	11.39	11.30	11.42	11.41	11.08	11.46
RPS27L	7.41	7.48	6.86	6.02	7.25	6.62	8.34	8.09	7.45	6.86	5.99
RPS28	11.74	11.38	11.65	11.69	11.19	12.07	11.71	11.88	11.93	11.59	11.75
RPS29 var1	10.70	10.76	10.73	10.61	10.51	10.83	10.94	11.01	10.89	10.93	10.55
RPS29 var2	3.96	4.60	5.14	4.21	4.22	4.54	4.63	5.09	2.54	4.41	4.16

Supplementary Table 2 continued. Normalized expression levels (log2) of all RPs analyzed by qRT-PCR across 22 different tissues.

normalized expression level	Placenta	Prostate	Skeletal muscle	Small intestine	Spleen	Testes	Thymus	Thyroid	Trachea	Skin	H7.514 hES
RPL35A	8.51	9.31	8.62	8.86	8.92	8.98	9.38	9.10	9.00	9.11	9.02
RPL36	9.30	10.29	9.50	9.68	9.70	9.65	9.69	9.24	9.92	10.32	9.63
RPL36A var1	9.02	9.82	9.29	9.41	9.64	8.82	9.59	8.78	9.61	10.13	9.62
RPL36A var2	0.83	0.20	0.20	0.43	0.66	0.20	0.48	0.20	0.50	2.28	0.08
RPL36AL	9.18	8.52	8.65	9.39	8.60	8.57	8.27	8.99	8.68	7.35	8.31
RPL37	11.64	11.32	11.16	11.08	11.58	10.84	11.45	11.40	11.45	11.47	10.67
RPL37A	11.80	11.55	11.81	11.10	11.62	11.69	11.44	11.75	11.75	11.72	10.94
RPL38	6.33	5.91	6.88	6.05	5.35	6.81	6.40	6.66	6.43	5.42	6.24
RPL39	11.70	11.42	11.47	11.33	11.78	10.88	11.81	11.49	11.51	11.41	10.60
RPL39L	0.83	1.23	0.09	0.26	0.30	6.85	3.45	0.35	2.08	1.76	3.20
RPL41	4.62	3.49	5.63	3.91	3.05	5.16	3.40	4.64	4.14	2.89	4.57
RPLP1	12.45	12.15	13.30	12.15	12.37	11.98	12.55	12.21	12.42	12.87	11.69
RPLP2	11.87	11.33	11.62	11.35	11.83	11.31	11.88	11.29	11.54	11.46	10.78
RPSA	2.42	2.09	1.91	2.39	3.13	1.95	2.35	2.82	2.77	2.31	3.48
RPS2	11.89	11.57	11.92	11.47	12.07	11.48	11.89	11.54	11.77	12.21	11.96
RPS3	11.28	10.98	10.67	10.74	11.27	10.75	11.02	11.14	10.93	10.95	10.76
RPS3A	10.40	10.02	9.97	10.07	10.39	9.85	10.07	10.42	9.81	9.83	10.23
RPS4X	10.28	9.32	9.77	9.38	8.69	9.12	9.58	10.29	9.47	10.02	9.78
RPS5	5.53	5.06	5.59	4.54	5.11	4.82	5.04	5.49	5.12	5.43	5.41
RPS6	14.98	16.09	15.17	15.30	16.14	15.85	15.73	15.05	15.27	14.48	13.71
RPS7	11.88	11.14	10.97	11.03	11.38	10.95	10.94	11.31	11.05	10.97	11.27
RPS8	9.60	8.99	9.08	8.72	9.27	8.47	8.85	8.90	8.80	9.12	9.13
RPS9	9.97	10.39	10.11	10.21	10.62	9.89	10.18	10.28	10.34	10.47	9.77
RPS10	11.29	11.29	11.12	11.26	11.07	11.15	11.12	11.44	11.22	11.49	10.92
RPS11	12.71	12.61	12.62	12.32	12.86	12.28	12.53	12.48	12.48	12.57	11.80
RPS12	9.88	9.25	8.94	9.01	9.61	9.18	9.50	9.24	9.27	9.36	9.01
RPS13	9.91	9.10	9.92	9.11	9.30	8.96	9.49	9.36	9.29	9.16	8.96
RPS14	12.48	12.05	12.33	12.06	12.18	11.67	11.81	12.29	12.03	12.09	11.37
RPS15	5.39	4.21	5.13	4.70	4.97	5.44	4.97	5.01	5.29	4.55	6.72
RPS15A	9.60	9.31	9.71	9.35	9.80	9.01	9.72	9.41	9.23	9.18	8.89
RPS16	12.27	11.71	12.30	12.03	12.17	11.63	12.33	11.93	12.11	12.02	11.52
RPS18	10.85	10.87	10.63	10.85	10.71	10.70	10.86	10.66	10.91	11.40	10.43
RPS19	12.69	13.07	12.31	12.83	13.25	12.39	12.82	12.79	12.71	13.01	12.80
RPS20	9.20	9.25	9.08	8.85	9.35	9.08	9.32	8.94	9.16	8.83	9.00
RPS21	11.37	11.37	11.51	11.49	11.62	11.13	11.69	11.57	11.49	11.61	10.98
RPS23	12.54	12.15	12.86	12.26	12.68	11.92	12.54	12.37	12.42	12.15	12.35
RPS24	2.31	2.68	5.22	2.85	3.06	5.43	3.39	3.63	3.70	3.30	7.32
RPS25	11.36	11.48	11.93	11.51	11.55	11.16	11.26	11.23	11.52	11.30	11.17
RPS26	3.18	2.33	5.62	4.90	2.91	3.15	1.94	3.02	2.56	0.99	5.07
RPS27	11.45	11.80	11.44	11.45	11.60	11.32	11.68	11.66	11.76	11.54	10.71
RPS27A	11.39	11.20	10.52	11.15	11.55	10.80	10.86	11.62	11.53	11.29	11.28
RPS27L	7.06	6.83	6.86	7.99	6.48	6.31	5.54	7.35	6.87	5.96	6.47
RPS28	11.64	11.42	11.57	11.50	11.96	11.09	11.78	11.86	11.89	12.18	11.00
RPS29 var1	11.21	10.23	10.78	10.80	11.30	10.62	11.13	10.47	10.62	10.87	10.50
RPS29 var2	4.25	4.95	3.97	4.52	4.52	4.11	4.63	5.65	4.32	3.39	4.34

Supplementary Table 3. Evolutionary stage and expression variation of ribosomal protein mRNAs examined.

RP gene	Evolution Stage (1-6)	Expression Variation
RPS10	1	0.017
RPL19	2	0.018
RPS21	2	0.018
RPS11	1	0.019
RPS25	3	0.020
RPS23	1	0.020
RPS14	1	0.021
RPL21	2	0.022
RPL32	2	0.022
RPL14	1	0.023
RPL4	1	0.023
RPS7	1	0.023
RPL30	1	0.023
RPL23A	3	0.023
RPL13A	3	0.023
RPL7A	3	0.023
RPL37A	1	0.023
RPS27	3	0.023
RPL23	1	0.024
RPS29 var 1	3	0.024
RPL11	1	0.024
RPS16	2	0.024
RPL22	1	0.024
RPS9	1	0.024
RPL35	2	0.025
RPS27A	4	0.025
RPL29	1	0.025
RPL37	3	0.025
RPL31	2	0.025
RPS28	3	0.026
RPL26	3	0.026
RPL2B	4	0.026
RPS20	2	0.027
RPS19	1	0.027
RPL9	2	0.027
RPL18A	3	0.028
RPL7	3	0.028
RPL10	1	0.028
RPLP2	1	0.028
RPL8	3	0.028
RPL36	2	0.029
RPS12	1	0.029
RPL5	1	0.029
RPL24	1	0.029
RPL27	2	0.029
RPS3A	3	0.029
RPLP1	3	0.030
RPS18	2	0.030
RPLP0	1	0.031
RPS3	1	0.031
RPS13	1	0.031
RPL17	2	0.031
RPL15	1	0.032
RPL35A	3	0.032
RPS2	1	0.033
RPS15A	3	0.033
RPL6	1	0.033
RPL10A	3	0.034
RPL39	3	0.035
RPL12	1	0.035
RPL18	1	0.036
RPL36A var 1	3	0.036
RPL28	2	0.038
RPS6	2	0.038
RPL27A	3	0.038
RPS8	1	0.039
RPL3	1	0.044
RPS4X	4	0.049
RPL36AL	6	0.054
RPL38	3	0.070
RPS5	1	0.075
RPL30L (LOC100652953)	3	0.076
RPL13	1	0.088
RPS27L	6	0.105
RPS15	1	0.127
RPL7L1	5	0.135
RPS29 var 2	6	0.143
RPSA	1	0.184
RPL41	4	0.194
RPL26L1	6	0.197
RPL34	2	0.207
RPS26	4	0.210
RPL22L	5	0.228
RPL6 var 1	6	0.263
RPS24	3	0.326
RPL10L	4	0.403
RPL13L	6	0.547
RPL36A var 2	6	1.010
RPL39L	5	1.106